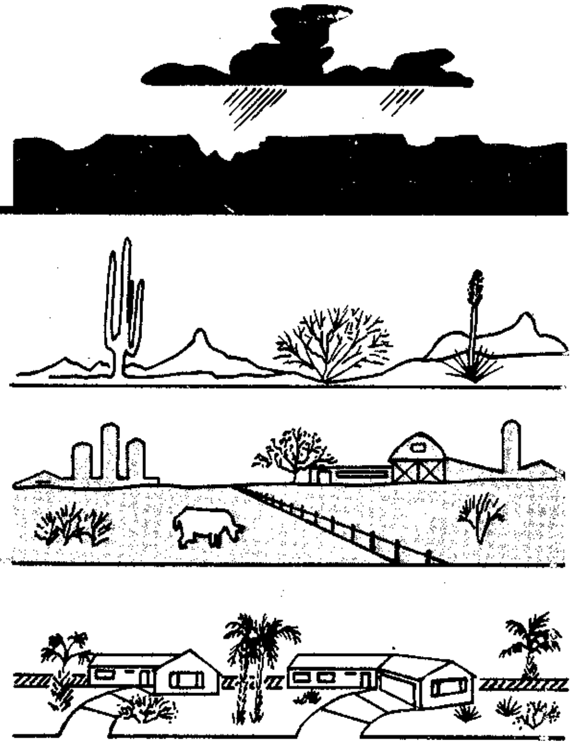

FLOOD CONTROL DISTRICT OF MARICOPA COUNTY

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A HYDROLOGIC ANALYSIS OF SAN DOMINGO WASH WATERSHED

Report on

A HYDROLOGIC ANALYSIS
OF
SAN DOMINGO WASH WATERSHED

Prepared by

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October 1989

A HYDROLOGIC ANALYSIS
OF
SAN DOMINGO WASH WATERSHED

TABLE OF CONTENTS
Continued

TABLE OF CONTENTS

LIST OF TABLES

LIST OF TABLES
Continued

LIST OF FIGURES

I. INTRODUCTION

A. Purpose

The purpose of this study is to determine the flows within the San Domingo Wash watershed generated by a 100 year, 24 hour storm. These discharges will be used in the San Domingo Wash Flood Insurance Study. This hydrology may also be used in the future for drainage master studies, or public projects that occur within this watershed.

B. Study Area

San Domingo Wash is a well-defined ephemeral wash that lies between the unincorporated area of Morristown and the town of Wickenburg, in north-central Maricopa county (see Figure 1). The wash flows southwesterly for approximately 12 miles and drains desert highlands into the Hassayampa River. The study area lies in both Maricopa and Yavapai counties and is contained within the Flood Control District's Lower Hassayampa planning area (#7).

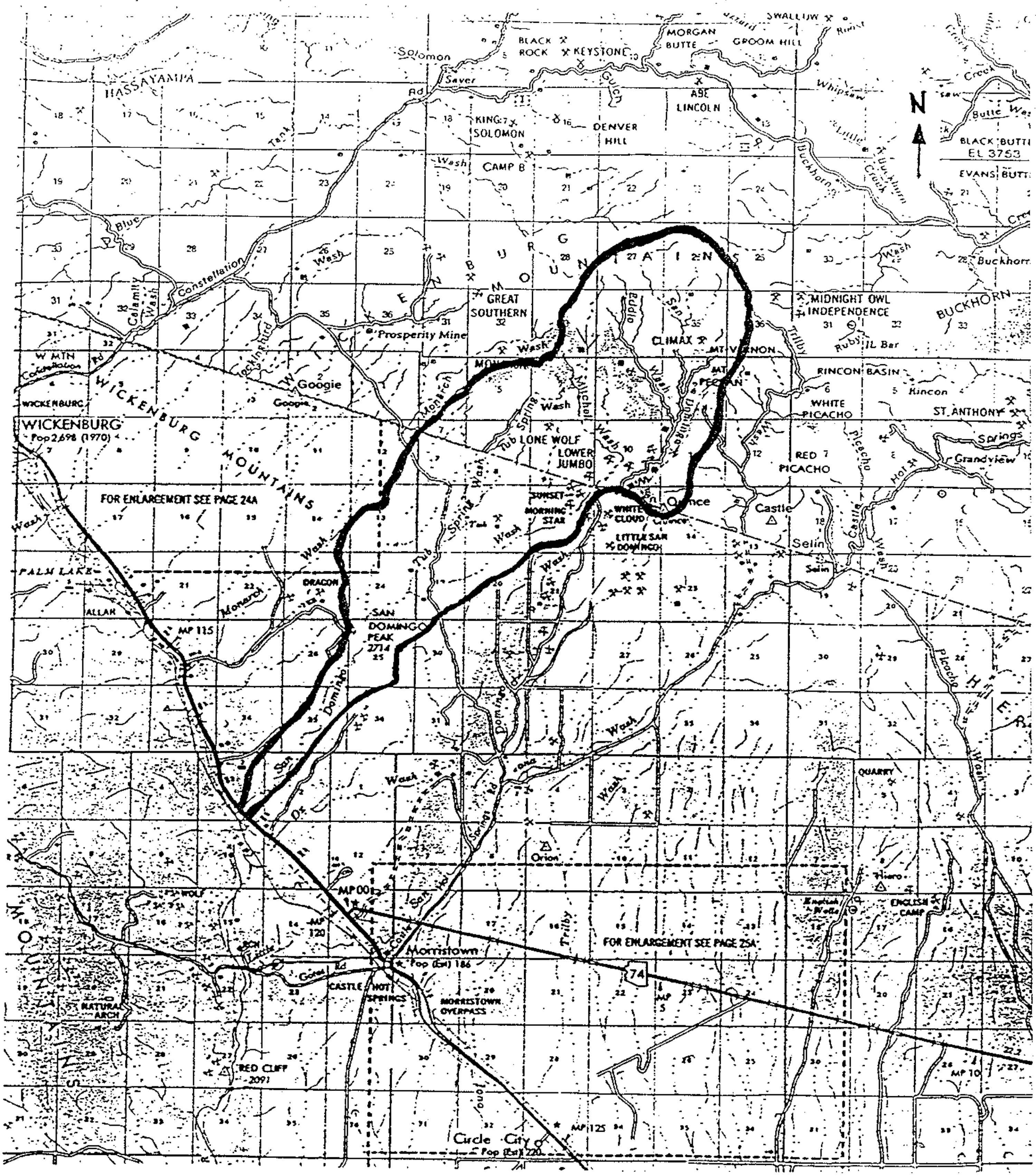

Figure 1

Location Map
San Domingo Wash Watershed

II. WATERSHED CHARACTERISTICS

A. Watershed Delineation

San Domingo Wash was delineated utilizing three 7-1/2-minute series (1=24,000) USGS topographic maps, Wickenburg, Red Picacho, and Morgan Butte (see Plate 1). Subwatershed areas, elevations, watercourse length, and other pertinent information were also determined from these maps.

The total area of this study is 20.28 square miles as measured by a manual planimeter. The watershed was subdivided into sixteen subwatersheds ranging in size from 0.41 square miles (262 acres) to 2.36 square miles (1510 acres).

B. Land Use

The study area is characterized as a natural dense upland watershed, having few inhibiting alterations or man-made structures. A gravel operation is located near the mouth of the wash, approximately three-quarter miles upstream. Land use is primarily cattle grazing, with few homes or roads, and some evidence of limited mining claims.

C. Soils

There are ten major soil association types within the San Domingo Wash watershed (see Plate 2). Six of the soil associations are of hydrologic soil group D, and four are of mixed hydrologic soil groups, as defined below:

> The six soil associations with a hydrologic soil group of D are the Cellar-Rock outcrop complex, the Dixaleta-Rock outcrop complex, the Gran-Wickenburg-Rock outcrop complex, the Lehmans-Rock outcrop complex, and the Rock Outcrop-Lehmans complex. They are described as having a shallow, well drained soil with moderately slow to moderately rapid permeability. The soils in this hydrologic soil group also have a low available water capacity and a medium to rapid runoff rate. These soils comprise approximately 80 percent of the total watershed area.

The four soil associations which are a mix of hydrologic soil groups (A, B, C, and D) are the Anthony-Arizo complex, the Eba-Nickel-Cave association, the Eba-Pinaleno complex, and the Nickel-Cave complex. The soils in this mix of hydrologic soil groups are deep well drained soils with moderately slow to slow permeability. These soils have a low available water capacity and a slow to medium rate of runoff. These soils comprise approximately 20 percent of the total watershed area.

D. Topography

Estimates of the main watercourse slope were developed from the USGS quadrangles for the study area. The mean elevation of the watershed is estimated at 2600 feet msl, ranging from 1850 to 4400 feet msl with an average slope of 5.4 %.

San Domingo Wash is characterized by steep side slopes, an incised channel averaging 100 feet in width, and a relatively clean, sandy bottom. The vegetation within the watershed is composed of various cacti, creosote bushes, mesquite, palo verde trees, and other species which heavily vegetate the overbanks of San Domingo Wash. Near the mouth of the wash, isolated sandbars have formed in the channel which have vegetation much like the banks but somewhat less mature.

III. HYDROLOGIC METHODS

A. Model

The hydrologic response to the 100 year, 24 hour storm was simulated using the U.S. Army Corps of Engineers HEC-1 computer program.

B. Precipitation

The 100 year, 24 hour storm was estimated as an average precipitation value of 4.60 inches total depth utilizing procedures for precipitation determination as described in the manual Hydrologic Design for Highway Drainage in Arizona (see Appendix A). Rainfall was distributed in time using the SCS Type II rainfall distribution, and computed with a 15 minute input step.

Areal reduction was applied to adjust point rainfall to the entire watershed. The areal reduction curve for the 24 hour storm was taken from the NOAA Technical Memorandum NWS HYDRO-40 (see Appendix A). The document in part utilized the data from the Walnut Gulch Experimental watershed to develop the curves for the Southwest region of the United States. The ratios for the 24 hour storm were:

Square Mile	Ratio
.01	1.00
10	.95
20	.92
30	.90

C. Rainfall Excess

The initial and uniform loss rate method of HEC-1 was utilized to generate rainfall excess. The parameters for the initial and uniform rates were developed as outlined in the Preliminary Outline - Maricopa County Hydrology Manual (Reference 4). The range of values determined from this method were 0.55 to 0.62 inches for the initial loss (STRTL), and 0.05 to 0.18 inches/hour for the uniform loss rate (CNSTL) (see Appendix B).

Since the loss rates are based upon hydrologic soil types, they were weighted for each subwatershed based upon percentage soil type. As was mentioned in the Soils section, 80 percent of the soil exists as hydrologic soil group D which consists of shallow rocky and gravelly loam with 4 to 15 inches to bedrock. This type of soil is likely to generate rapid runoff rates because of little or no soil moisture storage capacities and small detention losses.

D. Unit Hydrograph

The Soil Conservation Service's "Dimensionless Unit Hydrograph" method was used in the HEC-1 model to generate runoff from rainfall excess. Input data for this method consisted of a single parameter, TLAG, which by definition is equal to the lag, in hours, between the center of mass of rainfall excess and the peak of the unit hydrograph. The empirical relation is

$$TLAG = Tc * 0.6$$

L = Lag Time (hours)
Tc = Time of Concentration (hours)

where the time of concentration is determined from a graph of area and slope developed by the SCS (see Appendix C).

The HEC-1 program, by design, does not utilize different computational time intervals for each subbasin, therefore an analysis to determine the average computational time increment for the modeling of the entire study area was conducted using the methods as described in the National Engineering Handbook - Section 4 (Reference 8). The time increment was determined using the following equation:

$$.133Tc = \text{change in } D$$

Tc = Time of Concentration (hours)
D = Duration of Unit Excess Rainfall (hours)

Durations were determined for each subbasin and then averaged to obtain a time increment which would represent all of the subbasins. It was determined that a 5 minute time increment was appropriate, as listed in Table 1.

Table 1

Computational Time Interval
San Domingo Wash

SUBBASIN	Tc	DURATION OF EXCESS RAIN	
		hours	minutes
1	.518	.069	4.14
2	.444	.059	3.54
3	.493	.066	3.96
4	.579	.077	4.62
5A	.538	.072	4.32
5B	.660	.088	5.28
6	.493	.066	3.96
7	.403	.054	3.24
8	.701	.093	5.58
9A	.600	.080	4.80
9B	.740	.098	5.88
10	.741	.099	5.94
11	.420	.056	3.36
12	1.108	.147	8.82
13	.559	.074	4.44
14	1.177	.157	9.42

Total Duration of Excess Rainfall = 81.30 minutes
Average Duration of Excess Rain = 5.08 minutes

E. Channel Routing

The "normal-depth" routing method of the HEC-1 model was applied for channel routing. This routing method utilizes channel cross-sections and normal-depth computations to route computed storm runoff hydrographs through prescribed reaches. Channel cross-section locations were designated on the U.S.G.S. quadrangles to best represent the routing reach. Field cross-section data were obtained for each station.

In the HEC-1 model routing procedure, the RS card allows a wedge coefficient value (Muskingum X) to be used. The Muskingum X value employed in this program was equal to 0.2. The number of steps (NSTPS) per routing interval is an input parameter essential for application of this method, and was obtained using the following equation:

NSTPS = reach length/ average velocity /300

The normal-depth routing procedure in the HEC-1 program requires that a Manning's n value be determined for the left bank, channel, and right bank (see Appendix D). It was important to choose the values which represented the average routed channel reach. Thus, the channel characteristics were carefully evaluated for estimation of Manning's n values. The chosen values ranged from .045 to .054.

IV. DISCUSSION

The peak discharge determined for San Domingo Wash at U.S. Highway 60/70 was 26,690 cfs. This seemed reasonable, considering the slopes, soil types and other watershed characteristics. Reach velocities averaged 17 fps, with a range of 11 to 23 fps. The discharge per square mile was 1316 cfs, with a total rainfall excess of 2.70 inches for the watershed.

Subbasin discharges per square mile varied based on subbasin size and physical characteristics. The highest unit discharge was 2170 cfs per square mile generated by subbasin 7, which had an area of 0.63 square miles with steep slopes and rocky terrain. The lowest unit discharge was 1105 cfs per square mile from subbasin 14, which was 0.59 square miles in size and was mainly an area of more shallow slopes. A more detailed look at unit discharge and excess is provided in Table 2.

Rough estimates of velocity for each routing reach were obtained by dividing reach length by the travel time generated by the HEC-1 program. Concern developed when the resulting velocities reflected rapid channel travel times. Another analysis of velocity was done using a Flood Control District program called Manning. The field cross-section data was slightly altered to fit the manning's equation parameters, and approximate estimates of velocity were generated (see Appendix D). Using both methods, the velocities were high indicating that rapid travel times might, in fact, characterize the response of the watershed. The time to peak at the watershed outlet was 12.83 hours. This seemed reasonable for the given rainfall distribution and watershed characteristics.

Total rainfall excess values were generated by the HEC-1 program and seemed reasonable for this watershed. As was stated earlier, the 20.28 square mile basin yielded 26,690 cfs and a total excess value of 2.70 inches for a storm of 4.60 inches. The hydrologic soil characteristics also play an important role in the total excess volume in that soil group D is shallow and rocky with 4 to 15 inches to bedrock and a low water capacity.

An analysis of subbasin lag times was also conducted to compare the results with other methods. Two methods were used for comparison; the Kirpich method and the method explained in the Hydrology Manual (see Appendix E). The results of this analysis indicate that the SCS method used in the HEC-1 model was consistent with the other methods, and has been found to be within reasonable difference of estimated lag times.

Table 2

Unit Discharge and Excess
San Domingo Watershed

SUBBASIN	PEAK Q	AREA	UNIT DISHCARGE	EXCESS
	cfs	sq.mi.	cfs/sq.mi.	inches
1	4135	2.14	1932	3.12
2	2152	1.03	2089	3.14
3	2590	1.30	1992	3.13
4	2818	1.56	1806	3.13
5A	2426	1.28	1895	3.13
5B	1872	1.10	1702	3.14
6	1640	0.82	2000	3.15
7	1367	0.63	2170	3.15
8	1932	1.21	1597	2.51
9A	3836	2.16	1776	3.12
9B	2054	1.35	1521	2.33
10	3663	2.36	1552	2.74
11	874	0.41	2132	3.17
12	1933	1.61	1201	2.67
13	1318	0.73	1805	2.40
14	652	0.59	1105	2.16

TOTAL PEAK Q = 26690 cfs
TOTAL AREA = 20.23 square miles
DRAINAGE / AREA = 1316 cfs/square mile
EXCESS = 2.70 inches

V. CONCLUSIONS

The peak flow obtained using the HEC-1 model with areal reduction yielded 26,690 cfs for the 100 year flood at the confluence of San Domingo Wash and U.S. Highway 60/70. The resulting estimate of peak flow has been compared with other methods and has been found to be reasonable.

The HEC-1 model provided subbasin peaks at various concentration points on the watershed and should be considered in future floodplain mapping or watershed planning models.

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APPENDIX A

PRECIPITATION DATA

Steps to be used to determine precipitation values for various durations and return periods.

STEP 1. From the precipitation maps in the manual "Hydrologic Design for Highway Drainage in Arizona", determine the precipitation values for the 6 and 24 hour duration storms for return periods of 2, 5, 10, 25, 50 and 100 years. Tabulate these values in Table 1 in the column headed 'Map Values'

TABLE A-1

100 Year Precipitation for
San Domingo Wash Watershed

(Reference 3)

Return Period (Years)	Precipitation Values (inches)			
	6 hour duration		24 hour duration	
	Map Value	Corrected Value	Map Value	Corrected Value
2			2.08	2.10
5			2.73	2.70
10			3.12	3.11
25			3.68	3.63
50			4.09	4.10
100			4.63	4.60

NOTE: There is a possibility of making an error while reading the maps because, (1) a site is not easy to locate precisely on a series of 12 maps, (2) there may be some slight registration differences in printing, and (3) precise interpolation between isolines is difficult. In order to minimize any errors in reading the maps, these values should be plotted on the diagram "Precipitation Depth versus Return Period" Fig. 1.

FIGURE A-1
100 Year, 24 Hour Precipitation
San Domingo Wash Watershed
(Reference 3)

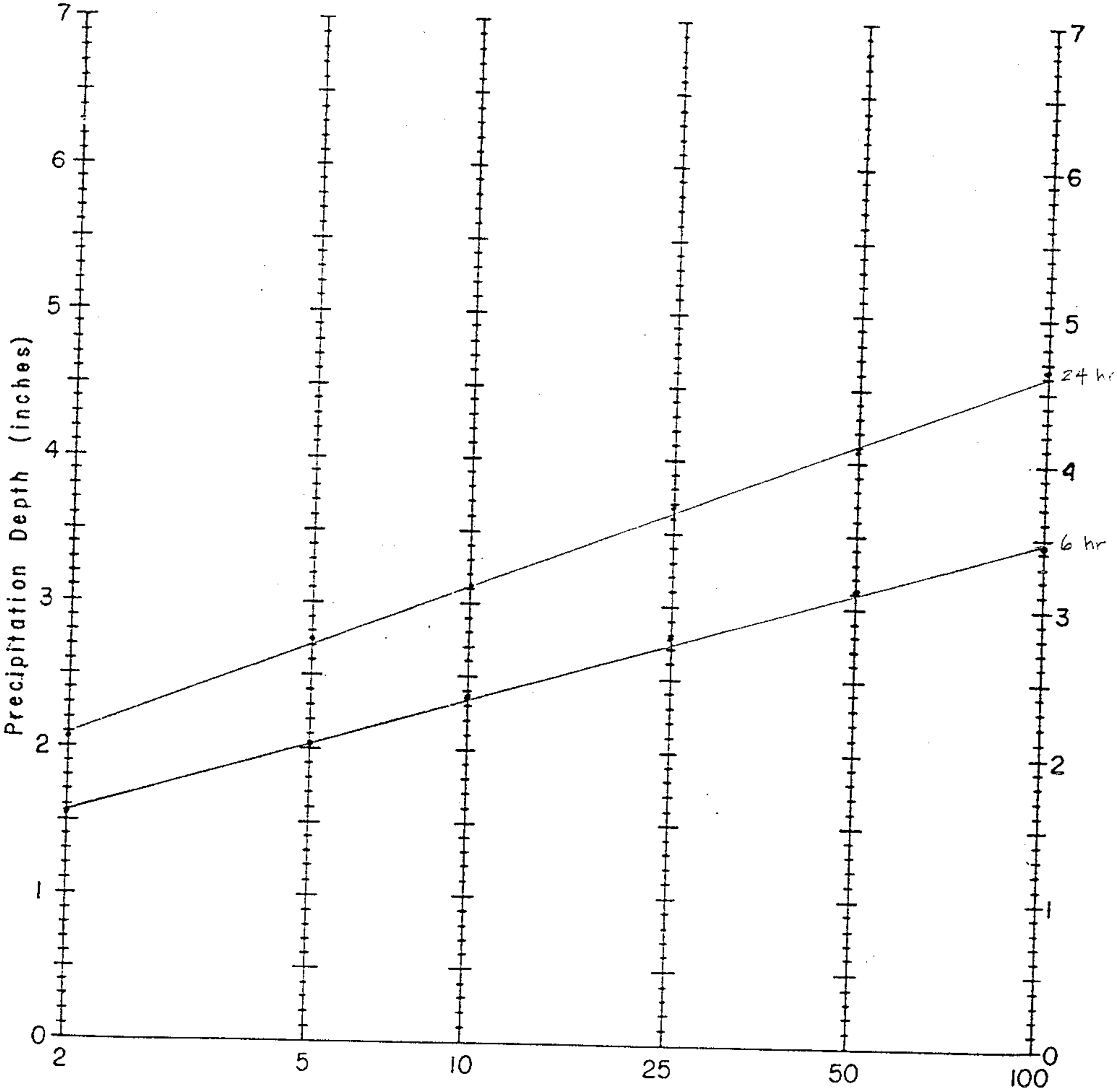


Figure I Precipitation Depth Versus Return Period for Partial – Duration Series

Table A-2

SCS Type II Rainfall Distribution
San Domingo Wash Hydrology

IN	15									
PB	4.60									
PC	.00	.01	.02	.04	.05	.06	.08	.09	.11	.12
PC	.13	.15	.16	.17	.19	.20	.22	.24	.26	.28
PC	.29	.31	.33	.35	.37	.39	.41	.44	.46	.48
PC	.51	.53	.55	.58	.61	.64	.68	.71	.75	.79
PC	.83	.88	.93	1.00	1.09	1.18	1.30	1.78	3.05	3.25
PC	3.38	3.49	3.57	3.64	3.70	3.75	3.80	3.84	3.87	3.91
PC	3.94	3.97	4.00	4.02	4.05	4.08	4.11	4.13	4.15	4.18
PC	4.20	4.22	4.24	4.26	4.28	4.30	4.31	4.33	4.35	4.37
PC	4.38	4.40	4.41	4.43	4.44	4.45	4.47	4.48	4.49	4.51
PC	4.52	4.54	4.55	4.56	4.58	4.59	4.60	4.60	4.60	4.60

FIGURE A-2
Areal Reduction
Depth-Area Ratio Curves
(Reference 10)

Figure 14.—$\bar{X}'_L$ (2.54-yr depth-area ratio, see sec. 4.3) for 3-, 6-, 12-, and 24-hr in southeast Arizona. Dashed lines are 3-hr and 24-hr Chicago $\bar{X}'_L$ (from TR 24)

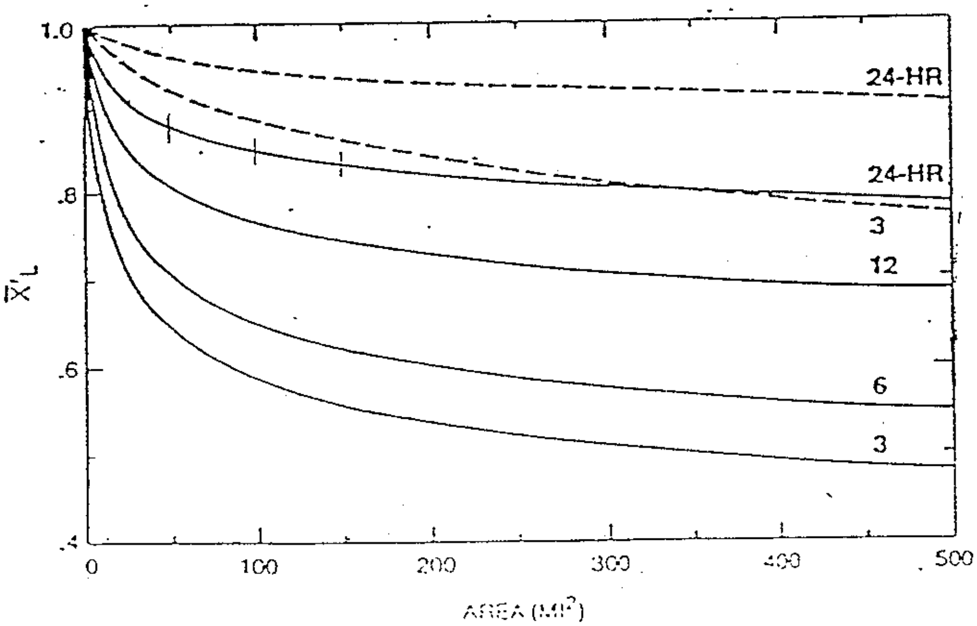


Figure 15.—Same as figure 14, but for central Arizona.

APPENDIX B

RAINFALL EXCESS

TABLE B-1

Surface Retention Loss
-Land Use and Surface Cover
(Reference 4)

Surface retention loss for various land surfaces in Maricopa County (addition to STRTL for IL+ULR method and IA for Green and Ampt method)

Land-Use and/or Surface Cover	Surface Retention Loss inches
(1)	(2)
Natural	
Desert and rangeland, flat slope	.35
Hillslopes, Sonoran desert	.15
Mountain, brush	.25
Developed (Residential and Commercial)	
Lawn and turf	.20
Desert landscape	.10
Pavement	.05
Agricultural	
Tilled	1.00
Irrigated pasture	.50

TABLE B-2

Initial Loss and Uniform Loss Rate
Values for Bare Ground
(Reference B-4)

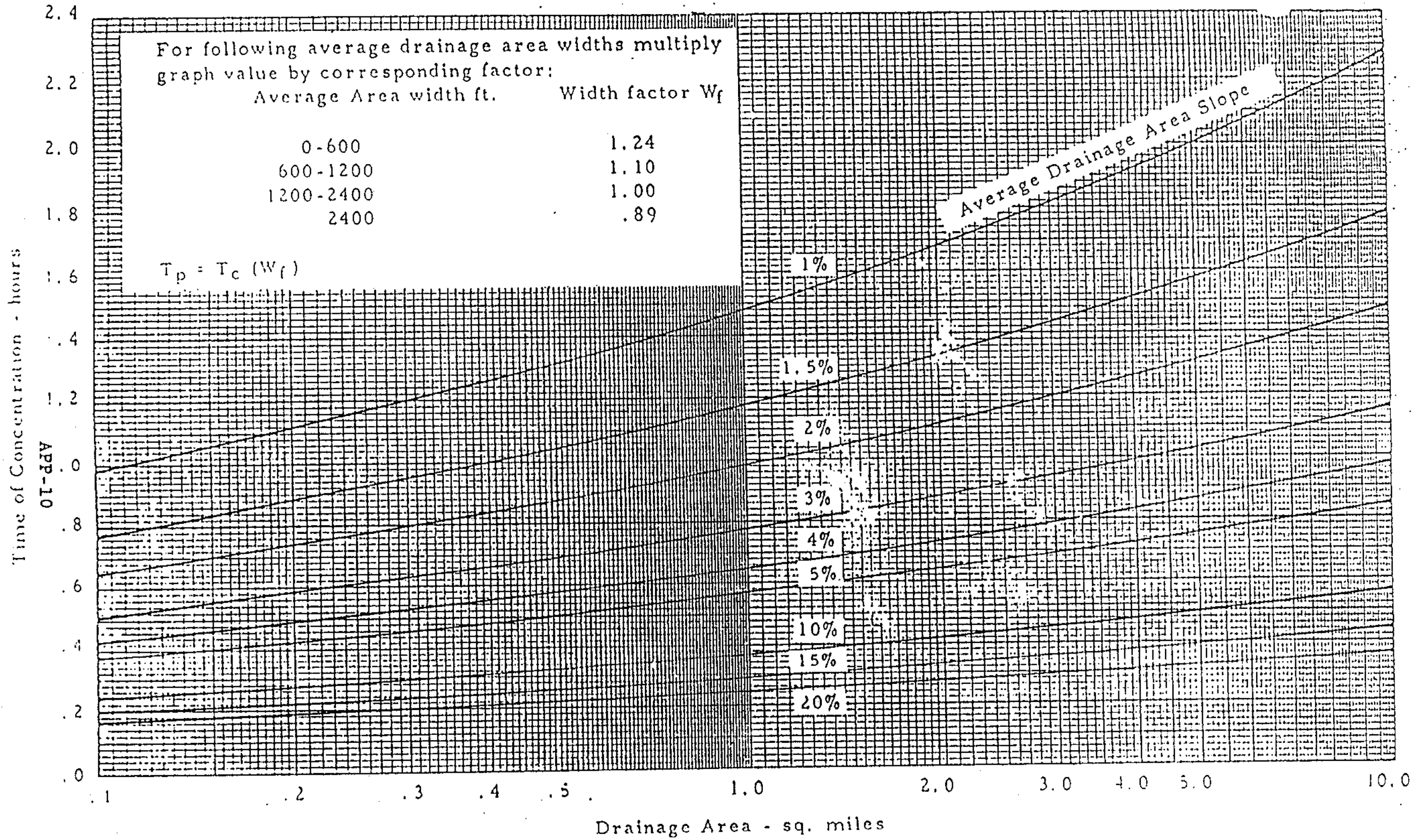
Hydrologic Soil Group	Uniform Loss Rate CNSTL	Initial Loss, in inches STRTL[1]		
		Dry	Normal	Saturated
(1)	(2)	(3)	(4)	(5)
A	.40	.6	.5	0
B	.25	.5	.3	0
C	.15	.5	.3	0
D	.05	.4	.2	0

[1] Selection of STRTL:
Dry - for nonirrigated lands such as desert and rangeland
Normal - for irrigated lawn, turf, and permanent pasture
Saturated - for irrigated agricultural land

APPENDIX C

SCS UNIT HYDROGRAPH

Figure C-1
Time of Concentration



TIME OF CONCENTRATION
FOR
DRAINAGE AREAS LESS THAN 10 SQ. MILES

Soil Conservation Service
(Reference 3)

APPENDIX D

CHANNEL ROUTING

TABLE 5-6. VALUES OF THE ROUGHNESS COEFFICIENT n (*continued*)

Type of channel and description	Minimum	Normal	Maximum
C. EXCAVATED OR DREDGED			
a. Earth, straight and uniform			
1. Clean, recently completed	0.016	0.018	0.020
2. Clean, after weathering	0.018	0.022	0.025
3. Gravel, uniform section, clean	0.022	0.025	0.030
4. With short grass, few weeds	0.022	0.027	0.033
b. Earth, winding and sluggish			
1. No vegetation	0.023	0.025	0.030
2. Grass, some weeds	0.025	0.030	0.033
3. Dense weeds or aquatic plants in deep channels	0.030	0.035	0.040
4. Earth bottom and rubble sides	0.028	0.030	0.035
5. Stony bottom and weedy banks	0.025	0.035	0.040
6. Cobble bottom and clean sides	0.030	0.040	0.050
c. Dragline-excavated or dredged			
1. No vegetation	0.025	0.028	0.033
2. Light brush on banks	0.035	0.050	0.060
d. Rock cuts			
1. Smooth and uniform	0.025	0.035	0.040
2. Jagged and irregular	0.035	0.040	0.050
e. Channels not maintained, weeds and brush uncut			
1. Dense weeds, high as flow depth	0.050	0.080	0.120
2. Clean bottom, brush on sides	0.040	0.050	0.080
3. Same, highest stage of flow	0.045	0.070	0.110
4. Dense brush, high stage	0.080	0.100	0.140
D. NATURAL STREAMS			
D-1. Minor streams (top width at flood stage <100 ft)			
a. Streams on plain			
1. Clean, straight, full stage, no rifts or deep pools	0.025	0.030	0.033
2. Same as above, but more stones and weeds	0.030	0.035	0.040
3. Clean, winding, some pools and shoals	0.033	0.040	0.045
4. Same as above, but some weeds and stones	0.035	0.045	0.050
5. Same as above, lower stages, more ineffective slopes and sections	0.040	0.048	0.055
6. Same as 4, but more stones	0.045	0.050	0.060
7. Sluggish reaches, weedy, deep pools	0.050	0.070	0.080
8. Very weedy reaches, deep pools, or floodways with heavy stand of timber and underbrush	0.075	0.100	0.150

APP-12

TABLE 5-6. VALUES OF THE ROUGHNESS COEFFICIENT n (*continued*)

Type of channel and description	Minimum	Normal	Maximum
b. Mountain streams, no vegetation in channel, banks usually steep, trees and brush along banks submerged at high stages			
1. Bottom: gravels, cobbles, and few boulders	0.030	0.040	0.050
2. Bottom: cobbles with large boulders	0.040	0.050	0.070
D-2. Flood plains			
a. Pasture, no brush			
1. Short grass	0.025	0.030	0.035
2. High grass	0.030	0.035	0.050
b. Cultivated areas			
1. No crop	0.020	0.030	0.040
2. Mature row crops	0.025	0.035	0.045
3. Mature field crops	0.030	0.040	0.050
c. Brush			
1. Scattered brush, heavy weeds	0.035	0.050	0.070
2. Light brush and trees, in winter	0.035	0.050	0.060
3. Light brush and trees, in summer	0.040	0.060	0.080
4. Medium to dense brush, in winter	0.045	0.070	0.110
5. Medium to dense brush, in summer	0.070	0.100	0.160
d. Trees			
1. Dense willows, summer, straight	0.110	0.150	0.200
2. Cleared land with tree stumps, no sprouts	0.030	0.040	0.050
3. Same as above, but with heavy growth of sprouts	0.050	0.060	0.080
4. Heavy stand of timber, a few down trees, little undergrowth, flood stage below branches	0.080	0.100	0.120
5. Same as above, but with flood stage reaching branches	0.100	0.120	0.160
D-3. Major streams (top width at flood stage >100 ft). The n value is less than that for minor streams of similar description, because banks offer less effective resistance.			
a. Regular section with no boulders or brush	0.025	.....	0.060
b. Irregular and rough section	0.035	.....	0.100

Table D-1

Manning's Coefficient Values
(Reference 5)

Table D-2

Routed Reach 1
Velocity Calculated using Mannings Equation

N= .04800
Q= 4051.0 (CFS)
S= .025000(FT/FT)
Z= 1.45:1
B= 63.0(FT)

RESULTS:

D= 4.65 (FT)	
A= 324.0 (SQ FT)	CRITICAL VELOCITY= 11.92 (FT/SEC)
V= 12.5 (FT/SEC)	FROUDE NUMBER= 1.070
W.S. WIDTH= 76.5 (FT)	SPECIFIC ENERGY, E= 7.07 (FT)
CRITICAL DEPTH= 4.85 (FT)	WETTED PERIMETER= 79.37 (FT)
CRITICAL SLOPE= .021566 (FT/FT)	HYDRAULIC RADIUS= 4.08 (FT)

Table D-3

Routed Reach 5
Velocity Calculated using Mannings Equation

N= .05800
Q= 2350.0 (CFS)
S= .032000 (FT/FT)
Z= 3.52:1
B= 87.0 (FT)

RESULTS:
D= 2.83 (FT)
A= 274.7 (SQ FT)
(FT/SEC)
V= 8.55 (FT/SEC)
W.S. WIDTH= 106.9 (FT)
CRITICAL DEPTH= 2.72 (FT)
CRITICAL SLOPE= .036595 (FT/FT)

CRITICAL VELOCITY= 8.93
FROUDE NUMBER= .941
SPECIFIC ENERGY, E= 3.97 (FT)
WETTED PERIMETER= 107.73 (FT)
HYDRAULIC RADIUS= 2.55 (FT)

Table D-4

Routed Reach 9
Velocity Calculated using Mannings Equation

N= .05900
Q= 3697.0 (CFS)
S= .024000 (FT/FT)
Z= 2.71:1
B= 36.0 (FT)

RESULTS:
D= 6.37 (FT)
A= 339.5 (SQ FT)
V= 10.89 (FT/SEC)
W.S. WIDTH= 70.5 (FT)
CRITICAL DEPTH= 5.90 (FT)
CRITICAL SLOPE= .031995 (FT/FT)

CRITICAL VELOCITY= 12.05 (FT/SEC)
FROUDE NUMBER= .875
SPECIFIC ENERGY, E= 8.21 (FT)
WETTED PERIMETER= 72.82 (FT)
HYDRAULIC RADIUS= 4.66 (FT)

Table D-5

Routed Reach A
Velocity Calculated using Mannings Equation

N= .04800
Q= 8190.0 (CFS)
S= .028000 (FT/FT)
Z= 1.77:1
B= 56.0 (FT)

RESULTS:
D= 7.15 (FT)
A= 491.3 (SQ FT)
CRITICAL VELOCITY= 14.63 (FT/SEC)
V= 16.67 (FT/SEC)
FROUDE NUMBER= 1.195
W.S. WIDTH= 81.3 (FT)
SPECIFIC ENERGY, E= 11.47 (FT)
CRITICAL DEPTH= 7.98 (FT)
WETTED PERIMETER= 85.09 (FT)
CRITICAL SLOPE= .019068 (FT/FT)
HYDRAULIC RADIUS= 5.77 (FT)

Table D-6

Routed Reach B
Velocity Calculated using Mannings Equation

N= .05600
Q= 14561.0 (CFS)
S= .025000 (FT/FT)
Z= 4.15:1
B= 86.0 (FT)

RESULTS:
D= 8.34 (FT)
A= 1006.6 (SQ FT)
(FT/SEC)
V= 14.47 (FT/SEC)
W.S. WIDTH= 155.3 (FT)
CRITICAL DEPTH= 8.35 (FT)
CRITICAL SLOPE= .024938 (FT/FT)

CRITICAL VELOCITY= 14.45
FROUDE NUMBER= 1.001
SPECIFIC ENERGY, E= 11.59 (FT)
WETTED PERIMETER= 157.24 (FT)
HYDRAULIC RADIUS= 6.4 (FT)

Table D-7

Routed Reach C
Velocity Calculated using Mannings Equation

N= .05400
Q= 16182.0 (CFS)
S= .022000 (FT/FT)
Z= 3.18:1
B= 40.0 (FT)

RESULTS:
D= 12.42 (FT)
A= 987.7 (SQ FT)
V= 16.38 (FT/SEC)
W.S. WIDTH= 119.0 (FT)
CRITICAL DEPTH= 12.44 (FT)
CRITICAL SLOPE= .021898 (FT/FT)

CRITICAL VELOCITY= 16.36 (FT/SEC)
FROUDE NUMBER= 1.002
SPECIFIC ENERGY, E= 16.59 (FT)
WETTED PERIMETER= 122.83 (FT)
HYDRAULIC RADIUS= 8.04 (FT)

Table D-8

Routed Reach D
Velocity Calculated using Mannings Equation

N= .06700
Q= 22487.0 (CFS)
S= .021000 (FT/FT)
Z= 2.00:1
B= 48.0 (FT)

RESULTS:
D= 17.00 (FT)
A= 1394.3 (SQ FT)
(FT/SEC)
V= 16.13 (FT/SEC)
W.S. WIDTH= 116.0 (FT)
CRITICAL DEPTH= 15.24 (FT)
CRITICAL SLOPE= .032074 (FT/FT)

CRITICAL VELOCITY= 18.00
FROUDE NUMBER= .820
SPECIFIC ENERGY, E= 21.04 (FT)
WETTED PERIMETER= 124.04 (FT)
HYDRAULIC RADIUS= 11.24 (FT)

Table D-9

Routed Reach E
Velocity Calculated using Mannings Equation

N= .06800
Q= 24734.0 (CFS)
S= .018000 (FT/FT)
Z= 15.24:1
B= 136.0 (FT)

RESULTS:
D= 9.12 (FT)
A= 2549.2 (SQ FT)
V= 9.70 (FT/SEC)
W.S. WIDTH= 422.8 (FT)
CRITICAL DEPTH= 7.55 (FT)
CRITICAL SLOPE= .039118 (FT/FT)

CRITICAL VELOCITY= 12.87 (FT/SEC)
FROUDE NUMBER= .696
SPECIFIC ENERGY, E= 10.59 (FT)
WETTED PERIMETER= 423.41 (FT)
HYDRAULIC RADIUS= 6.02 (FT)

Table D-10

Routed Reach F
Velocity Calculated using Mannings Equation

N= .07500
Q= 26216.0 (CFS)
S= .013000 (FT/FT)
Z= 9.67:1
B= 196.0 (FT)

RESULTS:
D= 10.18 (FT)
A= 2999.1 (SQ FT)
V= 8.74 (FT/SEC)
W.S. WIDTH= 393.0 (FT)
CRITICAL DEPTH= 7.25 (FT)
CRITICAL SLOPE= .045955 (FT/FT)

CRITICAL VELOCITY= 13.59 (FT/SEC)
FROUDE NUMBER= .558
SPECIFIC ENERGY, E= 11.37 (FT)
WETTED PERIMETER= 394.01 (FT)
HYDRAULIC RADIUS= 7.61 (FT)

APPENDIX E

LAG COMPARISON

Methods used for
Lag Comparison

Kirpich Method

$$Tc = \frac{L^{1.15}}{7700 \cdot H^{0.38}}$$

where Tc is the time of concentration, in hours
L is the length of the catchment along the mainstream from the basin outlet to the most distant ridge, in feet
H is the difference in elevation between the basin outlet and the most distant ridge, in feet

Once the time of concentration has been found then the lag time can be determined by the following relation:

$$Lag = Tc \cdot 0.6$$

Hydrology Manual Method

$$Lag = \frac{C \cdot (L \cdot Lca)^{m}}{S^{p}}$$

where Lag is basin lag, in hours
L is length of the longest watercourse, in miles
Lca is length along the watercourse to a point opposite the centroid, in miles
S is watercourse slope, in feet per mile
C is a coefficient (20*n, n is manning's coeffient)
m and p are exponents equal to 0.38 and 0.5

TABLE E-1

Lag Comparison

Watershed Number	SCS Method	Kirpich Method	Hydrology Manual
1	0.31	0.36	0.45
2	0.27	0.29	0.38
3	0.30	0.35	0.45
4	0.35	0.37	0.45
5A	0.32	0.34	0.42
5B	0.34	0.35	0.42
6	0.30	0.32	0.41
7	0.24	0.26	0.33
8	0.42	0.47	0.55
9A	0.36	0.37	0.45
9B	0.45	0.50	0.51
10	0.45	0.58	0.66
11	0.25	0.22	0.27
12	0.67	0.76	0.81
13	0.34	0.42	0.49
14	0.43	0.32	0.34

APPENDIX F

HEC-1 OUTPUT

```
1*****************************************                            ***************************************
*                                       *                            *                                     *
*   FLOOD HYDROGRAPH PACKAGE  (HEC-1)   *                            *   U.S. ARMY CORPS OF ENGINEERS      *
*             FEBRUARY 1981             *                            * THE HYDROLOGIC ENGINEERING CENTER   *
*           REVISED 16 MAY 89           *                            *         609 SECOND STREET           *
*                                       *                            *      DAVIS, CALIFORNIA 95616        *
* RUN DATE  10/10/1989  TIME  13:02:50  *                            *          (916) 551-1748             *
*                                       *                            *                                     *
*****************************************                            ***************************************


                    X     X  XXXXXXX   XXXXX          X
                    X     X  X        X     X        XX
                    X     X  X        X               X
                    XXXXXXX  XXXX     X       XXXXX   X
                    X     X  X        X               X
                    X     X  X        X     X         X
                    X     X  XXXXXXX   XXXXX         XXX


THIS PROGRAM REPLACES ALL PREVIOUS VERSIONS OF HEC-1 KNOWN AS HEC1 (JAN 73), HEC1GS, HEC1DB, AND HEC1KW.

THE DEFINITIONS OF VARIABLES -RTIMP- AND -RTIOR- HAVE CHANGED FROM THOSE USED WITH THE 1973-STYLE INPUT STRUCTURE.
THE DEFINITION OF -AMSKK- ON RM-CARD WAS CHANGED WITH REVISIONS DATED 28 SEP 81. THIS IS THE FORTRAN77 VERSION
NEW OPTIONS: DAMBREAK OUTFLOW SUBMERGENCE , SINGLE EVENT DAMAGE CALCULATION, DSS:WRITE STAGE FREQUENCY,
DSS:READ TIME SERIES AT DESIRED CALCULATION INTERVAL   LOSS RATE:GREEN AND AMPT INFILTRATION
KINEMATIC WAVE: NEW FINITE DIFFERENCE ALGORITHM

1                                          HEC-1 INPUT                                          PAGE  1

 LINE       ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10

   1        ID       SAN DOMINGO WASH WATERSHED
   2        ID       100 YEAR, 24 HOUR STORM EVENT
```

```
ID        MCFCD    19 JUNE 1989
ID        IN HOUSE STUDY DONE BY SS
ID        USES INITIAL AND UNIFORM LOSS RATE
ID             SCS DIMENSIONLESS UNIT HYDROGRAPH
ID             NORMAL-DEPTH ROUTING
ID             AREAL REDUCTION
ID
ID
ID        THIS MODEL DETERMINES THE FLOW BY USING A 5 MINUTE TIME STEP AND ALL
ID        PARAMETERS HAVE BEEN ADJUSTED FOR THIS INCLUDING THE NSTPS.  THE MANNING
ID        VALUES HAVE BEEN ADJUSTED FOR THIS RUN.  THE PARAMETERS FOR THE CALCULATION OF
ID        THE MANNINGS N VALUES UTILIZED THE PROGRAM MANNING.
ID
ID
ID
ID
*DIAGRAM
IT      5 22JUL89   0000     300
IO      5       0
IN     15
JD   4.60     .01
PC    .00     .01     .02     .04     .05     .06     .08     .09     .11     .12
PC    .13     .15     .16     .17     .19     .20     .22     .24     .26     .28
PC    .29     .31     .33     .35     .37     .39     .41     .44     .46     .48
PC    .51     .53     .55     .58     .61     .64     .68     .71     .75     .79
PC    .83     .88     .93    1.00    1.09    1.18    1.30    1.78    3.05    3.25
PC   3.38    3.49    3.57    3.64    3.70    3.75    3.80    3.84    3.87    3.91
PC   3.94    3.97    4.00    4.02    4.05    4.08    4.11    4.13    4.15    4.18
PC   4.20    4.22    4.24    4.26    4.28    4.30    4.31    4.33    4.35    4.37
PC   4.38    4.40    4.41    4.43    4.44    4.45    4.47    4.48    4.49    4.51
PC   4.52    4.54    4.55    4.56    4.58    4.59    4.60    4.60    4.60    4.60
JD   4.37      10
JD   4.23      20
JD   4.14      30

KK   SUB1
BA   2.14
LU    .55     .05
UD   .311
```

```
 40          KK      R1
 41          KM   ROUTE SUBBASIN 1 TO CONCENTRATION POINT A
 42          RS       1    ELEV       0     .20
 43          RC    .051    .045    .051    4700    .025
 44          RX      80      98     119     152     168     182     196     208
 45          RY   23.75   19.66    1.50    0.00    1.00    1.88    9.85   18.66

 46          KK    SUB2
 47          BA    1.03
 48          LU     .55     .05
 49          UD    .266
1                                        HEC-1 INPUT                                     PAGE  2

LINE         ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10


 50          KK    SUB3
 51          BA    1.30
 52          LU     .55     .05
 53          UD    .296

 54          KK      AA
 55          KM   COMBINE HYDROGRAPHS FOR SUBBASINS 2 AND 3
 56          HC       2

 57          KK       A
 58          KM   COMBINE HYDROGRAPHS FOR SUBBASIN 1 AND STATION AA
 59          HC       2

 60          KK      RA
 61          KM   ROUTE CONCENTRATION POINT A TO CONCENTRATION POINT B
 62          RS       2    ELEV       0     .20
 63          RC    .048    .042    .048   10200    .028
 64          RX       0      46      68     106     124     126     136     146
 65          RY   28.26   11.44    1.53    0.00    0.46    4.50   12.52   20.78

 66          KK    SUB4
 67          BA    1.56
 68          LU     .55     .05
 69          UD    .347
```

```
70          KK   SUB5A
71          BA    1.28
72          LU     .55      .05
73          UD    .323

74          KK      R5
75          KM   ROUTE SUBBASIN 5A TO CONCENTRATION POINT B
76          RS       3    ELEV       0     .20
77          RC    .050    .043    .050    8000    .032
78          RX       0      67      95     107     132     140     150     153
79          RY    9.33    1.07    1.99    0.12    0.32    4.00    8.50   10.85

80          KK   SUB5B
81          BA    1.10
82          LU     .55      .05
83          UD    .396

84          KK       5
85          KM   COMBINE HYDROGRAPHS FOR SUBBASINS 5A, AND 5B
86          HC       2

87          KK      BB
88          KM   COMBINE HYDROGRAPHS FOR SUBBASIN 4 AND STATION 5
89          HC       2
1                                 HEC-1 INPUT                                        PAGE  3

LINE        ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10


90          KK       B
91          KM   COMBINE HYDROGRAPHS FOR CONCENTRATION POINT A AND STATION BB
92          HC       2

93          KK      RB
94          KM   ROUTE CONCENTRATION POINT B TO CONCENTRATION POINT C
95          RS       2    ELEV       0     .20
96          RC    .054    .048    .054    7300    .025
97          RX       0      27      50      88     133     162     188     262
98          RY   19.77   11.48    2.75    1.13    0.00    1.33    7.75   21.33
```

```
KK   SUB6
BA    .82
LU    .55    .05
UD   .296

KK   SUB7
BA    .63
LU    .55    .05
UD   .242

KK     CC
KM   COMBINE HYDROGRAPHS FOR SUBBASINS 6 AND 7
HC      2

KK      C
KM   COMBINE HYDROGRAPHS FOR CONCENTRATION POINT B AND STATION CC
HC      2

KK     RC
KM   ROUTE CONCENTRATION POINT C TO CONCENTRATION POINT D
RS      3   ELEV      0     .20
RC   .050   .042   .050   13400   .022
RX      0     38     59     101    119     147     162     202
RY  19.66  11.89   3.29    0.00   0.35    2.95   10.11   18.56

KK   SUB8
BA   1.21
LU    .59    .11
UD   .421

KK  SUB9A
BA   2.16
LU    .55    .05
UD   .360

KK     R9
KM   ROUTE SUBWATERSHED 9A TO CONCENTRATION POINT D
RS      3   ELEV      0     .20
RC   .051   .047   .051   11000   .024
```

```
 131        RX       0      18      30      39      68      78      90      98
 132        RY    13.9    4.71    3.52    2.89    0.00    4.04   10.00   13.80
1                                         HEC-1 INPUT                                        PAGE  4

LINE        ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10


 133        KK   SUB9B
 134        BA    1.35
 135        LU     .61     .14
 136        UD    .444

 137        KK       9
 138        KM   COMBINE HYDROGRAPHS FOR SUBBASINS 9A AND 9B
 139        HC       2

 140        KK      DD
 141        KM   COMBINE HYDROGRAPHS FOR SUBBASIN 8 AND STATION 9
 142        HC       2

 143        KK       D
 144        KM   COMBINE HYDROGRAPHS FOR CONCECTRATION POINT C AND STATION DD
 145        HC       2

 146        KK      RD
 147        KM   ROUTE CONCENTRATION POINT D TO CONCENTRATION POINT F
 148        RS       1    ELEV       0     .20
 149        RC    .050    .047    .050    4200    .021
 150        RX       0      35      37      69     117     137     155     185
 151        RY   18.41   10.60    1.23    0.00    0.08    1.02   10.42   15.62

 152        KK   SUB10
 153        BA    2.36
 154        LU     .57     .08
 155        UD    .445

 156        KK   SUB11
 157        BA     .41
 158        LU     .55     .05
 159        UD    .252
```

```
160          KK      10
161          KM   COMBINE HYDROGRAPHS FOR SUBBASINS 10 AND 11
162          HC       2

163          KK       E
164          KM   COMBINE HYDROGRAPHS FOR CONCENTRATION POINT D AND STATION 10
165          HC       2

166          KK      RE
167          KM   ROUTE CONCENTRATION POINT E TO CONCENTRATION POINT F
168          RS       6    ELEV       0     .20
169          RC    .048    .045    .048   16400    .018
170          RX       0      37     144     215     307     406     460     600
171          RY   15.73    2.89    2.97    0.89    0.00    3.71    2.00   17.35
1                                         HEC-1 INPUT                                      PAGE  5

LINE         ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10


172          KK   SUB12
173          BA    1.61
174          LU     .57     .09
175          UD    .665

176          KK   SUB13
177          BA     .73
178          LU     .60     .13
179          UD    .335

180          KK      FF
181          KM   COMBINE HYDROGRAPHS FOR SUBBASINS 12 AND 13
182          HC       2

183          KK       F
184          KM   COMBINE HYDROGRAPHS FOR CONCENTRATION POINT E AND STATION FF
185          HC       2

186          KK      RF
187          KM   ROUTE CONCENTRATION POINT F TO CONCENTRATION POINT G
```

```
188          RS       2    ELEV      0     .20
189          RC    .048    .045   .048    5300    .013
190          RX       0      91    166     190     245     254     458     529
191          RY   15.00    0.63   0.83    0.00    0.45    1.56    1.97   24.48

192          KK   SUB14
193          BA     .59
194          LU     .62     .18
195          UD    .706

196          KK       G
197          KM   COMBINE HYDROGRAPHS FOR SUBBASIN 14 AND CONCENTRATION POINT F
198          HC       2
199          ZZ
```

1

SCHEMATIC DIAGRAM OF STREAM NETWORK

```
INPUT
 LINE    (V) ROUTING          (--->) DIVERSION OR PUMP FLOW

 NO.     (.) CONNECTOR        (<---) RETURN OF DIVERTED OR PUMPED FLOW

  36      SUB1
             V
             V
  40        R1
             .
             .
  46         .          SUB2
             .             .
             .             .
  50         .             .         SUB3
             .             .            .
             .             .            .
  54         .            AA............
             .             .
             .             .
  57         A............
             V
             V
  60        RA
```

```
          .
          .
66        .     SUB4
          .        .
          .        .
70        .        .     SUB5A
          .        .         V
          .        .         V
74        .        .        R5
          .        .         .
          .        .         .
80        .        .         .     SUB5B
          .        .         .         .
          .        .         .         .
84        .        .         5..........
          .        .         .
          .        .         .
87        .       BB..........
          .        .
          .        .
90        B..........
          V
          V
93        RB
          .
          .
99        .     SUB6
          .        .
          .        .
103       .        .     SUB7
          .        .        .
          .        .        .
107       .       CC..........
          .        .
          .        .
110       C..........
          V
          V
113       RC
          .
```

```
                  .
119               .        SUB8
                  .           .
                  .           .
123               .           .        SUB9A
                  .           .            V
                  .           .            V
127               .           .           R9
                  .           .            .
                  .           .            .
133               .           .            .        SUB9B
                  .           .            .            .
                  .           .            .            .
137               .           .            9............
                  .           .            .
                  .           .            .
140               .          DD............
                  .           .
                  .           .
143               D............
                  V
                  V
146              RD
                  .
                  .
152               .        SUB10
                  .           .
                  .           .
156               .           .        SUB11
                  .           .            .
                  .           .            .
160               .          10............
                  .           .
                  .           .
163               E............
                  V
                  V
166              RE
                  .
                  .
```

```
172         .         SUB12
            .             .
            .             .
176         .             .         SUB13
            .             .             .
            .             .             .
180         .            FF.............
            .             .
            .             .
183         F.............
            V
            V
186        RF
            .
            .
192         .         SUB14
            .             .
            .             .
196         G.............
```

(***) RUNOFF ALSO COMPUTED AT THIS LOCATION

```
1*****************************************
*                                       *
*   FLOOD HYDROGRAPH PACKAGE  (HEC-1)   *
*             FEBRUARY 1981             *
*           REVISED 16 MAY 89           *
*                                       *
*  RUN DATE  10/10/1989  TIME  13:02:50 *
*                                       *
*****************************************
```

```
*****************************************
*                                       *
*     U.S. ARMY CORPS OF ENGINEERS      *
*  THE HYDROLOGIC ENGINEERING CENTER    *
*          609 SECOND STREET            *
*       DAVIS, CALIFORNIA 95616         *
*           (916) 551-1748              *
*                                       *
*****************************************
```

SAN DOMINGO WASH WATERSHED
100 YEAR, 24 HOUR STORM EVENT
MCFCD   19 JUNE 1989
IN HOUSE STUDY DONE BY SS
USES INITIAL AND UNIFORM LOSS RATE

SCS DIMENSIONLESS UNIT HYDROGRAPH
NORMAL-DEPTH ROUTING
AREAL REDUCTION

THIS MODEL DETERMINES THE FLOW BY USING A 10 MINUTE TIME STEP AND ALL PARAMETERS HAVE BEEN ADJUSTED FOR THIS INCLUDING THE NSTPS. THE MANNING VALUES HAVE BEEN ADJUSTED FOR THIS RUN. THE PARAMETERS FOR THE CALCULATION OF THE MANNINGS N VALUES UTILIZED THE PROGRAM MANNING, WHICH DIFFER IN SLOPE VALUES, MANNINGS, ETC.


```
20 IO          OUTPUT CONTROL VARIABLES
                     IPRNT            5  PRINT CONTROL
                     IPLOT            0  PLOT CONTROL
                     QSCAL           0.  HYDROGRAPH PLOT SCALE

   IT          HYDROGRAPH TIME DATA
                      NMIN            5  MINUTES IN COMPUTATION INTERVAL
                     IDATE      22JUL89  STARTING DATE
                     ITIME         0000  STARTING TIME
                        NQ          300  NUMBER OF HYDROGRAPH ORDINATES
                    NDDATE      23JUL89  ENDING DATE
                    NDTIME         0055  ENDING TIME
                     ICENT           19  CENTURY MARK

                COMPUTATION INTERVAL    .08 HOURS
                     TOTAL TIME BASE  24.92 HOURS

      ENGLISH UNITS
           DRAINAGE AREA           SQUARE MILES
           PRECIPITATION DEPTH     INCHES
           LENGTH, ELEVATION       FEET
           FLOW                    CUBIC FEET PER SECOND
           STORAGE VOLUME          ACRE-FEET
           SURFACE AREA            ACRES
           TEMPERATURE             DEGREES FAHRENHEIT
```

22 JD INDEX STORM NO. 1

STRM 4.60 PRECIPITATION DEPTH

TRDA .01 TRANSPOSITION DRAINAGE AREA

23 PI PRECIPITATION PATTERN

.00	.00	.00	.00	.00	.00	.01	.01	.01	.00
.00	.00	.00	.00	.00	.01	.01	.01	.00	.00
.00	.01	.01	.01	.00	.00	.00	.00	.00	.00
.01	.01	.01	.00	.00	.00	.00	.00	.00	.01
.01	.01	.00	.00	.00	.01	.01	.01	.01	.01
.01	.01	.01	.01	.01	.01	.01	.00	.00	.00
.01	.01	.01	.01	.01	.01	.01	.01	.01	.01
.01	.01	.01	.01	.01	.01	.01	.01	.01	.01
.01	.01	.01	.01	.01	.01	.01	.01	.01	.01
.01	.01	.01	.01	.01	.01	.01	.01	.01	.01
.01	.01	.01	.01	.01	.01	.01	.01	.01	.01
.01	.01	.01	.01	.01	.01	.01	.01	.01	.01
.02	.02	.02	.02	.02	.02	.02	.02	.02	.03
.03	.03	.03	.03	.03	.04	.04	.04	.16	.16
.16	.42	.42	.42	.07	.07	.07	.04	.04	.04
.04	.04	.04	.03	.03	.03	.02	.02	.02	.02
.02	.02	.02	.02	.02	.02	.02	.02	.01	.01
.01	.01	.01	.01	.01	.01	.01	.01	.01	.01
.01	.01	.01	.01	.01	.01	.01	.01	.01	.01
.01	.01	.01	.01	.01	.01	.01	.01	.01	.01
.01	.01	.01	.01	.01	.01	.01	.01	.01	.01
.01	.01	.01	.01	.01	.01	.01	.01	.01	.01
.01	.01	.01	.01	.01	.00	.00	.00	.01	.01
.01	.01	.01	.01	.01	.01	.01	.00	.00	.00
.01	.01	.01	.00	.00	.00	.01	.01	.01	.00
.00	.00	.00	.00	.00	.01	.01	.01	.00	.00
.00	.00	.00	.00	.01	.01	.01	.00	.00	.00
.01	.01	.01	.00	.00	.00	.00	.00	.00	.01
.01	.01	.00	.00	.00	.00	.00	.00		

33 JD INDEX STORM NO. 2

STRM 4.37 PRECIPITATION DEPTH

TRDA 10.00 TRANSPOSITION DRAINAGE AREA

0 PI PRECIPITATION PATTERN

.00	.00	.00	.00	.00	.00	.01	.01	.01	.00
.00	.00	.00	.00	.00	.01	.01	.01	.00	.00
.00	.01	.01	.01	.00	.00	.00	.00	.00	.00
.01	.01	.01	.00	.00	.00	.00	.00	.00	.01
.01	.01	.00	.00	.00	.01	.01	.01	.01	.01
.01	.01	.01	.01	.01	.01	.01	.00	.00	.00
.01	.01	.01	.01	.01	.01	.01	.01	.01	.01
.01	.01	.01	.01	.01	.01	.01	.01	.01	.01
.01	.01	.01	.01	.01	.01	.01	.01	.01	.01
.01	.01	.01	.01	.01	.01	.01	.01	.01	.01
.01	.01	.01	.01	.01	.01	.01	.01	.01	.01
.01	.01	.01	.01	.01	.01	.01	.01	.01	.01
.02	.02	.02	.02	.02	.02	.02	.02	.02	.03
.03	.03	.03	.03	.03	.04	.04	.04	.16	.16
.16	.42	.42	.42	.07	.07	.07	.04	.04	.04
.04	.04	.04	.03	.03	.03	.02	.02	.02	.02
.02	.02	.02	.02	.02	.02	.02	.02	.01	.01
.01	.01	.01	.01	.01	.01	.01	.01	.01	.01
.01	.01	.01	.01	.01	.01	.01	.01	.01	.01
.01	.01	.01	.01	.01	.01	.01	.01	.01	.01
.01	.01	.01	.01	.01	.01	.01	.01	.01	.01
.01	.01	.01	.01	.01	.01	.01	.01	.01	.01
.01	.01	.01	.01	.01	.00	.00	.00	.01	.01
.01	.01	.01	.01	.01	.01	.01	.00	.00	.00
.01	.01	.01	.00	.00	.00	.01	.01	.01	.00
.00	.00	.00	.00	.00	.01	.01	.01	.00	.00
.00	.00	.00	.00	.01	.01	.01	.00	.00	.00
.01	.01	.01	.00	.00	.00	.00	.00	.00	.01
.01	.01	.00	.00	.00	.00	.00	.00		

34 JD INDEX STORM NO. 3

STRM 4.23 PRECIPITATION DEPTH

TRDA 20.00 TRANSPOSITION DRAINAGE AREA

0 PI PRECIPITATION PATTERN

.00	.00	.00	.00	.00	.00	.01	.01	.01	.00
.00	.00	.00	.00	.00	.01	.01	.01	.00	.00
.00	.01	.01	.01	.00	.00	.00	.00	.00	.00
.01	.01	.01	.00	.00	.00	.00	.00	.00	.01
.01	.01	.00	.00	.00	.01	.01	.01	.01	.01

.01	.01	.01	.01	.01	.01	.01	.00	.00	.00
.01	.01	.01	.01	.01	.01	.01	.01	.01	.01
.01	.01	.01	.01	.01	.01	.01	.01	.01	.01
.01	.01	.01	.01	.01	.01	.01	.01	.01	.01
.01	.01	.01	.01	.01	.01	.01	.01	.01	.01
.01	.01	.01	.01	.01	.01	.01	.01	.01	.01
.01	.01	.01	.01	.01	.01	.01	.01	.01	.01
.02	.02	.02	.02	.02	.02	.02	.02	.02	.03
.03	.03	.03	.03	.03	.04	.04	.04	.16	.16
.16	.42	.42	.42	.07	.07	.07	.04	.04	.04
.04	.04	.04	.03	.03	.03	.02	.02	.02	.02
.02	.02	.02	.02	.02	.02	.02	.02	.01	.01
.01	.01	.01	.01	.01	.01	.01	.01	.01	.01
.01	.01	.01	.01	.01	.01	.01	.01	.01	.01
.01	.01	.01	.01	.01	.01	.01	.01	.01	.01
.01	.01	.01	.01	.01	.01	.01	.01	.01	.01
.01	.01	.01	.01	.01	.01	.01	.01	.01	.01
.01	.01	.01	.01	.01	.00	.00	.00	.01	.01
.01	.01	.01	.01	.01	.01	.01	.00	.00	.00
.01	.01	.01	.00	.00	.00	.01	.01	.01	.00
.00	.00	.00	.00	.00	.01	.01	.01	.00	.00
.00	.00	.00	.00	.01	.01	.01	.00	.00	.00
.01	.01	.01	.00	.00	.00	.00	.00	.00	.01
.01	.01	.00	.00	.00	.00	.00	.00		

35 JD INDEX STORM NO. 4

STRM 4.14 PRECIPITATION DEPTH

TRDA 30.00 TRANSPOSITION DRAINAGE AREA

0 PI PRECIPITATION PATTERN

.00	.00	.00	.00	.00	.00	.01	.01	.01	.00
.00	.00	.00	.00	.00	.01	.01	.01	.00	.00
.00	.01	.01	.01	.00	.00	.00	.00	.00	.00
.01	.01	.01	.00	.00	.00	.00	.00	.00	.01
.01	.01	.00	.00	.00	.01	.01	.01	.01	.01
.01	.01	.01	.01	.01	.01	.01	.00	.00	.00
.01	.01	.01	.01	.01	.01	.01	.01	.01	.01
.01	.01	.01	.01	.01	.01	.01	.01	.01	.01
.01	.01	.01	.01	.01	.01	.01	.01	.01	.01
.01	.01	.01	.01	.01	.01	.01	.01	.01	.01

.01	.01	.01	.01	.01	.01	.01	.01	.01	.01
.01	.01	.01	.01	.01	.01	.01	.01	.01	.01
.02	.02	.02	.02	.02	.02	.02	.02	.02	.03
.03	.03	.03	.03	.03	.04	.04	.04	.16	.16
.16	.42	.42	.42	.07	.07	.07	.04	.04	.04
.04	.04	.04	.03	.03	.03	.02	.02	.02	.02
.02	.02	.02	.02	.02	.02	.02	.02	.01	.01
.01	.01	.01	.01	.01	.01	.01	.01	.01	.01
.01	.01	.01	.01	.01	.01	.01	.01	.01	.01
.01	.01	.01	.01	.01	.01	.01	.01	.01	.01
.01	.01	.01	.01	.01	.01	.01	.01	.01	.01
.01	.01	.01	.01	.01	.01	.01	.01	.01	.01
.01	.01	.01	.01	.01	.00	.00	.00	.01	.01
.01	.01	.01	.01	.01	.01	.01	.00	.00	.00
.01	.01	.01	.00	.00	.00	.01	.01	.01	.00
.00	.00	.00	.00	.00	.01	.01	.01	.00	.00
.00	.00	.00	.00	.01	.01	.01	.00	.00	.00
.01	.01	.01	.00	.00	.00	.00	.00	.00	.01
.01	.01	.00	.00	.00	.00	.00	.00		

1

RUNOFF SUMMARY
FLOW IN CUBIC FEET PER SECOND
TIME IN HOURS, AREA IN SQUARE MILES

	OPERATION	STATION	PEAK FLOW	TIME OF PEAK	AVERAGE FLOW FOR MAXIMUM PERIOD 6-HOUR	24-HOUR	72-HOUR	BASIN AREA	MAXIMUM STAGE	TIME OF MAX STAGE
	HYDROGRAPH AT									
+		SUB1	4135.	12.17	653.	179.	173.	2.14		
	ROUTED TO									
+		R1	4051.	12.25	652.	179.	173.	2.14		
+									5.08	12.25
	HYDROGRAPH AT									
+		SUB2	2152.	12.17	316.	87.	84.	1.03		
	HYDROGRAPH AT									
+		SUB3	2590.	12.17	398.	109.	105.	1.30		

	2 COMBINED AT									
+		AA	4718.	12.17	711.	195.	188.	2.33		
	2 COMBINED AT									
+		A	8455.	12.17	1354.	372.	358.	4.47		
	ROUTED TO									
+		RA	8190.	12.33	1353.	372.	358.	4.47		
+									6.99	12.25
	HYDROGRAPH AT									
+		SUB4	2818.	12.25	477.	131.	126.	1.56		
	HYDROGRAPH AT									
+		SUB5A	2426.	12.17	392.	108.	104.	1.28		
	ROUTED TO									
+		R5	2350.	12.33	392.	108.	104.	1.28		
+									3.57	12.33
	HYDROGRAPH AT									
+		SUB5B	1872.	12.25	337.	93.	89.	1.10		
	2 COMBINED AT									
+		5	4132.	12.33	725.	199.	192.	2.38		
	2 COMBINED AT									
+		BB	6775.	12.25	1195.	328.	316.	3.94		
	2 COMBINED AT									
+		B	14768.	12.25	2531.	695.	669.	8.41		
	ROUTED TO									
+		RB	14561.	12.42	2530.	694.	669.	8.41		
+									7.63	12.33
	HYDROGRAPH AT									
+		SUB6	1640.	12.17	252.	69.	67.	.82		

	HYDROGRAPH AT									
+		SUB7	1367.	12.08	194.	53.	51.	.63		
	2 COMBINED AT									
+		CC	2970.	12.17	444.	122.	117.	1.45		
	2 COMBINED AT									
+		C	16507.	12.33	2960.	813.	783.	9.86		
	ROUTED TO									
+		RC	16182.	12.50	2958.	811.	781.	9.86		
+									9.24	12.50
	HYDROGRAPH AT									
+		SUB8	1932.	12.25	324.	82.	79.	1.21		
	HYDROGRAPH AT									
+		SUB9A	3836.	12.25	659.	181.	174.	2.16		
	ROUTED TO									
+		R9	3697.	12.42	658.	181.	174.	2.16		
+									6.66	12.42
	HYDROGRAPH AT									
+		SUB9B	2054.	12.33	337.	84.	81.	1.35		
	2 COMBINED AT									
+		9	5630.	12.33	989.	263.	254.	3.51		
	2 COMBINED AT									
+		DD	7504.	12.33	1306.	343.	331.	4.72		
	2 COMBINED AT									
+		D	22358.	12.42	4164.	1125.	1084.	14.58		
	ROUTED TO									
+		RD	22487.	12.50	4163.	1124.	1083.	14.58		
+									10.14	12.50
	HYDROGRAPH AT									

+		SUB10	3663.	12.33	673.	174.	167.	2.36		
	HYDROGRAPH AT									
+		SUB11	874.	12.17	127.	35.	34.	.41		
	2 COMBINED AT									
+		10	4350.	12.25	797.	208.	200.	2.77		
	2 COMBINED AT									
+		E	25535.	12.50	4878.	1310.	1262.	17.35		
	ROUTED TO									
+		RE	24734.	12.75	4873.	1305.	1257.	17.35		
+									6.48	12.75
	HYDROGRAPH AT									
+		SUB12	1933.	12.50	450.	115.	111.	1.61		
	HYDROGRAPH AT									
+		SUB13	1318.	12.17	188.	47.	45.	.73		
	2 COMBINED AT									
+		FF	2862.	12.33	633.	161.	155.	2.34		
	2 COMBINED AT									
+		F	26531.	12.75	5424.	1447.	1394.	19.69		
	ROUTED TO									
+		RF	26216.	12.83	5420.	1445.	1392.	19.69		
+									6.96	12.83
	HYDROGRAPH AT									
+		SUB14	652.	12.58	137.	34.	33.	.59		
	2 COMBINED AT									
+		G	26690.	12.83	5537.	1474.	1420.	20.28		

*** NORMAL END OF HEC-1 ***

PLATE 1
SAN DOMINGO WASH WATERSHED
DELINEATED BOUNDARIES

PLATE 2

SAN DOMINGO WASH WATERSHED SOILS MAP