J-16a

REPORT ON THE SAN BERNARDINO COUNTY COMPREHENSIVE STORM DRAIN PLAN PROJECT NO. 3

VOLUME I

Hydrologic and Hydraulic
Design Criteria

Prepared for

SAN BERNARDINO COUNTY
FLOOD CONTROL DISTRICT

By

VERPET ENGINEERING COMPANY
6824 Melrose Avenue
Los Angeles, California

May 1973

CONTENTS

A. HYDROLOGIC DESIGN CRITERIA

1. GENERAL ANALYSIS OF THE AREA:

The study area encompasses approximately 70 square miles of the County of San Bernardino and is divided into two portions by the San Bernardino Freeway (Interstate 10). The upper portion is an approximate triangle bounded by Sierra Avenue to the west and Lytle Creek, Highland Avenue and Riverside Avenue to the east; the lower portion's boundaries are Palmetto Avenue to the west, Anderson Street to the east, and the San Bernardino-Riverside County Line to the south.

The cities of Colton and Rialto lie totally within the study area, whereas only approximately half of the city of Fontana to the west and half of the city of Loma Linda to the east are included within this area.

The remainder, including densely populated areas such as Bloomington and Crestmore is unincorporated County area.

A certain percentage of the study area, especially in the north triangular portion, is still undeveloped, therefore future street extensions and new streets at 1,320 foot intervals both in a north-south and east-west direction had to be taken into account as well as future land use conditions in order to provide for ultimate drainage requirements.

Furthermore, such requirements were also dictated by the intensity of rainfall and soil conditions within the area under consideration, since both factors are variable.

Other characteristics of the lower portion study area are Reche Canyon, a major natural watercourse entering the study area at the southeast end and adding over 4,000 acres to the existing drainage area, the Santa Ana River flowing in a northeasterly-southwesterly direction and being the downstream end of all storm drain projects with the exception of one, the Riverside Freeway (Interstate 395), as well as the Jurupa Mountains in the southwest and the Loma Hills in the mid-south.

2. DESIGN CRITERIA:

Method Used

Pursuant to comparative studies and consultations with representatives of the San Bernardino County Flood Control District as well as the cities of Colton, Rialto and Fontana, the Modified Rational Method has been selected for the determination of design peak flows for storm drains and channels within the study area for the following reasons:

a) It was deemed necessary not only to produce a satisfactory design for the San Bernardino County Flood Control District, but to also provide the cities involved with a plan responsive to their individual needs, namely the sizing of tributary laterals and secondary trunk lines prior to their entering the main channels or main trunk lines.

   For this purpose a maximum area increment of 40 acres was adopted between points of concentration in all areas where development has already taken place or will be possible in the future by the use of a 1,320 foot by 1,320 foot street network, dictated by and blending with the surrounding existing development.

b) The Modified Rational Method is recommended for tributary drainage areas of 5,000 acres or less, a limit exceeded by no single secondary trunk line, not even by a main channel or main trunk line with the exception of project areas 3-3 and 3-4 partially affecting channel sections only where the incremental cost is relatively small.

c) A detailed hydrology map with the design runoff, tributary area and time of concentration at any concentration point would be a valuable tool to all government agencies involved for a future detailed hydraulic design and an orderly future development of the undeveloped project areas.

Return Period

a) Tributary laterals - A 10 year frequency was used for street flows, followed by a 25 year frequency for lateral drains where the street capacity was exceeded by the 10 year storm.

b) Secondary trunk lines - A 25 year frequency was employed here since these lines normally run in an easterly-westerly direction with no adequate fall and therefore the difference between a 25 year frequency and a 10 year frequency exceeds the street capacity.

c) Main channels and main trunk lines - A 25 year frequency was also used for all main channels and conduits except for a 100 year storm for the Cactus-Rialto Channel, an approximately 8-mile long channel running through densely populated areas and carrying the heaviest runoff among all main channels.

Conversion factors to various frequencies are contained in the Frequency Relationship Nomograph, Plate III.

Rainfall Intensity

Records of rain gauge stations located in and around the study area indicate a variation in maximum rainfall intensity depending upon their location.

From such records and the adjacent comprehensive storm drain plan data, an isohyetal pattern was developed for a 50 year return period and a 6 hour maximum precipitation as reflected by the isohyets on the Isohyetal Map, Plate I.

Furthermore, as shown on Plate II, a set of duration-intensity curves for a 10 year return period (one for each isohyet) was developed, thereby enabling the determination of the 10 year rainfall intensity as a function of the point concentration time and the isohyetal value depending upon the location of the tributary subarea.

The yielded 10 year rainfall intensity value could be easily then converted to any desired frequency by the use of Plate III.

Soil Infiltration

Data supplied by the Redlands office of the Soil Conservation Service, U. S. Department of Agriculture, were used to compile the Soil Map, Plate V.

It shows the four hydrologic soil groups A, B, C and D in decreasing order of permeability as encountered within the study area.

Land Use

The ultimate development or land use of the study area was of primary concern, for had it not been taken into account, the proposed system might as a result have been adequate at the present time but rendered gradually inadequate as development progressed.

For this purpose, the San Bernardino County Planning Commission and the three major cities of Colton, Rialto and Fontana were requested to provide information regarding their ultimate zoning plans or anticipated land use within the limits of their jurisdiction or sphere of influence.

As a result, an ultimate land use Zoning Map, Plate VI, was developed for the entire area under study.

Coefficient of Runoff

Surface detention (depression storage), evaporation and infiltration losses are to be accounted for by the introduction of the coefficient of runoff, a factor expressing the fractional portion of rainfall converted to runoff.

In the Rational Method it is assumed that a maximum of 85 percent of the rainfall appears as runoff because of losses in depression storage and evaporation.

The runoff from pervious surfaces is further reduced by the relationship between the rainfall intensity and the loss rate due to infiltration.

The coefficient of runoff is computed by the formula:

$$C = 0.85 \left[a_1 + \frac{(I-f)}{I} a_2\right]$$

where $a_1 = \frac{\% \text{ of impervious}}{100}$ and $a_2 = \frac{\% \text{ pervious}}{100}$ and $a_1 = 1.0\text{-}a$

Recommended values of a_2 by the Soil Conservation Service, U.S. Department of Agriculture have as follows:

No.	Land Use	a_2 = % Pervious
1	Commercial	5
2	Multiple family	20
3	Industrial and trailer park	25
4	Single family	55
5	School	60
6	Park	80
7	Mountain	90
8	Agricultural	100

Curve numbers yielding infiltration losses for various types of development and hydrologic soil groups are also given in the same bibliography as well as a nomograph for infiltration loss versus curve number.

As a result of the study conducted and forwarded to the San Bernardino County Flood Control District under separate cover coefficient of runoff curves were developed in terms of the 10 year rainfall intensity.

Coefficient of runoff curves are plotted in four separate plates, Plates IVa, IVb, IVc and IVd, one for each hydrologic soil group and for all types of land use.

3. DESIGN PROCEDURE:

The entire study area was found to be comprised of 18 individual project areas and, as previously stated, the Modified Rational Method was selected for the determination of design peak flows for channels and storm drains within each project area.

1. Each project area was divided into drainage subareas not greater than 40 acres, wherever future growth pattern could be predicated in terms of surrounding existing development.

2. Time of concentration for the initial subarea with an area not greater than 10 acres and a flow path of 1,000 feet or less was determined from Plate VII. It should be noted that all times of concentration were computed in multiples of 1/2 minute.

3. The average isohyetal or isopluvial value of the drainage subarea was recorded by the use of Plate I.

4. The rainfall intensity "I" was determined by entering Plate II with a duration equal to the time of concentration and the appropriate isohyetal value; the yielded intensity was of a 10 year frequency and was converted as required to any desired frequency by use of the appropriate factor derived from Plate III.

5. The acreage "A" of the subarea was computed.

6. Hydrologic soil groups encountered in the subarea were recorded by use of Plate V.

7. Existing and anticipated land use in the subarea was also recorded by use of Plate VI.

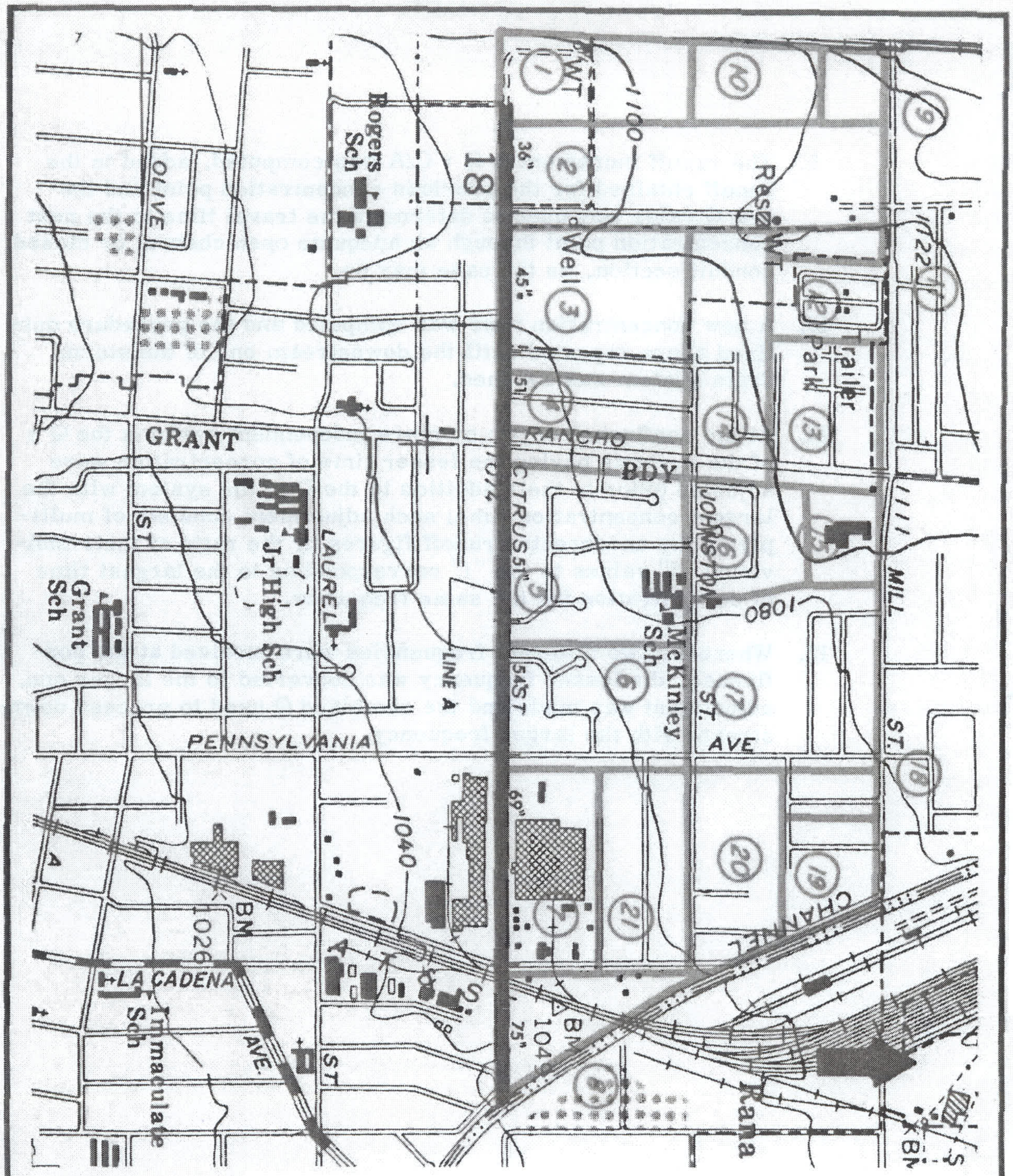
8. The coefficient of runoff "C" was computed by entering Plate IV - a, b, c, d depending upon the appropriate hydrologic soil group - with the 10 year rainfall intensity and the prevailing land use.

9. The runoff increment $\Delta Q = CIA$ was computed, added to the runoff obtained for the previous concentration point and the new Q value was used to determine the travel time to the next concentration point through an adequate open channel or closed conduit section, as the case may be.

10. A new concentration time was computed and the procedure outlined above repeated until the downstream end of the storm drain system was reached.

11. At the confluence of two or more independent systems the Q's of the systems having the lesser time of concentration were adjusted prior to their addition to the Q of the system with the largest concentration time; such adjustment consists of multiplying the uncorrected runoff figures by the ratio of their individual "I" values to the "I" corresponding to the largest time of concentration for the same frequency.

12. Whenever two different frequencies were involved at the confluence, the lesser frequency was converted to the larger one, adjustment was made and the combined Q used to proceed downstream with the larger frequency.



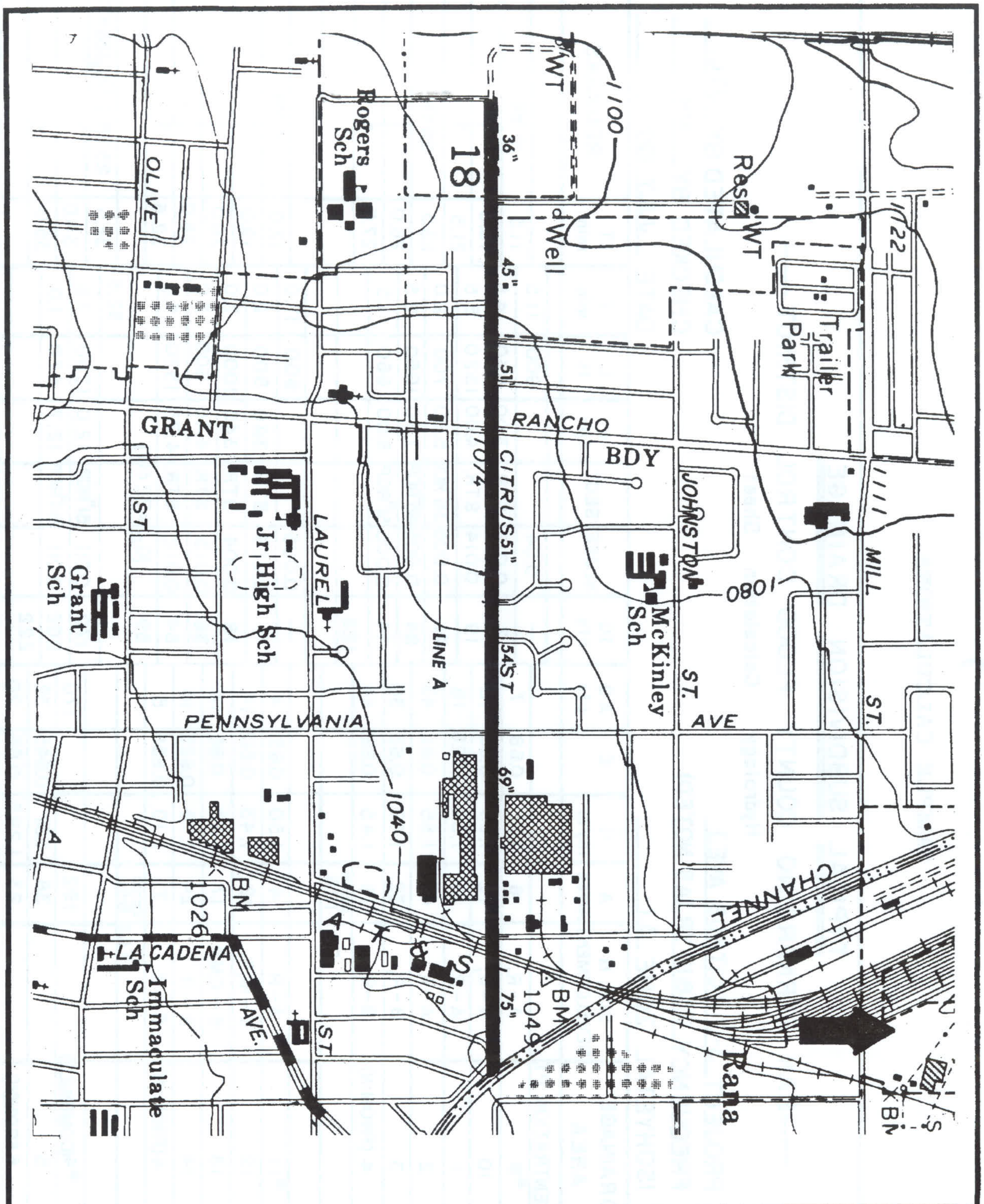
PROPOSED STORM DRAIN

EXISTING STORM DRAIN

SAN BERNARDINO COUNTY FLOOD CONTROL DISTRICT	DATE MAY 1973
COMPREHENSIVE STORM DRAIN PLAN	SCALE 1"=1000'
PROJECT NO. 3-7	SHEET 1 OF 2

PHONE 931-8167

VERPET ENGINEERING CO.
6834 MELROSE AVE. LOS ANGELES, CALIFORNIA 90038



PROPOSED STORM DRAIN
EXISTING STORM DRAIN

	SAN BERNARDINO COUNTY FLOOD CONTROL DISTRICT	DATE MAY 1973
PHONE 931-8167 VERPET ENGINEERING CO. 6824 MELROSE AVE. LOS ANGELES, CALIFORNIA 90038	COMPREHENSIVE STORM DRAIN PLAN **PROJECT NO. 3-7**	SCALE 1"=1000' SHEET 1 OF 2

SAMPLE CALCULATIONS

TYPICAL SUBDIVISION DRAINAGE

—SAN BERNARDINO COUNTY FLOOD CONTROL DISTRICT—

Hydrology Calculation Sheet

PROJECT 3-7 (CITRUS AVE.)
FREQUENCY 25&10 YR. (AS NOTED)
ISOHYETAL ZONE 3.1

CALCULATED BY J.T.C.
CHECKED BY MR.
DATE JULY 1972

	DRAINAGE AREA	SOIL & DEVELOPMENT	A Acres	i in/hr	C	AQ cfs	IQ cfs	SLOPE	SECT.	v fps	L ft.	T min.	IT min.	REMARKS
	CONCENTRATION PT.						—	0.04			900	11.5		
	#9	A-R,	6	1.81	0.68	7	7	0.016	STR.	3.00	830	4.5	11.5	10 YR.
	10	A-R,	12	1.55	0.65	12	19	0.014	STR.	4.00	1320	5.5	16.0	
	1	A-R,	18	1.34	0.625	15	41	0.005	36"RCP	5.80	700	2.0	21.5	
	2	A-R,	45	1.55	0.61	43	84	0.005	45"RCP	7.70	1050	2.5	23.5	25 YR.
	3	B-R,	32	1.49	0.63	30	114	0.005	51"RCP	8.00	660	1.5	26.0	
	4 (FROM:N)	B-R,	15	1.45	0.627	14	128						27.5	
		EA =	128											
							—	0.005			900	17.0		
	#11	A-R	4	1.50	0.65	4	4	0.028	STR.	3.40	500	2.0	17.0	10 YR.
M=10 R=2 C=2 MR=15	12	B-M,R,	12	1.43	0.812	14	18	0.004	STR.	3.40	1000	7.0	19.0	
	13	B-C,MR	17	1.23	0.86	18	36	0.013	STR.	4.40	600	2.0	26.0	
	14	B-R	24	1.18	0.625	18	54	0.012	STR.	4.75	1320	4.5	28.0	
	— 4 (FROM: N)	C-R	7	1.10	0.655	5	59	(Q_{25} = 72 cfs)					32.5	
		EA =	64									32.5		
							170	0.011	51"RCP	12.0	1250	1.5	32.5	25 YR. (1.10/1.45)(128+72)
	#4 (COMBINED)		192			170	202	0.011	54"RCP	12.7	970	1.0	34.0	
R=30 S=8	5		38	1.31	0.645	32	222						35.0	
	6 FROM (W)		23	1.295	0.65	20								
		EA =	253											

SHEET 1 of 3

SAMPLE CALCULATIONS

TYPICAL SUBDIVISION DRAINAGE

—SAN BERNARDINO COUNTY FLOOD CONTROL DISTRICT—

Hydrology Calculation Sheet

PROJECT 3-7 (CITRUS AVE.)
FREQUENCY 25 & 10 YR. (AS NOTED)
ISOHYETAL ZONE 3.1

CALCULATED BY J.T.C.
CHECKED BY M.R.
DATE JULY 1972

DRAINAGE AREA	SOIL & DEVELOPMENT	A Acres	i in/hr	C	AQ cfs	IQ cfs	SLOPE	SECT.	v fps	L ft.	T min.	IT min.	REMARKS
15	B – C	8	1.74	0.932	13	—	0.009			1000	12.5	12.5	10 YR.
16	C – C, R,	16	1.55	0.777	19	13	0.02	STR.	4.10	850	3.5	16.0	
17	C – R,	37	1.375	0.69	35	32	0.014	STR.	4.50	1250	4.5	20.5	
6 FROM(N)	B – R,	7	1.26	0.635	6	67	0.012	STR.	5.30	1320	4.0	24.5	
	EA	68				73	(Q_{25}=88 cfs)						
CONCENTRATION PT.													
6 (COMBINED)		321			297						35.0		
7 (FROM:W)	B – M	21	1.27	0.81	21							35.0	25 YR. $(222+\frac{1.295}{1.52}\times 88)$
						297	0.006	69" RCP	11.4	1470	2.0	37.0	
	EA =	342				318							
18	B – R,	5	1.62	0.685	6	—	0.009			800	14.5	14.5	10 YR.
19	B – R,	12	1.34	0.65	11	6	0.006	STR.	2.10	900	7.0	21.5	
20	A – R,	21	1.22	0.595	15	17	0.008	STR.	3.10	900	5.0	26.5	
21	B – R,	21	1.17	0.625	15	32	0.010	STR.	3.90	660	2.5	29.0	
7 (FROM:N)	A – M	2	1.125	0.575	1	47	0.012	STR.	4.80	660	2.5	31.5	
	EA =	61				48	(Q_{25}= 58 cfs)						

SHEET 2 of 3

SAMPLE CALCULATIONS

TYPICAL SUBDIVISION DRAINAGE

—SAN BERNARDINO COUNTY FLOOD CONTROL DISTRICT—

Hydrology Calculation Sheet

PROJECT 3-7 (CITRUS AVE.) CALCULATED BY J.T.C.

FREQUENCY 25 & 10YR (AS NOTED) CHECKED BY M.R.

ISOHYETAL ZONE 3:1 DATE JULY 1972

DRAINAGE AREA	SOIL & DEVELOPMENT	A Acres	i in/hr	C	AQ cfs	IQ cfs	SLOPE	SECT.	v fps	L ft.	T min.	IT min.	REMARKS
7 (COMBINED)		403			372						37.0		
8	A – M	17	1.24	0.795	17							37.0	
	EA=	420				372	0.006	75" RCP	12.05	950	1.5	38.5	25 YR (318 + 1.27/1.36 × 58)
						389							

SHEET 3 of 3

6. HYDRAULIC CRITERIA

Principles of detailed hydraulic design are contained in any accepted hydraulic design textbook and therefore were not included in this report.

However, some specific criteria upon which this report was based are as follows:

a) Coefficient of roughness (Manning)

Earth channel	= 0.025
Concrete lined channel	= 0.014 (A.B.M. = 0.015)
Reinforced concrete box (R.C.B.)	= 0.014
Reinforced concrete pipe (R.C.P.)	= 0.013

No corrugated metal pipes were used in this report.

b) Channel side slopes

Earth channel	2 = 1
Concrete lined channel	1-1/2 = 1

Side slopes of 1 = 1 for concrete lined channels were used at some specific locations where an existing channel with 1 = 1 slopes was either found adequate or was enlarged to provide for adequate flow conditions.

c) Freeboard

Normal freeboard in excess of the design flow depth was allowed for open channels and reinforced concrete boxes carrying a 25-year frequency storm.

No freeboard allowance was made for a 100-year storm, however, the Cactus-Rialto channel designed for such a frequency, was also insured to contain the normal freeboard should the storm under consideration be of a 25-year frequency.

Freeboard allowance for straight and curved portions follow:

Straight portions:

Section	Normal Freeboard		
	$S < 0.7S_c$	$S > 1.3S_c$	$S \approx S_c$
Trapezoidal channel	$0.20H_e$	0.25D	$0.50D_c$
Rectangular or R.C.B.	$0.10H_e$	0.25D	$0.50D_c$

Where:

s = actual slope
D = normal depth
H_e = energy head
S_c = critical slope
D_c = critical depth

Curved portions:

For subcritical flow allow $t + \frac{F.B}{2}$ and for supercritical flow $2t + \frac{F.B}{2}$, where:

F.B = normal freeboard, as described above

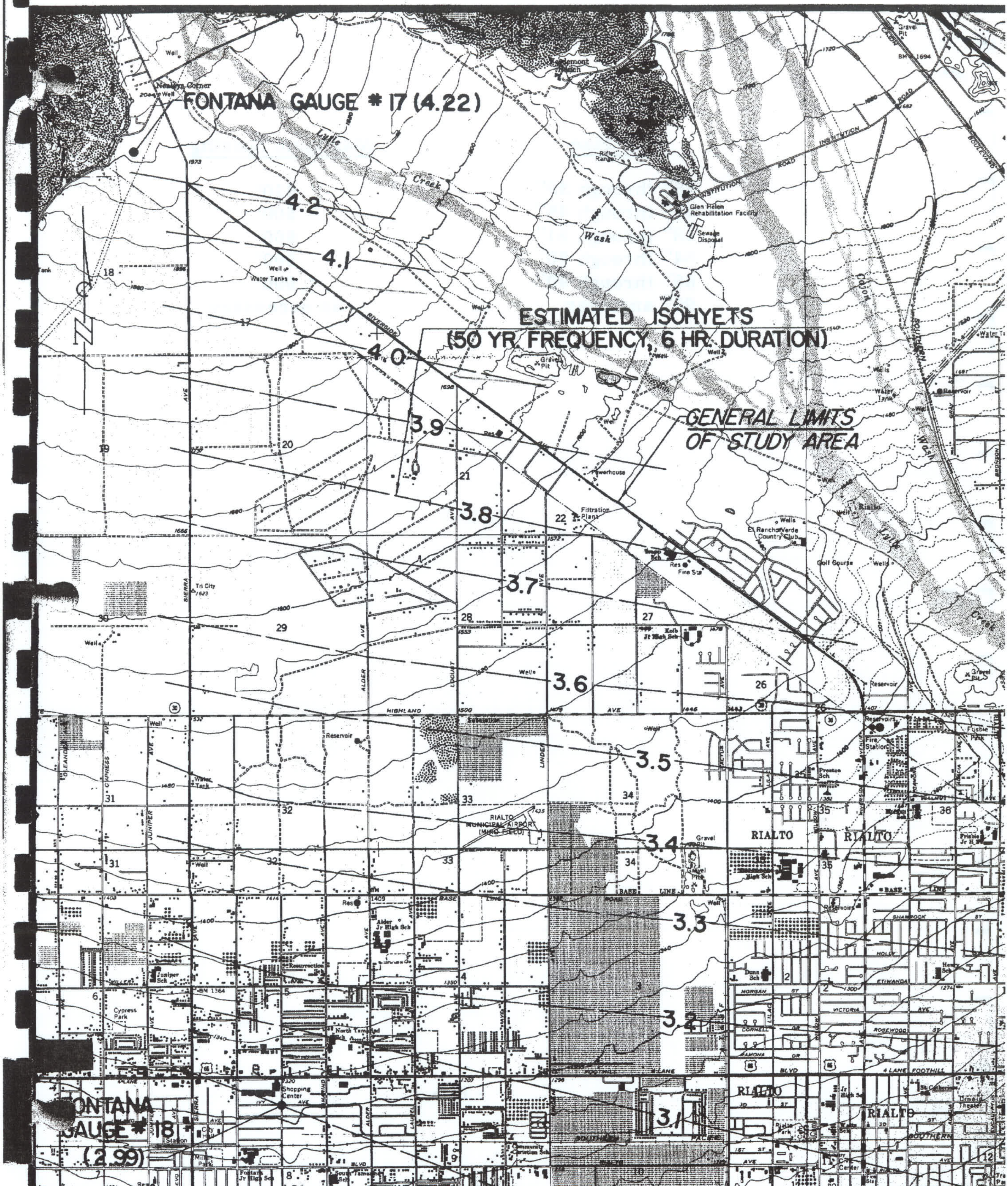
$$t = \frac{v^2(b + 2dctga)}{2gR}$$

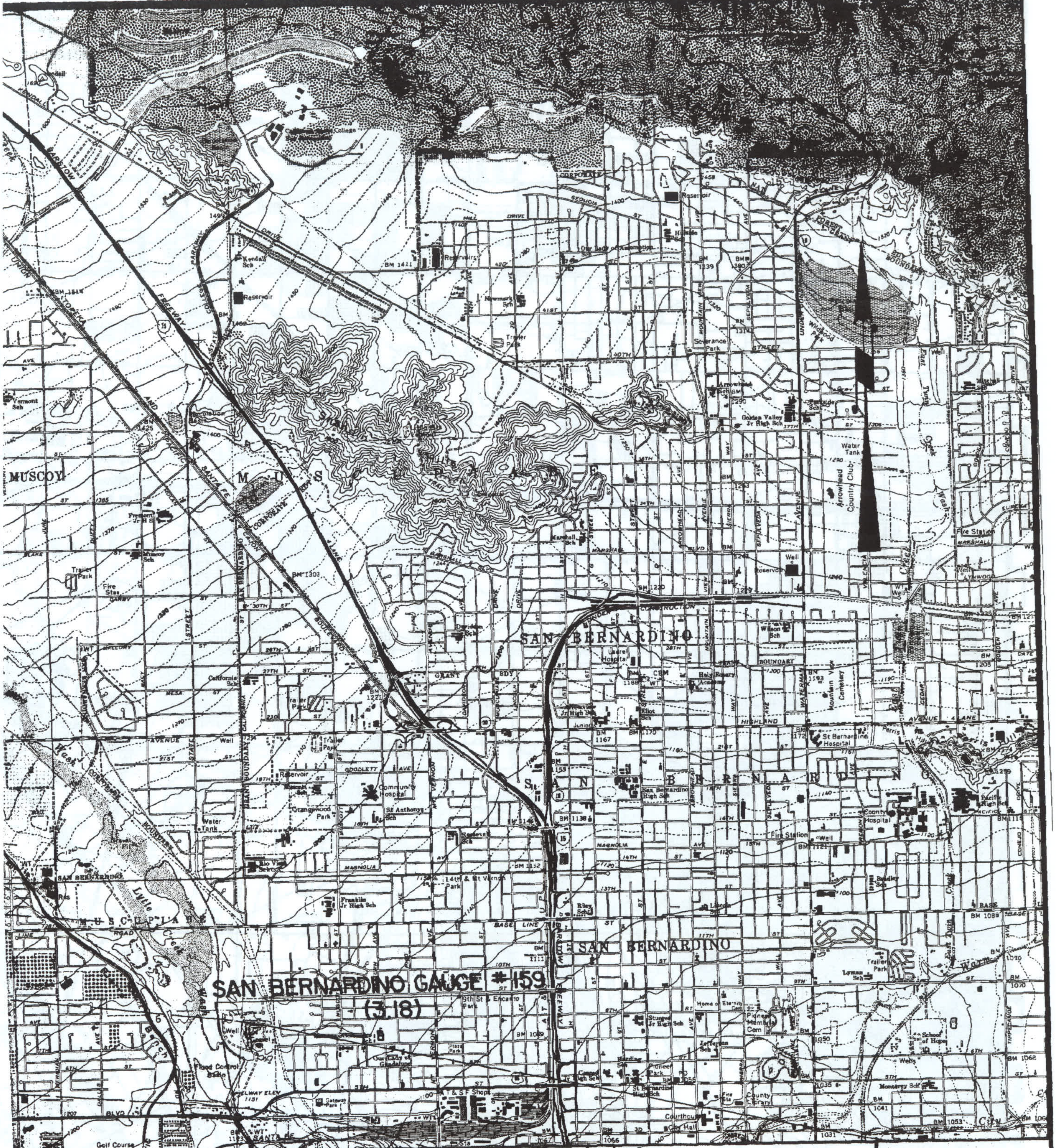
v = flow velocity in ft./sec.
b = channel width in ft.
d = flow depth in ft.
a = angle of side slope with the horizontal
g = 32.2 ft./sec.^{2}
R = curve radius in ft. at center line

d) Manholes

Manholes were basically placed at grade breaks, points of change of pipe size and major street intersections. However, intermediate manholes for access purposes were also provided with a maximum spacing as indicated below.

Pipe Size	Maximum Spacing
36" through 39"	350'
42" through 45"	500'
48" through 51"	600'
54" through 60"	800'
66" through 90"	1,000'
96" and over	as necessary


FONTANA GAUGE # 17 (4.22)
ESTIMATED ISOHYETS
(50 YR FREQUENCY, 6 HR DURATION)
GENERAL LIMITS
OF STUDY AREA
4.2
4.1
4.0
3.9
3.8
3.7
3.6
3.5
3.4
3.3
3.2
3.1
FONTANA
GAUGE # 18
(2.99)
RIALTO
RIALTO MUNICIPAL AIRPORT (MIRO FIELD)
Glen Helen Rehabilitation Facility
El Rancho Verde Country Club
Lytle Creek Wash
HIGHLAND AVE
BASE LINE
FOOTHILL BLVD



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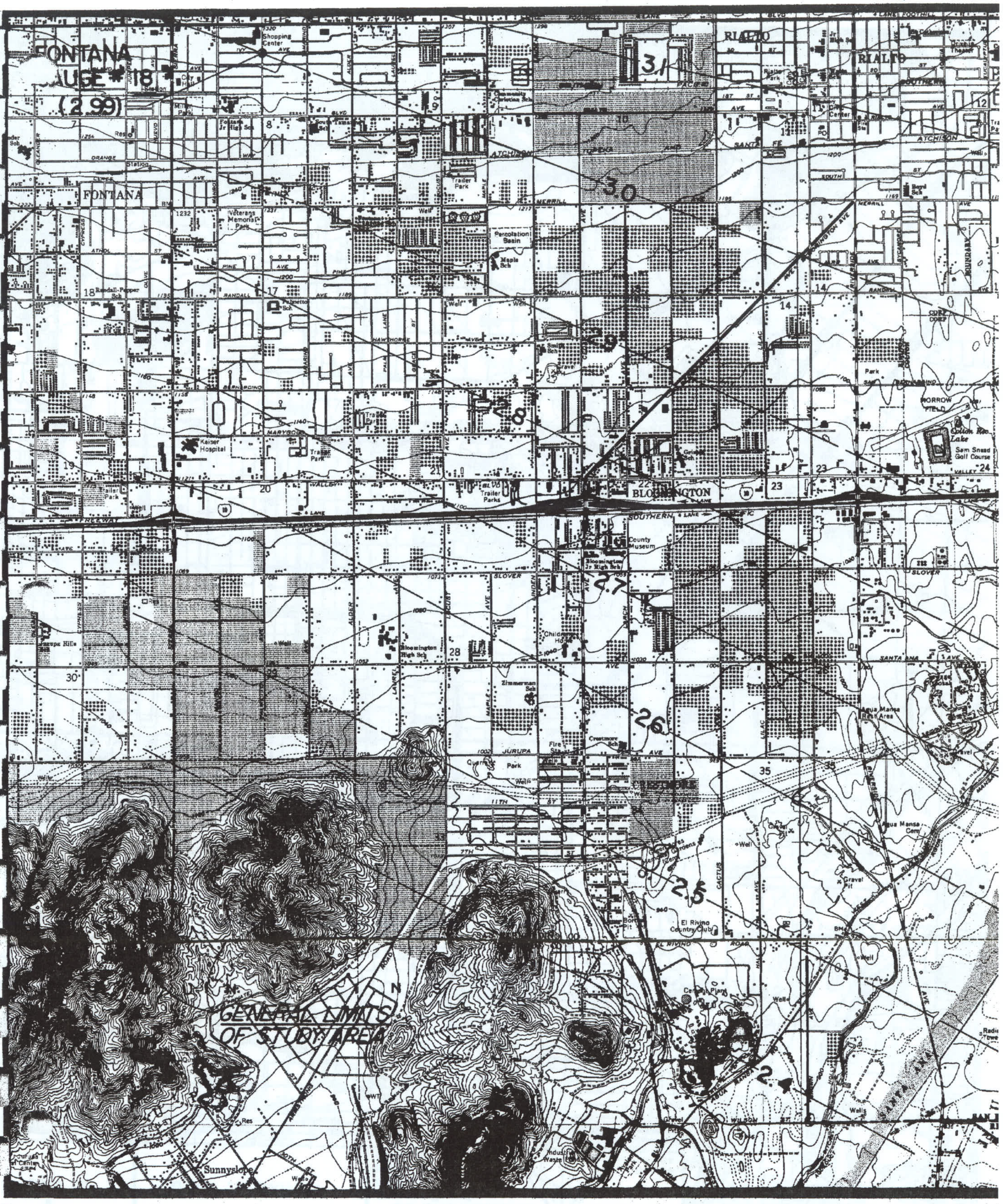
ISOHYETAL MAP
(50 YR.-6 HR)

PLATE I
A



FONTANA GAUGE # 18
(2.99)
3.1
3.0
2.9
2.8
2.7
2.6
2.5
2.4
RIALTO
FONTANA
BLOOMINGTON
CRESTMORE
GENERAL LIMITS OF STUDY AREA
Kaiser Hospital
Veterans Memorial Park
Percolation Basin
Bloomington High Sch
Zimmerman Sch
County Museum
Trailer Parks
El Rivino Country Club
MORROW FIELD
Sam Snead Golf Course
Sunnyslope

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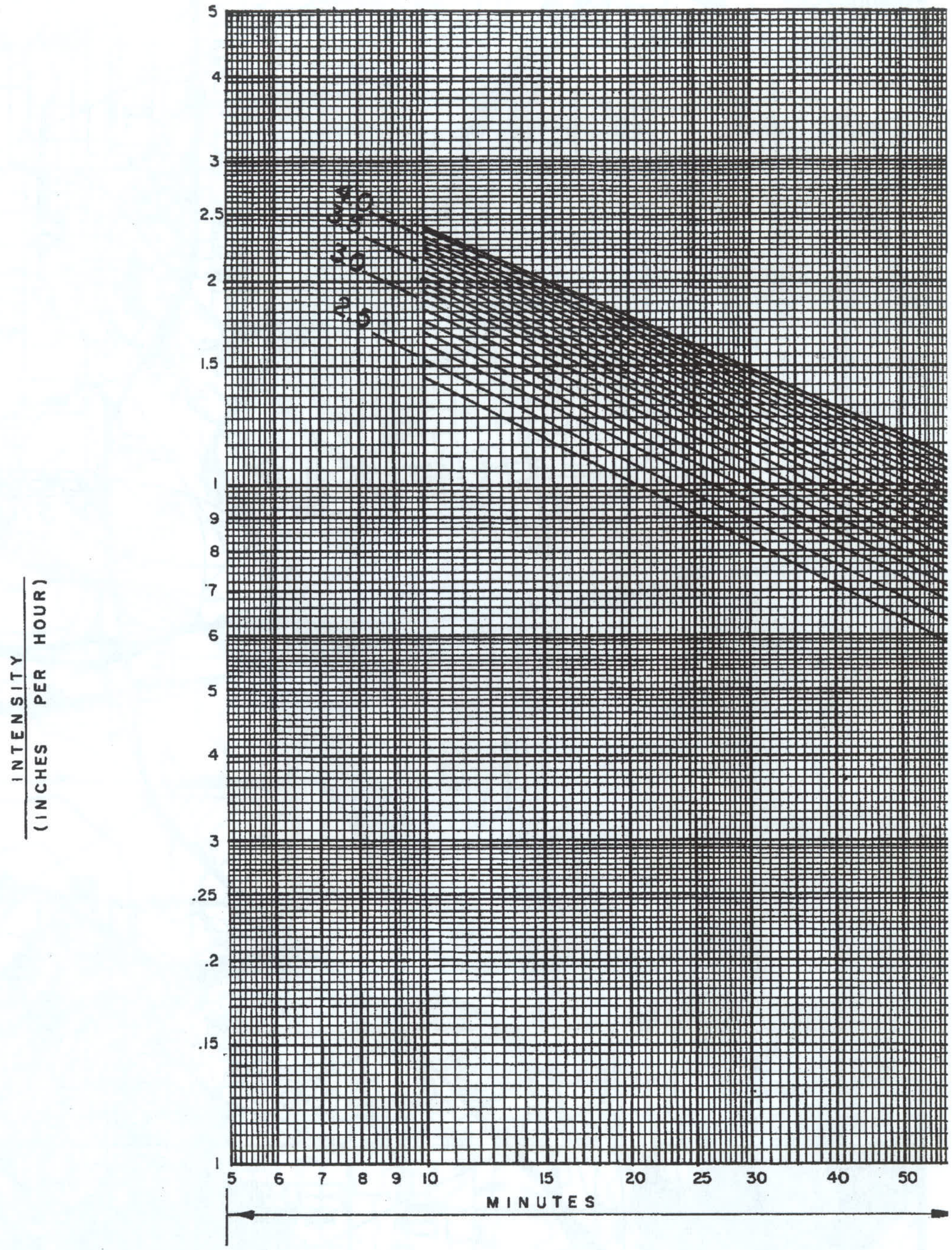
ISOHYETAL MAP
(50 YR-6 HR)

PLATE I
B



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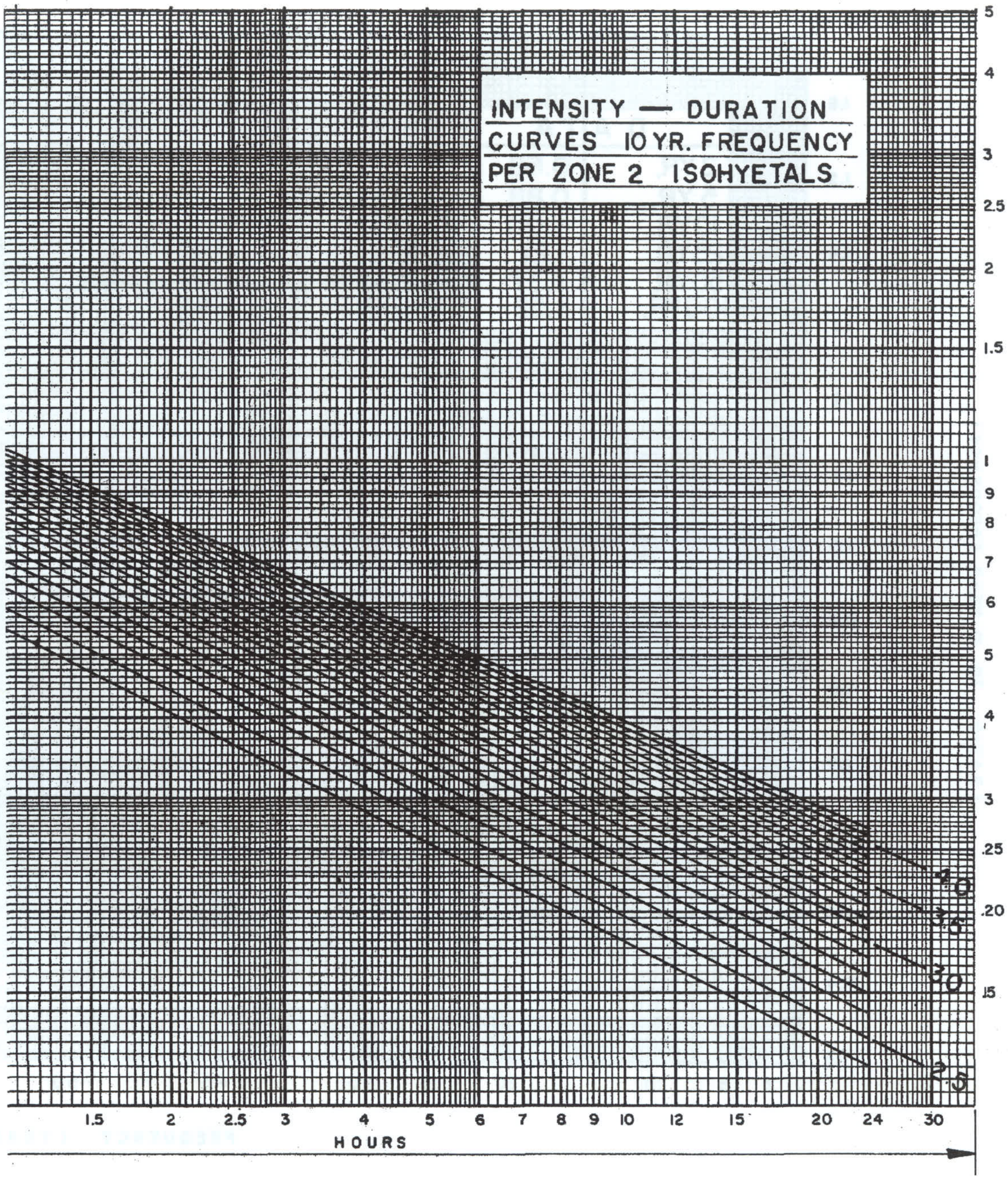
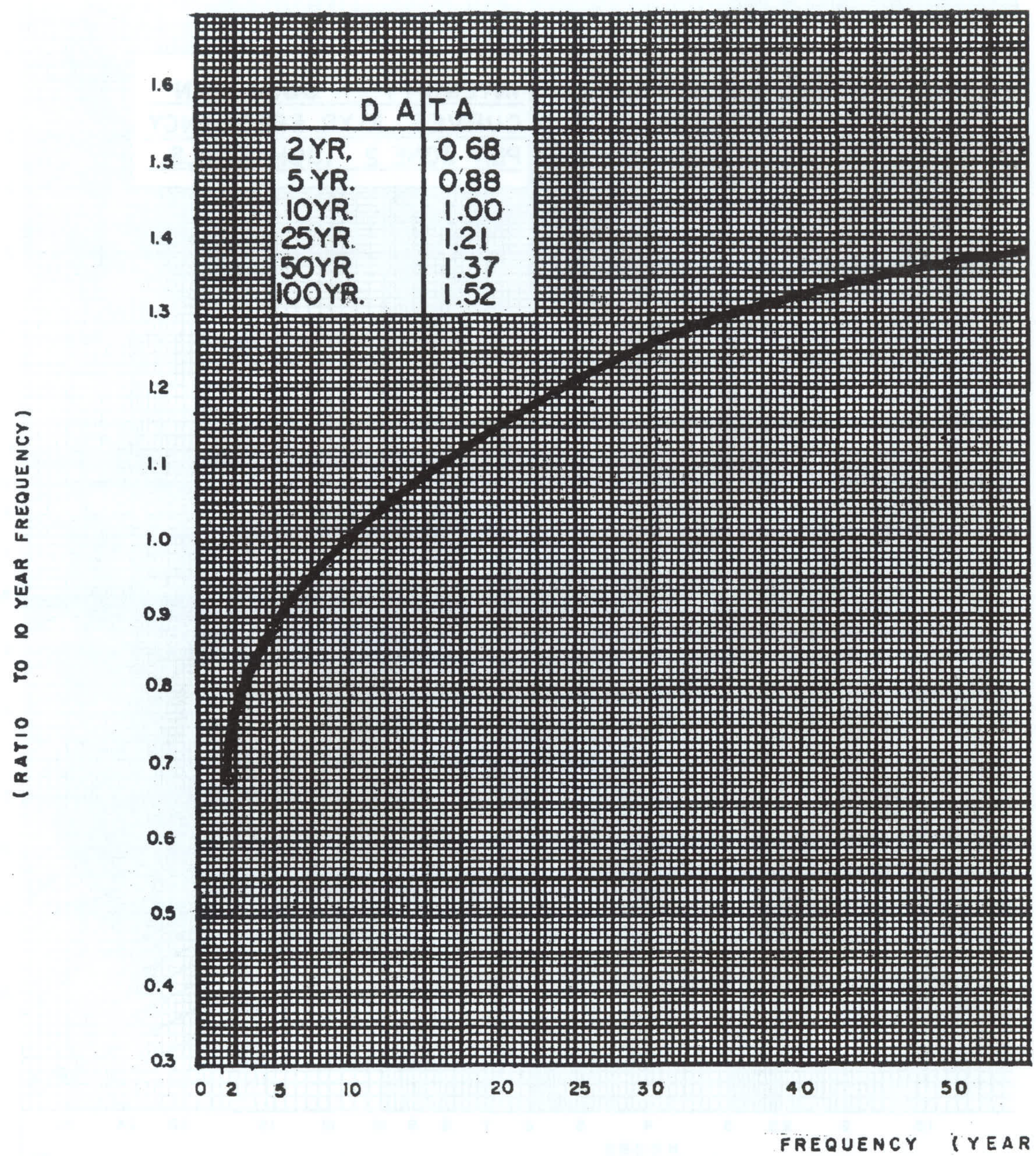
INTENSITY D



DURATION

RATION CURVES

PLATE II



DATA	
2 YR.	0.68
5 YR.	0.88
10 YR.	1.00
25 YR.	1.21
50 YR.	1.37
100 YR.	1.52

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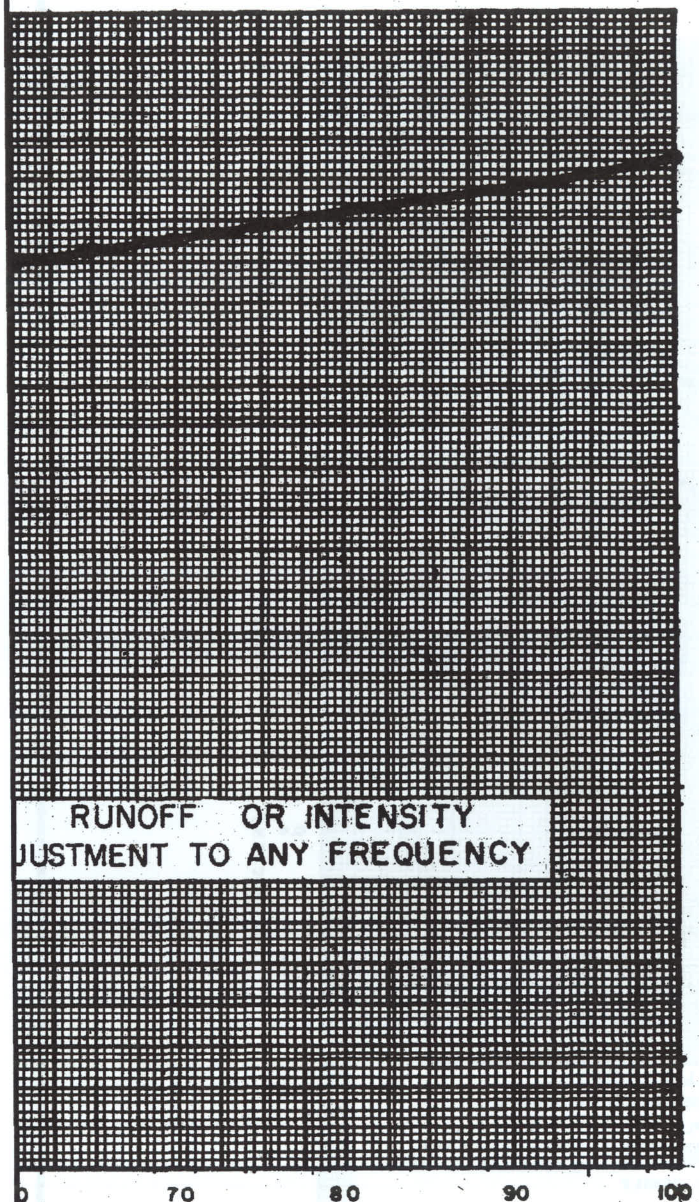
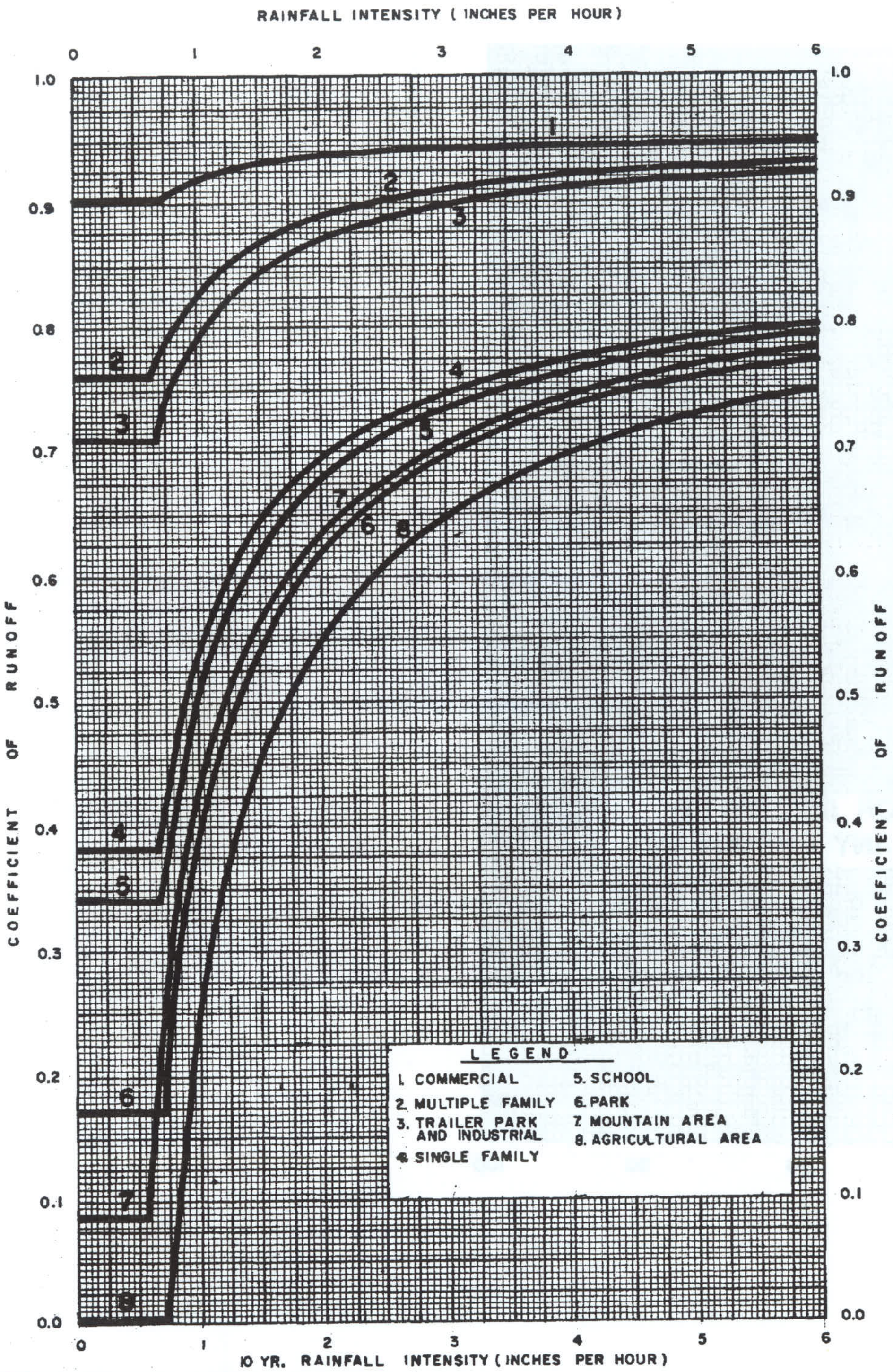
FREQUENCY



RELATIONSHIP

PLATE III



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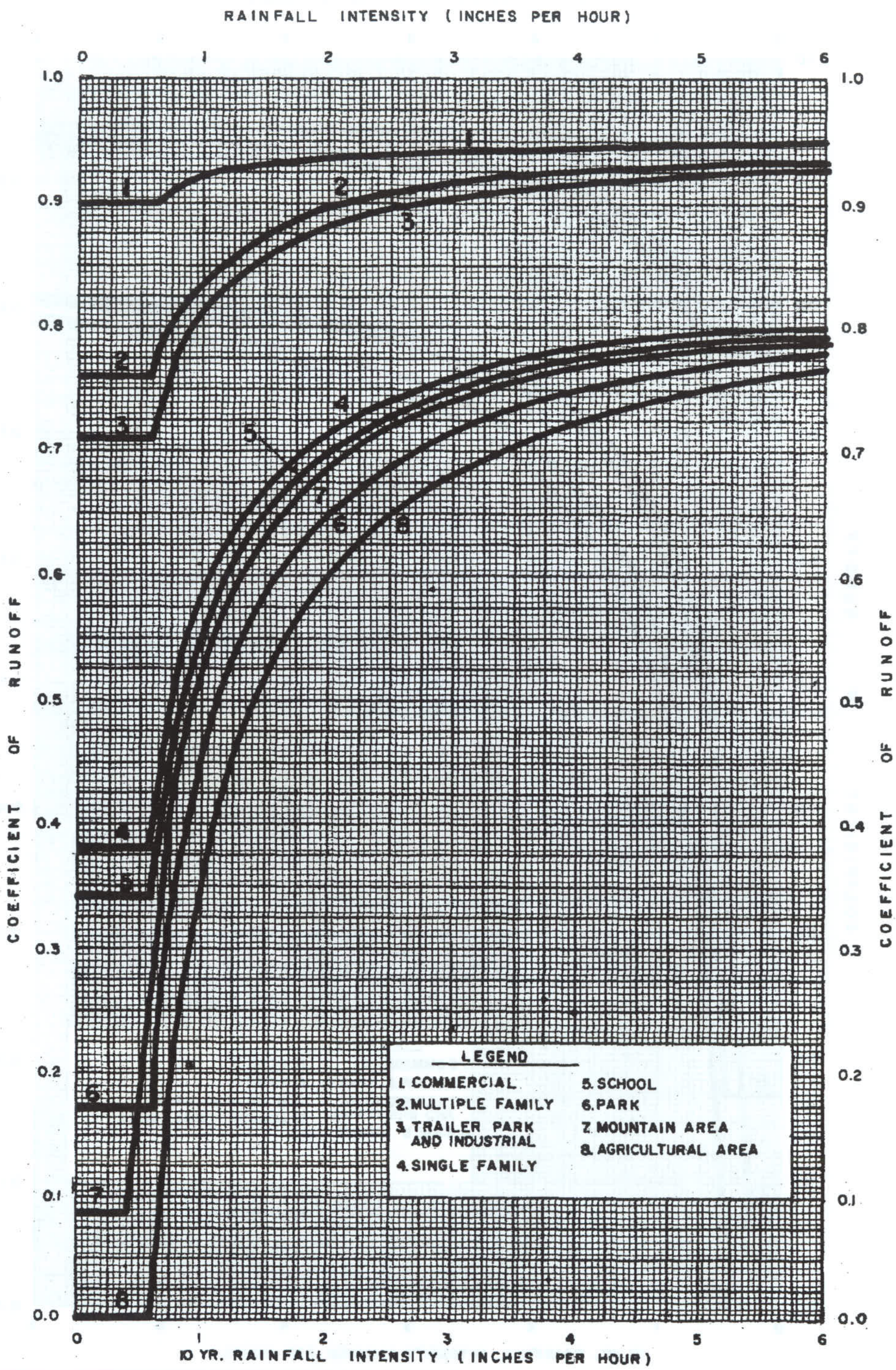
COEFFICIENT OF RUNOFF CURVES
SOIL GROUP "A"

PLATE IV a



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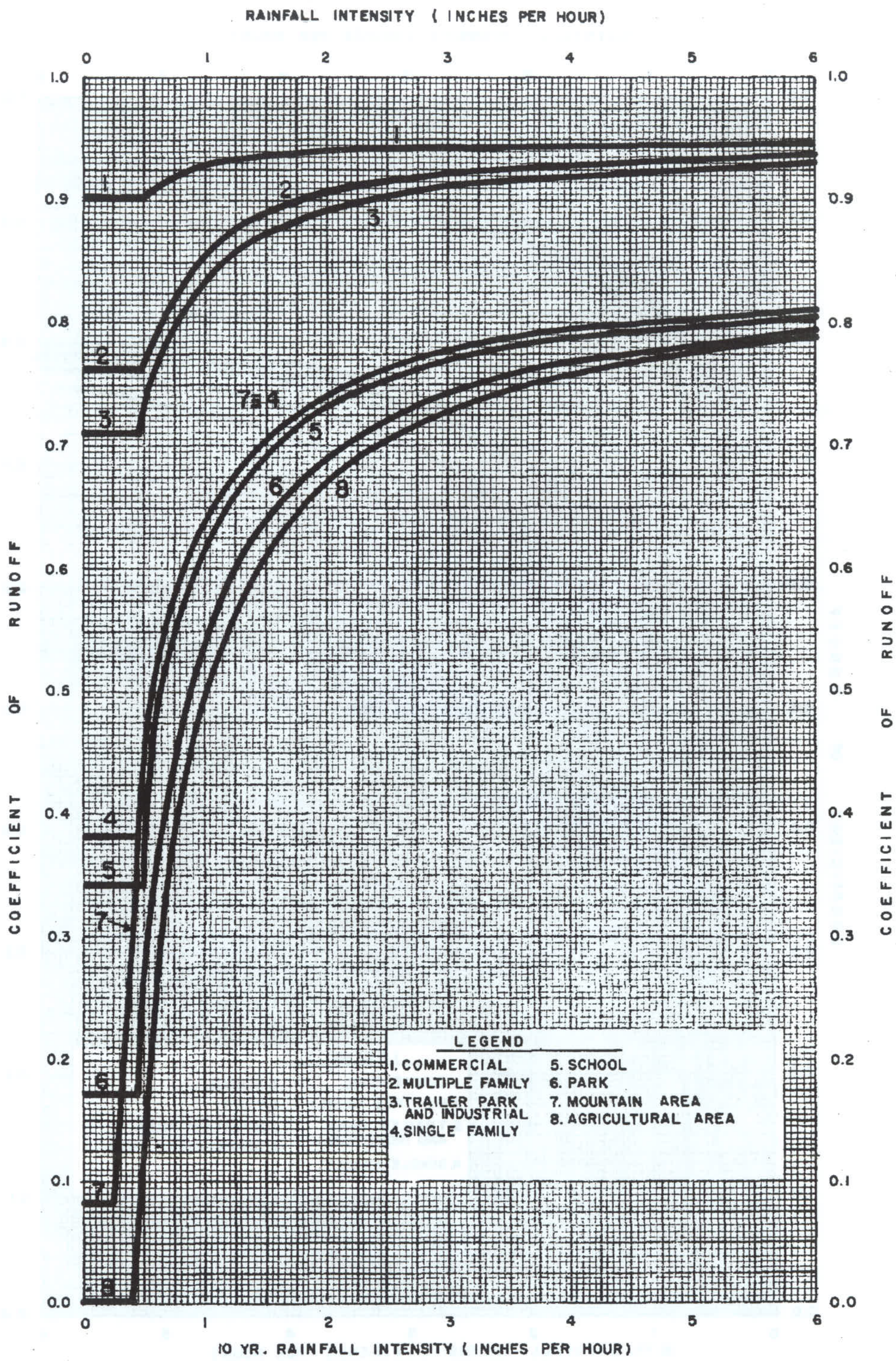
COEFFICIENT OF RUNOFF CURVES
SOIL GROUP "B"

PLATE IV b



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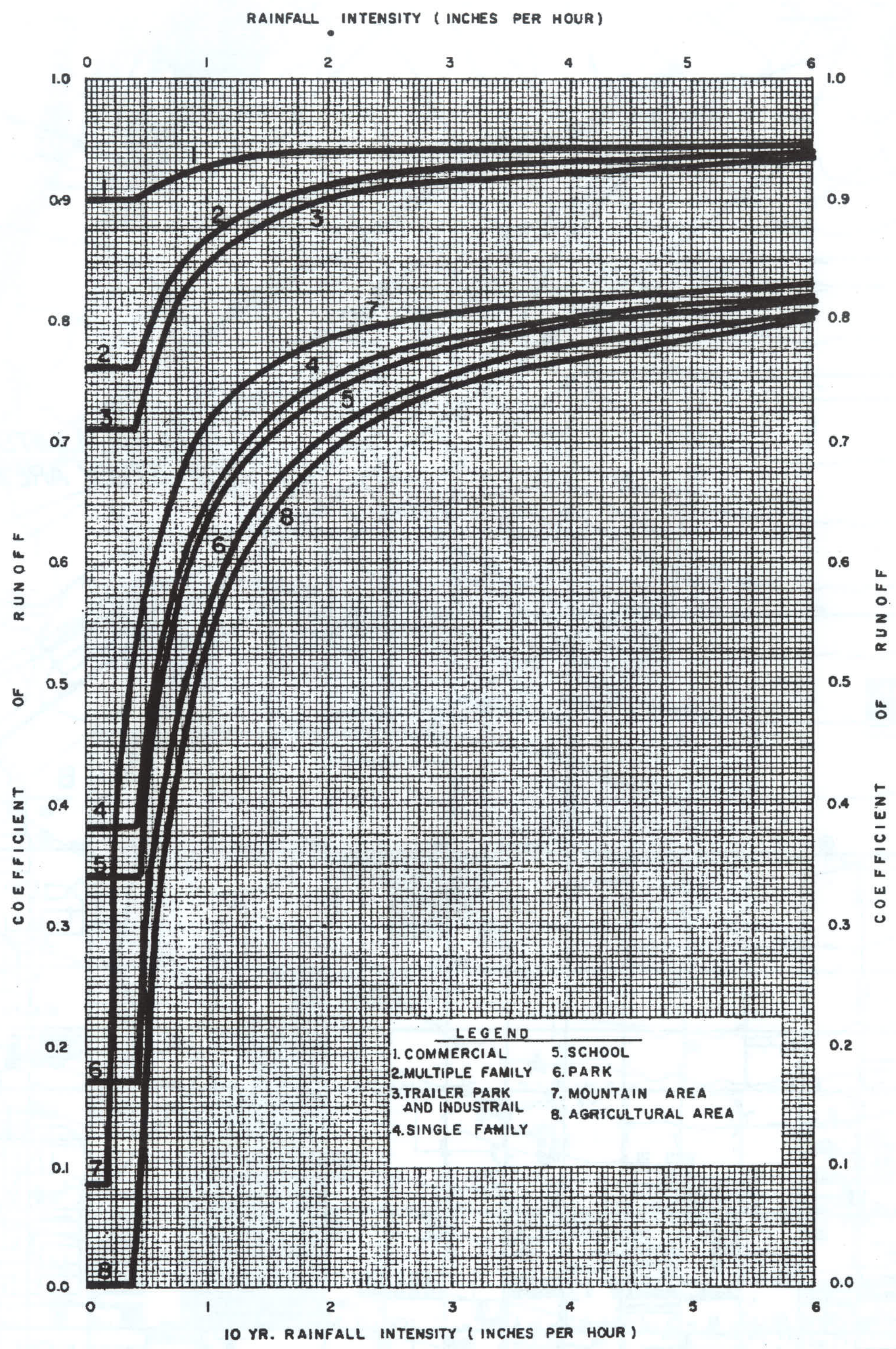
COEFFICIENT OF RUNOFF CURVES
SOIL GROUP "C"

PLATE IV c



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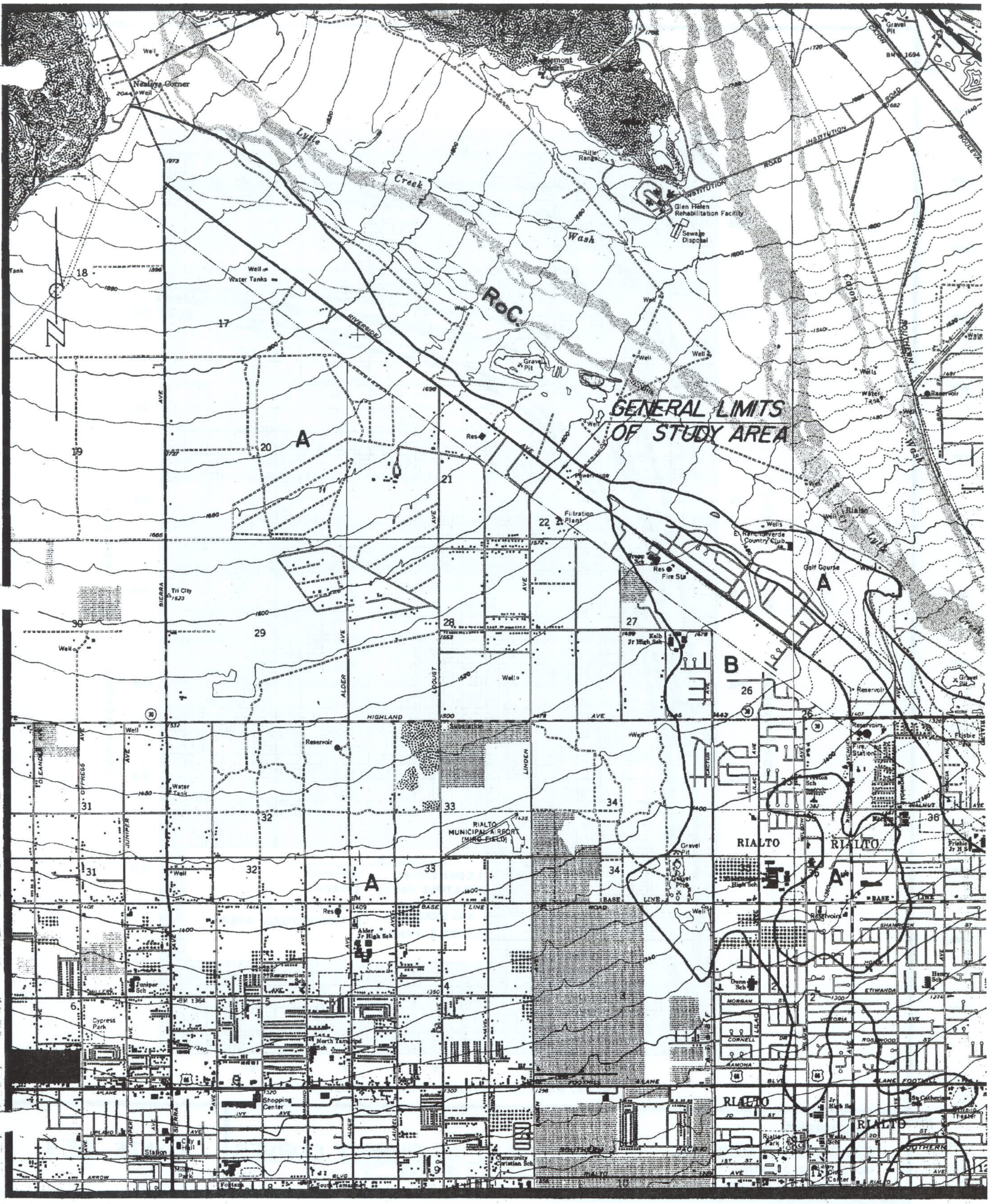
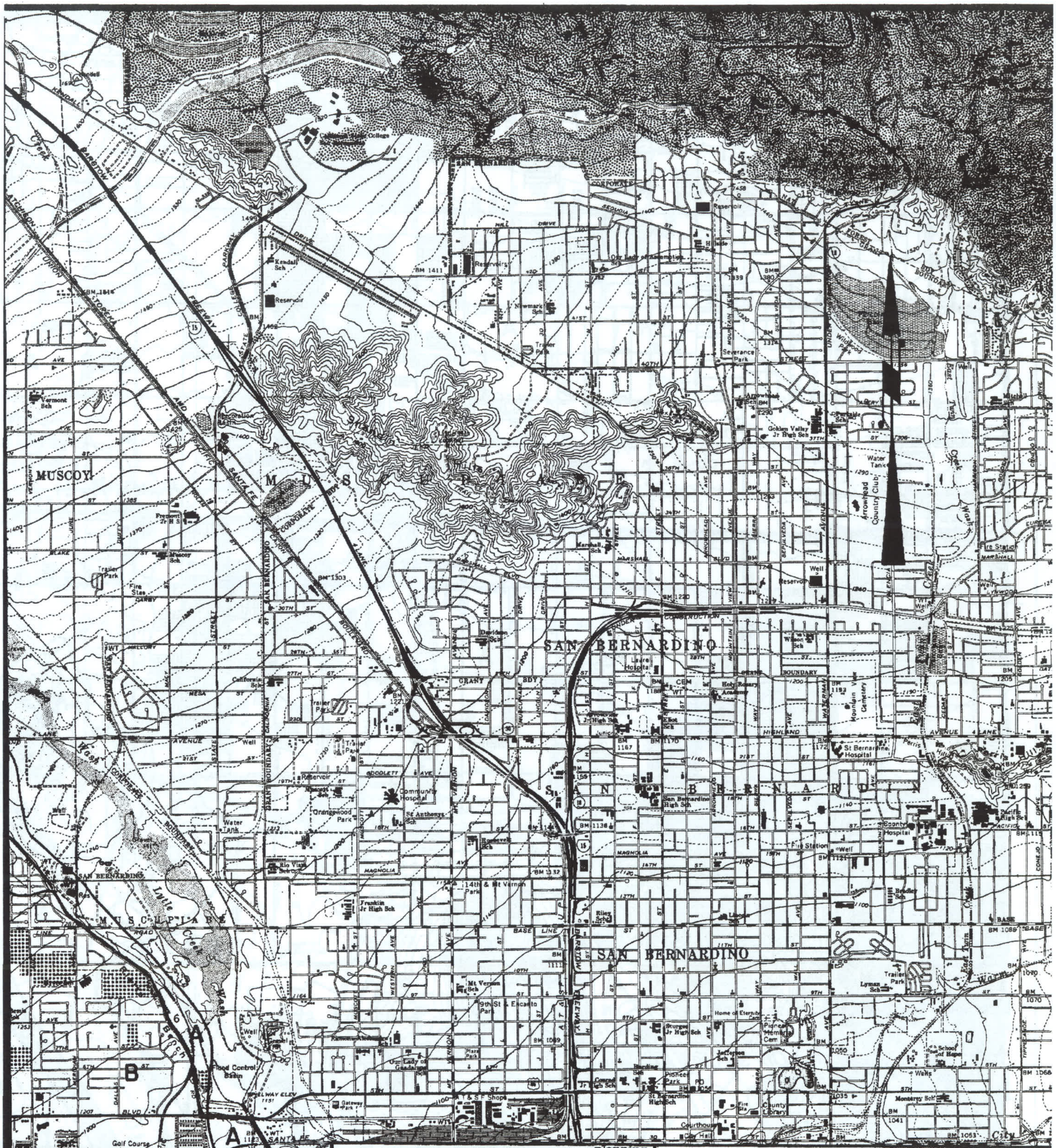
COEFFICIENT OF RUNOFF CURVES
SOIL GROUP "D"

PLATE IV d


GENERAL LIMITS
OF STUDY AREA
RoC
A
B
Lytle Creek Wash
Glen Helen Rehabilitation Facility
Sewage Disposal
INSTITUTION ROAD
Riverside Ave
Highland Ave
Base Line
Foothill Blvd
Filtration Plant
Rancho Verde Country Club
Golf Course
Kolb Jr High Sch
RIALTO MUNICIPAL AIRPORT (MIRO FIELD)
RIALTO
Alder Jr High Sch
Tri City
Cypress Park
Shopping Center
Community Christian Sch
Reservoir
Gravel Pit
Juniper Sch
City Hall
Station



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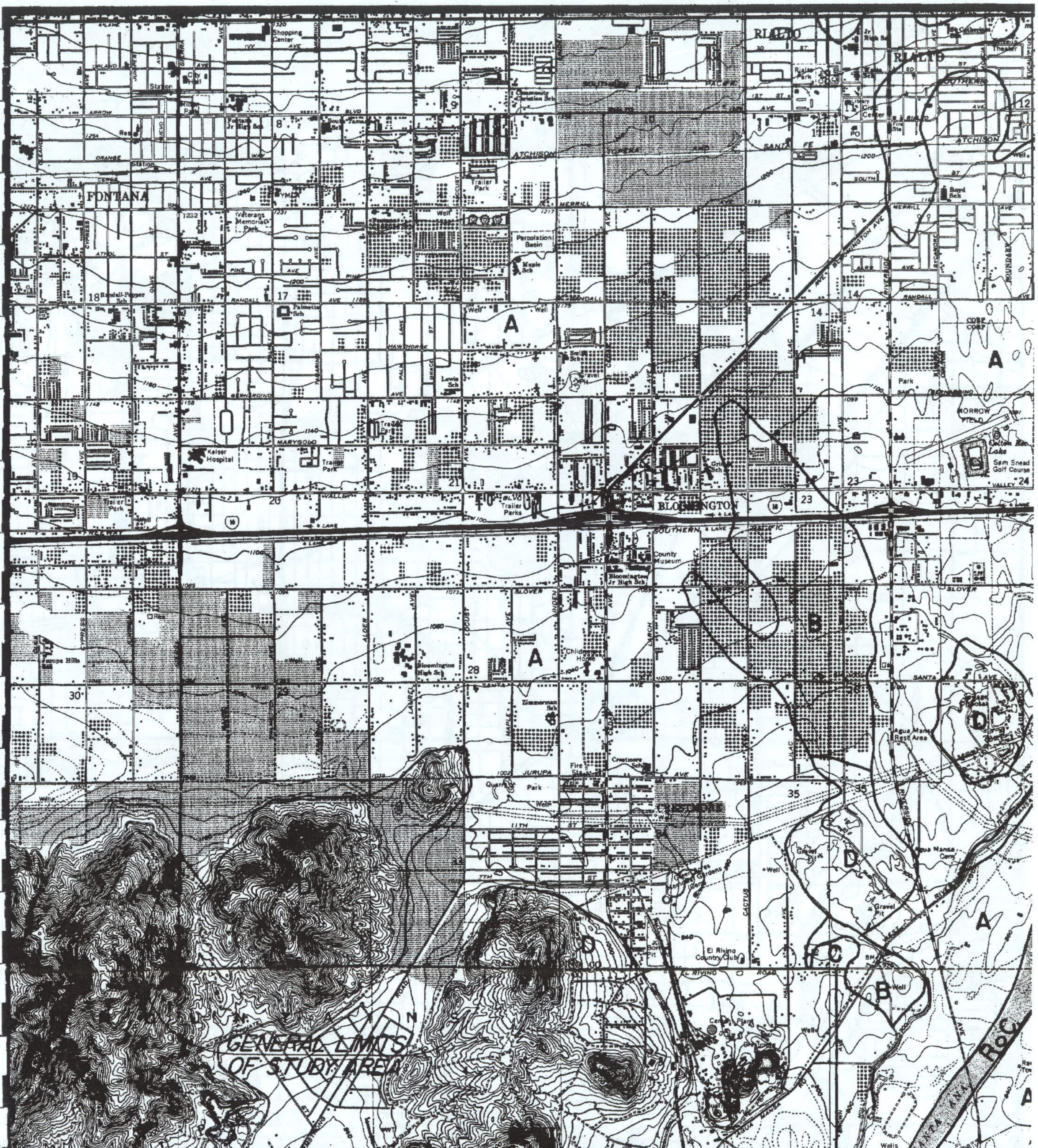
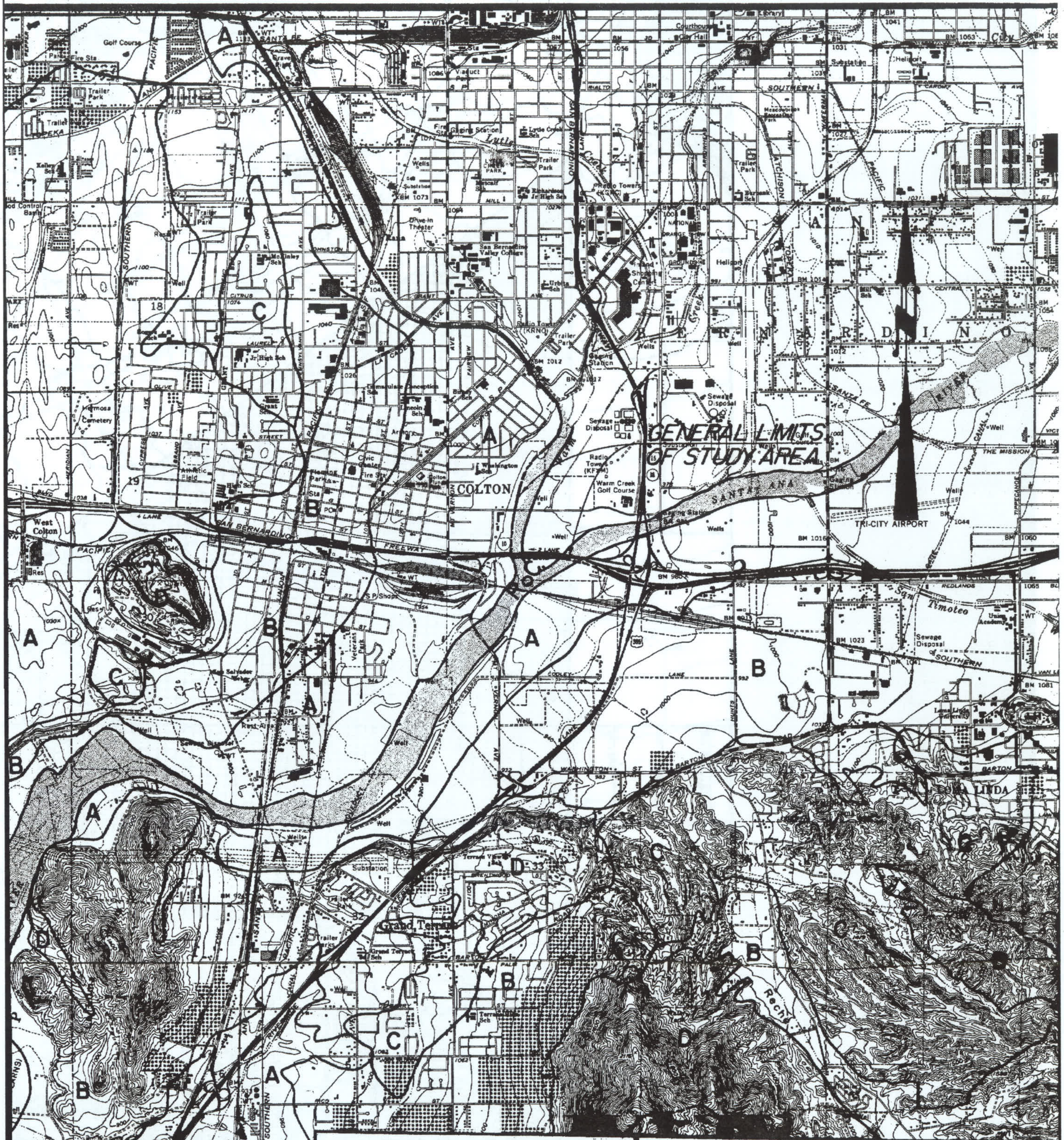
SOIL MAP

PLATE V
A



RIALTO
FONTANA
BLOOMINGTON
Kaiser Hospital
County Museum
Bloomington Jr High Sch
Bloomington High Sch
Percolation Basin
Sam Snead Golf Course
Agua Mansa Rest Area
El Rivino Country Club
Cement Plant
Sunnyslope
GENERAL LIMITS OF STUDY AREA
A
B
C
D



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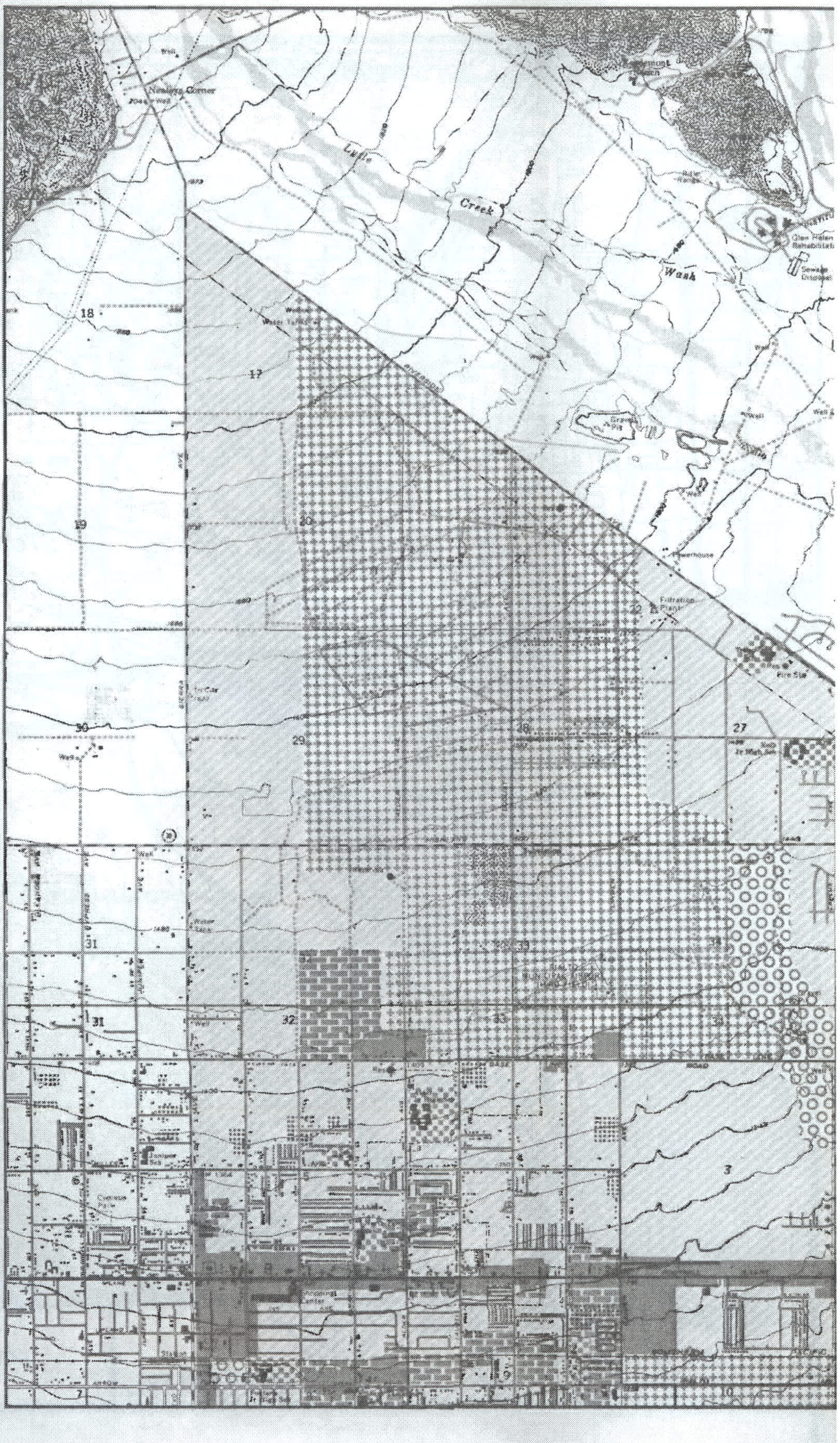
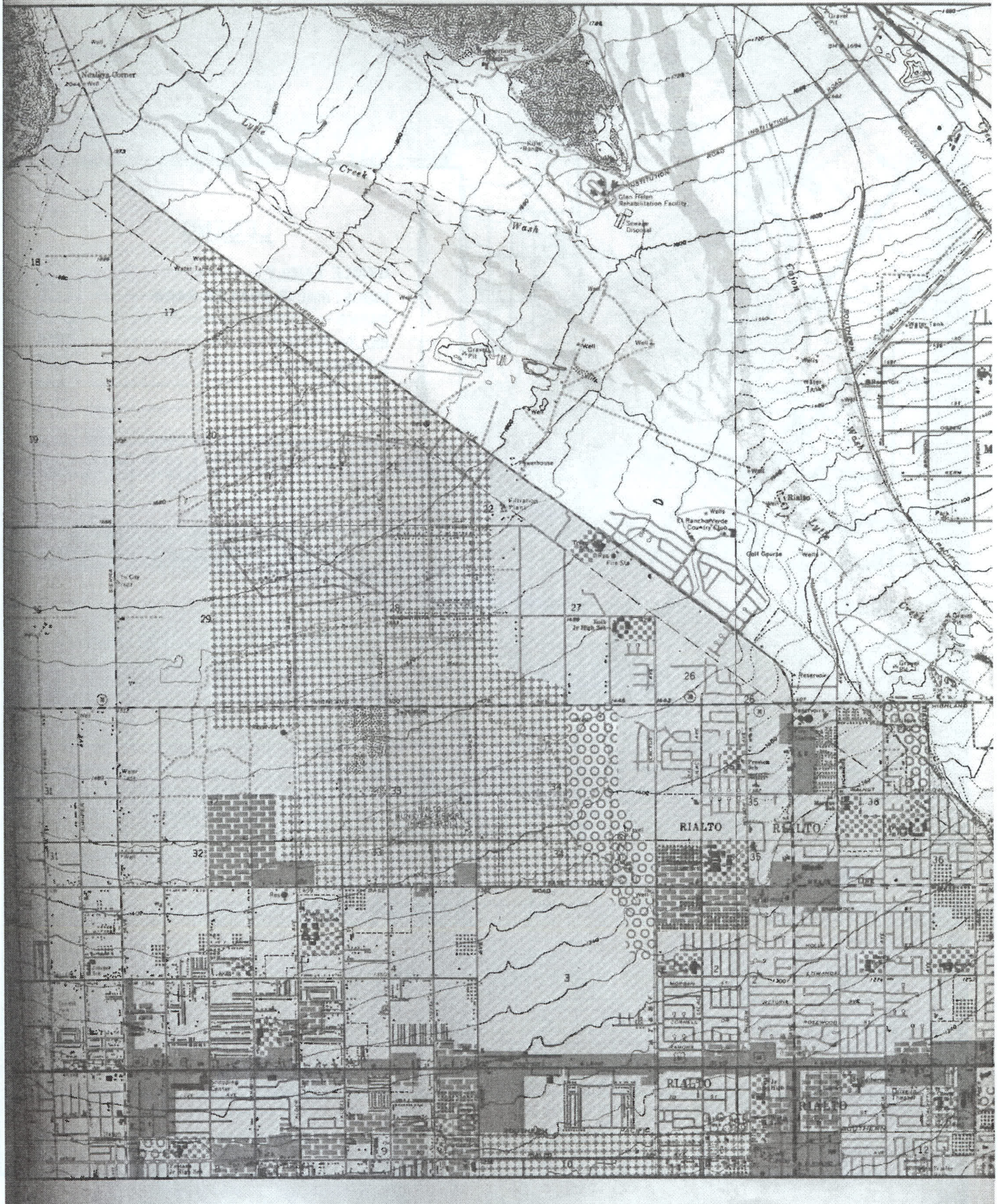
SOIL MAP

PLATE V B


Creek
Wash
Glen Helen Rehabilitation
Sewage Disposal
Powerhouse
Filtration Plant
Shopping Center



Lytle
Creek
Wash
Glen Helen Rehabilitation Facility
Sewage Disposal
Filtration Plant
Powerhouse
El Rancho Verde Country Club
Golf Course
Cajon
Wash
Rialto
RIALTO

LEGEND
SINGLE FAMILY
INDUSTRIAL & TRAILER PARK
PARKS
MULTI-FAMILY
COMMERCIAL
SCHOOLS
MOUNTAINS
MUSCOY
SAN BERNARDINO
SAN BERNARDINO
SAN BERNARDINO
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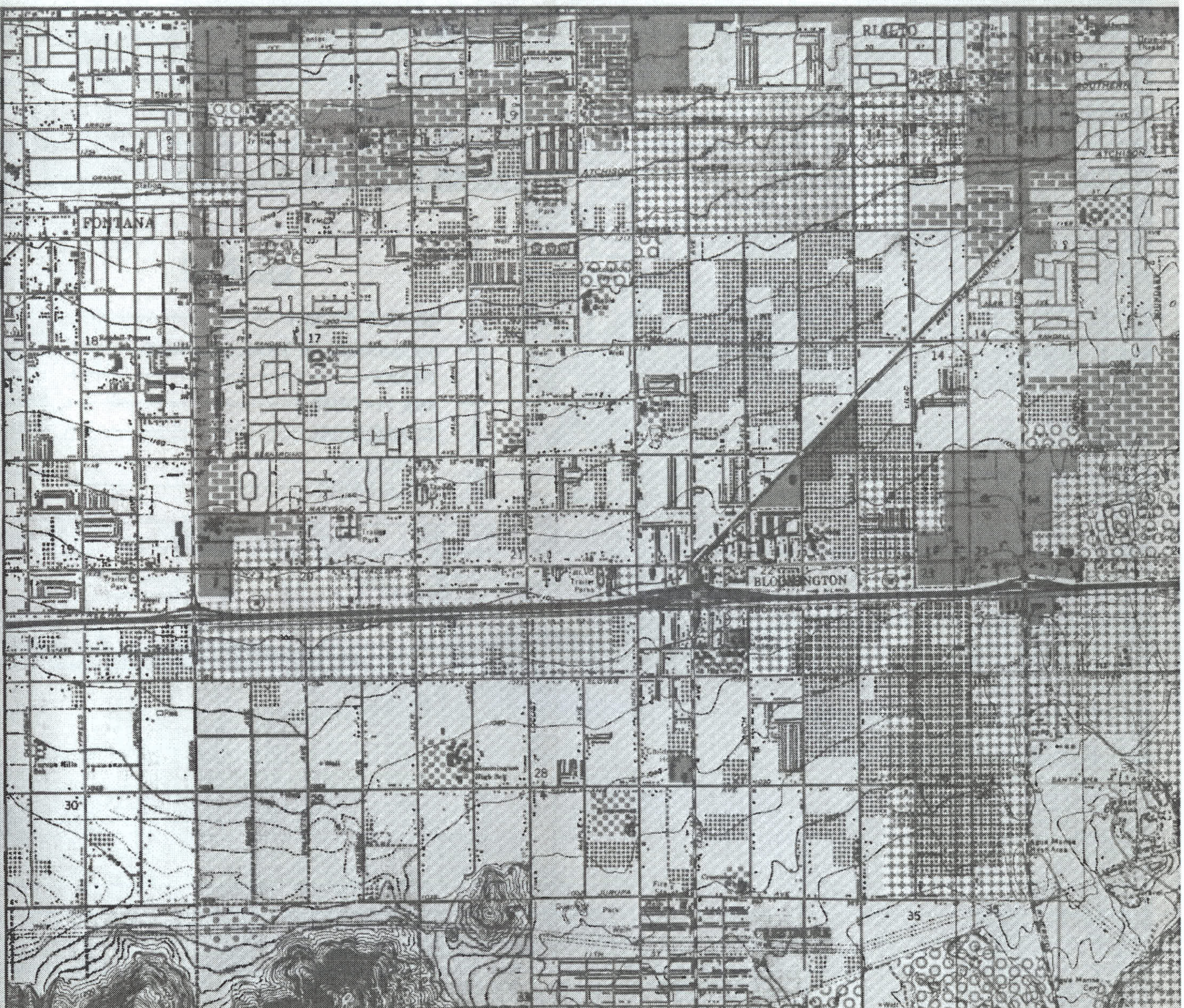
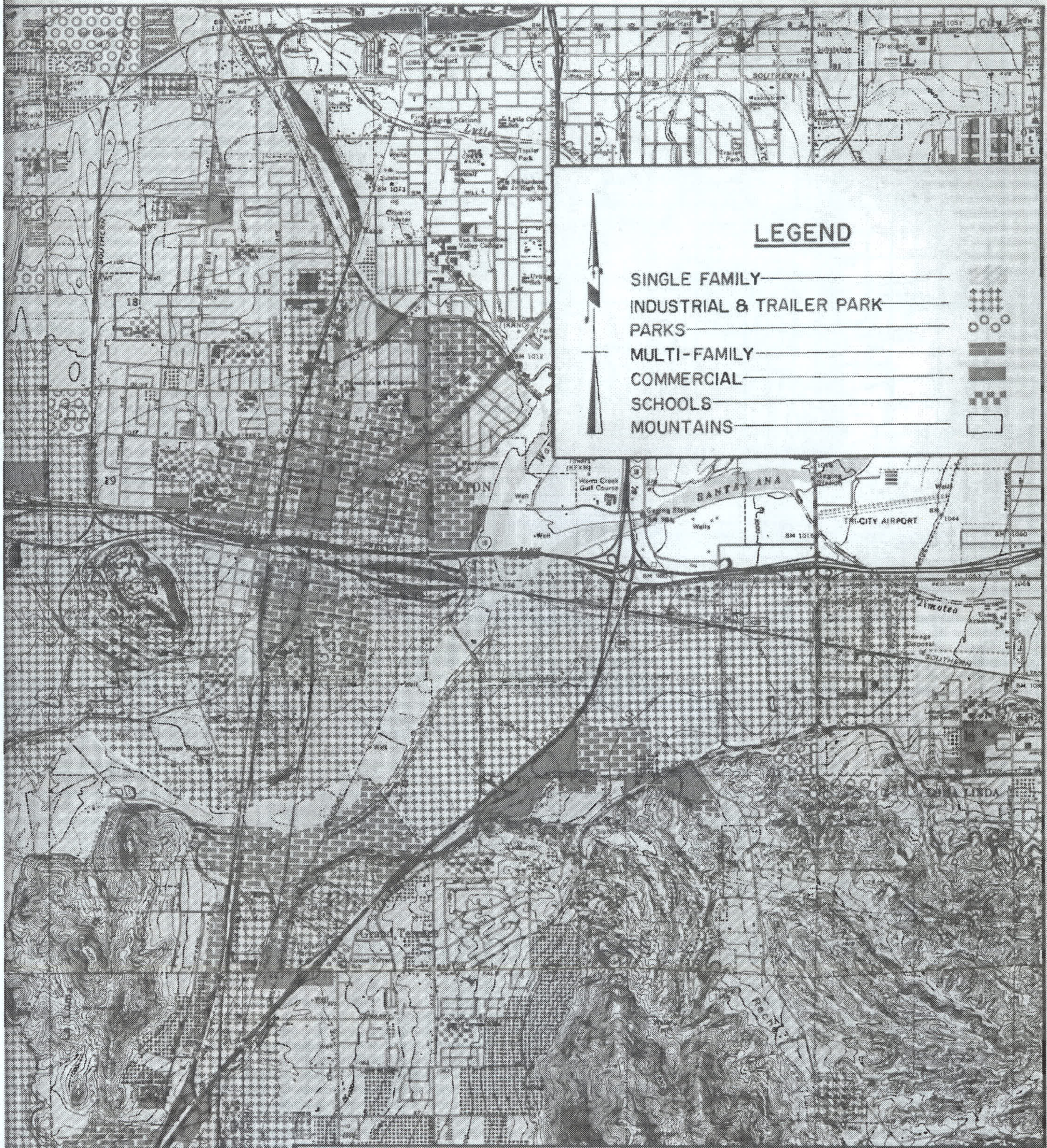
ZONING MAP
PLATE VI
A



FONTANA
RIALTO



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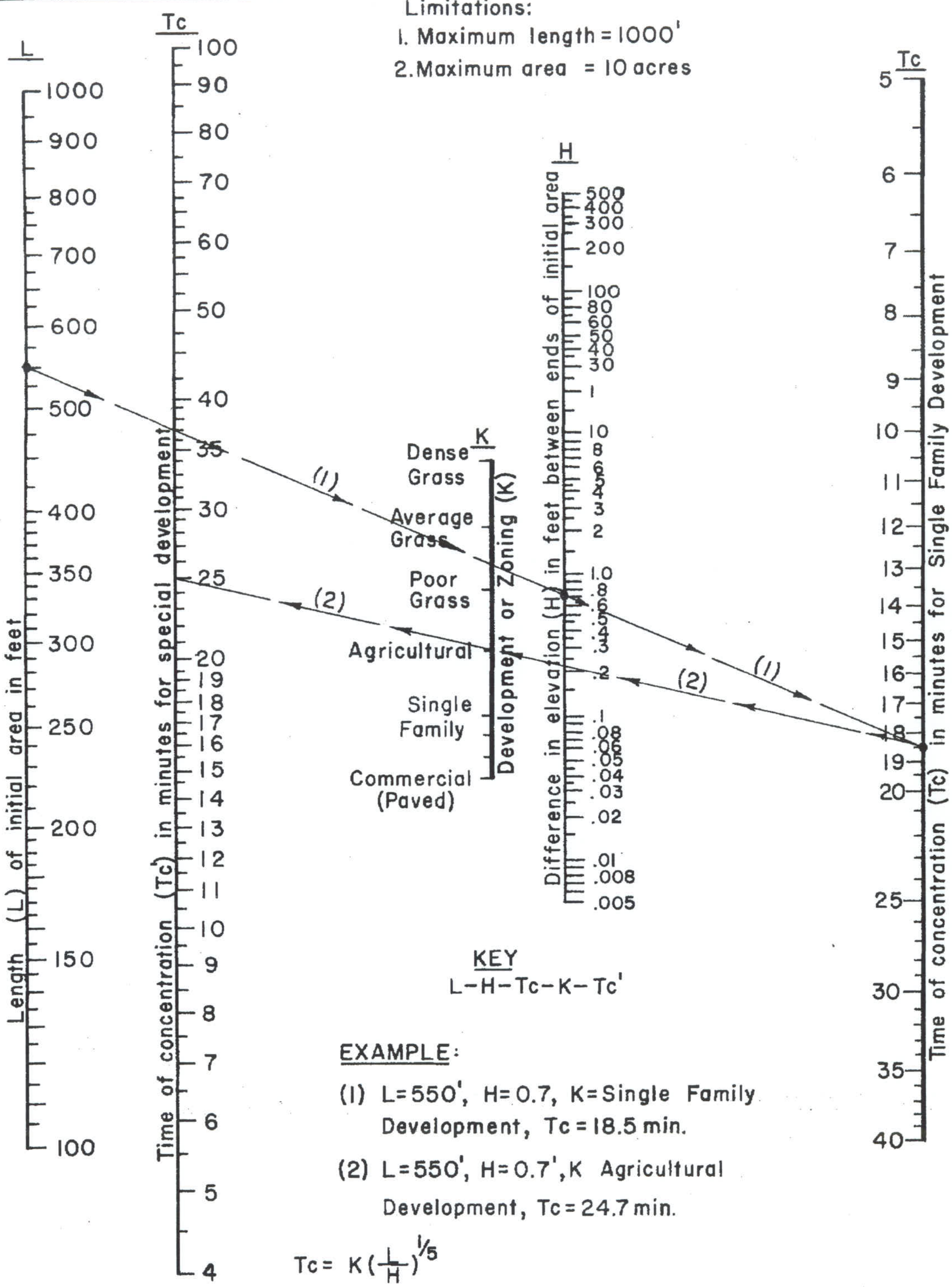
ZONING MAP

PLATE VI B

TIME OF CONCENTRATION FOR INITIAL SUBAREAS

Limitations:

1. Maximum length = 1000'
2. Maximum area = 10 acres



KEY

L–H–Tc–K–Tc'

EXAMPLE:

(1) L=550', H=0.7, K=Single Family Development, Tc=18.5 min.

(2) L=550', H=0.7', K Agricultural Development, Tc=24.7 min.

$$Tc = K\left(\frac{L}{H}\right)^{1/5}$$

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TIME OF CONCENTRATION NOMOGRAPH (AFTER KIRPICH)

PLATE VII