



Kassab Travel Center Project

Appendix H Hydrology Study

Hydrology Study
for
29301 RIVERSIDE DRIVE
LAKE ELSINORE, CA 92530

JUNE 01, 2018



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Project Description:

The site comprises of 2 assessor's parcel (lots - APN 378-030-007 AND APN 378-030-009). Currently, the site is vacant, undeveloped land with shrubs, grass and weeds grown throughout the site. The site is located on the west side of the intersection of Riverside Drive and Collier Avenue in the City of Lake Elsinore. The site is approximately 2.40 acres (104,045 sf) with moderate terrain that predominantly slopes from the east to the west; with approximately 8 feet of topographic relief across the site. Drainage flow at the site is dominated by sheet flowing across the property towards the west. Figure 1 shows the site and surrounding features.

The project proposes to develop commercial buildings with associated paved driveway, parking, walkway and landscape throughout. The proposed development consists of two single-story commercial buildings (one restaurant and one food mart with gasoline dispensing island) with total impervious coverage of 91,422 sf.

Purpose and objective:

The purpose and objective of this hydrology study are as follows:

- 1) to determine the design peak 10-year & 100-year frequency storm runoff for the project site.
- 2) To establish the finished pad elevation of proposed buildings that will be at least one foot (1-ft) above the water surface elevation of the 100-yr storm event.
- 3) To determine the hydraulic capacities of proposed storm drainage systems including ribbon gutter and parkway culvert to convey onsite storm runoffs into WQMP BMPS and ultimately to the street gutter in case of heavy rain.

Existing Drainage Pattern:

The watershed for the site is comprised of a single subarea (Subarea C). Currently, the drainage runoff from the site is towards the natural topographic direction from east to the west.

Proposed Drainage Pattern:

The watershed for the site is divided into two subareas; namely Subarea A and Subarea B. Subarea B is the tributary area from the C-store (23,242 sft) and adjacent paved area discharged into the proposed Bioretention basin located north of the driveway from Collier Ave.; and Subarea A is the remainder portion that includes the dispenser area, restaurant and the associated paved parking and driveway areas (62,929 sft). Discharge from the Subarea A is into the proposed Bioretention basin, located west of the driveway from Riverside Drive.

Methodology:

The hydrology calculations performed utilized the Section D -Rational Method of the Riverside County Flood Control and Water Conversation District Hydrology Manual (RCHM), dated April 1978. The 10-Year and 100-Year storm return frequency rainfall was used for existing and developed conditions.

The watershed studied consists of proposed project site is situated within the Riverside County within the 2-year and 100-year 1-hour isohyet of 0.57 and 1.45 inches respectively (see enclosed Hydrology Map in Figure 2 to 4). The isohyet for 10-yr 1-hour rainfall was then interpolated from Figure 4 as 0.92 inches. The slope for the rainfall intensity curve for the site area was found to be 0.45 (see Figure 5).

Flood Insurance Rate Maps (FIRM):

The site is located in Zone X of the Federal Emergency Management Agency (FEMA) Flood Insurance Rate Maps (FIRM), Riverside County, California and incorporated areas panel 2028 of 3805 with map number 06065C2028G dated August 28, 2008. A Zone X is designation as areas determined to be outside of the 0.2% annual chance floodplain or areas of 0.2% annual chance flood: areas of 1% annual chance flood with average depths of less than 1 foot or with drainage areas less than 1 square mile; and areas protected by levees from 1% annual chance flood. The majority of the site falls within the later definition of Zone X. The FIRM map for this project is located in Figure 6.

Watershed Precipitation Data:

Precipitation data from the Isohyetal maps of the RCHM was used in this report and is shown below.

Table 1 – Precipitation Data (Rational Method Calculations)

Storm Event	Precipitation (inches)	Ref. Figure/Appendix
10-Yr, 1-Hr	0.92	
25-Yr, 1-Hr	1.12	
100-Yr, 1-Hr	1.45	

Hydrology Calculations & Summary:

Time of Concentration (Tc)

2.55e time of concentration (Tc) was obtained by first defining the subareas and their respective length of flow, elevation difference, and type of development. This data was then plotted onto Figure D-3 (see Figure 7), Time of Concentration Nomograph, in order to obtain the time of concentration for each drainage subarea per RCHM. Subarea Initial Time of Concentrations (Tc) has been shown in Table 2 below:

Table 2 – Time of Concentration

Development Stage (Pre/Post)	Node @ High Elev. (ft)	Node @ Low elev (ft)	Node Elev. Diff. (ft)	Flow length, L (ft)	Tc (min)	Ref. Appendix
Post-dev	1267.10	1264.55	2.55	280	7.6	
Post-dev	1266.25	1265.14	1.11	320	9.5	
Pre-dev	1269.00	1261.00	8.00	510	15.0	

Rainfall Intensity, I (in/hr)

This site-specific precipitation values from Table 1 were plotted onto Plate D-4 (Figure 8) in order to find the rainfall intensities (I), based on the log-log slope of site location (= 0.45) per Figure 5.

Subarea Rainfall Intensity (I) has been shown in table 3 below.

Table 3 – Rainfall Intensity

Subarea	Tc (Min)		100 Yr Rainfall Intensity, I_{100} (in/hr)		25 Yr Rainfall Intensity, I_{25} (in/hr)		10 Yr Rainfall Intensity, I_{10} (in/hr)		Ref. Appendix
	Pre	Post	Pre	Post	Pre	Post	Pre	Post	
A(Apn: 378-030-007)		7.6		3.65		2.82		2.26	
B(Apn: 378-030-009)		9.5		3.3		2.55		2.06	
A+B	15		2.82		2.08		1.67		

Soil Types and Runoff Index Numbers

Soil types on and near the project site (for on-site tributary) and corresponding Runoff Index Numbers (AMC II) used in this report are shown in Appendix A.

For the entire project site, soil type “B” is shown per Figure 8. For the existing condition, barren soil is selected as the site is 100% undeveloped with single subarea. For the developed condition, the project is composed of pervious (landscape) and impervious (roof, driveway/walkway/retaining wall) areas and the site is divided into two Subareas. Mixed cover has been calculated based on proportioning area of Landscape and Impervious Area.

Table 4 – On-site Pre-developed Runoff Index Numbers

Soil Cover	Soil Type	Quality of Cover	Area (SF)			SCS Curve No. (AMC II)		SCS Curve No. (AMC III)
			Pervious	Imp.	Total			
Barren	B	-	104,045	0	104,045		86	97
Landscape	B	-	0	0	0		56	
Imp. Area		-	0	0	0		98	
Mixed Cover	B	-				86 (0)	0 (0)	0
						56 (0)		
						98 (0)		

Table 5 – On-site Post-developed Condition Runoff Index Numbers; Subarea A

Soil Cover	Soil Type	Quality of Cover	Area (SF)			SCS Curve No. (AMC II)		SCS Curve No. (AMC III)
			Pervious	Imp.	Total			
Landscape	B	Good		0			56	76
Imp. Area		-	0				98	100
Mixed Cover	B	-					92	98
			10,605	66,752	77,357	56 (10,605)		
						98 (66,752)		

Table 6 – On-site Post-developed Runoff Index Numbers: Subarea B

Soil Cover	Soil Type	Quality of Cover	Area (SF)			SCS Curve No. (AMC II)		SCS Curve No. (AMC III)
			Pervious	Imp.	Total			
Landscape	B	Good		0			56	76
Imp. Area		-	0				98	100
Mixed Cover	B	-					96	99
			1,463	25,205	26,668	56 (1,463)		
						98 (25,205)		

Calculation of Runoff Coefficient, C:

The Runoff Coefficient, C can be calculated based on the % impervious and the Runoff Index based on rainfall intensity (see Appendix B) for the pre- and post-developed conditions and are presented below.

Pre-developed condition (Subarea A+B):

$$C_{10} = 0.79 + ((0.81 - 0.79) / 0.5) * 0.17 = 0.80$$

$$C_{25} = 0.79 + ((0.81 - 0.79) / 0.5) * 0.17 = 0.81$$

$$C_{100} = 0.83 + ((0.84 - 0.83) / 0.5) * 0.32 = 0.84$$

Post-developed condition, Subarea A:

$$C_{10} = 0.89$$

$$C_{25} = 0.90$$

$$C_{100} = 0.90$$

Post-developed condition, Subarea B:

$$C_{10} = 0.90$$

$$C_{25} = 0.90$$

$$C_{100} = 0.90$$

Calculation of Flow, Q:

The pre and post-development flow computations were performed and are presented below.

Table 7 – Runoff Flow

Subarea	Development Stage (Pre/Post)	Area, A (Ac)	Design Storm Frequency		Rainfall Intensity, I (in/hr)	Runoff Coefficient, C	Flow, Q = CIA, (cfs)
			Yr	Hr			
A	Post	1.78	10	1	2.26	0.9	3.61
			100		3.65	0.90	5.83
B	Post	0.61	10	1	2.06	0.9	1.14
			100		3.3	0.90	1.82
A+B	Pre	2.39	10	1	1.67	0.80	3.19
			100		2.82	0.84	5.66

Summary:

For the entire project site, Subarea A+B:

Pre-developed $Q_{100} = 5.66$ cfs

Pre-developed $Q_{25} = 4.02$ cfs

Pre-developed $Q_{10} = 3.19$ cfs

For Subarea A:

Post-developed $Q_{100} = 5.83$ cfs

Post-developed $Q_{25} = 4.51$ cfs

Post-developed $Q_{10} = 3.57$ cfs

For Subarea B:

Post-developed $Q_{100} = 1.82$ cfs

Post-developed $Q_{25} = 1.41$ cfs

Post-developed $Q_{10} = 1.14$ cfs

For Subarea A+B:

Post-developed $Q_{100} = 7.75$ cfs

Post-developed $Q_{25} = 5.92$ cfs

Post-developed $Q_{10} = 3.75$ cfs

Delta $Q_{100} = 7.75 - 5.66 = 2.09$ cfs;

Delta $Q_{25} = 5.92 - 4.02 = 1.9$ cfs;

Delta $Q_{10} = 3.61 - 3.19 = 0.42$ cfs

Results:

This hydrology study indicates that the Q100-yr storm events will produce a runoff of 5.83 cfs for Subarea A and 1.82 cfs for Subarea B respectively and that of 10-yr storm events will produce a runoff of 3.61 cfs for Subarea A and 1.14 cfs for Subarea B respectively in the post- development stage from the subject site.

The Q25-yr storm events will produce a runoff of 4.51 cfs for Subarea A and 1.41 cfs for Subarea B respectively in the post-development stage from the subject site. Total runoff for 100- yr/25-yr/10-yr storm would be 7.75 cfs/5.92cfs/3.75 cfs respectively.

The differences of flows in 100-yr storm event would be 2.09 cfs or $(2.09/5.66 \times 100 =)$ 37% increase and that of 25-yr would be 1.9 cfs or $(1.9/4.02 \times 100 =)$ 47.3% increase and that of 10-yr would be 0.42 cfs or $(0.42/3.19 \times 100 =)$ 13.1% increase. The difference in all cases of storm events between the pre-and post-developed conditions are still within the range of moderate increase. Furthermore, the flow pattern would be reversed as opposed to the pre-developed condition and the storm water will be captured in on-site in landscape area where bioretention basins are proposed. Only excess runoff would be allowed to overflow onto street gutters through via parkway culvert. Considering the flow of 25-yr rainfall events, corresponding design storm drain overflow channel of 3' widex 3" deep (metal) for Subarea A and 3-4" PVC (SDR 35) pipe for Subarea B (see Appendix C).

Further analysis was done (see Appendix C) to find out the required minimum pad elevation considering the highest Q at Node 2 which resulted in a channel depth of 0.0782 ft (1") over the entire parking area of Subarea A. Therefore, the proposed minimum pad elevation (1265.33') is okay.

Conclusions:

The increase in runoff cause by this development will be mitigated by containing the 100 year runoff within the street r/w. The on-site BMP and storage facilities are adequate to handle the increase runoff .

FIGURES



FIGURE 1
SITE VICINITY MAP
NOT TO SCALE



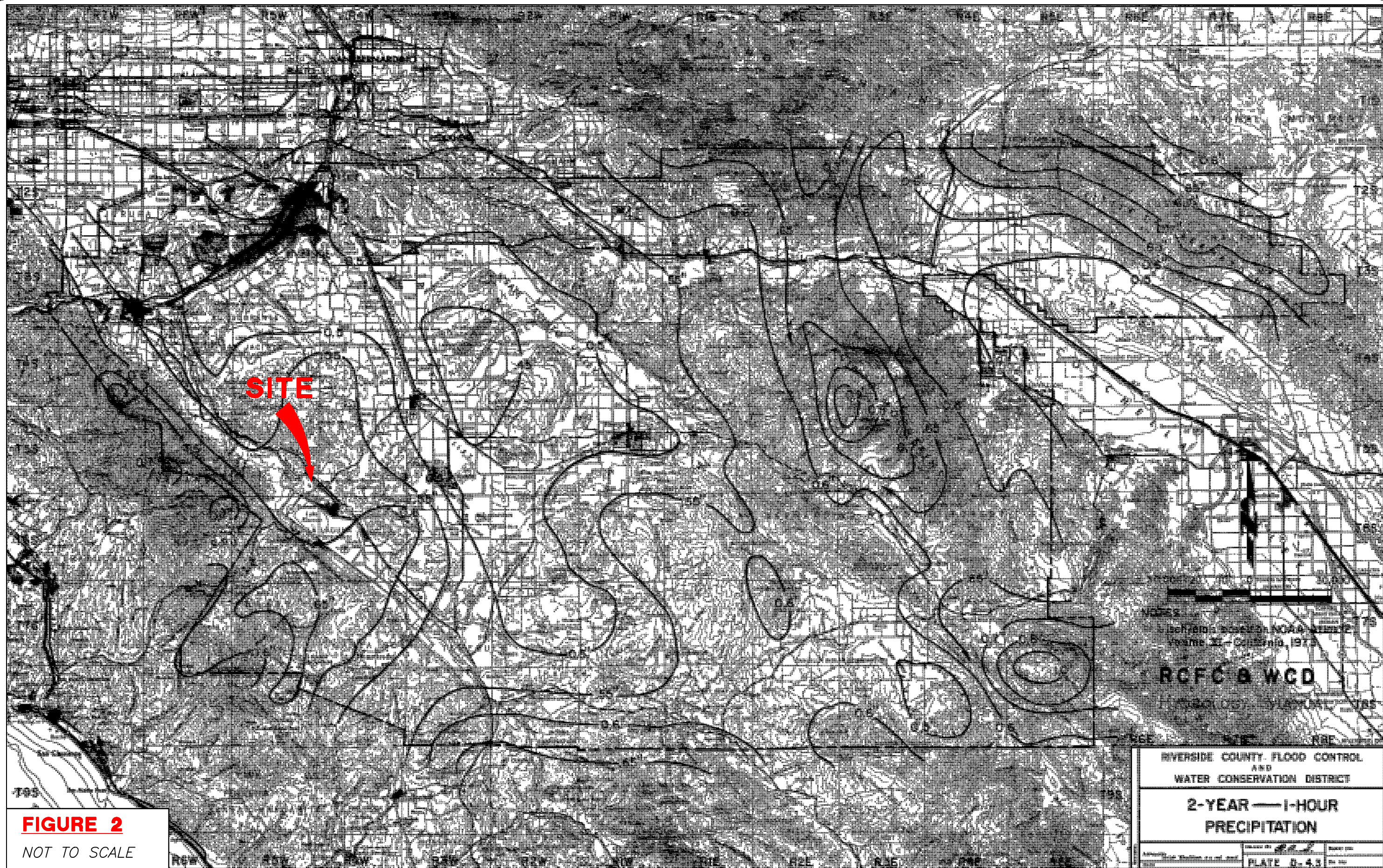
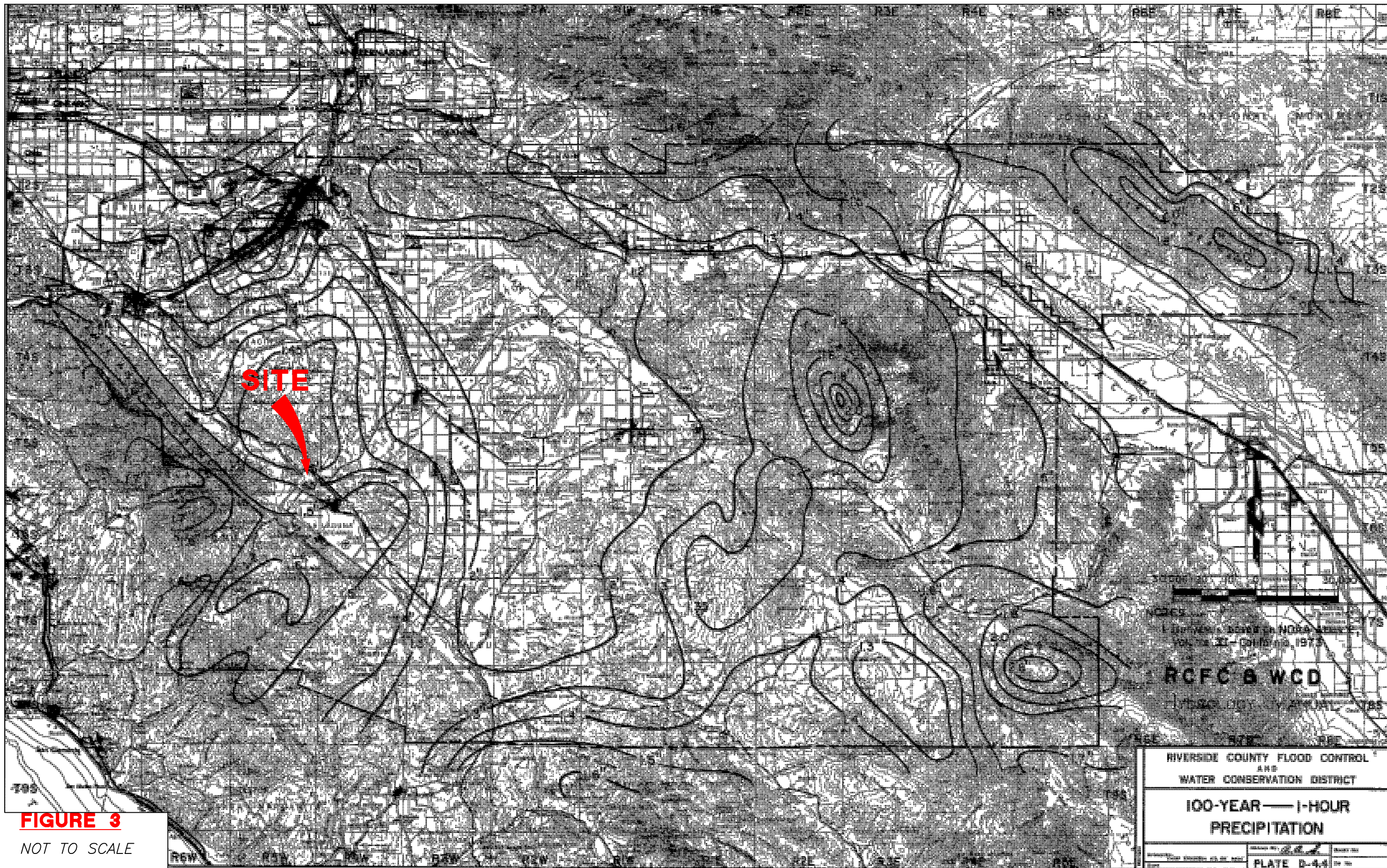
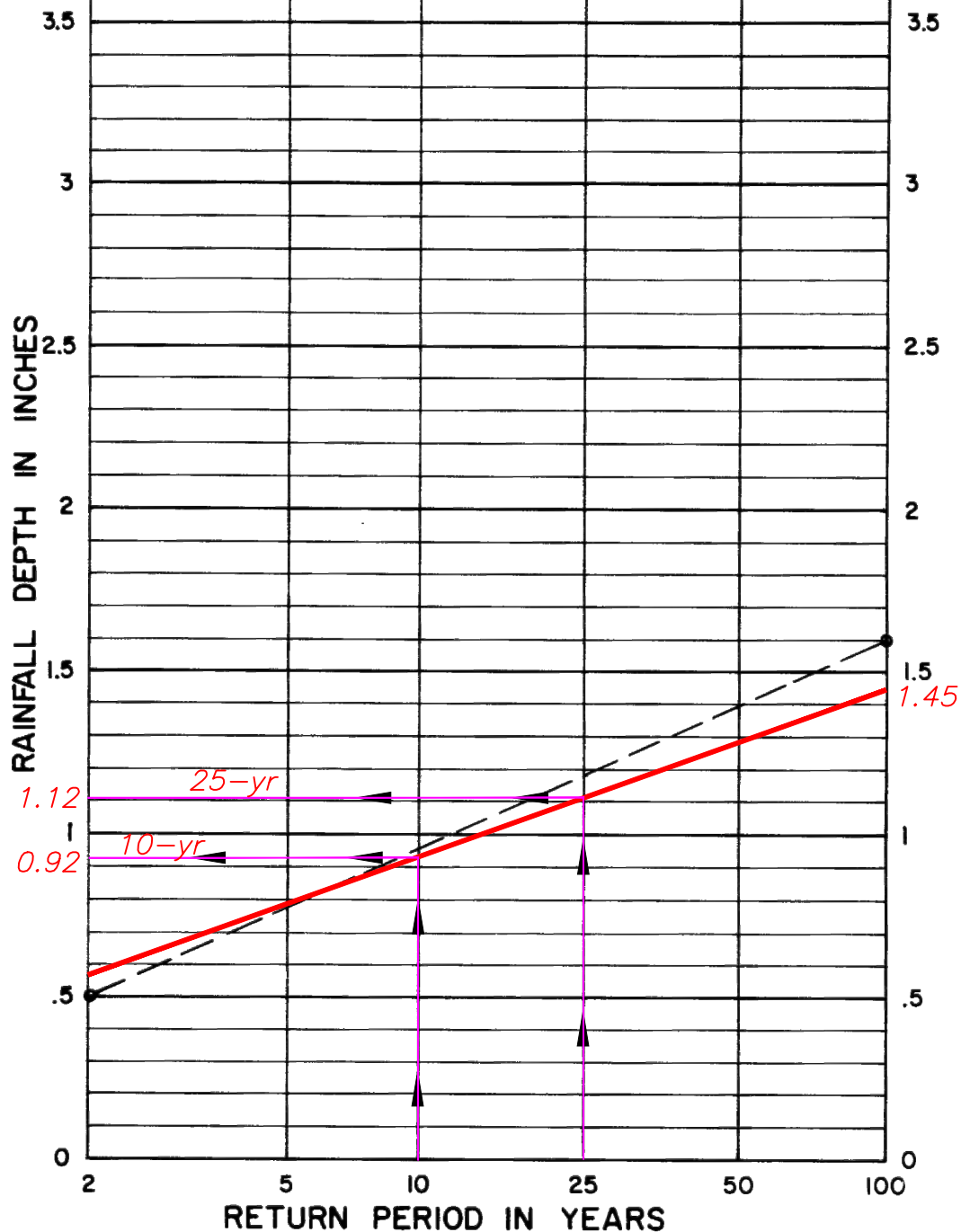


FIGURE 2

NOT TO SCALE





NOTE:

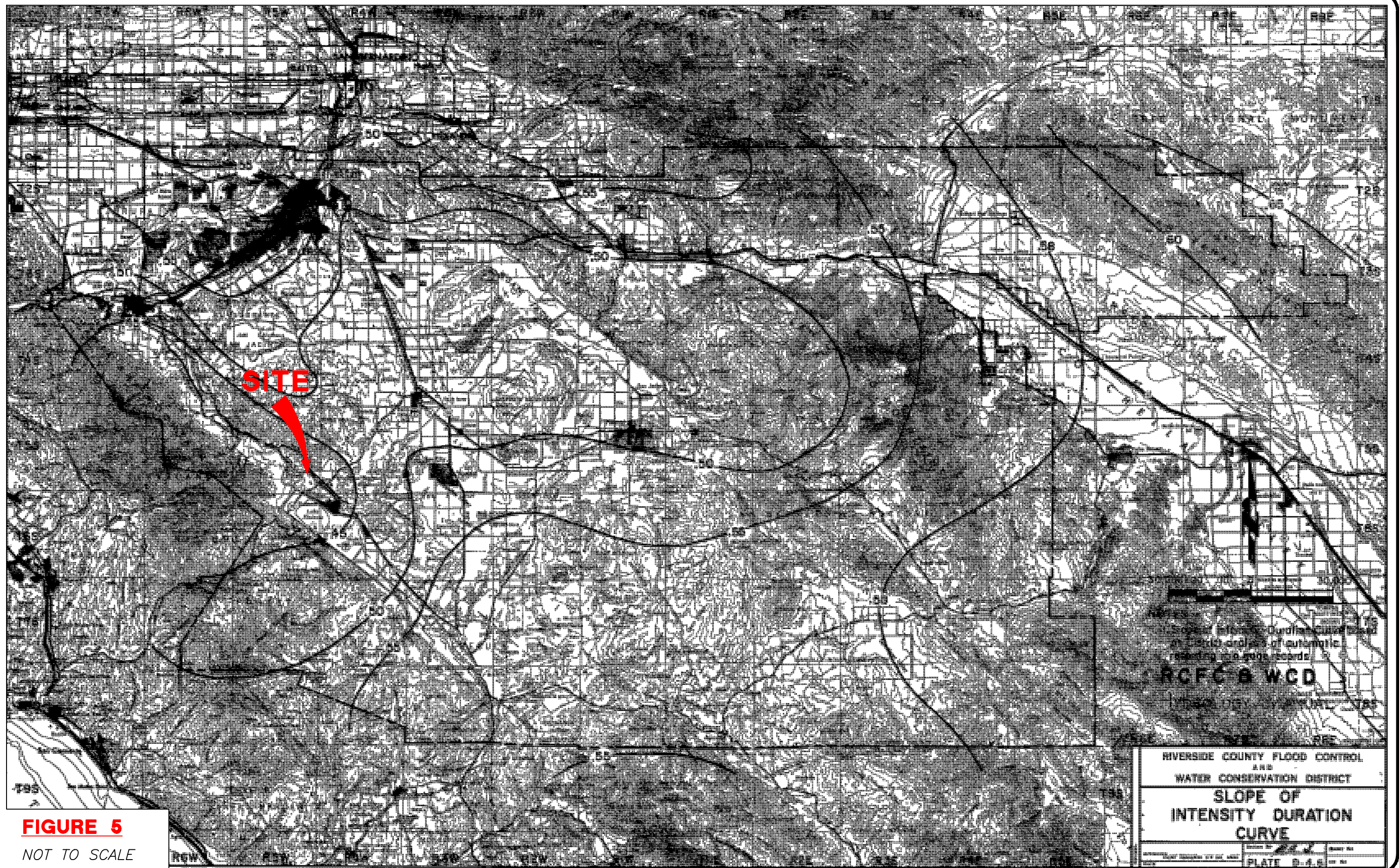
1. For intermediate return periods plot 2-year and 100-year one hour values from maps, then connect points and read value for desired return period. For example given 2-year one hour = .50" and 100-year one hour = 1.60", 25-year one hour = 1.18"

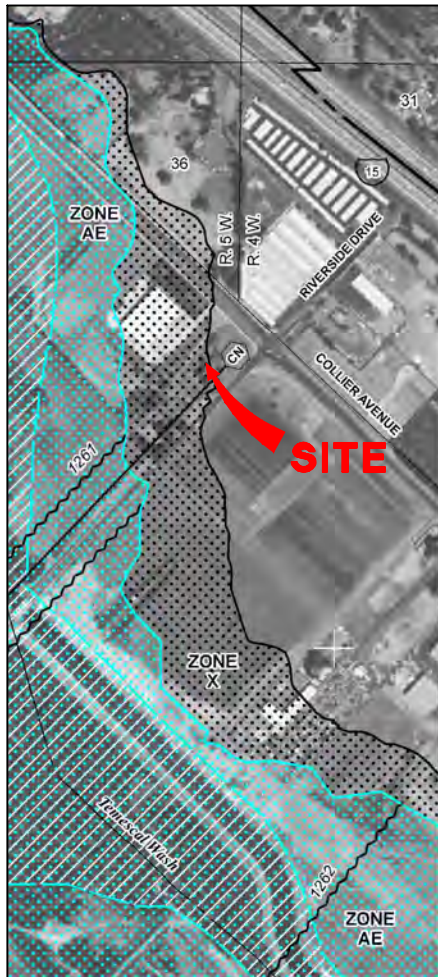
Reference: NOAA Atlas 2, Volume XI-California, 1973.

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RAINFALL DEPTH VERSUS
RETURN PERIOD FOR
PARTIAL DURATION SERIES

FIGURE 4





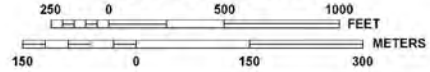
SITE

37°28'00"N

33°41'15" 117°20'37.5" 68°00"E



MAP SCALE 1" = 500'



NFIP

PANEL 2028G

FIRM

FLOOD INSURANCE RATE MAP

RIVERSIDE COUNTY,
CALIFORNIA
AND INCORPORATED AREAS

PANEL 2028 OF 3805

(SEE MAP INDEX FOR FIRM PANEL LAYOUT)

CONTAINS

COMMUNITY	NUMBER	PANEL	SUFFIX
LAKE ELSINORE, CITY OF	060636	2028	G
RIVERSIDE COUNTY	060245	2028	G

Notice to User: The Map Number shown below should be used when placing map orders; the Community Number shown above should be used on insurance applications for the subject community.



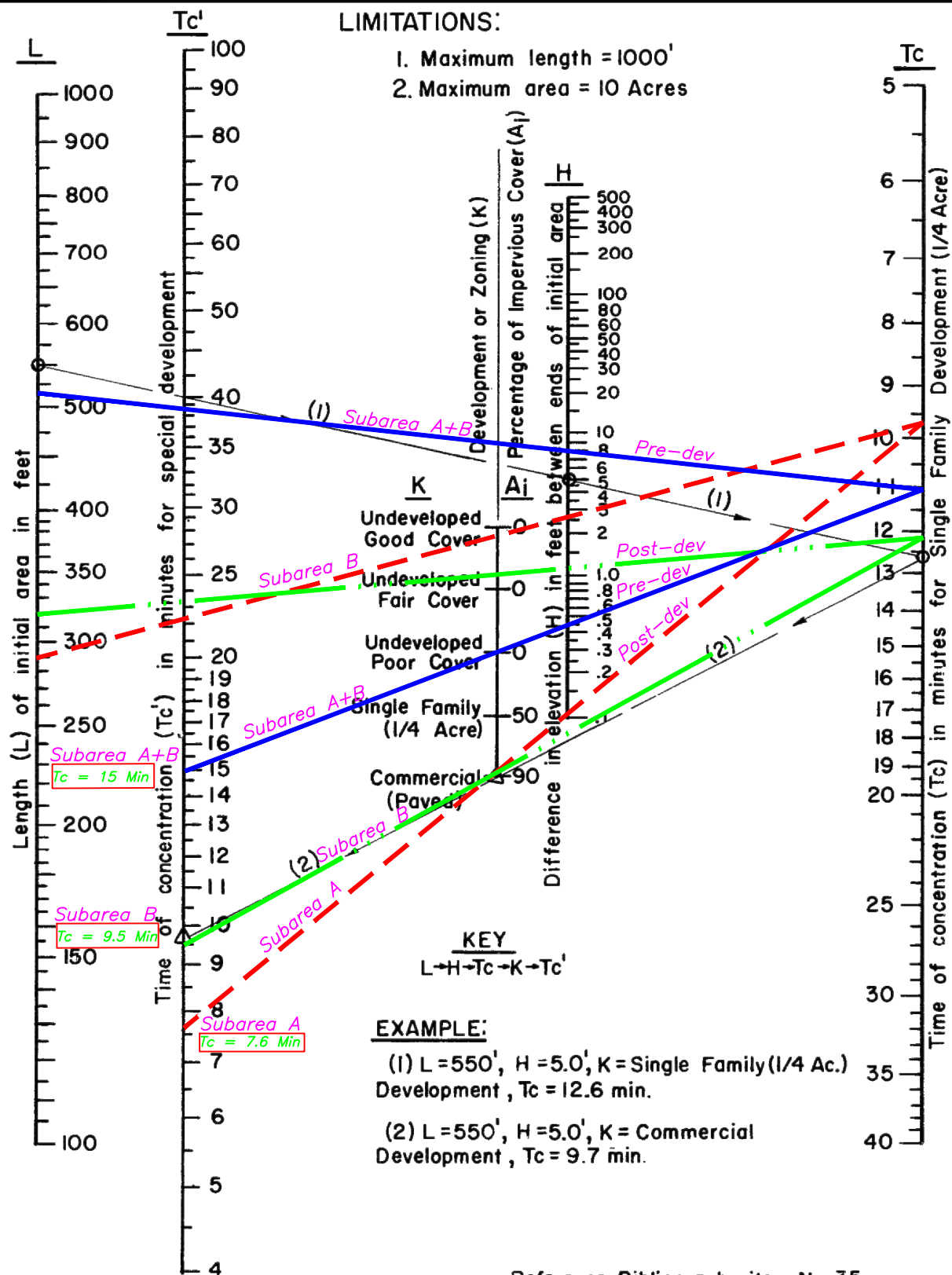
MAP NUMBER
06065C2028G

EFFECTIVE DATE
AUGUST 28, 2008

Federal Emergency Management Agency

FIGURE 6
FLOOD INSURANCE RATE MAP (FIRM)
NOT TO SCALE





Reference: Bibliography item No. 35.

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**TIME OF CONCENTRATION
 FOR INITIAL SUBAREA**

FIGURE 7

100-YR

$I=3.65"/hr$

$I=3.30"/hr$

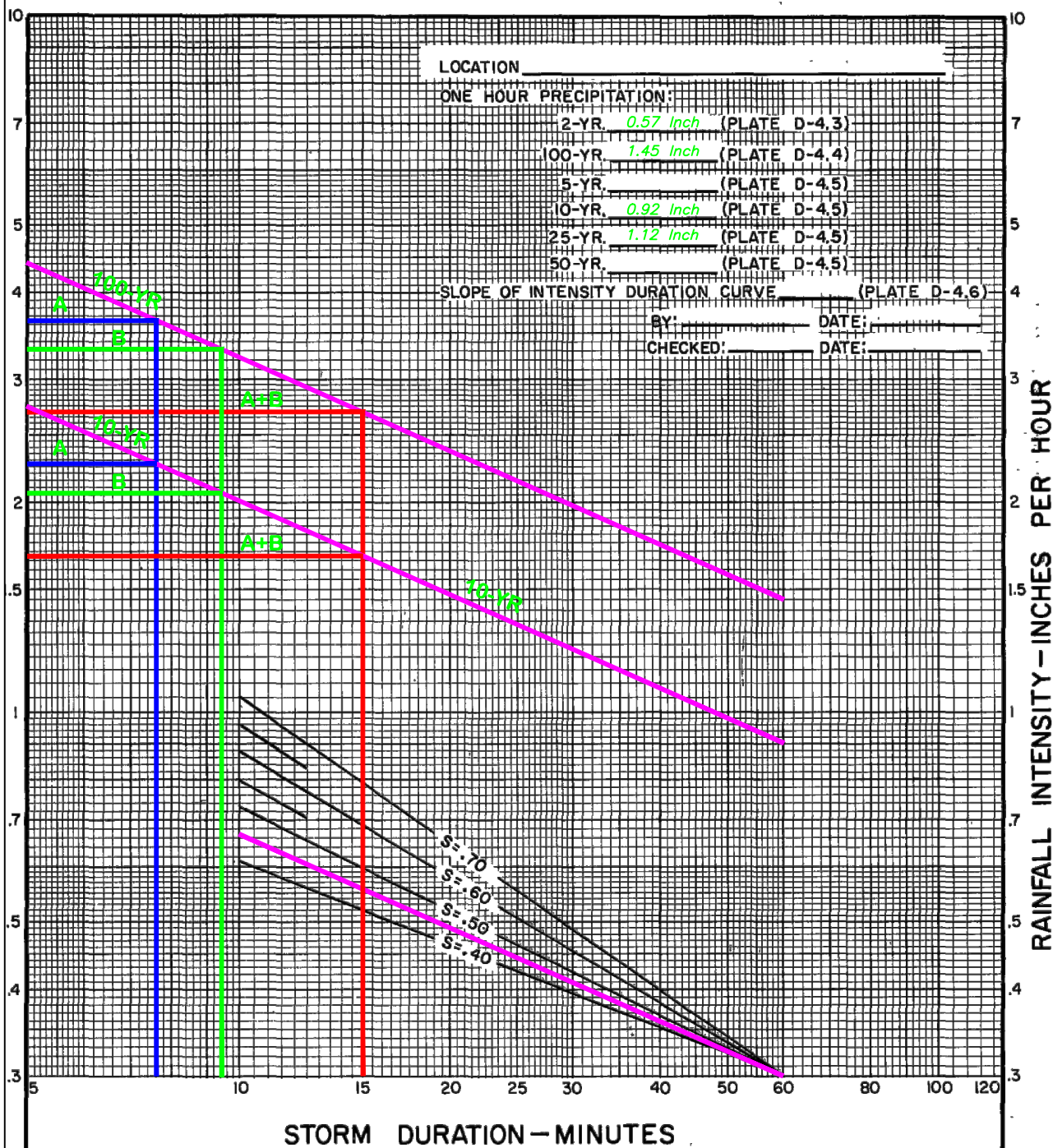
$I=2.82"/hr$

10-YR

$I=2.26"/hr$

$I=2.06"/hr$

$I=1.67"/hr$



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INTENSITY—DURATION
CURVES
CALCULATION SHEET

FIGURE 8-a

PLATE D-4.7

25-YR
 $I=2.82"/hr$
 $I=2.55"/hr$
 $I=2.08"/hr$

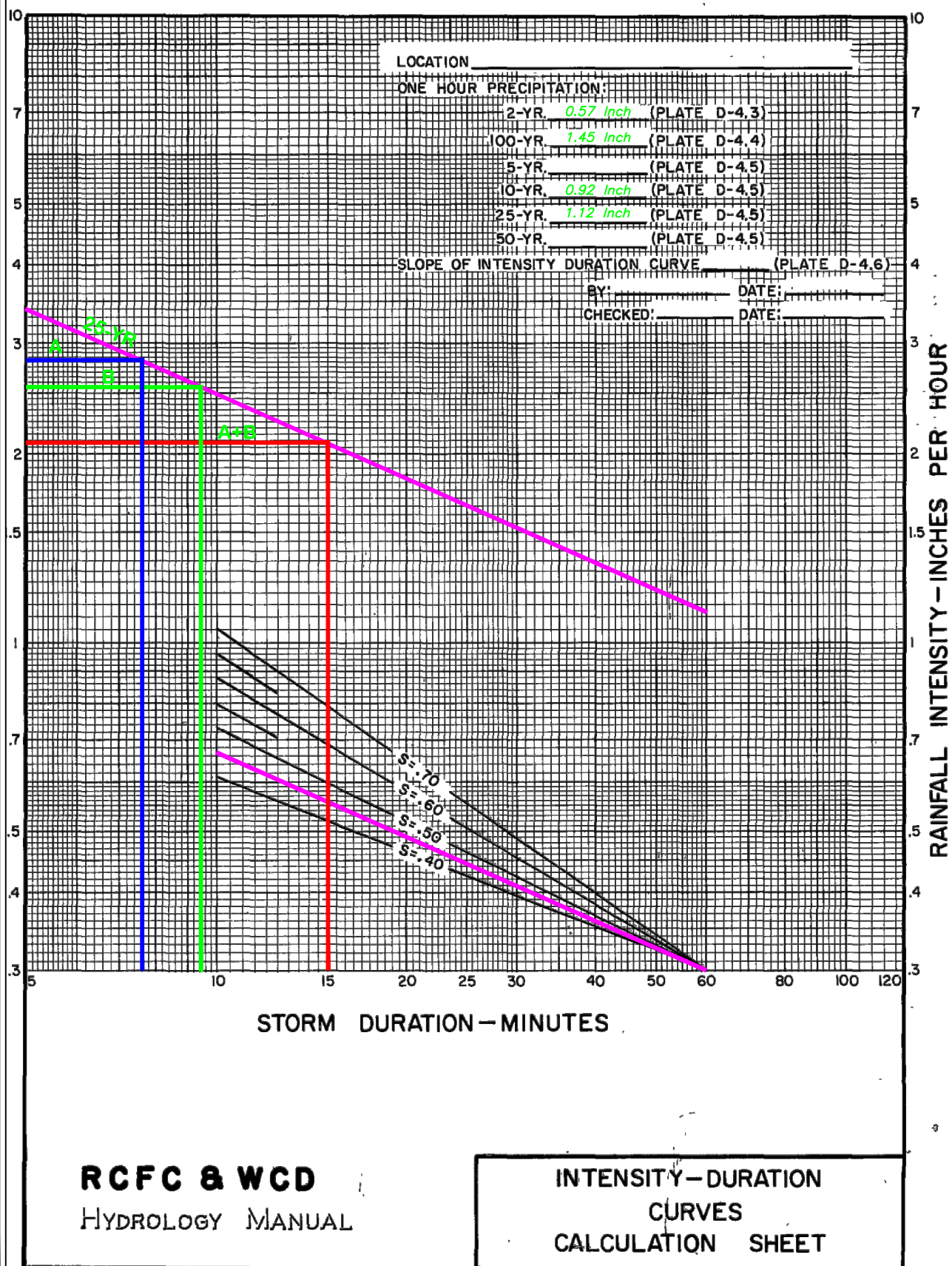
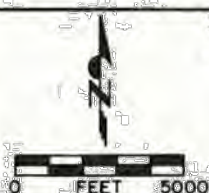


FIGURE 8-b

PLATE D-4.7

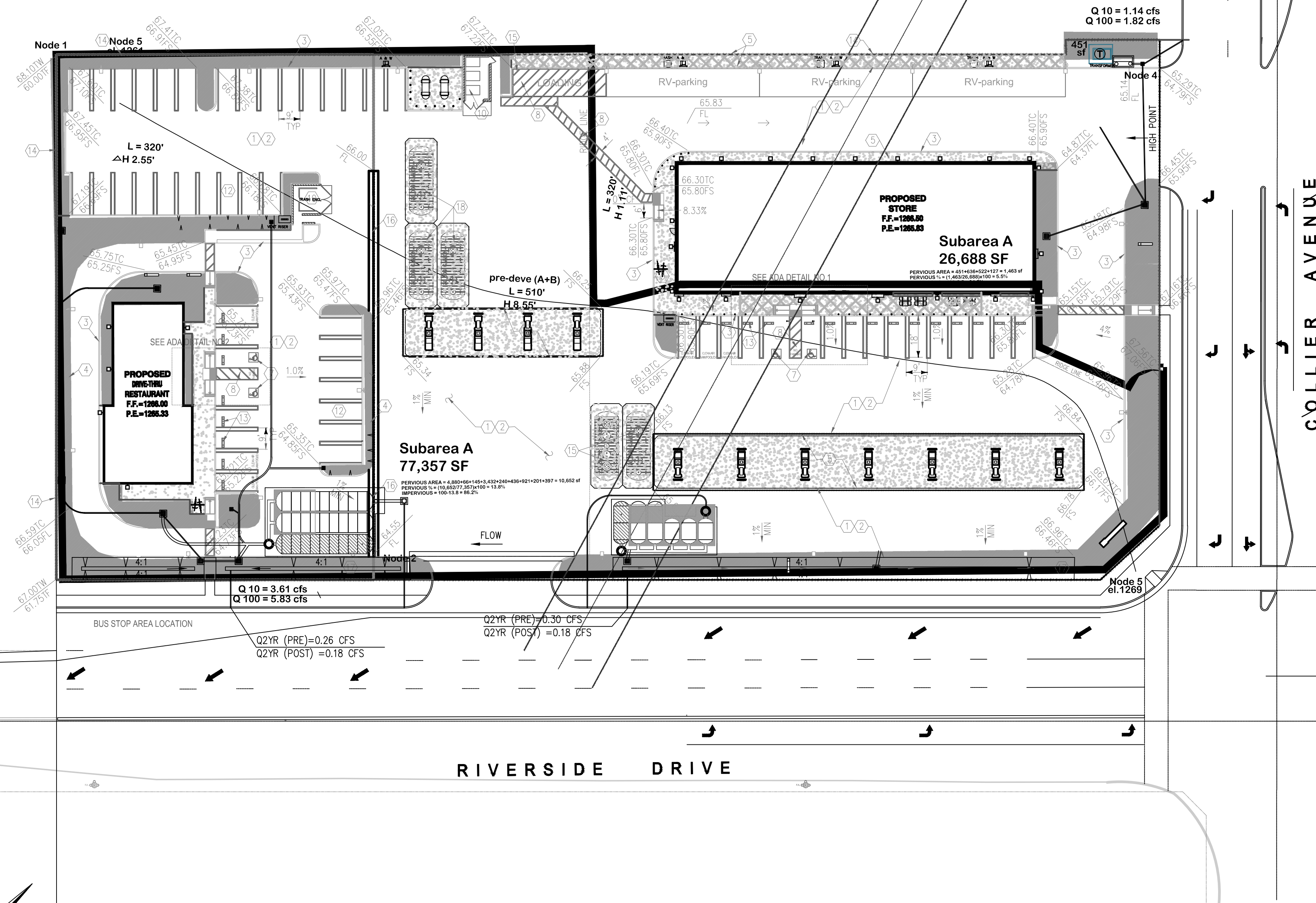


LEGEND
 — SOILS GROUP BOUNDARY
 A SOILS GROUP DESIGNATION
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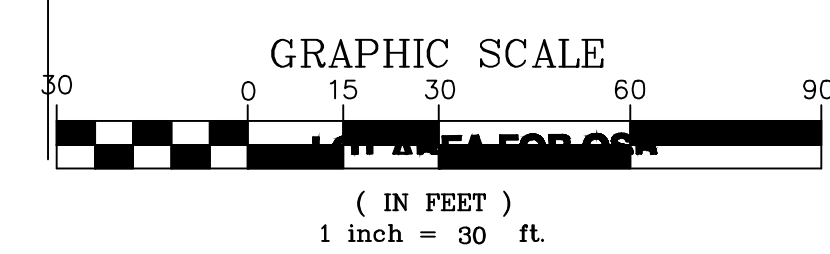
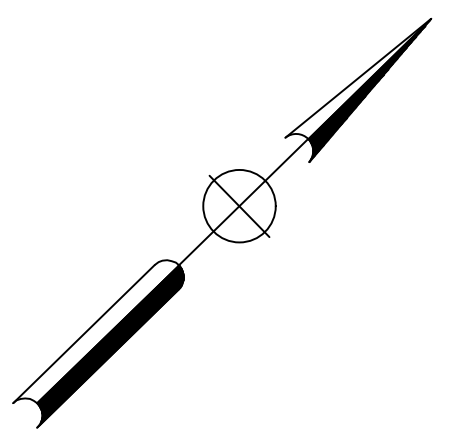
**HYDROLOGIC SOILS GROUP MAP
 FOR
 ELSINORE**

FIGURE 9



LEGEND

- BLDG./PAVED AREA
- LANDSCAPE
- CONSTRUCTION NOTES (SEE ATTACHED GRADING PLAN)
- OUTLET PIPE, 4" PVC SDR 35



Underground Service Alert

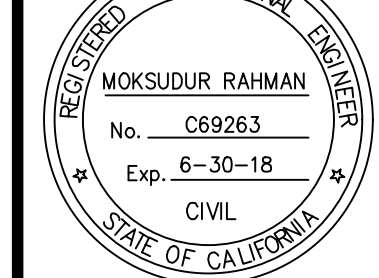


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PLANS PREPARED BY:

RAHMAN ENGINEERING
6939 SCHAEFER AVE, SUITE # D-170,
CHINO, CA 91710
TEL: (213) 400 - 8078

PREPARED BY:

MOKSUDUR RAHMAN
R.C.E. NO. 36117 EXP. DATE :
ACCEPTED BY:
DATE:

SCALE

Horizontal
1" = 30'
Vertical
N/A

CITY OF LAKE ELSINORE

HYDROLOGIC SUBAREAS
THE KASSAB TRAVEL CENTER
29301 RIVERSIDE DRIVE
LAKE ELSINORE, CA 92530

APPENDICES

APPENDIX A-SOIL COVER TYPE

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
<u>NATURAL COVERS -</u>					
Barren (Rockland, eroded and graded land)		78	86	91	93
Chaparral, Broadleaf (Manzonita, ceanothus and scrub oak)	Poor	53	70	80	85
	Fair	40	63	75	81
	Good	31	57	71	78
Chaparral, 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
<u>URBAN COVERS -</u>					
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
<u>AGRICULTURAL COVERS -</u>					
Fallow (Land plowed but not tilled or seeded)		76	85	90	92

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RUNOFF INDEX NUMBERS
FOR
PERVIOUS AREA

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
<u>AGRICULTURAL COVERS</u> (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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**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. ($\frac{1}{2}$ 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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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 moisture 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	--

RCFC & WCD
HYDROLOGY MANUAL

RUNOFF COEFFICIENT
CURVE DATA

APPENDIX B-RUNOFF COEFFICIENT

APPENDIX B

RCFC & WCD HYDROLOGY MANUAL

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	.86	.87	.87	.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	.88	.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	.88	.89
75.	.67	.82	.85	.87	.87	.88	.88	.88	.88	.88	.89
80.	.72	.84	.86	.87	.88	.88	.88	.88	.88	.88	.89
85.	.76	.85	.87	.88	.88	.88	.88	.88	.88	.88	.89
90.	.81	.87	.88	.89	.89	.89	.89	.89	.89	.89	.90
95.	.86	.88	.89	.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. = 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	.85	.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	.86	.87	.88
30.	.27	.71	.79	.82	.84	.85	.86	.86	.87	.87	.88
35.	.31	.72	.80	.83	.84	.85	.86	.86	.87	.87	.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	.87	.88	.88
55.	.49	.78	.83	.85	.86	.87	.88	.88	.88	.88	.89
60.	.54	.79	.84	.85	.86	.87	.88	.88	.88	.88	.89
65.	.58	.80	.84	.86	.87	.87	.88	.88	.88	.88	.89
70.	.63	.82	.85	.87	.88	.88	.88	.88	.88	.88	.89
75.	.67	.83	.86	.87	.88	.88	.88	.88	.88	.88	.89
80.	.72	.85	.87	.88	.88	.88	.88	.88	.88	.88	.89
85.	.76	.86	.88	.88	.88	.88	.88	.88	.88	.88	.89
90.	.81	.87	.88	.88	.88	.88	.88	.88	.88	.88	.89
95.	.86	.89	.89	.89	.89	.89	.89	.89	.89	.89	.90
100.	.90	.90	.90	.90	.90	.90	.90	.90	.90	.90	.90

10-Yr Rainfall

100-Yr Rainfall

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	.86	.87	.87	.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	.88	.88	.88	.88	.88	.89
60.	.54	.80	.84	.86	.87	.88	.88	.88	.88	.88	.89
65.	.58	.82	.85	.87	.88	.88	.88	.88	.88	.88	.89
70.	.63	.83	.86	.87	.88	.88	.88	.88	.88	.88	.89
75.	.67	.84	.87	.88	.88	.88	.88	.88	.88	.88	.89
80.	.72	.85	.87	.88	.88	.88	.88	.88	.88	.88	.89
85.	.76	.86	.88	.88	.88	.88	.88	.88	.88	.88	.89
90.	.81	.88	.88	.88	.88	.88	.88	.88	.88	.88	.89
95.	.86	.89	.89	.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. = 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	.86	.87	.87	.88
10.	.09	.71	.80	.83	.84	.85	.86	.86	.87	.87	.88
15.	.13	.73	.80	.83	.85	.86	.86	.87	.87	.88	.88
20.	.18	.74	.81	.84	.85	.86	.86	.87	.87	.88	.88
25.	.22	.75	.81	.84	.85	.86	.87	.87	.87	.88	.88
30.	.27	.76	.82	.84	.86	.86	.87	.87	.87	.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	.88	.89
50.	.45	.80	.84	.86	.87	.87	.88	.88	.88	.88	.89
55.	.49	.81	.85	.86	.87	.88	.88	.88	.88	.88	.89
60.	.54	.82	.85	.87	.88	.88	.88	.88	.88	.88	.89
65.	.58	.83	.86	.87	.88	.88	.88	.88	.88	.88	.89
70.	.63	.84	.87	.88	.88	.88	.88	.88	.88	.88	.89
75.	.67	.85	.87	.88	.88	.88	.88	.88	.88	.88	.89
80.	.72	.86	.88	.88	.88	.88	.88	.88	.88	.88	.89
85.	.76	.87	.88	.88	.88	.88	.88	.88	.88	.88	.89
90.	.81	.88	.88	.88	.88	.88	.88	.88	.88	.88	.89
95.	.86	.89	.89	.89	.89	.89	.89	.89	.89	.89	.90
100.	.90	.90	.90	.90	.90	.90	.90	.90	.90	.90	.90

RUNOFF COEFFICIENT CURVE DATA

RCFC & WCD

HYDROLOGY MANUAL

RUNOFF COEFFICIENTS FOR PI INDEX NO. = 92

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	.73	.81	.84	.85	.86	.87	.87	.87	.88	.88
5.	.04	.74	.81	.84	.85	.86	.87	.87	.87	.88	.88
10.	.09	.75	.82	.84	.85	.86	.87	.87	.87	.88	.88
15.	.13	.76	.82	.85	.86	.87	.87	.88	.88	.88	.88
20.	.18	.76	.83	.85	.86	.87	.87	.88	.88	.88	.88
25.	.22	.77	.83	.85	.86	.87	.87	.88	.88	.88	.88
30.	.27	.78	.83	.85	.86	.87	.87	.88	.88	.88	.88
35.	.31	.79	.84	.86	.87	.87	.88	.88	.88	.88	.88
40.	.36	.80	.84	.86	.87	.88	.88	.88	.88	.88	.88
45.	.40	.81	.85	.86	.87	.88	.88	.88	.88	.88	.88
50.	.45	.82	.85	.87	.88	.88	.88	.88	.88	.88	.88
55.	.49	.82	.85	.87	.88	.88	.88	.88	.88	.88	.88
60.	.54	.83	.87	.88	.88	.88	.88	.88	.88	.88	.88
65.	.58	.84	.87	.88	.88	.88	.88	.88	.88	.88	.88
70.	.63	.85	.87	.88	.88	.88	.88	.88	.88	.88	.88
75.	.67	.86	.88	.88	.88	.88	.88	.88	.88	.88	.88
80.	.72	.87	.88	.88	.88	.88	.88	.88	.88	.88	.88
85.	.76	.87	.88	.88	.88	.88	.88	.88	.88	.88	.88
90.	.81	.88	.89	.89	.89	.89	.89	.89	.89	.89	.89
95.	.86	.89	.90	.90	.90	.90	.90	.90	.90	.90	.90
100.	.90	.90	.90	.90	.90	.90	.90	.90	.90	.90	.90

10-Yr Rainfall

100-Yr Rainfall

RUNOFF COEFFICIENTS FOR RI INDEX NO. = 94

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	.77	.83	.85	.86	.87	.87	.88	.88	.88	.89
5.	.04	.78	.83	.85	.86	.87	.87	.88	.88	.88	.89
10.	.09	.78	.84	.86	.87	.87	.87	.88	.88	.88	.89
15.	.13	.79	.84	.86	.87	.87	.87	.88	.88	.88	.89
20.	.18	.80	.84	.86	.87	.88	.88	.88	.88	.88	.89
25.	.22	.80	.85	.86	.87	.88	.88	.88	.88	.88	.89
30.	.27	.81	.85	.87	.87	.88	.88	.88	.88	.88	.89
35.	.31	.81	.85	.87	.88	.88	.88	.88	.88	.88	.89
40.	.36	.82	.86	.87	.88	.88	.88	.88	.88	.88	.89
45.	.40	.83	.86	.87	.88	.88	.88	.88	.88	.88	.89
50.	.45	.83	.86	.88	.88	.88	.88	.88	.88	.88	.89
55.	.49	.84	.87	.88	.88	.88	.88	.88	.88	.88	.89
60.	.54	.85	.87	.88	.88	.88	.88	.88	.88	.88	.89
65.	.58	.85	.88	.88	.88	.88	.88	.88	.88	.88	.89
70.	.63	.86	.88	.88	.88	.88	.88	.88	.88	.88	.89
75.	.67	.87	.88	.88	.88	.88	.88	.88	.88	.88	.89
80.	.72	.87	.88	.88	.88	.88	.88	.88	.88	.88	.89
85.	.76	.88	.88	.88	.88	.88	.88	.88	.88	.88	.89
90.	.81	.89	.89	.89	.89	.89	.89	.89	.89	.89	.89
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 PI INDEX NO. = 96

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	.81	.85	.87	.88	.88	.88	.88	.88	.88	.88
5.	.04	.81	.85	.87	.88	.88	.88	.88	.88	.88	.88
10.	.09	.82	.86	.87	.88	.88	.88	.88	.88	.88	.88
15.	.13	.82	.86	.87	.88	.88	.88	.88	.88	.88	.88
20.	.18	.83	.86	.87	.88	.88	.88	.88	.88	.88	.88
25.	.22	.83	.86	.87	.88	.88	.88	.88	.88	.88	.88
30.	.27	.84	.87	.88	.88	.88	.88	.88	.88	.88	.88
35.	.31	.84	.87	.88	.88	.88	.88	.88	.88	.88	.88
40.	.36	.85	.87	.88	.88	.88	.88	.88	.88	.88	.88
45.	.40	.85	.87	.88	.88	.88	.88	.88	.88	.88	.88
50.	.45	.85	.88	.88	.88	.88	.88	.88	.88	.88	.88
55.	.49	.86	.88	.88	.88	.88	.88	.88	.88	.88	.88
60.	.54	.86	.88	.88	.88	.88	.88	.88	.88	.88	.88
65.	.58	.87	.88	.88	.88	.88	.88	.88	.88	.88	.88
70.	.63	.87	.88	.88	.88	.88	.88	.88	.88	.88	.88
75.	.67	.88	.89	.89	.89	.89	.89	.89	.89	.89	.89
80.	.72	.88	.89	.89	.89	.89	.89	.89	.89	.89	.89
85.	.76	.89	.89	.89	.89	.89	.89	.89	.89	.89	.89
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

10-Yr Rainfall

100-Yr Rainfall

RUNOFF COEFFICIENTS FOR RI INDEX NO. = 98

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	.85	.88	.88	.89	.89	.89	.89	.89	.89	.89
5.	.04	.86	.88	.88	.89	.89	.89	.89	.89	.89	.89
10.	.09	.86	.88	.88	.89	.89	.89	.89	.89	.89	.89
15.	.13	.86	.88	.88	.89	.89	.89	.89	.89	.89	.89
20.	.18	.86	.88	.88	.89	.89	.89	.89	.89	.89	.89
25.	.22	.87	.88	.88	.89	.89	.89	.89	.89	.89	.89
30.	.27	.87	.88	.88	.89	.89	.89	.89	.89	.89	.89
35.	.31	.87	.88	.88	.89	.89	.89	.89	.89	.89	.89
40.	.36	.87	.88	.88	.89	.89	.89	.89	.89	.89	.89
45.	.40	.87	.88	.88	.89	.89	.89	.89	.89	.89	.89
50.	.45	.88	.88	.88	.89	.89	.89	.89	.89	.89	.89
55.	.49	.88	.88	.88	.89	.89	.89	.89	.89	.89	.89
60.	.54	.88	.88	.88	.89	.89	.89	.89	.89	.89	.89
65.	.58	.88	.88	.88	.89	.89	.89	.89	.89	.89	.89
70.	.63	.89	.89	.89	.89	.89	.89	.89	.89	.89	.89
75.	.67	.89	.89	.89	.89	.89	.89	.89	.89	.89	.89
80.	.72	.89	.89	.89	.89	.89	.89	.89	.89	.89	.89
85.	.76	.89	.89	.89	.89	.89	.89	.89	.89	.89	.89
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

RUNOFF COEFFICIENT

CURVE DATA

APPENDIX C-DESIGN CALCULATIONS

Hydraulic Analysis Report

Project Data

Project Title:

Designer:

Project Date: Sunday, December 31, 2017

Project Units: U.S. Customary Units

Notes:

Channel Analysis: Channel Analysis

Notes:

Input Parameters

Channel Type: Rectangular

Channel Width: 3.0000 ft

Longitudinal Slope: 0.0300 ft/ft

Manning's n: 0.0130

Flow: 4.5100 cfs

Result Parameters

Depth: 0.2253 ft

Area of Flow: 0.6758 ft²

Wetted Perimeter: 3.4505 ft

Hydraulic Radius: 0.1958 ft

Average Velocity: 6.6739 ft/s

Top Width: 3.0000 ft

Froude Number: 2.4780

Critical Depth: 0.4125 ft

Critical Velocity: 3.6445 ft/s

Critical Slope: 0.0046 ft/ft

Critical Top Width: 3.00 ft

Calculated Max Shear Stress: 0.4217 lb/ft²

Calculated Avg Shear Stress: 0.3666 lb/ft²

Hydraulic Analysis Report

Project Data

Project Title:

Designer:

Project Date: Tuesday, January 02, 2018

Project Units: U.S. Customary Units

Notes:

Channel Analysis: Channel Analysis

Notes:

Input Parameters

Channel Type: Circular

Pipe Diameter: 0.3300 ft

Longitudinal Slope: 0.0500 ft/ft

Manning's n: 0.0090

Flow: 0.5000 cfs

Result Parameters

Depth: 0.2306 ft

Area of Flow: 0.0638 ft²

Wetted Perimeter: 0.6534 ft

Hydraulic Radius: 0.0977 ft

Average Velocity: 7.8319 ft/s

Top Width: 0.3028 ft

Froude Number: 3.0057

Critical Depth: 0.3251 ft

Critical Velocity: 5.8639 ft/s

Critical Slope: 0.0317 ft/ft

Critical Top Width: 0.08 ft

Calculated Max Shear Stress: 0.7196 lb/ft²

Calculated Avg Shear Stress: 0.3049 lb/ft²