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HYDROLOGICAL ANALYSES

for

FEMA DESIGNATED WASHES 5, 6A, 6B & 6C

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October 24, 1991
Revised November 11, 1991

Prepared for:

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ARIZONA, U.S.A.

Prepared by:

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Registered Professional Engineer (Civil)
CERTIFICATE NO
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DAVID W.
DUST
Date Signed
ARIZONA, U.S.A.

CVL

TRANSMITTAL

COE & VAN LOO

TO: City of Phoenix
125 E. Washington St.
Phoenix, AZ 85004

DATE: 11/12/91

PROJECT: FEMA MAPPING

PROJECT NO: 1100-010

SUBJECT: Hydrologic Analyses

ATTN: Mr. Paul Kienow

TRANSMITTING VIA: delivery

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THE FOLLOWING ARE SUBMITTED:

- ___ ORIGINALS
- ___ PHOTOCOPIES
- ___ PRINTS
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1	11/11/91	hydrological analyses - Washes 5 & 6 - revised; disk in map pocket with HEC-1's

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REMARKS OR REPLY Summary of major revisions:

100yr-24hr HEC-1 w/CN's-AMC II

2yr-24hr HEC-1 w/CN's-AMC I

10yr-24hr interpolated to maintain a skew of -.1

Please call if you have any questions.

91 NOV 12 AM 10: 09 MARICOPA COUNTY

COPY TO: Dave Johnson, FCDMC;
Amir Motamedi, FCDMC

SINCERELY,
COE & VAN LOO

David W. Dust, P.E.

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COE & VAN LOO CONSULTANTS, INC. 4550 North 12th Street Phoenix, Arizona 85014-4291 (602)264-6831 FAX(602)264-0928

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FLOOD CONTROL DISTRICT of Maricopa County

Interoffice Memorandum

CMT. NO.	SUBJECT: Scottsdale Alluvial Tatum Ranch CVL study	☐ FILE ☐ DESTROY

TO: AMM FROM: AA DATE: 11-21-91

The HEC-1 Program is in the right order and the cards are used in a correct manner. The schematic is also correct. However, ~~the~~ Table 3 on page 12, the value under the area for wash 5 does not agree with the total area for the HEC-1 run. There is no explanation for this difference in the latest submittal. The n Value chosen for Lag Calculation is low and should be ~~a~~ ~~[illegible]~~ higher than 0.04 for this area.

If you have any questions please let me know.

Afshin Ahouraiyan

6910-007 3-90

Coe & Van Loo Consultants, Inc.
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ENGR
REMARKS 2 AMM

MEMO

TO: Paul Kienow, City of Phoenix

FROM: Paul Hoskin, Coe & Van Loo Consultants, Inc.

DATE: November 12, 1991

RE: *Hydrological Analysis for FEMA Designated Washes 5, 6A, 6B & 6C,* Revised November 11, 1991

This morning you should have received the above referenced report. This report has been revised per our recent discussions, to more closely reflect FEMA's requirements to perform the alluvial fan analysis. We believe that the results in our report have been sufficiently well calibrated to reflect the true field conditions. Our report should be used for this area for the following reasons:

1) Results in the report have been calibrated against local gauged data.

2) Results include Depth-Area Ratio (Areal Reduction) factors based upon Hydro-40: NOAA Technical Memorandum, August 1984. Hydro-40 includes the latest research conducted in the southwest and specifically Arizona. Curves are based upon more localized data than the curves previously proposed by NOAA in the NOAA Atlas 2, 1972.

3) Flood hydrograph attenuation, using the 8-point cross-section and normal depth routing is appropriate for the conditions observed. Channel storage and infiltration losses can be expected to be significant, particularly for the low return period storm events.

4) The 2-year event has been modeled assuming dry soil conditions (AMC I) and the 100-year event using average (wet) conditions (AMC II). A regional skew curve of -0.1 has been applied to the flood-frequency regression curves as consistent with Bulletin 17B of the Water Resources Council. The gradient of the flood-frequency curves is consistent with the FEMA results using regional regression equations.

5) Results are more characteristic of the area than FEMA's which were based upon generalized regional regression equations. FEMA's results are also in error due to the use of an incorrect mean annual precipitation value.

73MI.046

CVL

6) Use of the CVL hydrology will reduce the areas affected by FEMA's alluvial fan flooding for Washes 5, 6A, 6B and 6C, even if it is not possible to refute the application of alluvial fan methodology to these watersheds.

In conclusion, it therefore remains our opinion that the CVL hydrologic analysis represents the best and most thorough for Washes 5, 6A, 6B and 6C, and that a case should be made for its use by FEMA. The support of you and other communities is therefore requested.

cc: Mark Borushko, SunCor
Mark Voigt, Stanford Ranch
Dave Johnson, FCDMC
Joe Tram, FCDMC

CVL

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i Summary

Coe & Van Loo Consultants, Inc., (CVL) has been contracted to evaluate the flood plains for Washes 5, 6A, 6B, and 6C designated on the Preliminary Flood Insurance Rate Maps (FIRM) dated July 9, 1991. CVL's scope of work includes the evaluation of these maps on a hydrological, geomorphological, and hydraulic basis. However, this report only addresses the hydrological basis of the Preliminary FIRM map.

The preliminary FEMA discharges were computed using regional regression equations published in 1978 as part of a research project for the Arizona Department of Transportation (ADOT) (Roeske, 1978). Review of this methodology indicates that the regression equations have high standard errors and that the precipitation data for the regression equations are prone to interpretation error.

To evaluate the preliminary discharges published with the Preliminary FIRM maps, CVL has developed a HEC-1 Rainfall-Runoff Simulation model that is based on methodologies consistent with City of Phoenix, Flood Control District of Maricopa County (FCDMC), and City of Scottsdale drainage policy. In addition, the Preliminary FEMA discharges have also been compared with results of the FCDMC's analysis of USGS gauge data collected from watercourses located in Maricopa County, Arizona. Comparison of the preliminary FEMA discharges with the results from the computer model and the results of the FCDMC's analyses of gauge data indicates that:

a) the Preliminary FEMA discharges appear excessively high; and

b) the 100-year discharges, computed with the HEC-1 computer model as part of this study, fall within an appropriate range when compared with the FCDMC's analyses of USGS gauge data.

The results of this study indicate that application of the regional regression equations are inherently prone to potentially significant errors and are inadequate for establishing peak discharges for Washes 5, 6A, 6B & 6C. Therefore, it is recommended that the HEC-1 computed discharges documented in this report, be used for the floodplain delineation purposes for Washes 5, 6A, 6B, & 6C.

1.0 Introduction

Coe & Van Loo Consultants, Inc., (CVL) has been contracted to evaluate a portion of the recently released preliminary FIRM maps for Northeast Phoenix. As part of this evaluation, CVL has developed a HEC-1 model for the drainage basins for Washes 5, 6a, 6b & 6c, as designated in the Preliminary Flood Insurance Rate Maps (FIRM) (dated July 9, 1991). This report documents in detail the HEC-1 model development, the result of the hydrologic analyses, and the comparison of HEC-1 computed discharges with a frequency analysis of USGS gauge data and the preliminary FEMA discharges.

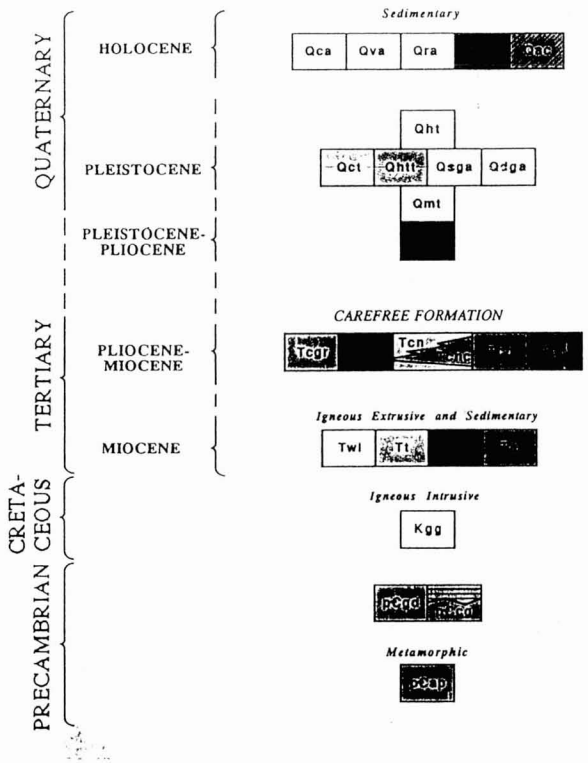
This report only addresses the hydrological aspects of the Preliminary FIRM maps and support data, dated July 9, 1991. Other aspects of the preliminary floodplain mapping will be addressed in a separate report by CVL. However, the report does provide the technical information to show that the preliminary FEMA discharges appear excessively high and that the hydrologic analyses documented in this report result in discharges that more closely reflect local conditions.

Geology by T. L. Péwé (1984-1989), P. L. Doorn (1986-1989), R. Kenny (1984-1985), J. T. Bales (1984-1985), and T. L. Gorey (1986-1989)

FIGURE 1A

GEOLOGY MAP

TIME RELATION OF MAP UNITS



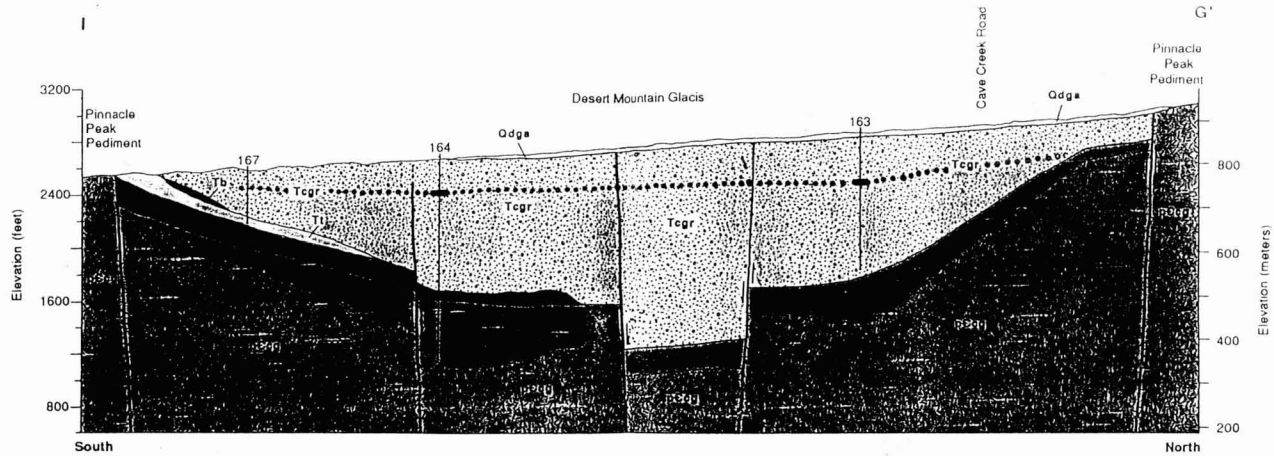


FIGURE 1A
SYMBOLS

contact
dashed where gradational or inferred

fault
dashed where inferred, dotted where buried
U = upthrown side and D = downthrown side

20 strike and dip of bedding

70 strike and dip of foliation

A — A' location of geologic cross section

▲ 21.7 location of K-Ar dated sample (age in millions of years)

★ 4 location and sample number for grain-size analyses

SYMBOLS

contact - *dashed where inferred*

fault - *dashed where inferred, dotted where buried; arrows indicate direction of relative motion along the fault*

160 well
- *number is well number (Table 2, Appendix B)*
- *length of vertical line below surface represents well depth as per vertical scale*
- *thick line indicates water level in well at time of well completion (Table 2); dotted where water table may be inferred*

Source: Doorn & Pewe (1991)

GEOLOGY MAP

FIGURE 1B

CYL

2.0 Watershed Description

As indicated on Plate 1, the drainage basins are primarily located on gently sloping alluvial plains, with typical slopes of 2 percent to the southwest. Figures 1A and 1B illustrate the findings of a recent geologic investigation of the area by Doorn and Péwé (1991). As indicated on these figures, the drainage areas are primarily located on deep deposits of alluvium, with older igneous rock formations located at the upper and lower limits of the drainage areas.

The drainage basins are located primarily within an undisturbed desert area, with only small areas of residential development. The vegetation within the drainage basins is comprised predominantly of Creosote, Mesquite, Palo Verde, Saguaro cacti, and other varieties of cacti. Field observations indicate that the area is not subject to extensive grazing nor recreational use. The overall vegetation in the area was judged to be in good condition, with 60% to 80% ground cover. To illustrate the typical vegetation conditions in the drainage basin, photographs taken of typical vegetation cover are given in Appendix A (Plate A1).

3.0 Hydrologic Analyses

3.1 HEC-1 Model Development

CVL has developed a HEC-1 model for the drainage basins for Washes 5, 6A, 6B, and 6C as designated on the preliminary FIRM's dated July 9, 1991 (Plate 2). The following is a summary of the HEC-1 model developed for fans 5, 6A, 6B, & 6C.

Parameter	Description/Source
• HEC-1 Program	Version 4.0, Sept. 1990
• Rainfall Distribution	SCS Type IIA
• Rainfall Depths	NOAA Atlas 2
• Depth-Area Ratios	NOAA NWS Hydro 40
• Lag Time	Corps of Engineers Lag Eq.
• Curve Numbers	SCS TR-55: Desert Conditions, Vegetation Coverage: good observed (fair used in computations)
• Soil Types	SCS Soil Data
• Hydrograph Routing Methodology	Normal Depth Routing

The SCS Type IIA rainfall distribution was selected for this analysis for two main reasons. First, the Type IIA distribution is based on recorded rainfall events in the arid southwest. Secondly, use of the Type IIA distribution is consistent with previous studies prepared for both the City of Phoenix and the City of Scottsdale. As part of these previous studies, sensitivity and verification analyses were conducted with the conclusion that the Type IIA distribution was best suited for the area (WRA, 1989) (WRA, 1990).

Point rainfall depths for the study area have been calculated from NOAA Atlas 2 isopluvial mapping (NOAA, 1973). The use of the NOAA Atlas 2 rainfall data is consistent with Flood Control District of Maricopa County (FCDMC), City of Phoenix, and City of Scottsdale drainage policy.

Lag Times for the drainage areas have been calculated using the following Lag Equation (U.S. Army Corps of Engineers, 1982):

$$Lag = 24\bar{n}\left(\frac{L * Lc}{S^{1/2}}\right)^{0.38} \qquad \textit{Eq. (1)}$$

Lag = *Lag Time (hrs)*
L = *Length of Watercourse (mi)*
L_{ca} = *Length along Watercourse to Centroid of Basin (mi)*
S = *Slope (ft/mi)*
$\bar{n}$ = *Basin Factor*

Lag Time calculations for each of the drainage basins are given in Appendix A. Plate A3 in Appendix A provides a guide for the selection of $\bar{n}$ Factors. The use of ***Eq. (1)*** is consistent with FCDMC policy.

As indicated in Plate 1, the drainage basins are comprised of an intricate system of shallow sand/gravel bed washes that drain small ridges with relatively steep side slopes. These small ridges are primarily covered by scattered brush and cacti; whereas, the washes are bordered by relatively dense stands of brush and small trees. Based on these characteristics and the basin factor guide information on Plate A3 (Appendix A), a basin factor of 0.04 has been selected for this study.

Curve numbers have been estimated for the drainage areas based on SCS soil mapping (SCS, 1978) and curve number guidelines for desert conditions published by the SCS (SCS, 1986). In September of 1991, the vegetation cover was observed to be in good condition; however, it may be possible for the vegetation condition to be slightly less than good in mid-summer. Therefore, curve number values corresponding to "fair" vegetation conditions have been used in this study. The curve numbers used to compute the 100-year event correspond to

Anticedent Moisture Condition II (AMC II); whereas, curve numbers corresponding to AMC I have been used in the 2-year event computations.

As indicated on the soil map given in Appendix A, the drainage areas are primarily comprised of Type C & D soils, with some pockets of Type B soil. The curve number calculations, the TR-55 curve number table, and the soil map (Plate A2) are given in Appendix A.

The normal-depth channel routing option in HEC-1 has been used in this study, as consistent with FCDMC policy. This routing option allows for both hydrograph attenuation and translation. The routing parameters and channel sections used in this study are given in Appendix A.

3.2 Flow Diversion

As indicated in Plate 1, the drainage basin for Wash 5 has been divided into three sub-basins. At the concentration points for sub-basins 5A1 & 5A2, a major flow diversion to the southwest was observed in the field and can be seen in Plate 1. Uniform flow calculations based on field measurements have been used to estimate rating curves for the flow diversion.

Uniform flow calculations and photographs (Plate A4) of the flow diversion are given in Appendix A. As indicated in Plate 1 and Plate A4 (Appendix A), the flows from sub-basins 5A1 & 5A2 intermix in a relatively flat and well vegetated area that extends for a distance of several hundred feet. The diversion occurs during both low and high flow events at the southwesterly limit of this relatively flat and well vegetated area.

3.3 Comparison and Verification Tests

The HEC-1 model was used to compute the 2 and 100-year peak discharges for Wash 5, 6A, 6B and 6C. Results are given in Appendix C and summarized in Table 1. The 10-year event, shown in Table 1, were interpolated using the 2 and 100-year peak discharges for each watershed and using the skew coefficient equation published in Bulletin #17B (U.S. WRC, 1981). A skew coefficient of -0.10 was used and is consistent with Bulletin #17B guidelines for central Arizona (U.S. WRC, 1981).

The computed 100-year peak discharges and the preliminary FEMA discharges (dated July 9, 1991) are summarized in Table 2, in terms of cubic feet per second (cfs) and cubic feet per second per square mile (CSM). Table 2 also lists the discharges corresponding to the Discharge versus Drainage Area Curves prepared by the FCDMC. These curves shown in Figure 2 are based on frequency analyses of USGS gauge data collected in Maricopa County, Arizona. Table 3 is a comparison of the preliminary FEMA discharges and the discharges proposed by this study.

The FCDMC's brief report and technical support data are given in Appendix B. This study by the FCDMC appears to be thorough and the most recent analysis of USGS data collected in Maricopa County. Hence, the results of the FCDMC's study have been used to evaluate the preliminary FEMA discharges and the discharges computed as part of this study. Comparison of the 100-year discharges summarized in Tables 2 & 3 and shown in Figure 2 indicates that:

a) The preliminary FEMA discharges fall close to the FCDMC's "maximum" curve and appear excessively high;

b) The 100-year discharges computed as part of this study fall between the FCDMC's "average" and "similar to streams 5 and 6" curves;

Table 1: HEC-1 Computed Discharges for Washes 5 & 6 at FEMA Designated Apices

Wash ID	Discharges for Specified Return Period					
	Drainage Area (Sq. Mi.)	Q_{100} cfs	Q_{10}[1] cfs	Q_2 cfs	Skew	Transformation Constant
5	2.11	1598	410	70	-.10	6.32
6a	3.54	2251	411	45	-.10	5.75
6b	0.43	493	170	19	-.10	3.80
6c	1.57	1265	213	21	-.10	4.34

(1) 10 year events were calculated based on the computed 100 and 2-year events and a skew of -.10 using the following equation (FEMA, 1981):

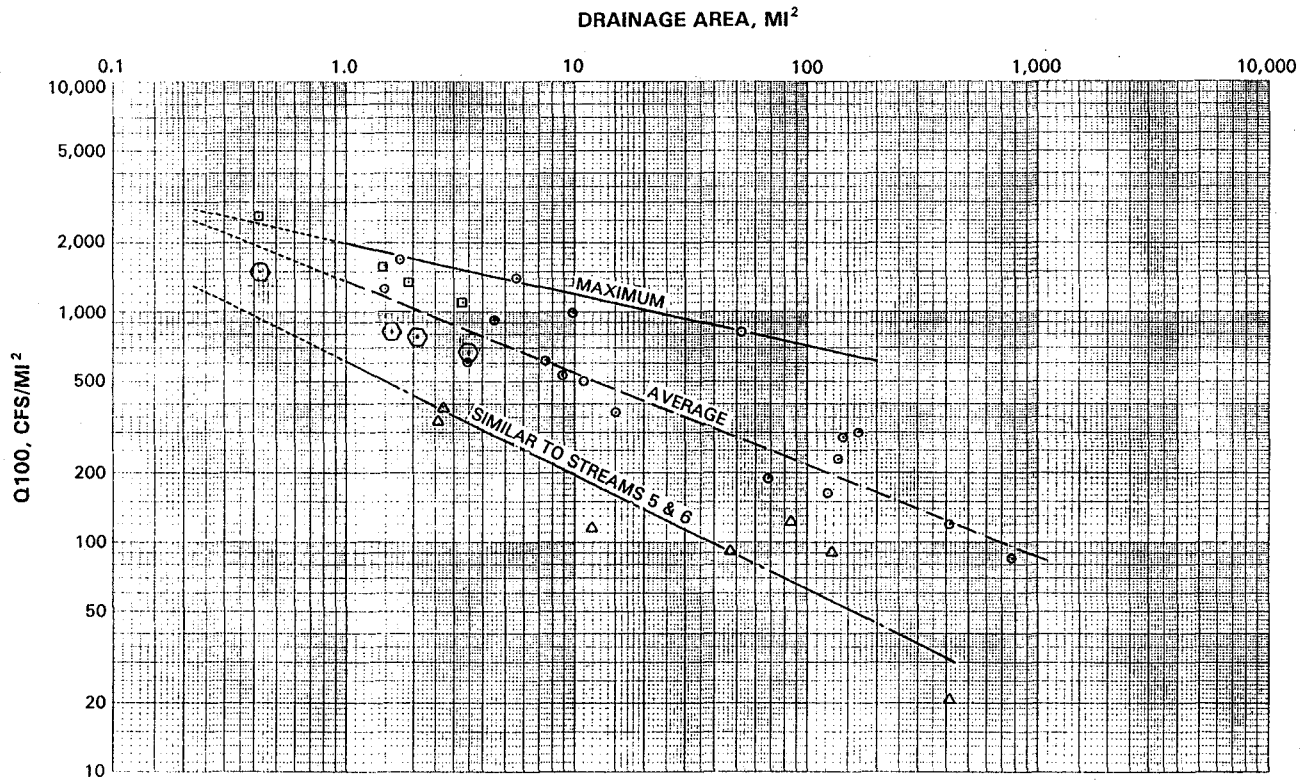
$$\text{Skew} = -2.50 + 3.12 \left[\frac{\log(Q_{100})/Q_{10})}{\log(Q_{10}/Q_2)}\right]$$

Table 2: Comparison of Computed 100-Year Discharges

Wash ID	CVL (11/91)[1]			FEMA (7/91)[2]			FCDMC CSM[3] Curves	
	Area Mi.^{2}	Q_{100} CFS	Q_{100} csm	Area mi^2	Q_{100} CFS	Q_{100} csm	For 5 & 6 Ave	Total Co. Ave.
5	2.11	1598	760	1.99	2744	1380	420	1000
6a	3.54	2251	640	3.32	3735	1130	360	810
6b	0.43	493	1150	.43	1151	2680	~950[4]	~1900[4]
6c	1.57	1265	810	1.49	2373	1590	500	1150

NOTE: CSM = cfs per sq. mi.

1 HEC-1 given in Appendix B
2 Preliminary FEMA Discharges (see Appendix A)
3 Frequency Analysis of USGS Gauge
4 Extrapolated Values



LEGEND

- ○ STREAM FLOW STATIONS
- △ STREAM FLOW STATIONS (CHARACTERISTICS MORE SIMILAR TO STREAMS 5 & 6)
- □ PRELIMINARY FEMA DISCHARGES (JULY 9, 1991)
- ⬡ HEC-1 COMPUTED DISCHARGES PER THIS STUDY

Source: FCDMC's Analyses of USGS Gauge Data Collected in Maricopa County (Appendix B)

PEAK DISCHARGE VERSUS DRAINAGE AREA CURVES FOR 100-YEAR DISCHARGES

(SHOWING STATIONS MORE SIMILAR TO STREAMS 5 & 6)

FIGURE 2

CYL

Table 3: Comparison of FEMA and Proposed Discharges

	CVL (11/91)				FEMA (7/91)			
Wash ID	A sq. mi.	Q_{100} cfs	Q_{10} cfs	Q_2 cfs	A sq. mi.	Q_{100} cfs	Q_{10} cfs	Q_2 cfs
5	2.11	1500	410	70	~~1.99~~	2740	600	80
6A	3.54	2250	410	45	3.32	3740	840	120
6B	0.43	490	120	20	0.43	1150	230	30
6C	1.57	1270	210	20	1.49	2370	520	70

4.0 Conclusions and Recommendations

The preliminary FEMA discharges are based on regression equations documented in the report written by Roeske and titled *Methods for Estimating the Magnitude and Frequency of Floods in Arizona*. The results shown in Table 2 strongly imply that the regional regression equations published in 1978 are inadequate for delineating flood plains for Washes 5, 6A, 6B, and 6C. The regression equations and support data documented in the report have three very significant shortcomings.

First of all, the regression equations for Region 3 have standard errors that range from 58 to 81 percent, with a standard error of 66 percent for the 100 year event equation. Standard errors of this magnitude clearly indicate that there are very significant discrepancies between the regression equations and the base gauge data. Plate A5 in Appendix A is a plot of data used to develop the Region 3-100 year regression equation. The data scatter shown in Plate A5 illustrates why the standard errors for the regression equations are excessive.

Secondly, it is important to note that the Region 3 regression equations are based on data collected from drainage basins with a wide range of values for the parameters used in the regression equations. Table 4 is a comparison of the drainage basin characteristics for the data used to develop the Region 3 regression equation and the corresponding values for Washes 5&6.

Table 4: Comparison of Drainage Area Parameters

Parameter	Region 3 Regression Equation	Washes 5 & 6
a) Drainage Area (sq. mi.):	0.065 to 5499	0.4 to 3.5±
b) Mean Basin Elev. (ft.):	1780 to 7400	2800±
c) Mean Annual Precipitation (in.):	10 to 30	12.26[1]

[1] Per Arizona State Climatologist (10/91)

As indicated in Table 4, the drainage parameters for Washes 5 & 6 fall at the low end of the range of parameters for the data used to develop the regression equations. Therefore, it may be expected that the discharges computed using the regression equations may be high for Washes 5 & 6.

Thirdly, the Roeske report provides precipitation data (mean annual rainfall) on a map with a scale of 1" = 60± miles. Due to the scale of this map and the 2 inches of rainfall interval in the isopluvials, it is very difficult to accurately estimate mean annual precipitations for a relatively small drainage area. The error in applying rainfall data from the map can be significant. As indicated in Table 4, FEMA has used mean annual precipitation values of 15 to 16 inches for Washes 5 & 6; whereas, the Arizona State Climatologist has a gauge in Carefree (near the study area) with a recorded mean annual precipitation of 12.26 inches. Therefore, application of the regional regression equations are inherently prone to potentially very significant errors, with respect to the drainage basins evaluated in this study.

The preliminary alluvial fan floodplains, as indicated in the July 1991 mapping, will have a very severe economic impact on many individuals living in existing homes and on owners of undeveloped land. Hence, the delineation of these floodplains should not be taken lightly and should be based on the best available data and methodologies. Yet the data provided in this

report clearly documents that the regional regression equations used by FEMA are prone to significant error and appear to be excessively high when compared with recent frequency analyses by the FCDMC and the site specific HEC-1 model simulations for Washes 5, 6A, 6B, and 6C. Therefore, it is recommended that HEC-1 generated discharges documented in this study be adopted for Washes 5 & 6, since the computed discharges correlate well with the FCDMC's study and are based on methodologies consistent with FCDMC, City of Phoenix, and City of Scottsdale drainage policy.

5.0 References

Doorn, P., and Péwé T., *Geologic and Gravimetric Investigations of the Carefree Basin, Maricopa County, Arizona: Arizona Geological Survey Special Paper 8*, Arizona Geological Survey, 1991.

Roeske, R.H. *Final Report: Methods for Estimating the Magnitude and Frequency of Floods in Arizona*, submitted to ADOT Highway Division, prepared by the USGS, September 1978.

Soil Conservation Service (SCS), *Urban Hydrology for Small Watersheds: Technical Release 55 (TR-55)*, June 1986.

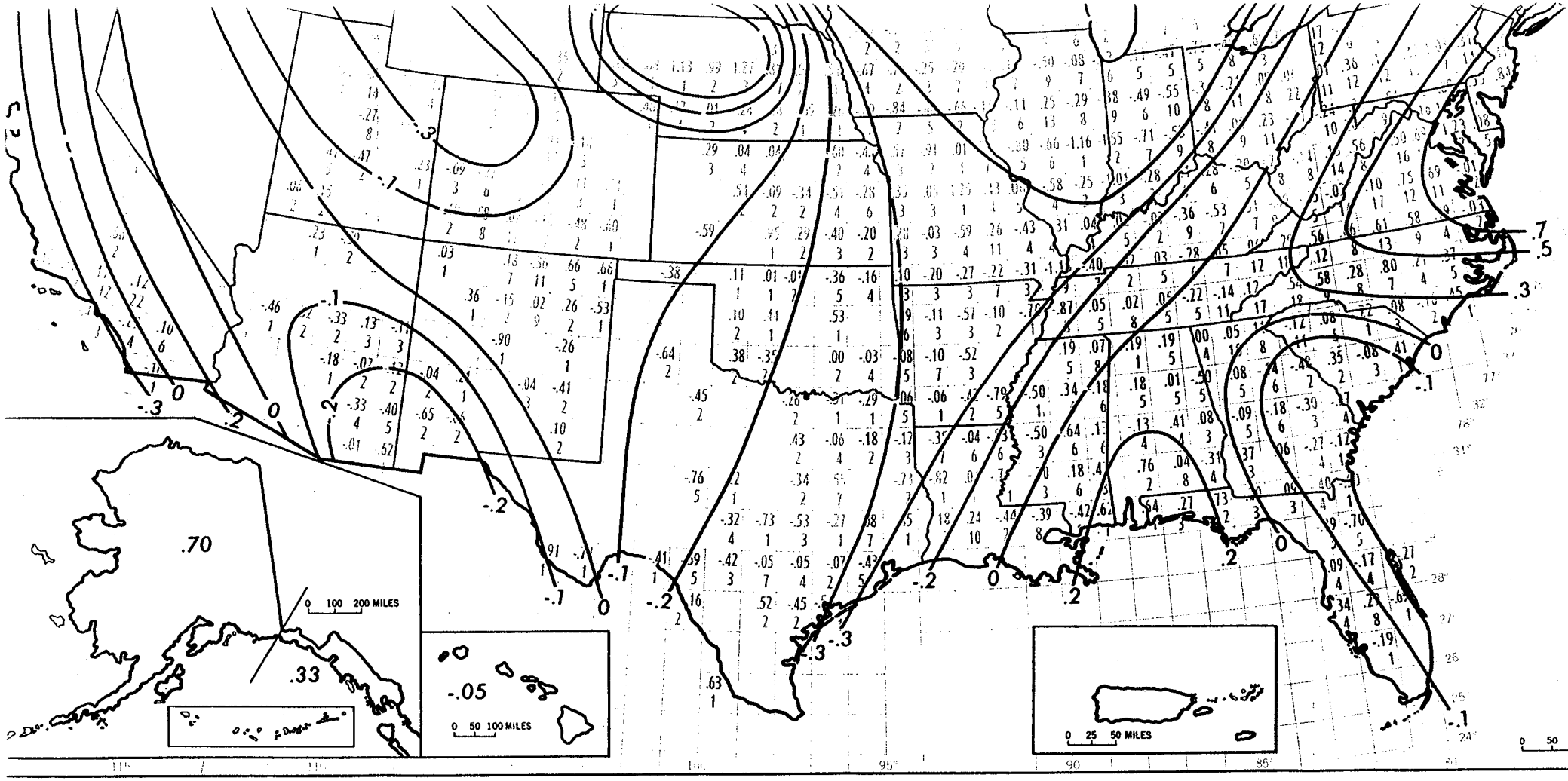
United States Water Resources Council, *Guidelines for Determining Flood Flow Frequency: Bulletin #17B*, Washington, D.C., Sept. 1981.

Water Resources Associates (WRA), *Concept Drainage Study: Paradise Valley Fan Terrace: Part of Peripheral Areas C and D: ST-886374*, prepared for the City of Phoenix, February 1990.

Water Resources Associates (WRA), *General Drainage Plan for North Scottsdale, Arizona* prepared for the City of Scottsdale, June 1989.

Appendix A

Computation Sheets & Technical Support Data



GENERALIZED SKEW COEFFICIENTS OF LOGARITHMS OF ANNUAL MAXIMUM STREAMFLOW

AVERAGE SKEW COEFFICIENT BY ONE DEGREE QUADRANGLES

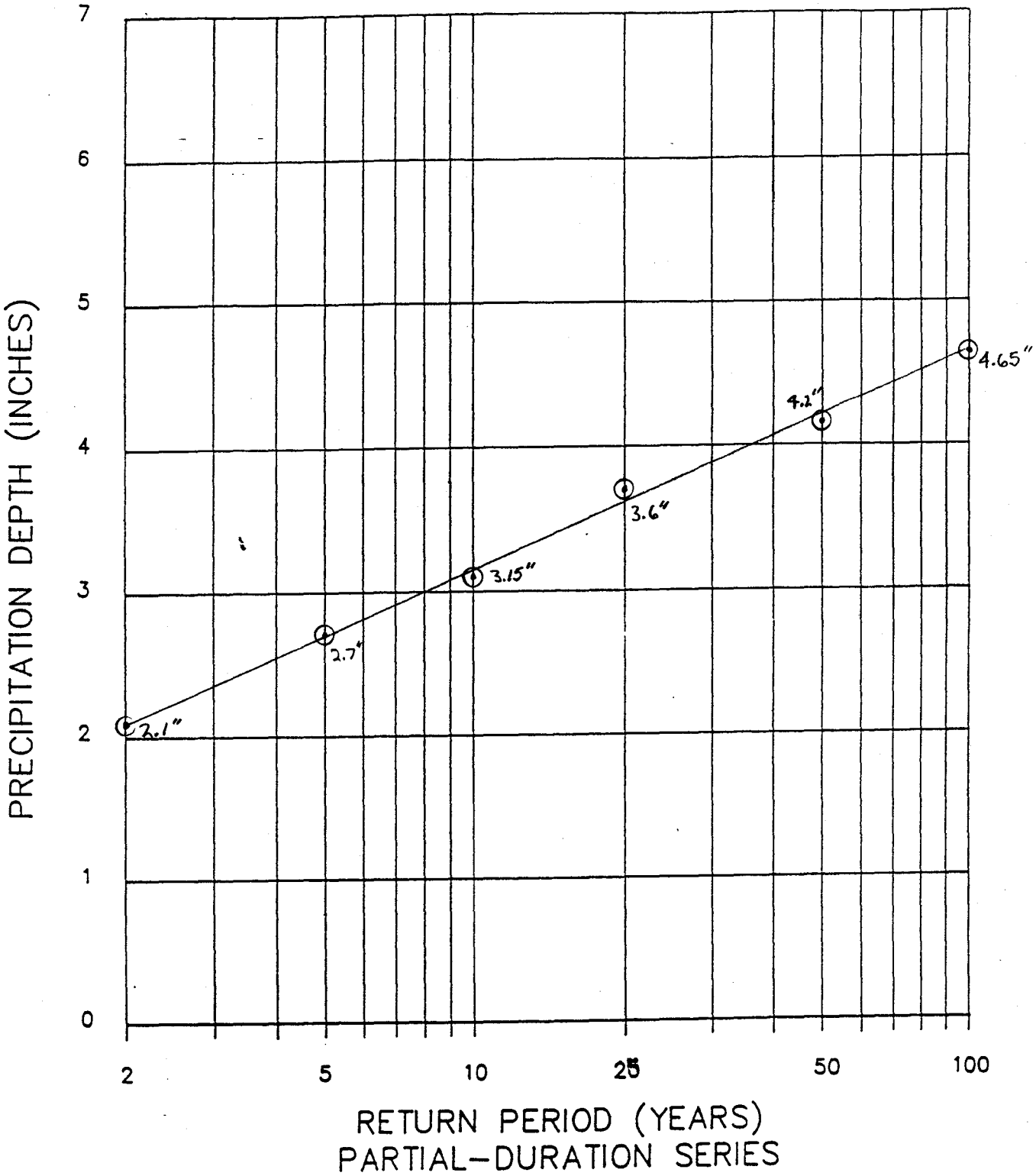
Lower number in each quadrangle is number of stream gaging stations for which the average shown above it was computed

Source: (U.S. WRC, 1981)

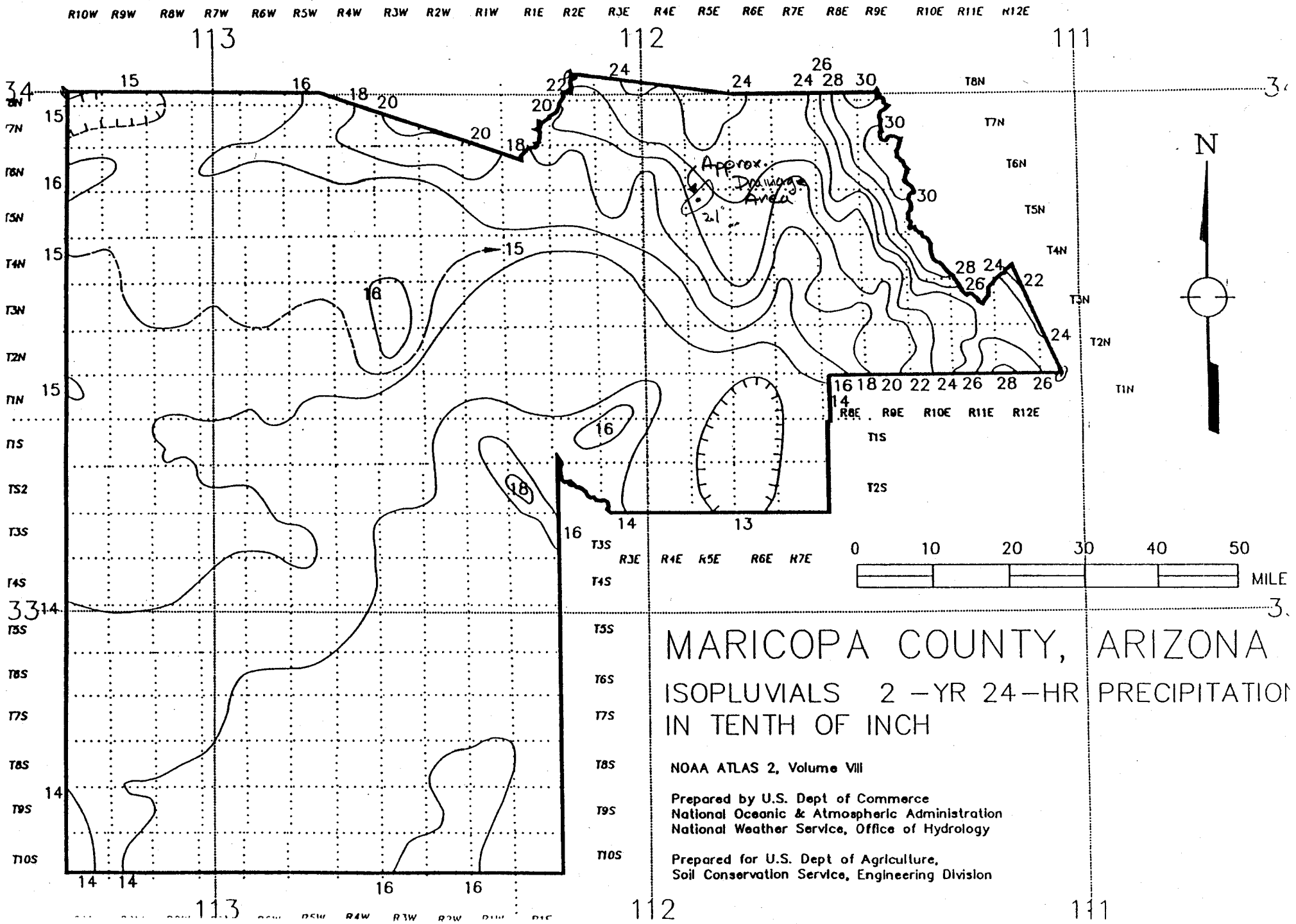
POINT RAINFALL VALUES - PER NOAA ATLAS 2

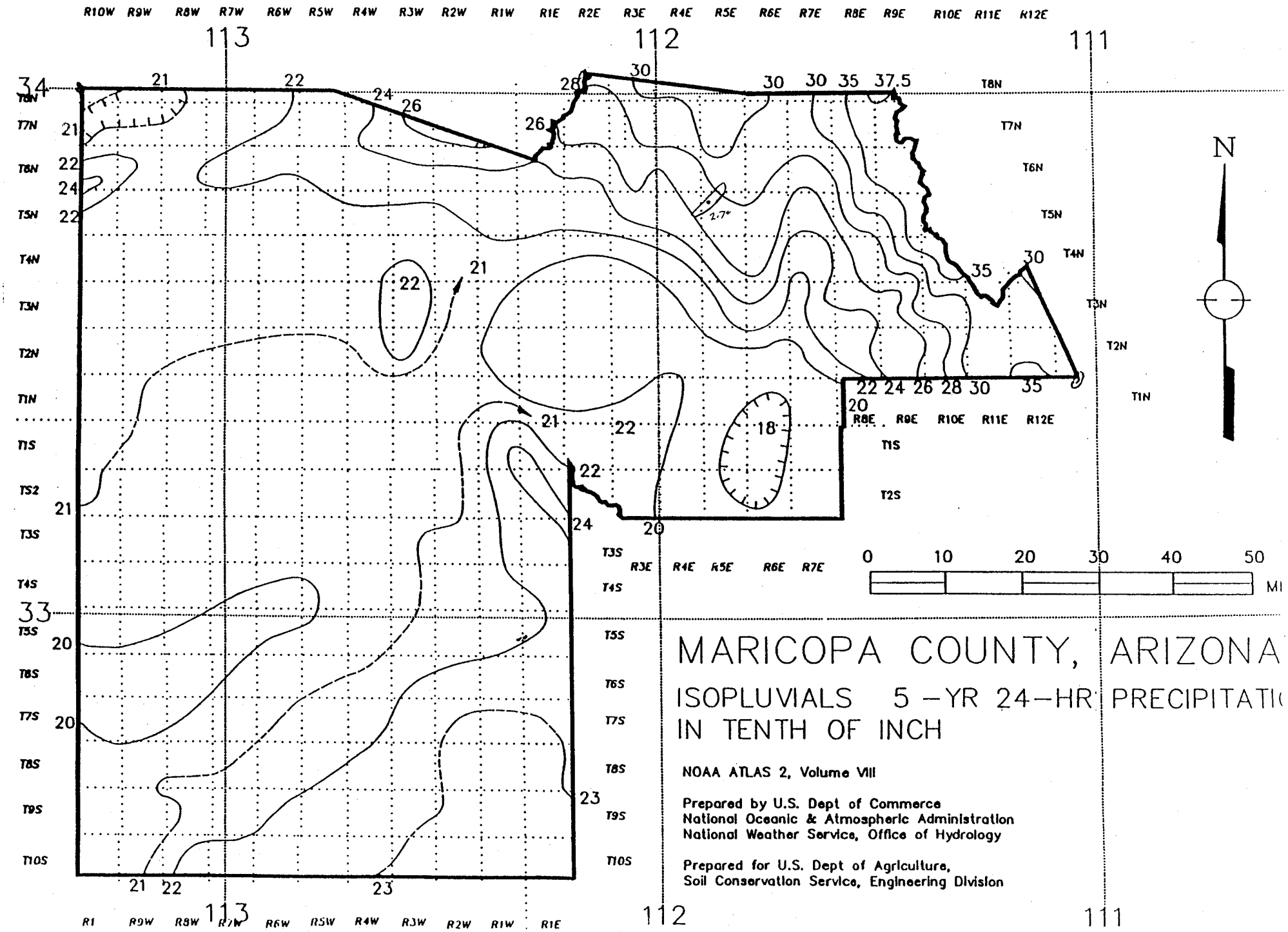
RETURN PERIOD (YRS)	PRECIPITATION DEPTH (*) (IN)
2	2.10
5	2.70
10	3.15
25	3.60
50	4.20
100	4.65

(*) See precipitation versus return period plot:



Percipitation Depth versus Return Period for Partial-Duration Series


MARICOPA COUNTY, ARIZONA
ISOPLUVIALS 2 -YR 24-HR PRECIPITATION
IN TENTH OF INCH
NOAA ATLAS 2, Volume VIII
Prepared by U.S. Dept of Commerce
National Oceanic & Atmospheric Administration
National Weather Service, Office of Hydrology
Prepared for U.S. Dept of Agriculture,
Soil Conservation Service, Engineering Division
N
0 10 20 30 40 50
MILE
Approx. Drainage Area
R10W R9W R8W R7W R6W R5W R4W R3W R2W R1W R1E R2E R3E R4E R5E R6E R7E R8E R9E R10E R11E R12E
T8N T7N T6N T5N T4N T3N T2N T1N T1S T2S T3S T4S T5S T6S T7S T8S T9S T10S
113 112 111
34 33


MARICOPA COUNTY, ARIZONA
ISOPLUVIALS 5 -YR 24-HR PRECIPITATI
IN TENTH OF INCH
NOAA ATLAS 2, Volume VIII
Prepared by U.S. Dept of Commerce
National Oceanic & Atmospheric Administration
National Weather Service, Office of Hydrology
Prepared for U.S. Dept of Agriculture,
Soil Conservation Service, Engineering Division
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T8N T7N T6N T5N T4N T3N T2N T1N T1S T2S T3S T4S T5S T6S T7S T8S T9S T10S
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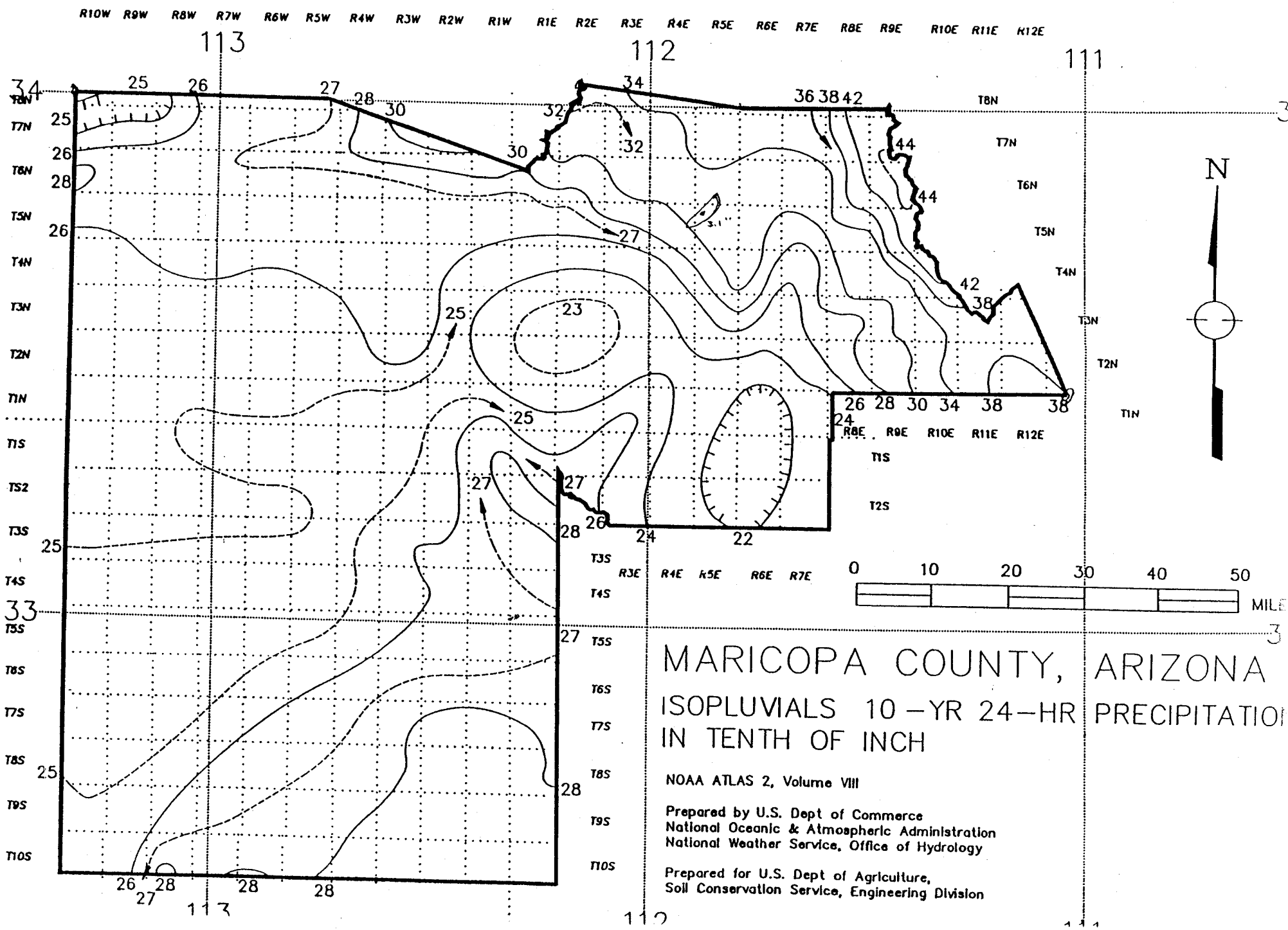
MARICOPA COUNTY, ARIZONA
ISOPLUVIALS 10-YR 24-HR PRECIPITATION
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NOAA ATLAS 2, Volume VIII
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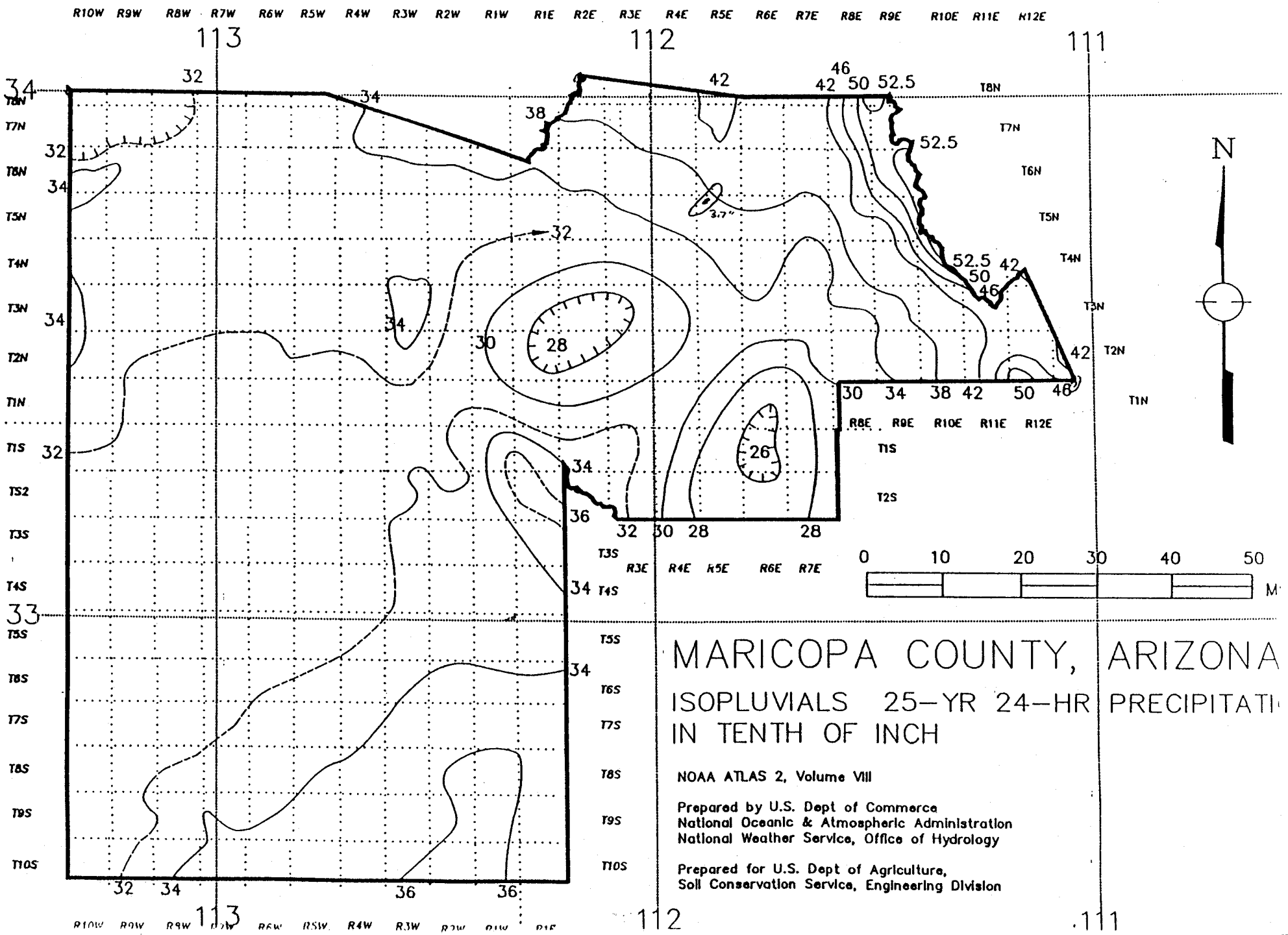
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ISOPLUVIALS 25-YR 24-HR PRECIPITATI
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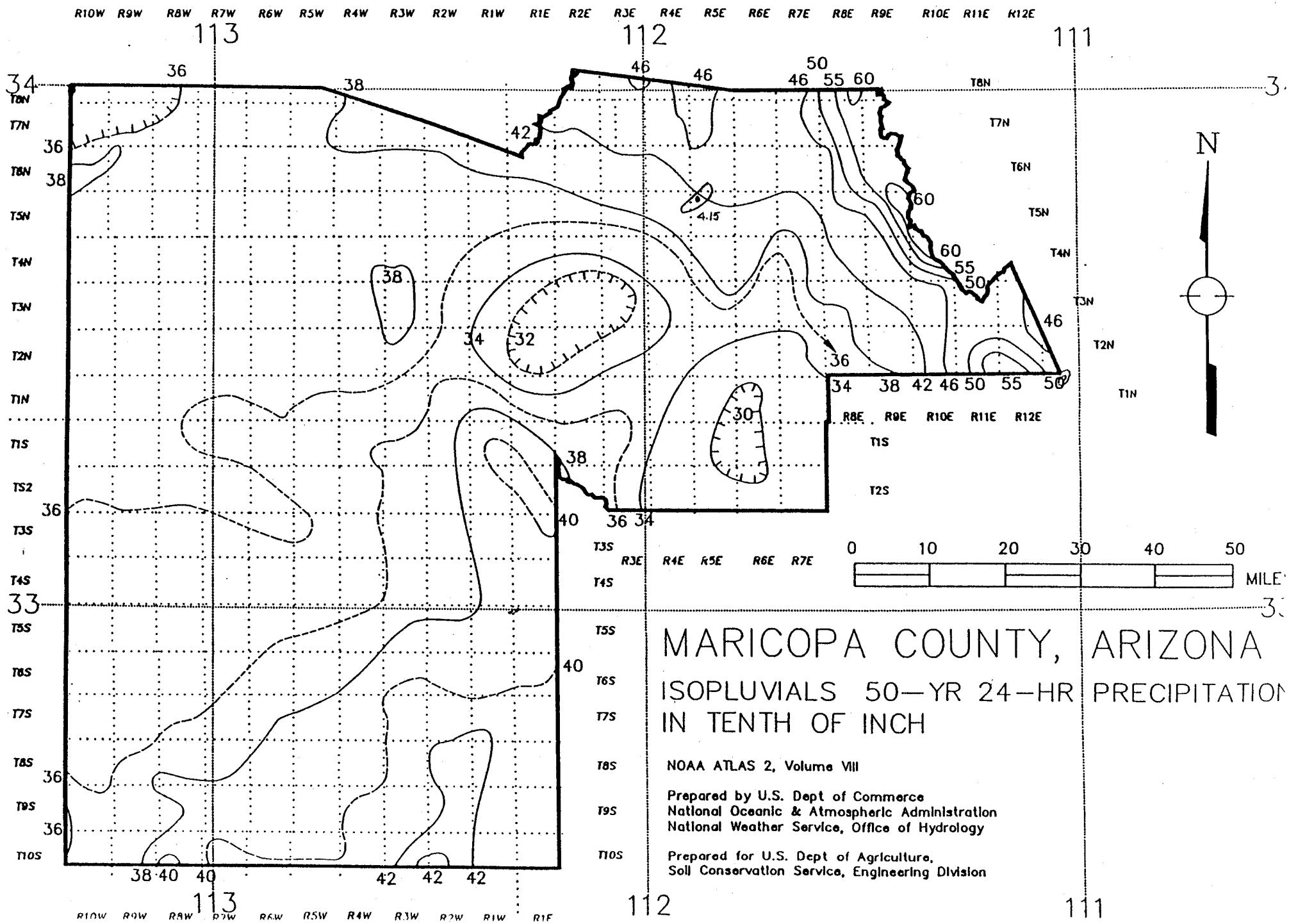
MARICOPA COUNTY, ARIZONA
ISOPLUVIALS 50—YR 24—HR PRECIPITATION
IN TENTH OF INCH
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Prepared for U.S. Dept of Agriculture,
Soil Conservation Service, Engineering Division
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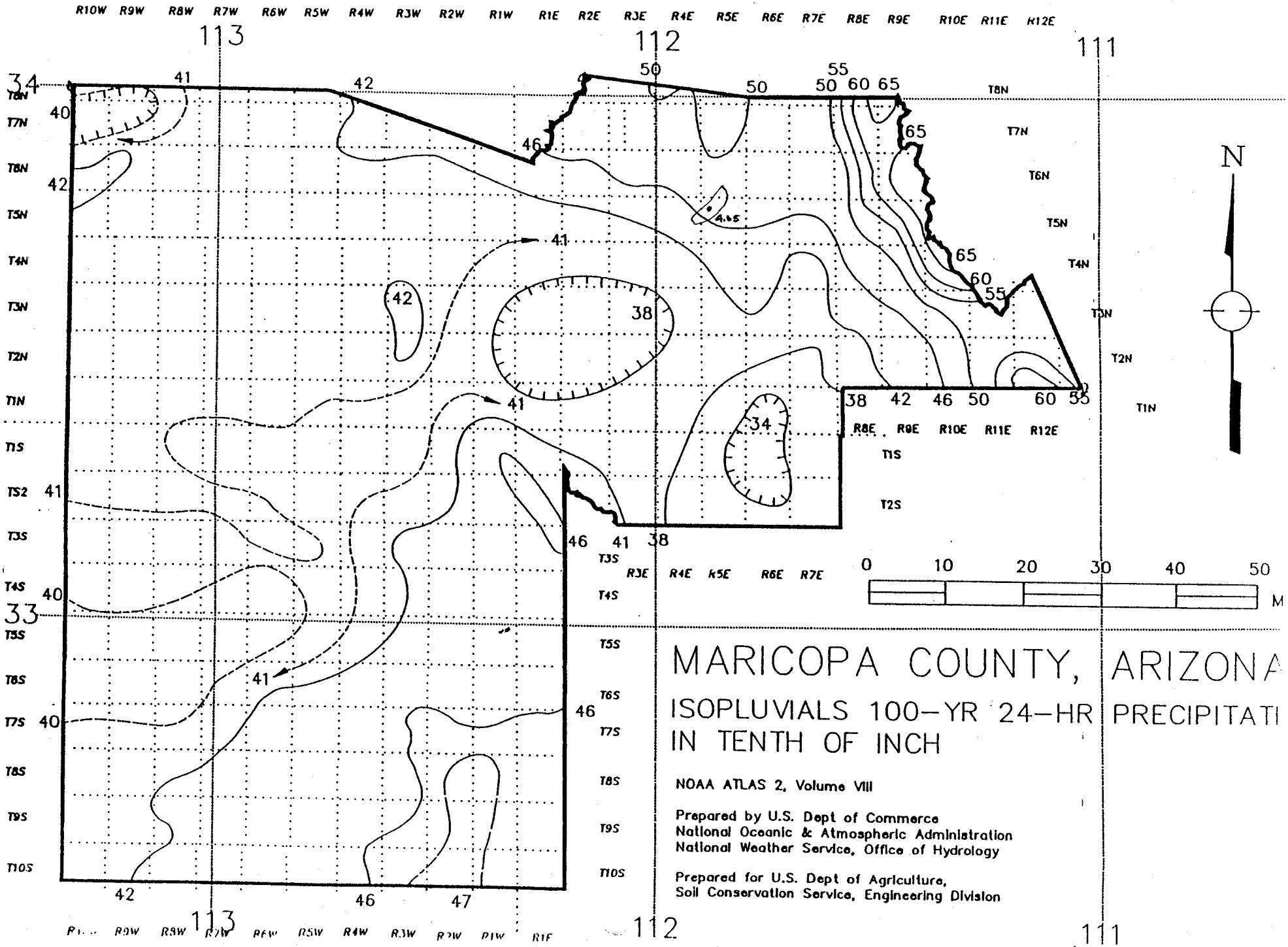
MARICOPA COUNTY, ARIZONA
ISOPLUVIALS 100-YR 24-HR PRECIPITATI
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ESTIMATED DEPTH-AREA RATIOS: HYDRO 40

AREA (sq. mi.)	RATIO (24 hr. Event)
0	1.000
1	0.990 (*)
2	0.980 (*)
3	0.970 (*)
4	0.965

(*) Interpolated values from Depth-Area Ratio Curves

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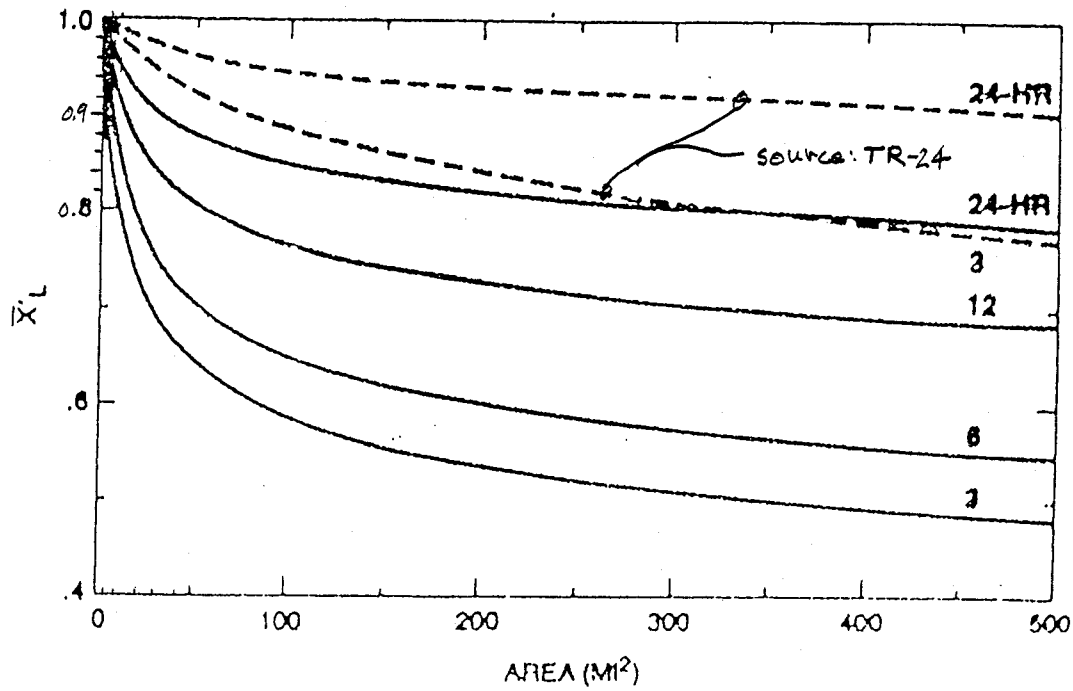

Figure 15.—Same as figure 14, but for central Arizona.

Depth-Area Ratio Curves
Source Hydro-40 : NOAA Technical Memorandum
August 1984

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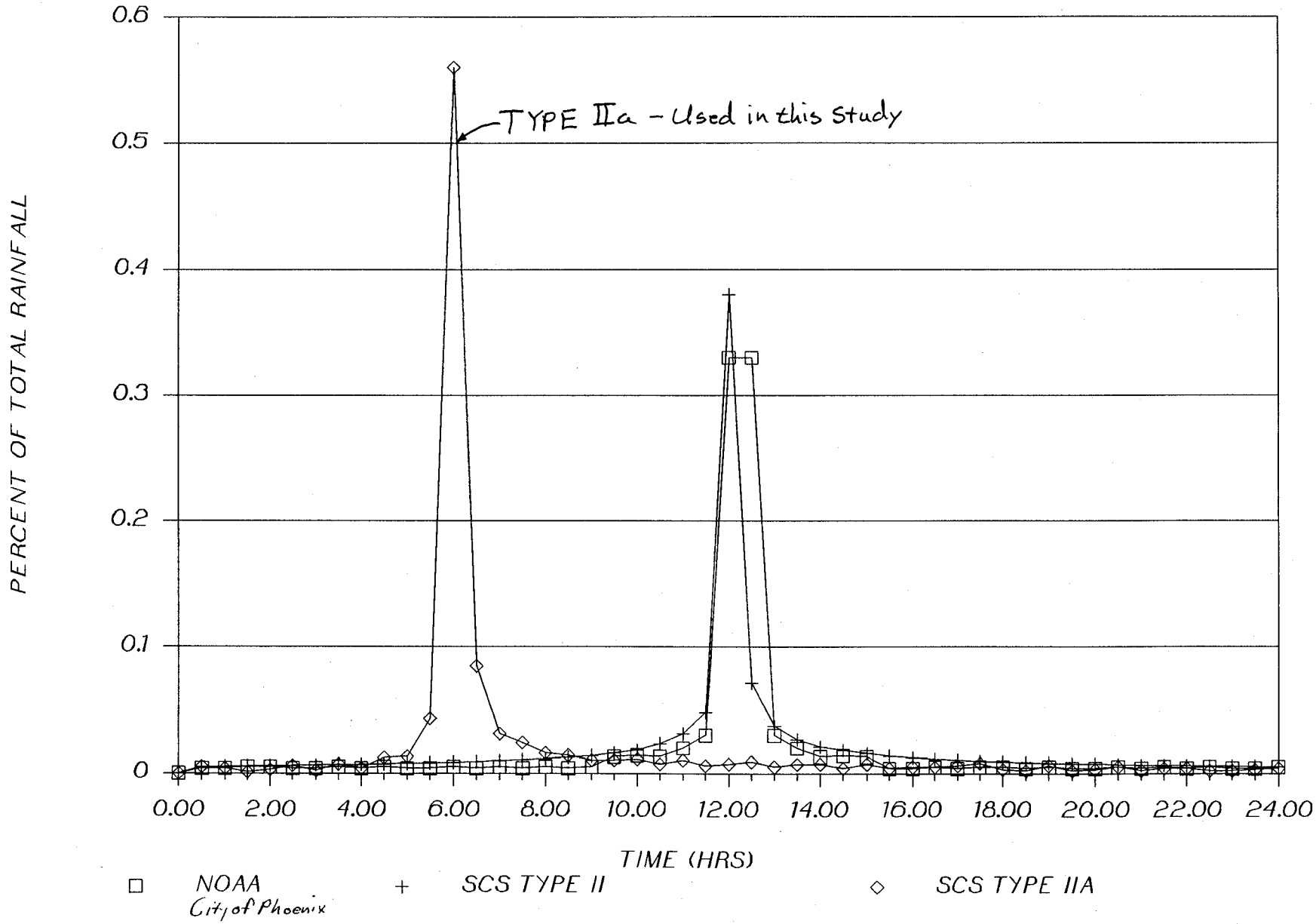
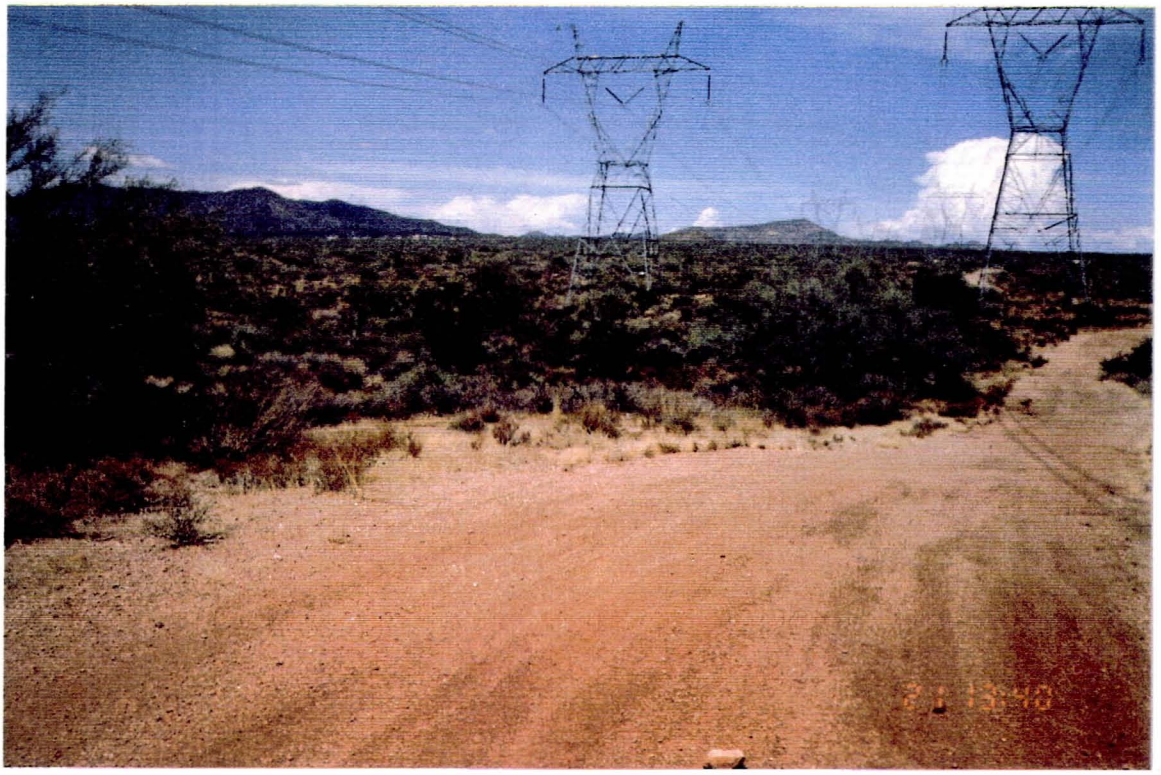
RAINFALL DISTRIBUTION COMPARISONS





Looking northeasterly at Sub-basins 5A1 and 6A

Looking northeasterly near Sub-basin 5A3 concentration point

PLATE A1 - TYPICAL VEGETATION COVER AND CONDITION

CURVE NUMBERS & SOIL TYPES

SUB-BASIN	ESTIMATED %(1) SOIL TYPES B	C	D	WEIGHTED-CN(2) AMC II FAIR	AMC I FAIR	AVERAGE
5A1	0	89	11	82	65	73 73.5 74
5A2	25	50	25	80	63	72
5A3	3	24	74	84 85	69	77
6A	12	67	21	81	64	73
6B	3	42	55	84 83.48	68 66.9	76 75.
6C1	8	71	21	81	65 64	73
6C2	16	34	50	82	66 65	74

(1) Soil Survey of Aguila-Carefree Area Parts of Maric Counties AZ, SCS, 1978

(2) Source: TR-55, June 1986

AMC II CN (Desert Fair - Type B Soil)= 72
CN (Desert Fair - Type C Soil)= 81
CN (Desert Fair - Type D Soil)= 86

AMC I CN (Desert Fair - Type B Soil)= 52
CN (Desert Fair - Type C Soil)= 64
CN (Desert Fair - Type D Soil)= 70

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Project No. _____
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Curve Number Adjustment for AMC

CN for Condition II	Corresponding CN for Condition I	III
100	100	100
95	87	99
90	78	98
85	70	97
80	63	94
75	57	91
70	51	87
65	45	83
60	40	79
55	35	75
50	31	70
45	27	65
40	23	60
35	19	55
30	15	50
25	12	45
20	9	39
15	7	33
10	4	26
5	2	17
0	0	0

Source: McCuen R.H., A Guide to Hydrologic Analysis Using SCS Methods, Prentice-Hall Inc., New Jersey, 1982.

SOIL MAP

Source:
SCS Soil Survey
Aguila Carefree
Area, 1978

Soil Unit	Hydrologic Soil Group
06	B
26	C
33	C
34	C
61	D
72	D
93	D
96	B

PLATE A2

2000'
0' 1000'

Table 2-2d.—Runoff curve numbers for arid and semiarid rangelands[1]

Cover description		Curve numbers for hydrologic soil group—			
Cover type	Hydrologic condition[2]	A[3]	B	C	D
Herbaceous—mixture of grass, weeds, and low-growing brush, with brush the minor element.	Poor		80	87	93
	Fair		71	81	89
	Good		62	74	85
Oak-aspen—mountain brush mixture of oak brush, aspen, mountain mahogany, bitter brush, maple, and other brush.	Poor		66	74	79
	Fair		48	57	63
	Good		30	41	48
Pinyon-juniper—pinyon, juniper, or both; grass understory.	Poor		75	85	89
	Fair		58	73	80
	Good		41	61	71
Sagebrush with grass understory.	Poor		67	80	85
	Fair		51	63	70
	Good		35	47	55
Desert shrub—major plants include saltbush, greasewood, creosotebush, blackbrush, bursage, palo verde, mesquite, and cactus.	Poor	63	77	85	88
	Fair	55	72	81	86
	Good	49	68	79	84

[1]Average runoff condition, and $I_a = 0.2S$. For range in humid regions, use table 2-2c.

[2]*Poor:* <30% ground cover (litter, grass, and brush overstory).
Fair: 30 to 70% ground cover.
Good: >70% ground cover.

[3]Curve numbers for group A have been developed only for desert shrub.

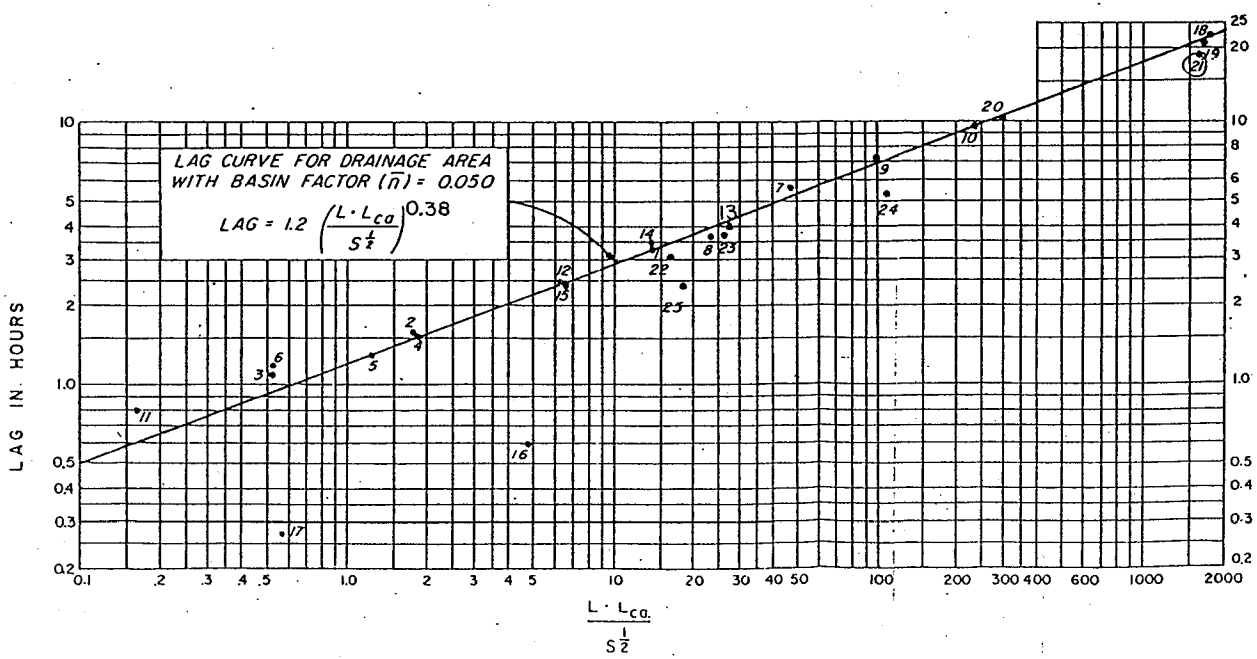
Source: SCS TR-55, Second Ed., June 1986

LAG TIME CALCULATIONS

SUB-BASIN I.D.	AREA (mi2)	L (mi)	Lc (mi)	S (ft/mi)	n	LAG (1) (hrs)
5A1	0.43	3.48	0.90	126	0.04	0.591
5A2	0.94	3.03	1.71	92	0.04	0.759
5A3	1.77	3.86	1.60	100	0.04	0.799
6A	3.54	5.34	2.86	147	0.04	1.048
6B	0.43	2.30	1.17	106	0.04	0.577
6C1	1.00	3.50	1.74	165	0.04	0.723
6C2	0.57	2.64	1.50	110	0.04	0.663

(1) LAG = 24n(L*Lc/S^.5)^.38 (HRS)

		CONTRIBUTING AREA SQ. MI.	L MILES	L_{ca} MILES	S FT/MI.	LAG HOURS	ESTIMATED $\bar{n}$
1.	SAN GABRIEL RIVER AT SAN GABRIEL DAM, CALIF.	162.0	23.2	11.6	350	3.3	0.050
2.	WEST FORT SAN GABRIEL RIVER AT COGSWELL DAM, CALIF.	40.4	9.3	4.3	450	1.6	.050
3.	SAN ANITA CREEK AT SANTA ANITA DAM, CALIF.	10.8	5.8	2.5	690	1.1	.050
4.	SAN DIMAS CREEK AT SAN DIMAS DAM, CALIF.	16.2	8.6	4.8	440	1.5	.050
5.	EATON WASH AT EATON WASH DAM, CALIF.	9.5	7.3	4.4	600	1.3	.050
6.	SAN ANTONIO CREEK NEAR CLAREMONT, CALIF.	16.9	5.9	3.0	1,017	1.2	.055
7.	SANTA CLARA RIVER NEAR SAUGUS, CALIF	355.0	36.0	15.8	140	5.6	.050
8.	TEMECULA CREEK AT PAUBA CANYON, CALIF.	168.0	26.0	11.3	150	3.7	.050
9.	SANTA MARGARITA RIVER NEAR FALLBROOK, CALIF.	645.0	46.0	22.0	105	7.3	.055
10.	SANTA MARGARITA RIVER AT YSIDORA, CALIF.	740.0	61.2	34.3	85	9.5	.055
11.	LIVE OAK CREEK AT LIVE OAK DAM, CALIF.	2.3	2.9	1.5	700	0.8	.070
12.	TUJUNGA CREEK AT BIG TUJUNGA DAM, CALIF.	81.4	15.1	7.3	290	2.5	.050
13.	MURRIETA CREEK AT TEMECULA, CALIF.	220.0	27.2	10.3	95	4.0	.050
14.	LOS ANGELES RIVER AT SEPULVEDA DAM, CALIF.	152.0	19.0	9.0	145	3.5	.050
15.	PACOIMA WASH AT PACOIMA DAM, CALIF.	27.8	15.0	8.0	315	2.4	.050
16.	ALHAMBRA WASH ABOVE SHORT STREET, CALIF.	14.0	9.5	4.6	85	0.6	.015
17.	BROADWAY DRAIN ABOVE RAYMOND DIKE, CALIF.	2.5	3.4	1.7	100	0.28	.015
18.	GILA RIVER AT CONNOR NO. 4 DAM SITE, ARIZ.	2840.0	131.0	71.0	29	21.5	.050
19.	SAN FRANCISCO RIVER AT JUNCTION WITH BLUE RIVER, ARIZ.	2000.0	130.0	74.0	32	20.6	.050
20.	BLUE RIVER NEAR CLIFTON, ARIZ	790.0	77.0	37.0	65	10.3	.050
21.	SALT RIVER NEAR ROOSEVELT, ARIZ.	4310.0	160.0	66.0	45	18.6	.050
22.	NEW RIVER AT ROCK SPRINGS, ARIZ.	67.3	20.2	9.7	141	3.1	.045
23.	NEW RIVER AT NEW RIVER, ARIZ.	85.7	23.2	13.6	145	3.7	.045
24.	NEW RIVER AT BELL ROAD, ARIZ.	187.0	47.6	20.7	83	5.3	.037
25.	SKUNK CREEK NEAR PHOENIX, ARIZ.	64.6	17.6	10.0	89	2.4	.033



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

$\bar{n}$=0.200: DRAINAGE AREA HAS COMPARATIVELY UNIFORM SLOPES AND SURFACE CHARACTERISTICS SUCH THAT CHANNELIZATION DOES NOT OCCUR. GROUND COVER CONSISTS OF CULTIVATED CROPS OR SUBSTANTIAL GROWTHS OF GRASS AND FAIRLY DENSE SMALL SHRUBS, CACTI, OR SIMILAR VEGETATION. NO DRAINAGE IMPROVEMENTS EXIST IN THE AREA.

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

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

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

TERMINOLOGY

L = LENGTH OF LONGEST WATERCOURSE.

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

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

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

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

NOTE:
TO OBTAIN THE LAG (IN HOURS) FOR ANY AREA, MULTIPLY THE LAG OBTAINED FROM THE CURVE BY:

$$\frac{\bar{n}}{0.050} \text{ OR } 20\bar{n}$$

GILA RIVER BASIN,
NEW RIVER & PHOENIX CITY STREAMS, ARIZONA

LAG RELATIONSHIPS

U.S. ARMY ENGINEER DISTRICT
LOS ANGELES, CORPS OF ENGINEERS
TO ACCOMPANY DESIGN MEMO NO. 2

PLATE A3

COMPUTATIONAL TIME STEP INTERVAL: "NMIN" (IT CARD: FIELD 1)

BASIN I.D.	LAG TIME	LAG x 5/3=Tc
5A1	0.59	0.983
5A2	0.759	1.265
5A3	0.79	1.317
6A	1.05	1.750
6B	0.58	0.967
6C1	0.72	1.200
6C2	0.67	1.117
		8.598

Therefore Tc(ave)=1.22 hours=73.4 min.

Variable "NMIN" IT-Card: Field 1

SCS Recommended: 0.10 Tc <= NMIN <= 0.25 Tc
(REF: Hydrologic Design Manual for Maricopa Co.)

Assuming Tc=Tc(ave), then
7.3 min <= NMIN <= 18.4 min.
Therefore set NMIN=10 min.

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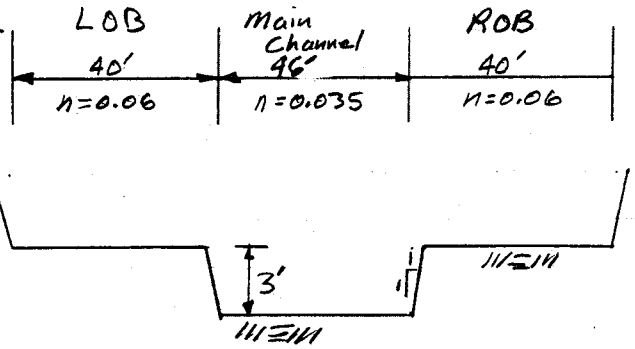
Normal Depth Routing Parameters

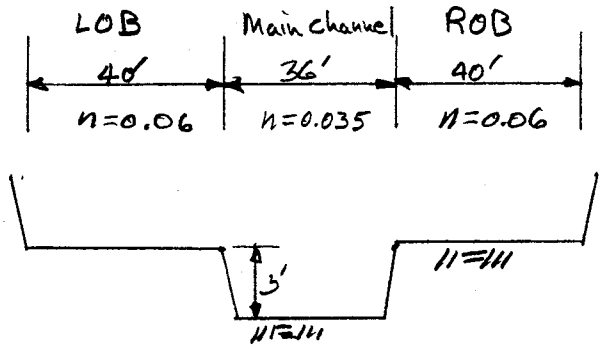
- Routing ID: R1



Gradient: 2%
Reach Length: 20,380 ft
$\bar{V}$bar : 5 fps
Nmin : 10 min

- $NSTPS = \left(\frac{20{,}380'}{5\,fps}\right)\left(10^{-1}\right)\left(\frac{1\,min}{60\,s}\right) = 6.8 \Rightarrow 7$

- Routing ID: R2



Gradient: 2%
Length : 13940
$\bar{V}$bar : 7 fps
Nmin : 10 min

- $NSTPS = \frac{13940'}{7\,fps}\left(10^{-1}\right)\left(60^{-1}\right) = 3.3 \Rightarrow 3$

$$NSTPS = \left(\frac{\text{Reach Length}}{\text{Average Vel}}\right)\left(N_{min}\right)^{-1}\left(\frac{1\,min}{60\,sec}\right) \quad (\text{HEC-1, Manual})$$

Looking at downstream limit of flow diversion-channel on the right is the main channel of Wash 5; whereas, the channel on the left directs flow out of the Study Area.

Looking upstream from the downstream limit of flow diversion-the flow diversion occurs over a distance of several hundred feet along the left bank (located at right in this photograph)

PLATE A4 - FLOW DIVERSION AT CONCENTRATION POINT FOR SUB-BASINS 5A1 & 5A2

Project FEMA Washes 5 & 6
Project No.
Sheet No. of
Calculated by DWD Date 10/91

UNIFORM FLOW COMPUTATIONS

LOCATION/DESCRIPTION:

Main Channel - Wash 5 : Uniform Flow Computations and Summary of Flow Split

CROSS SECTION PARAMETERS: FILENAME: MAIN1.SEC

No. of Cross Section Points:	6	Bed Slope:	0.02000	Max Elev:	14.0
Bank Stations.....Left:	1003.0	Right....:	1017.0	Min Elev:	10.0
Encroachment Stations..Left:	1000.0	Right....:	1057.5		
Manning-n Values.....LOB:	0.045	CHANNEL..:	0.030	ROB.....:	0.055

CROSS SECTION POINTS:

No.	Elev.	Sta.	No.	Elev.	Sta.	No.	Elev.	Sta.	No.	Elev.	Sta.
1)	11.0	1000.0	2)	10.5	1002.5	3)	10.0	1003.0	4)	10.0	1017.0
5)	10.5	1017.5	6)	14.0	1057.5						

COMPUTED PARAMETERS:

WSEL	Q(cfs)	V(fps)	Fr No.	ne	D(ft)	TW(ft)	A(sf)	WP(ft)
10.20	6.6	2.3	0.925	0.030	0.2	14.4	2.8	14.6
10.50	29.9	4.1	1.046	0.031	0.5	15.0	7.3	15.4
11.00	82.5	4.9	1.017	0.034	0.7	23.2	16.8	23.7
11.50	169.8	5.7	0.987	0.037	1.0	28.9	29.8	29.4
12.00	288.9	6.3	0.969	0.040	1.3	34.6	45.7	35.2
13.00	635.4	7.4	0.951	0.043	1.9	46.1	86.1	46.6

NOTES:

Flow Split Summary; Input Data for HEC-1 Model

Stage	Q(cfs) Total	Q split	% split
10.20	17	10	59
10.50	74	44	59
11.00	204	121	59
11.50	531	361	68
12.00	1083	794	73
13.00	2690	2050	76

Project FEMA Washes 5&6
Project No.
Sheet No. of
Calculated by DWD Date 10/91

UNIFORM FLOW COMPUTATIONS

LOCATION/DESCRIPTION:

Split to South - Uniform Flow Computations

CROSS SECTION PARAMETERS: FILENAME: SPLIT1.SEC

No. of Cross Section Points:	19	Bed Slope:	0.02000	Max Elev:	15.0
Bank Stations.....Left:	940.5	Right....:	965.5	Min Elev:	10.0
Encroachment Stations..Left:	775.0	Right....:	1000.0		
Manning-n Values.....LOB:	0.070	CHANNEL..:	0.040	ROB.....:	0.070

CROSS SECTION POINTS:

No.	Elev.	Sta.	No.	Elev.	Sta.	No.	Elev.	Sta.	No.	Elev.	Sta.
1)	15.0	775.0	2)	11.0	845.0	3)	11.0	870.0	4)	10.5	875.0
5)	10.0	875.5	6)	10.0	878.5	7)	10.5	879.0	8)	11.0	884.0
9)	11.0	930.0	10)	10.5	940.0	11)	10.0	940.5	12)	10.0	965.5
13)	10.5	966.0	14)	11.0	980.0	15)	10.5	992.0	16)	10.0	992.5
17)	10.0	997.5	18)	10.5	998.0	19)	11.0	1000.0			

COMPUTED PARAMETERS:

WSEL	Q(cfs)	V(fps)	Fr No.	ne	D(ft)	TW(ft)	A(sf)	WP(ft)
10.20	9.7	1.4	0.576	0.049	0.2	34.2	6.7	34.7
10.50	44.2	2.6	0.652	0.049	0.5	36.0	17.3	37.2
11.00	121.3	2.6	0.603	0.055	0.6	84.0	47.3	85.4
11.50	361.4	2.8	0.570	0.062	0.8	163.8	126.9	165.2
12.00	793.5	3.8	0.599	0.064	1.2	172.5	211.0	173.9
13.00	2051.0	5.2	0.641	0.065	2.1	190.0	392.3	191.4

NOTES:

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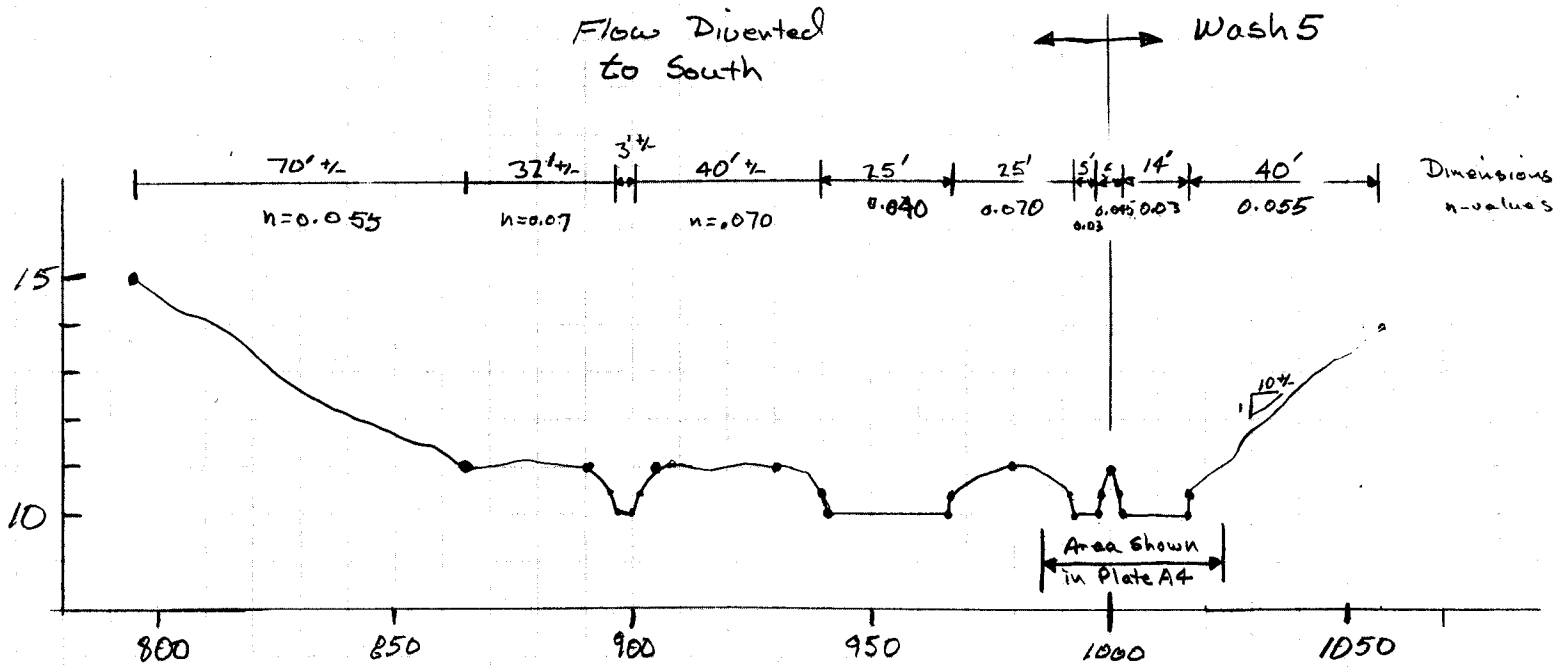
Project FEMA Washes 5A
Project No. _____
Sheet No. _____ of _____
Calculated by DWD Date 10/91
Checked by _____ Date _____



- Cross Section Looking Downstream at Flow Diversion
  Note: Cross Section based on approximate field measurements and aerial photographs.
- Location: Near CP of Sub-basins 5A1 & 5A2

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Project FEMA Washes 5 & 6

Project No.

Sheet No. of

Calculated by DWD Date

Checked by Date

Point List – Flow Diversion

Flow to South

Pt.#	Elev.	STA	n-values
1	15	775	
2	11	845	
3	11	870	
4	10.5	875	
5	10	875.5	n=.070
6	10	878.5	
7	10.5	879	
8	11.0	884	
9	11.0	930	
10	10.5	940	
11	10	940.5	LB n=0.035
12	10	965.5	RB
13	10.5	966	
14	11	980	
15	10.5	992	n=.070
16	10.0	992.5	
17	10.0	997.5	
18	10.5	998.0	
19	11.0	1000	

Wash 5

PT#	Elev.	STA.	n-values
1	11.0	1000	
2	10.5	1002.5	n=0.045
3	10.0	1003.0	LB n=0.030
4	10.0	1017.0	RB
5	10.5	1017.5	n=0.055
6	14.0	1057.5	

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Project FEMA WASHES 5 & 6

Project No.

Sheet No. of

Calculated by Date

Checked by Date

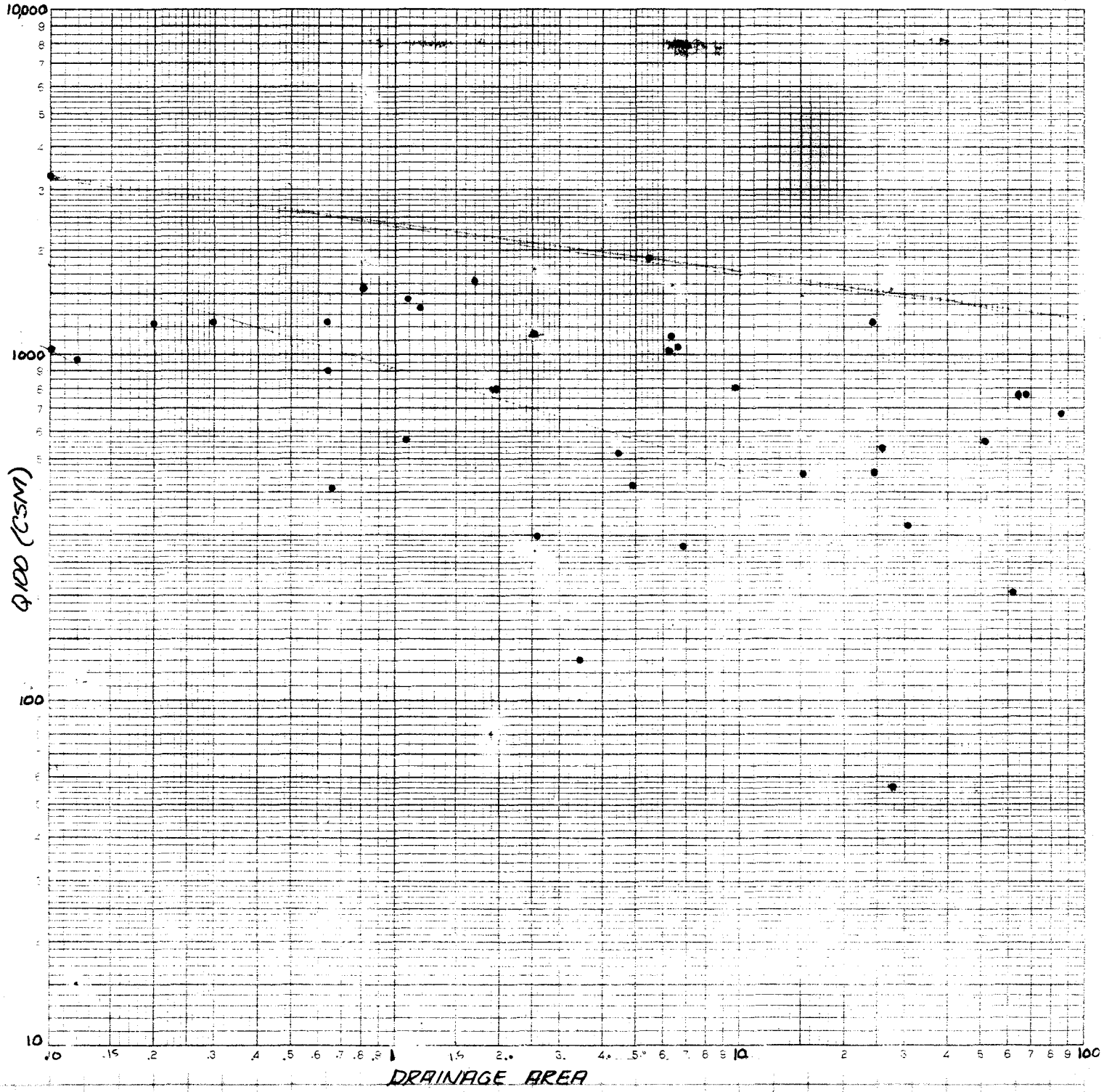

PLATE A5 - PEAK DISCHARGE VERSUS DRAINAGE AREA

PLOT OF DATA PROVIDED IN ROESKE REPORT

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CVL FORM 114

(ROESKE, 1978)

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Project WASHES 5 & 6

Project No.

Sheet No. of

Calculated by Date

Checked by Date

Roeske Data

STA.NO.	DA (mi²)	Q100 (cfs)	Q100 (CSM)	Precip. (in)
09404310	0.2	246	1230	12.2
09505238	0.10	104	1040	24.0
09397800	27.60	1560	56	22.1
09424410	1.99	1590	800	12.0
09424430	1.70	2740	1610	11.2
09424480	6.95	1940	280	10.4
09424700	0.64	574	900	12.1
09468300	0.83	1300	1570	19.0
09496600	0.10	327	3270	18.0
09496700	0.06	170	2830	18.0
09496800	2.55	2940	1150	20.0
09498510	1.09	618	570	22.0
09498600	0.66	271	410	29.0
09498900	6.44	7240	1120	21.0
09501100	0.12	115	960	16.0
09504400	1.19	1640	1380	26.0
09505326	0.30	376	1250	27.0
09505600	3.42	449	130	26.0
09505900	0.64	796	1240	14.5
09507600	6.65	6980	1050	30.0
09507700	4.92	2050	420	27.5
09510080	9.80	7850	800	24.5
09510100	4.49	2340	520	24.5
09510170	2.60	775	300	20.0
09505245	0.60	1510	2520	22.0
09512700	1.11	1640	1480	14.2
09516600	6.31	6520	1030	12.2
09515800	5.57	10600	1900	11.0

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Project WASHES 5&6

Project No.

Sheet No. of

Calculated by Date

Checked by Date

Roeske Data

STA. NO.	DA (mi^2)	Q100 (cfs)	Q100 (CSM)	Precip. (in.)
09467120	30.30	9700	320	16.0
09497900	62.10	12800	206	24.8
09501300	24.30	30,800	1267	15.0
09505300	24.60	11,100	451	22.8
09505320	25.70	13,900	541	25.0
09510150	52.30	29,500	564	23.5
09510180	15.20	6,800	447	16.0
09513780	67.30	51,500	765	20.0
09513800	85.70	58,800	686	19.5
09513860	64.60	48,900	757	12.2

Preliminary FEMA Discharges (7/91)

Table 3. Summary of Discharges (Cont'd)

Flooding Source and Location	Drainage Area (Square Miles)	Peak Discharges (cfs) 10-Year	50-Year	100-Year	500-Year
Basin 1A At Apex	1.46	365	1,124	1,660	3,613
Basin 1B At Apex	1.79	508	1,609	2,380	5,134
Basin 2A At Apex	0.80	343	1,135	1,706	3,794
Basin 2B At Apex	7.88	1,301	3,970	5,844	12,640
Basin 3 At Apex	0.41	210	688	1,039	2,359
Basin 4A At Apex	0.63	285	927	1,395	3,156
Basin 4B At Apex	0.78	326	1,053	1,580	3,551
Basin 4C At Apex	1.78	551	1,739	2,591	5,739
Basin 4D At Apex	9.70	1,739	5,242	7,628	15,932
Basin 5 At Apex	1.99	592	1,849	2,744	6,035

Table 3. Summary of Discharges (Cont'd)

Flooding Source and Location	Drainage Area (Square Miles)	Peak Discharges (cfs) 10-Year	50-Year	100-Year	500-Year
Basin 6A At Apex	3.32	828	2,534	3,735	8,099
Basin 6B At Apex	0.43	230	761	1,151	2,631
Basin 6C At Apex	1.49	508	1,596	2,373	5,239

Appendix B

Frequency Analyses by FCDMC

Appendix B

Frequency Analyses by FCDMC

FREQUENCY ANALYSES OF USGS GAUGE DATA

By the FCDMC

Hydrology
Scottsdale Alluvial Fan

The purpose of this study was to review the results of the hydrolgy for the Flood Insurance Study of the alluvial fan flooding hazards in the Scottsdale area. We decided that the best way to evaluate these results were to compare them with U S Geological Survey Streamflow data, results of other studies, and by doing a similiar study using the methodology described in the Hydrologic Design Manual for Maricopa County, Arizona. Because of the work involved and the fact that only streams 5 and 6 affect the area within the unincorporated county, we decided to do the comparison only on these streams rather than for the entire study. If the results from our assessment compared with those from the Flood Insurance Study, for these areas, we could then assume that the entire study was reasonable. If they disagreed, we would assume that the hydrology for the entire Flood Insurance Study would need to be reevaluated.

Per FEMA's Contractors Study Guidelines, the first requirement in developing hydrology, is the use of U S Geological Survey data and performing Log Pearson III analysis. Based on this, we performed Log Pearson III analysis for the U S Geological Survey gaged streamflow sites in Maricopa County, where regulation is not a major factor. From this analysis table 1 was developed, showing the drainage area, the period of record, and the 100-year discharge, which had been determined by the Log Pearson III analysis, both in CFS and CFS/SQ. MI., for each of the gaged sites. This data was then plotted as CFS/SQ. MI. versus drainage area as shown on figure 1. Lines were then drawn through this plotted data showing MAXIMUM and AVERAGE expected values. These are shown on figure 1. We then designated those streamflow stations with physical characteristics that may be somewhat similiar to streams 5 and 6. A line was then drawn through the average of the values for these sites as shown on figure 2. This analysis of streamflow data should give a reasonable guide for 100-year discharges developed from other methods, such as, rainfall runoff models for areas within Maricopa County.

Our next step was to look at the analysis performed by Water Resources Associates, Inc., September 25, 1989, "Concept Drainage Study, Paradise Valley Fan Terrace, Part of Peripheral Areas C and D". Figures 3 and 4 were taken from that report. They compare the results of their study with other studies, one of which is a study by Eychaner of the U S Geological Survey. Figure 5 shows the results of the Water Resources Associates, Inc. study and the results of our data analysis. From this, it can be seen that their results and the results of the U S Geological Survey study compared well with our analysis of the streamflow data.

We then developed a rainfall runoff model for streams 5 and 6 using the methodology described and recommended in the Hydrologic Design Manual for Maricopa County. This methodology includes using the HEC-1 computer model with the Green and Ampt method used to estimate rainfall losses, the S-graph method for unit hydrograph, and a 24-hour, 100-year storm with SCS type II rainfall distribution. We also ran the model using the rainfall that was used in the Flood Insurance study, a 24-hour, 100-year, storm with SCS type IIA rainfall distribution. The results from both of these were then plotted along with the results from figure 5. These plots are shown on figure 6. Comparison on figure 6 indicate that the results from the rainfall runoff analysis seem to be reasonable based on the analysis of the data and the previous studies.

The values obtained from the report, received for review, for the Flood Insurance Study were then plotted and compared with these other results. This is shown in figure 7 and table 2. This indicates that the results from the Flood Insurance Study, approach or exceed, the results of the vary highest values determined from any of the streamflow data. They also greatly exceed the results from the other studies including the rainfall runoff model developed using the Hydrologic Design Manual for Maricopa County

The highest value for a streamflow station in Maricopa County, from the Log Pearson III analysis, was for the Salt River Tributary in South Mountain Park, Station No. 9 on table 1. A physical comparison was made between the drainage basin for the Salt River Tributary and for streams 5 and 6. Figures 8 and 9 show these basins outlined on topographic maps and figures 10 and 11 show photographs of the areas. From these, it can be seen that the Salt River Tributary is a nearly square basin with very steep sides while Streams 5 and 6 are long narrow basins with no side drainage. In fact, streams 5 and 6 resemble a mesa that is sloping. From this comparison you would expect the runoff from the Salt River Tributary to be considerably greater than that for streams 5 and 6.

Our conclusion from this study is that the 100-year discharges determined for the Flood Insurance study are extremeny high, probably two to three times what would be expected. We would expect results in the same range as what are determined using the Hydrologic Design Manual for Maricopa County with the SCS type II rainfall distribution. We thus believe, that based on this analysis, a carefull review of the methods used for the Flood Insurance Study should be made for the entire basin. We strongly feel that the results of rainfall runoff modeling must be compared with streamflow data from similiar type drainage basins, to insure that the best results are obtained.

Table 1. Summary of Log Pearson III Analysis for Maricopa County.

ID NO.	STATION NO.	STATION NAME	D.A. MI2	RECORD PERIOD	100-YEAR DISCHARGE CFS/MI2	100-YEAR DISCHARGE CFS
1	510070	W FK SYCAMORE CR N SUNFL	4.58	66-74		
				83-86	917	4,200
2	510080	W FY SYCAMORE CR N SUNFL	9.8	61-79	1,000	9,800
3	510100	E FK SYCAMORE CR N SUNFL	4.49	61-86	957	4,300
4	510150	SYCAMORE CR N SUNFLOWER	53.4	62-76	824	44,000
5	510170	CAMP CR NR SUNFLOWER	2.6	63-79	346	900
6	510180	ROCK CR NR SUNFLOWER	15	63-72	373	5,600
7	510200	SYCAMORE CR NR FT MCDOWELL	165	60-89	312	51,400
8	512100	INDIAN BEND WASH NR SCOTTS	142	61-84	293	41,600
9	512200	SALT R TRIB IN S MTN PK	1.75	61-89	1,714	3,000
10	512300	CAVE CR NR CAVE CREEK	121	58-89	165	20,000
11	513780	NEW R NR ROCK SPRINGS	67.3	62-89	602	40,500
12	513800	NEW R AT NEW RIVER	85.7	61-82	501	42,900
13	513820	DEADMAN WASH NR NEW RIVER	11.1	60-79	504	5,600
14	513860	SKUNK CR NR PHOENIX	64.6	60-89	467	30,200
15	514200	WATERMAN WASH NR BUCKEYE	403	64-90	21	8,600
16	515500	HASSAYAMPA R @ B D N WICK	417	46-83	120	50,300
17	515800	HARTMAN WASH NR WICKENBURG	5.57	64-79	1,400	7,800
18	516500	HASSAYAMPA R NR MORRISTOWN	774	39-42		
				64-89	85	65,700
19	516600	OX WASH NR MORRISTOWN	7.44	63-79	618	4,600
20	516800	JACKRABBIT WASH NR TONOPAH	137	64-79	237	32,500
21	517200	CENTENNIAL W TRIB NR WENDEN	2.79	63-79	394	1,100
22	517280	TIGER WASH NR AGUILA	85.2	63-79	121	10,300
23	517400	WINTERS WASH NR TONOPAH	47.8	62-79	92	4,400
24	519600	RAINBOW WASH TRIB N BUCKEYE	3.45	63-79	609	2,100
25	519750	BENDER WASH NR GILA BEND	68.8	63-79	190	13,100
26	519760	SAUCEDA WASH NR GILA BEND	126	63-79	90	11,300
27	520100	MILITARY WASH NR SENTINEL	8.70	63-79	551	4,800
28	520200	BLACK GAP WASH NR AJO	12.1	63-79	116	1,400
29	520230	CRATER RANGE WASH NR AJO	1.49	63-79	1,275	1,900

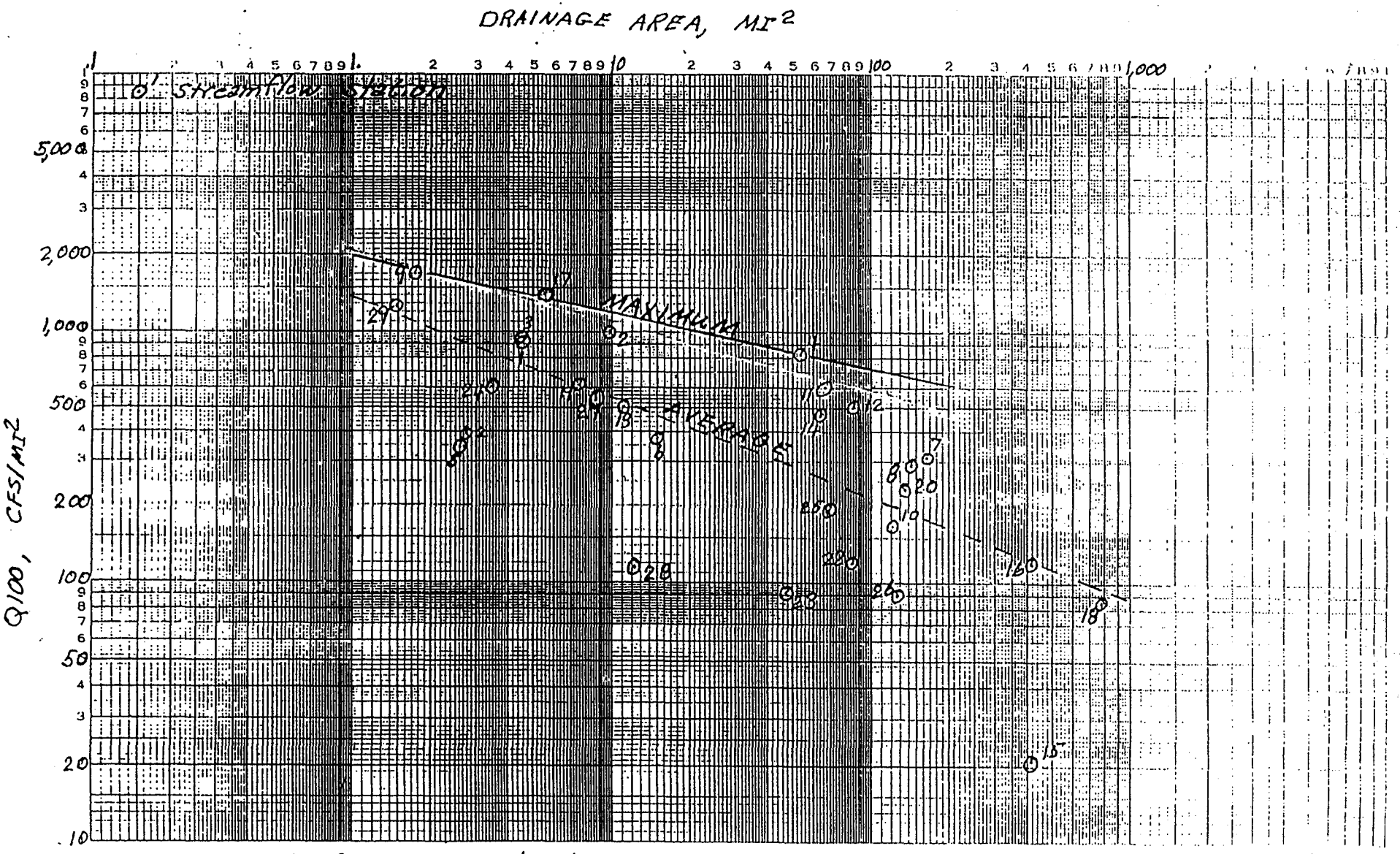


Figure 1.- Plot of 100-year discharge, from Log Pearson III Analysis, for streamflow stations in Maricopa County.

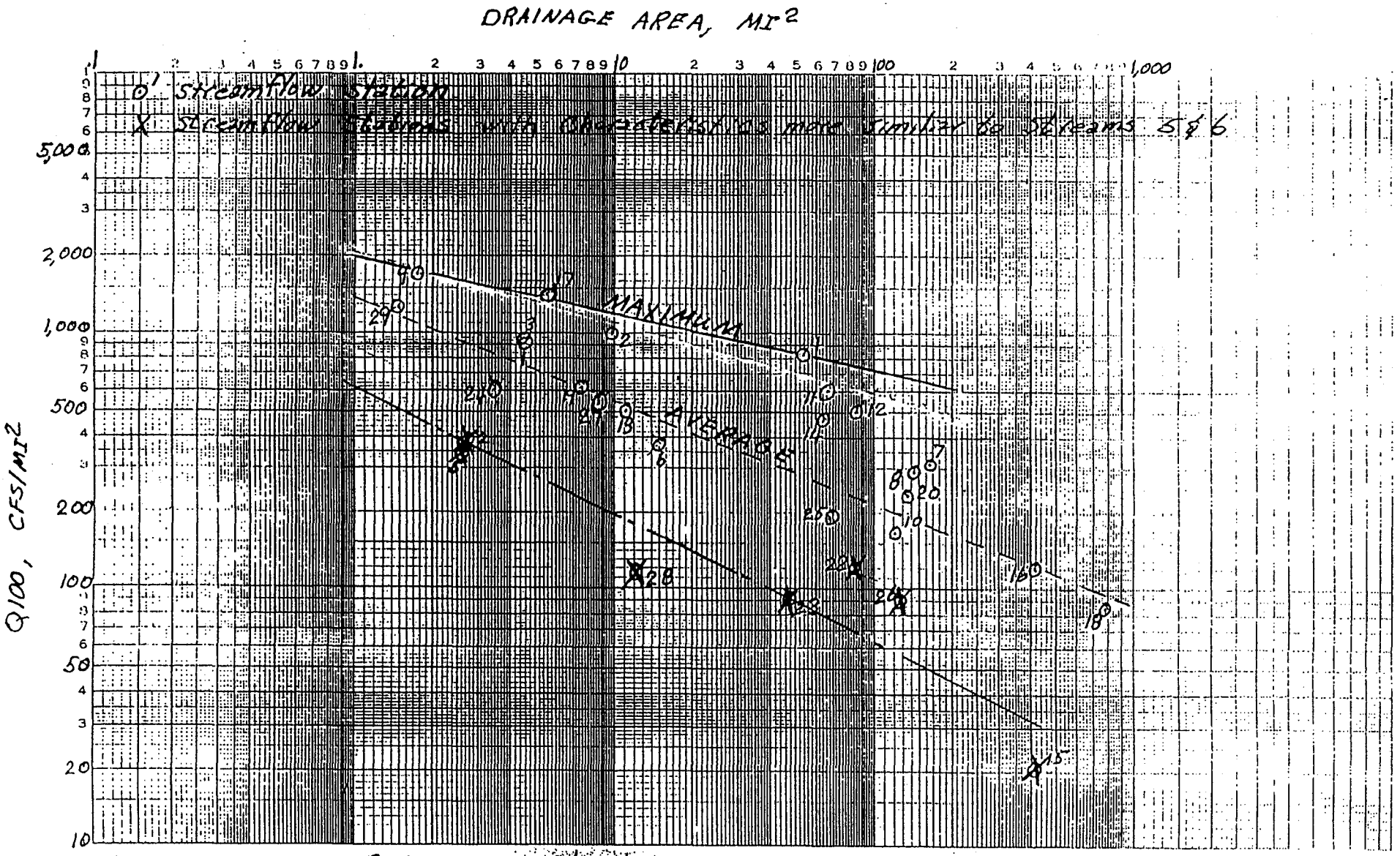
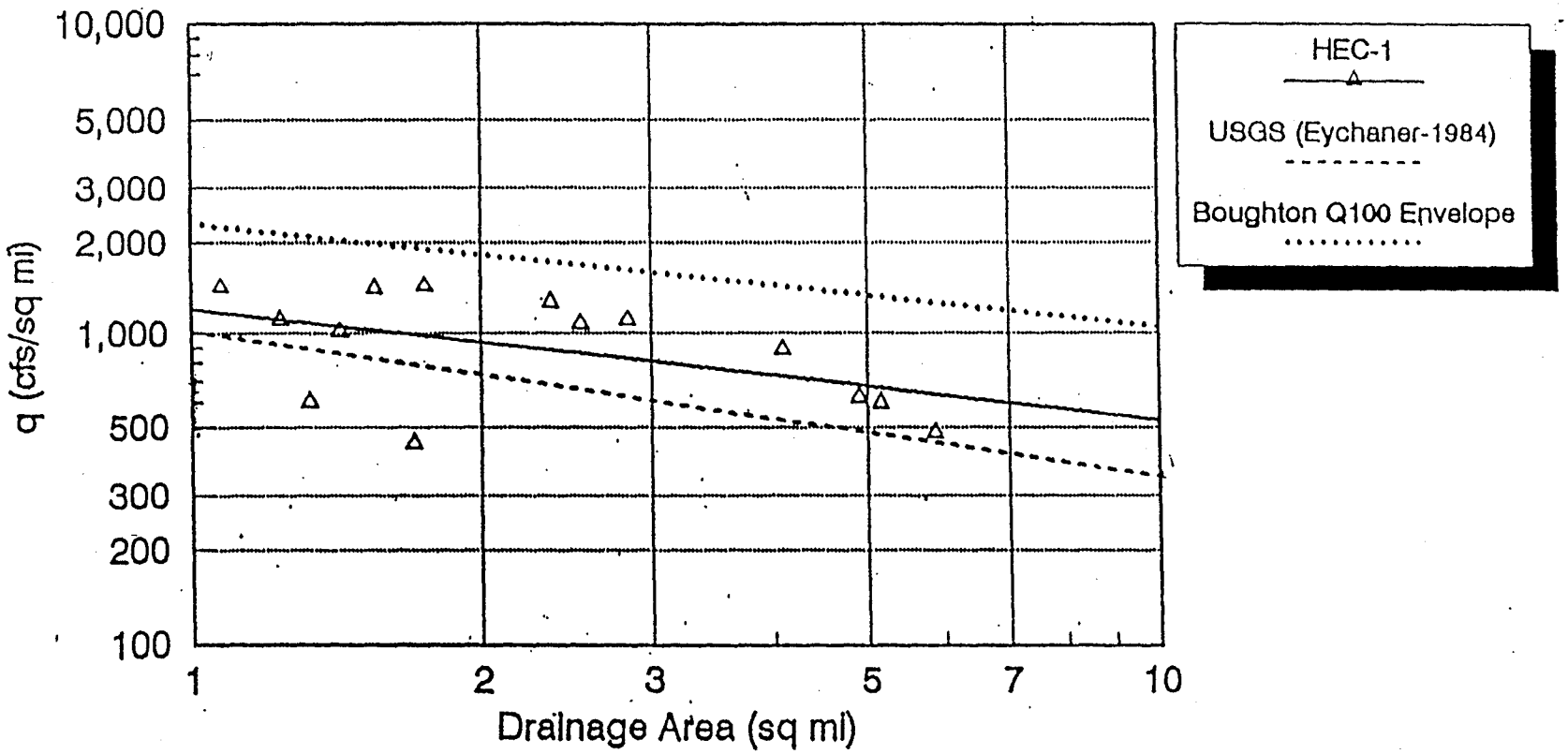


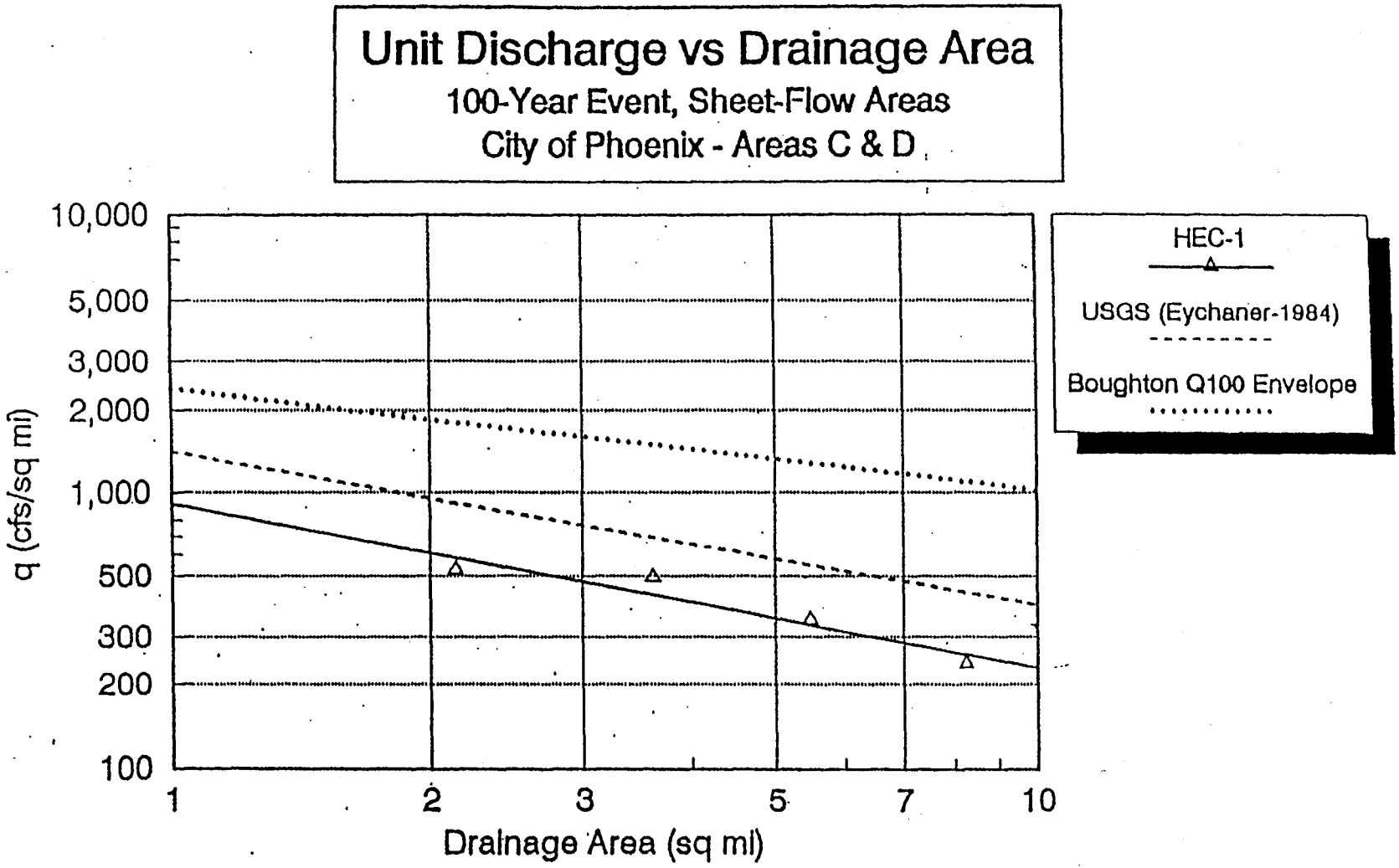
Figure 2.- Plot of 100-year discharges, showing stations more similar to streams 5 and 6.



USGS Data from Primary Equations (Table 1)
HEC-1 data based on 24-hour, SCS Type IIA Storm
AMC II

Water Resources Associates, Inc.	UNIT DISCHARGE VS. DRAINAGE AREA 100-YEAR EVENT NON-SHEETFLOW AREAS	FIGURE 3.10
PROJECT NO. AC00060 DRAWN BY RLW DATE 9/25/89 CHECKED BY JJH		

Figure 3.- Plot of 100-year discharge determined by Water Resources Associates, Inc, Compared with other studies for non-sheetflow areas.



USGS Data from Primary Equations (Table 1)
HEC-1 data based on 24-hour, SCS Type IIA Storm
AMC II

Water Resources Associates, Inc.	UNIT DISCHARGE VS. DRAINAGE AREA 100-YEAR EVENT SHEETFLOW AREAS	FIGURE 3.11
PROJECT NO AC00060 DRAWN BY RLW		
DATE 9/25/89 CHECKED BY JNH		

Figure 4.— Plot of 100-year discharge determined by Water Resources Associates, Inc, Compared with other studies for sheetflow areas.

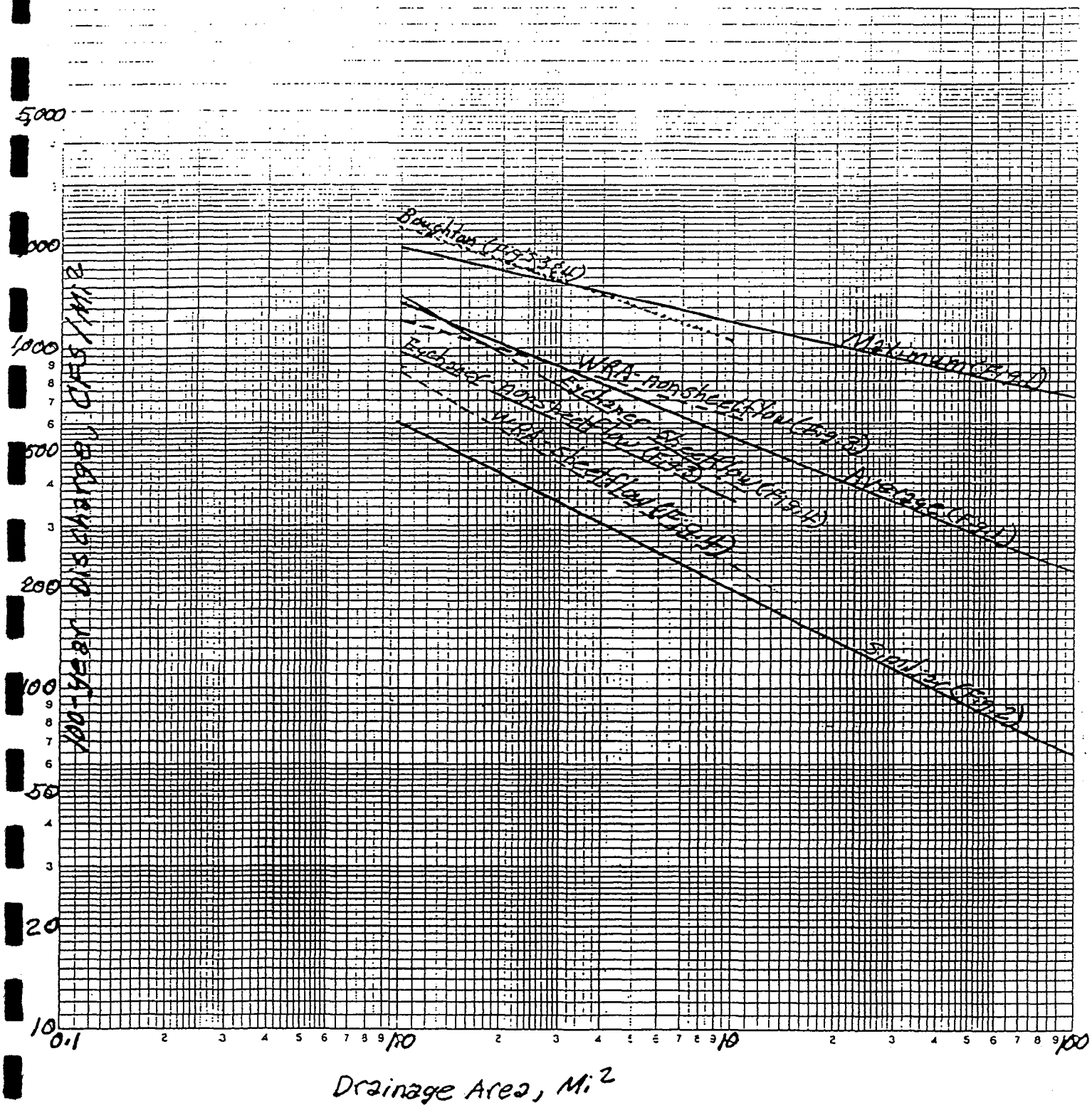


Figure 5.- Comparison of results shown on figures 1-4.

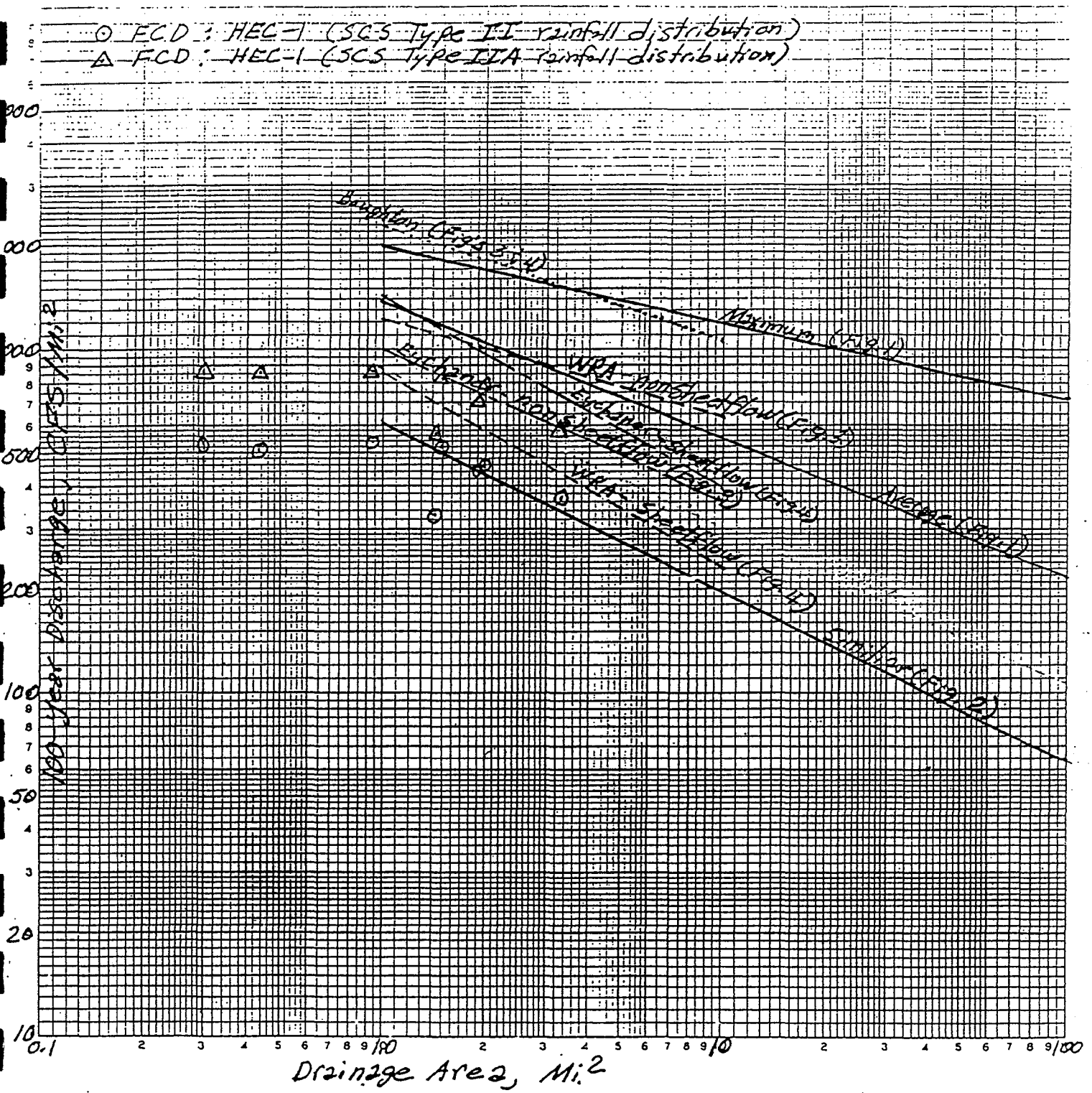


Figure 6.- Comparison of FCD Rainfall Runoff model results with resuts from Streamflow data and Water Resources Associates, Inc. Study.

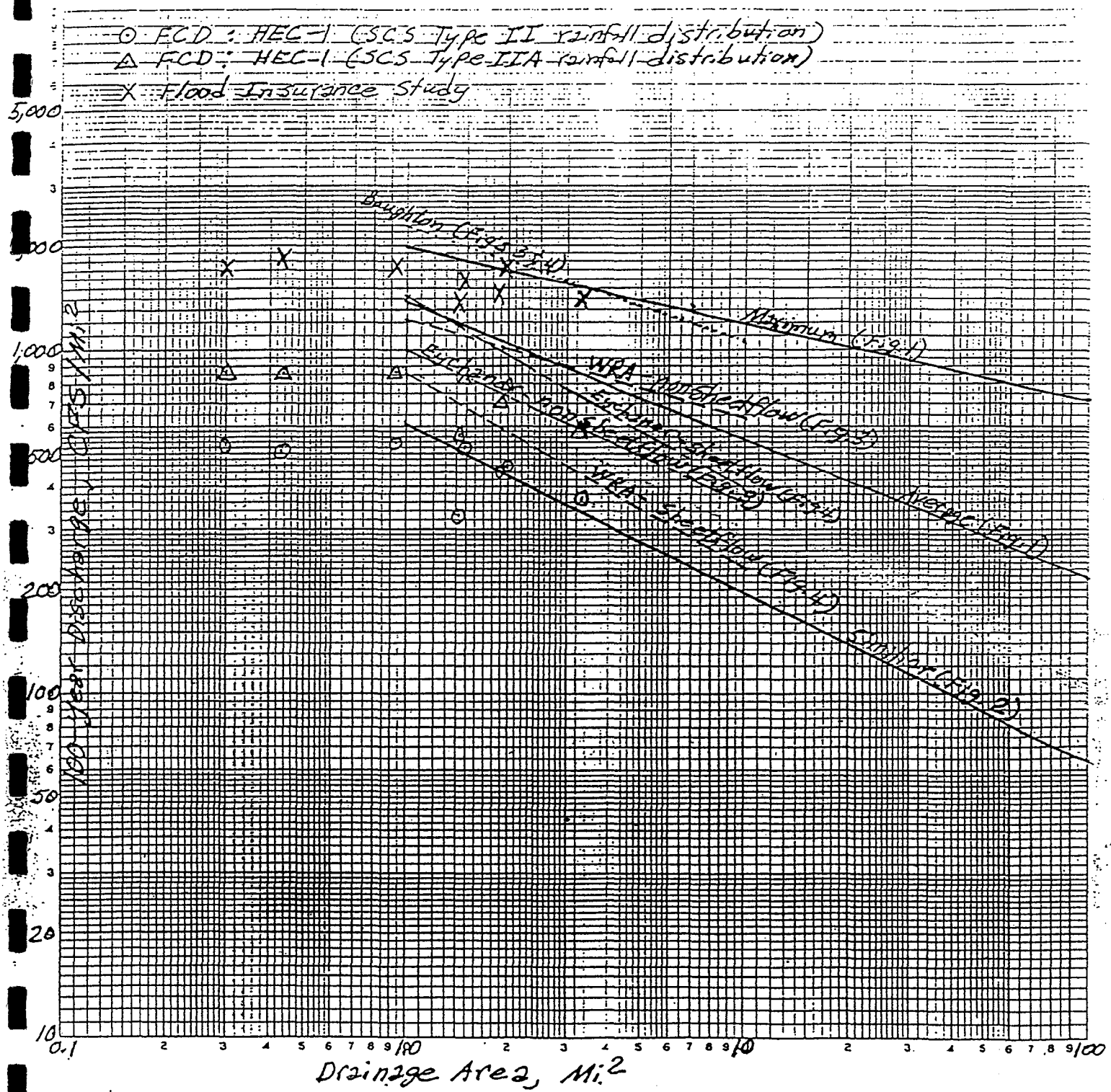


Figure 7.– Comparison of 100-year discharges from Flood Insurance Study with the Streamflow data Analysis, Water Resources Associates, Inc. Study and Flood Control District study.

Table 2. Comparison of results by each study method.

100-Year Discharges, in CFS/Sq. Mi.

Basin	D. A. Sq. Mi.	Sheet Flow Eychaner	Sheet Flow WRA, Inc	Non Sheet Flow Eychaner	Non Sheet Flow WRA, Inc
1380	0.93	1,500	890	1,010	1,230
1390N	1.49	1,140	680	830	1,090
1390S	.43				
1430	1.43	1,180	700	840	1,100
1440	1.89	990	600	760	1,020
1441	3.32	730	440	600	860
1470	.30				
1475	1.99	970	580	740	1,000

Table 2. Continued.

100-Year Discharge, in CFS/Sq. Mi.

Basin	Log Pearson III Average All Sta.	Log Pearson III Average Similiar Sta.	MCFCD Type II Rainfall	MCFCD TypeIIA Rainfall	Flood Insurance Study
1380	1,400	640	540	860	1,770
1390N	1,170	510	520	840	1,600
1390S			510	860	1,860
1430	1,190	520	330	570	1,370
1440	1,070	460	440	710	1,470
1441	850	340	370	610	1,400
1470			530	870	1,730
1475	1,040	450	460	800	1,740

EXHIBIT 4: APEXES ASSOCIATED WITH DRAINAGE BASINS

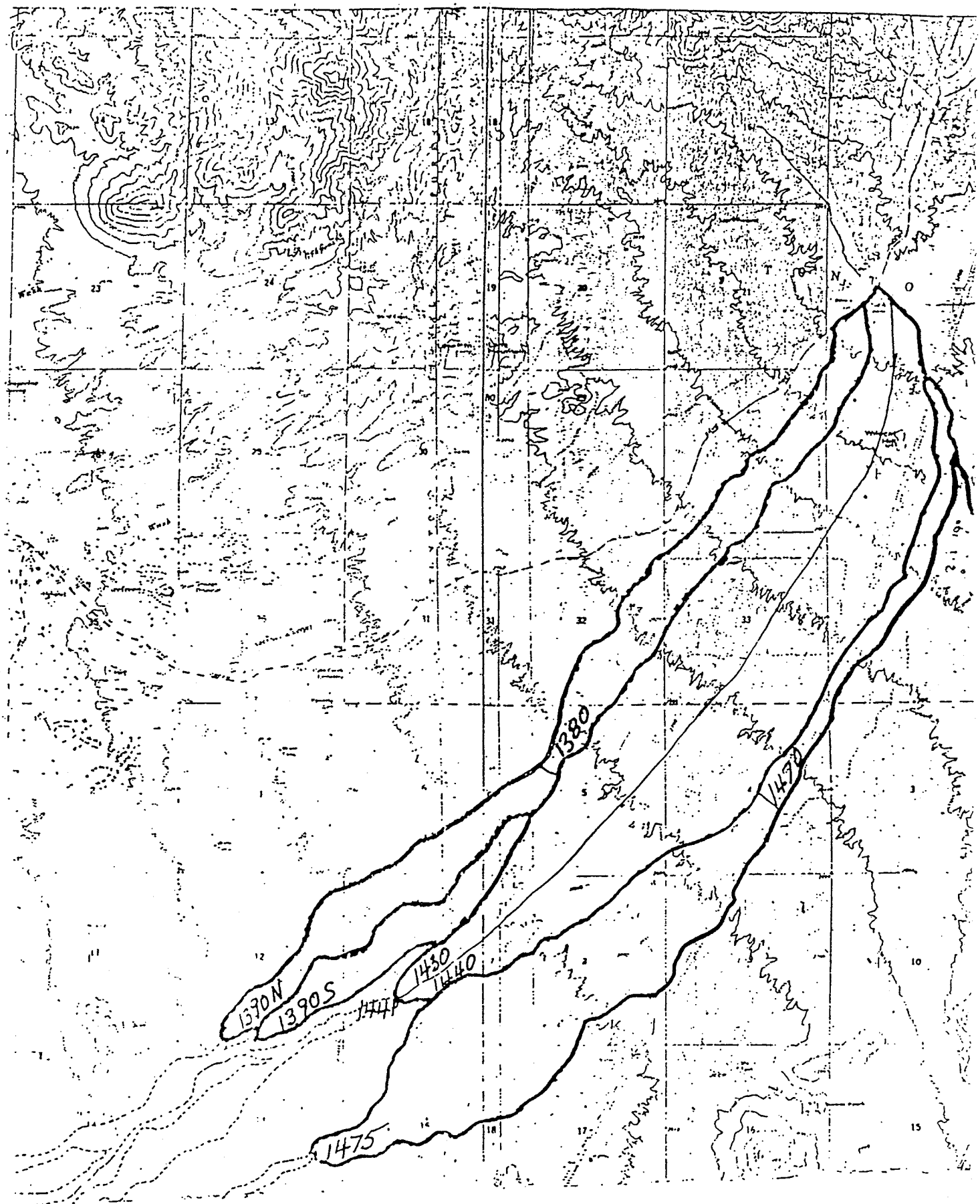


Figure 8.- Streams 5 and 6, Drainage basins.

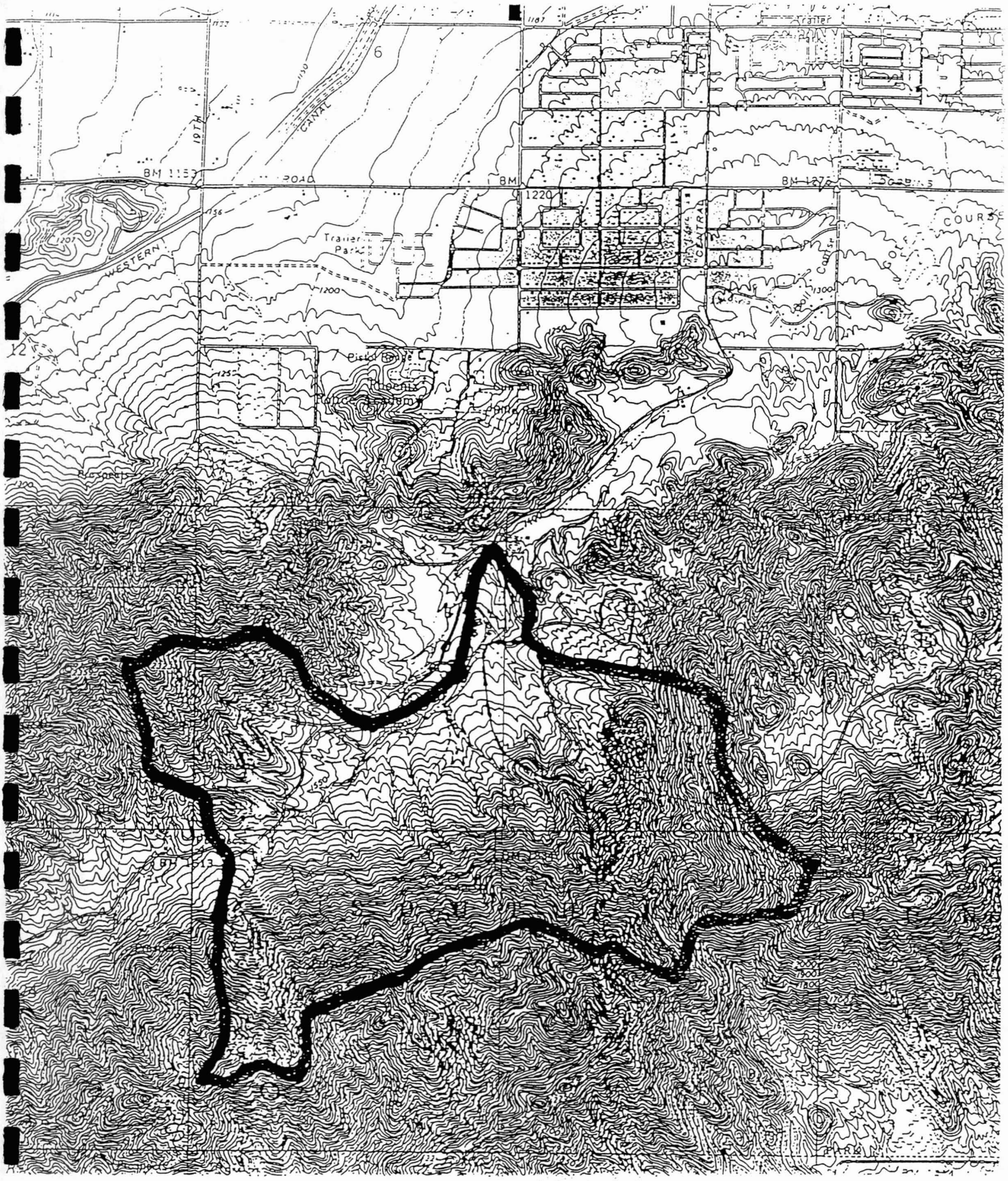
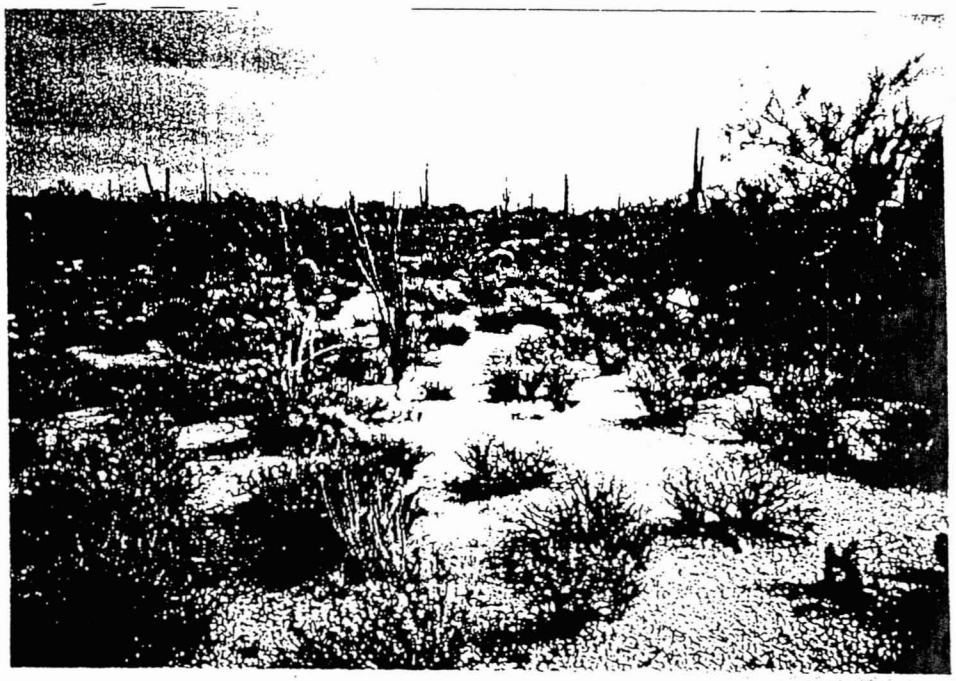
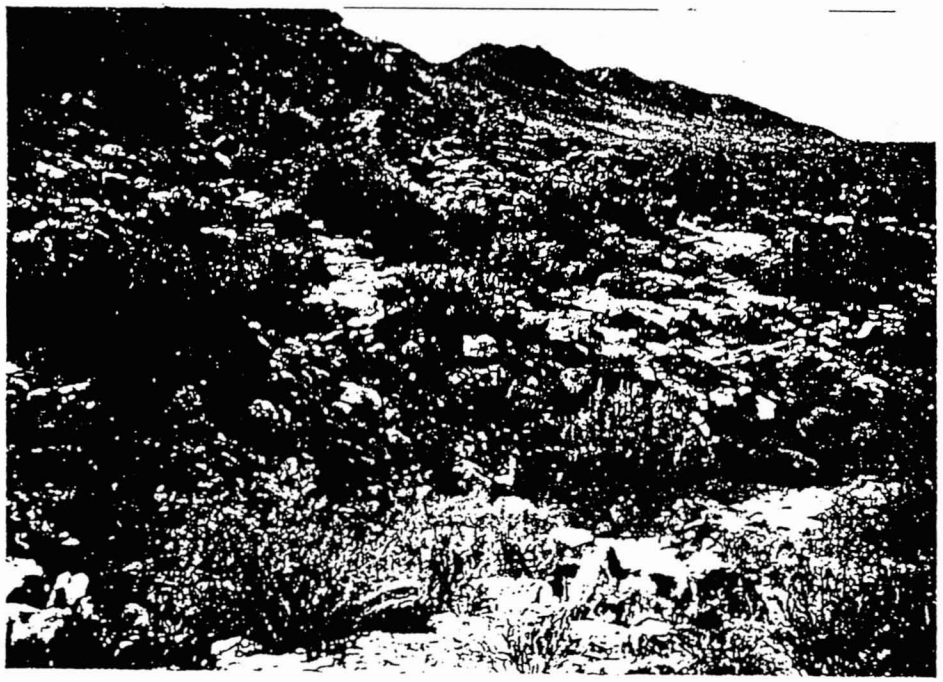


Figure 9. – Salt River Tributary in South Mountain Park, Drainage basin.



Looking (east) upstream through the basin

Figure 10. - SCOTTSDALE ALLUVIAL FAN



Looking upstream along the east side of the basin

Looking downstream in the channel at the lower end of the basin

Figure 11. - SOUTH MOUNTAIN TRIBUTARY

PROVISIONAL - SUBJECT TO REVISION

GILA RIVER BASIN

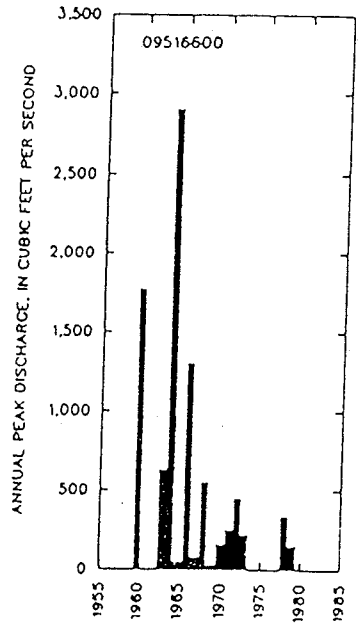
09516600 OX WASH NEAR MORRISTOWN, AZ

LOCATION.--Lat 33°53'00", long 112°39'00", in NW¼ sec.11, T.6 N., R.4 W., Maricopa County, Hydrologic Unit 15070103, at U.S. Highway 60, 2.4 mi northwest of Morristown.

DRAINAGE AREA.--6.31 mi^2.

ANNUAL PEAK DISCHARGE

WATER YEAR	DATE	ANNUAL PEAK DISCHARGE (FT^3/S)	DISCHARGE CODES
1960	00-00-60	1,770	HP
1963	08-26-63	628	
1964	08-26-64	2,900	
1965	09-02-65	50	ES
1966	09-13-66	1,300	
1967	09-00-67	80	ES
1968	00-00-68	550	
1969	01-15-69	30	
1970	09-05-70	160	
1971	08-20-71	250	
1972	09-00-72	450	
1973	10-00-72	220	
1974	00-00-74	0	
1975	00-00-75	0	
1976	00-00-76	0	
1977	00-00-77	0	
1978	02-22-78	335	
1979	12-18-78	150	ES



MAGNITUDE AND PROBABILITY OF INSTANTANEOUS PEAK FLOW BASED ON 17 YEARS OF RECORD

1960, 1963-79

DISCHARGE, IN FT^3/S, FOR INDICATED RECURRENCE INTERVAL IN YEARS, AND EXCEEDANCE PROBABILITY, IN PERCENT

2	5	10	25	50	100
50%	20%	10%	4%	2%	1%
194	662	1,240	2,400	3,660	5,330

WEIGHTED SKEW (LOGS)= -0.10
MEAN (LOGS)= 2.28
STANDARD DEV. (LOGS)= 0.64

BASIN CHARACTERISTICS

MAIN CHANNEL SLOPE (FT/MI)	STREAM LENGTH (MI)	MEAN BASIN ELEVATION (FT)	FORESTED AREA (PERCENT)	SOIL INDEX	MEAN ANNUAL PRECIPITATION (IN)	RAINFALL INTENSITY, 24-HOUR 2-YEAR (IN)	RAINFALL INTENSITY, 24-HOUR 50-YEAR (IN)
101	6.6	2,290	0.0	3.0	12.2	1.8	3.8

X

PROVISIONAL - SUBJECT TO REVISION

GILA RIVER BASIN

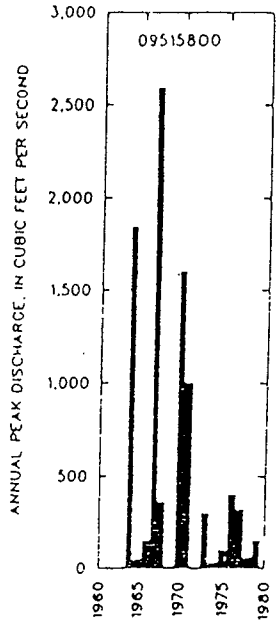
09515800 HARTMAN WASH NEAR WICKENBURG, AZ

LOCATION.--Lat 33°57'46", long 112°49'40", in SE¼ sec.12, T.7 N., R.6 W., Maricopa County, Hydrologic Unit 15070103, at U.S. Highway 60, 5.7 mi west of Wickenburg.

DRAINAGE AREA.--5.57 mi^2.

ANNUAL PEAK DISCHARGE

WATER YEAR	DATE	ANNUAL PEAK DISCHARGE (FT^3/S)	DISCHARGE CODES
1964	08-23-64	1,840	
1965	09-04-65	50	
1966	09-13-66	150	
1967	08-14-67	2,600	
1968	12-19-67	360	
1969	08-00-69	5.0	ES
1970	09-05-70	1,600	
1971	08-19-71	1,000	
1972	09-03-72	0.5	ES
1973	10-07-72	300	ES
1974	07-30-74	35	ES
1975	07-13-75	100	
1976	09-25-76	400	ES
1977	09-27-77	320	ES
1978	01-17-78	60	ES
1979	11-11-78	150	ES



MAGNITUDE AND PROBABILITY OF INSTANTANEOUS PEAK FLOW
BASED ON 16 YEARS OF RECORD
1964-79

DISCHARGE, IN FT^3/S, FOR INDICATED RECURRENCE INTERVAL
IN YEARS, AND EXCEEDANCE PROBABILITY, IN PERCENT

2	5	10	25	50	100
50%	20%	10%	4%	2%	1%
218	796	1,550	3,150	4,960	7,450

WEIGHTED SKEW (LOGS)= -0.05
MEAN (LOGS)= 2.33
STANDARD DEV. (LOGS)= 0.67

BASIN CHARACTERISTICS

MAIN CHANNEL SLOPE (FT/MI)	STREAM LENGTH (MI)	MEAN BASIN ELEVATION (FT)	FORESTED AREA (PERCENT)	SOIL INDEX	MEAN ANNUAL PRECIPITATION (IN)	RAINFALL INTENSITY, 24-HOUR 2-YEAR (IN)	50-YEAR (IN)
71.6	5.4	2,690	0.0	3.0	11.0	1.6	3.8

RECEIVED JAN 9 1991 PROVISIONAL - SUBJECT TO REVISION

GILA RIVER BASIN

09516500 HASSAYAMPA RIVER NEAR MORRISTOWN, AZ

LOCATION.--Lat 33°53'06", long 112°39'41", in SW¼SE¼ sec.3, T.6 N., R.4 W., Maricopa County, Hydrologic Unit 15070103, 3.0 mi northwest of Morristown, 7 mi southeast of Wickenburg.

DRAINAGE AREA.--796 mi^2.

ANNUAL PEAK DISCHARGE

WATER YEAR	DATE	ANNUAL PEAK DISCHARGE (FT^3/S)	DISCHARGE CODES	WATER YEAR	DATE	ANNUAL PEAK DISCHARGE (FT^3/S)	DISCHARGE CODES
1939	09-06-39	6,200		1971	08-18-71	2,000	
1940	02-01-40	160		1972	08-27-72	700	
1941	03-02-41	6,100		1973	10-07-72	2,000	
1942	08-05-42	100	ES	1974	07-20-74	650	ES
1943	08-03-43	7,700		1975	07-29-75	50	LT
1944	08-09-44	3,520		1976	02-09-76	800	
1945	08-02-45	2,200		1977	08-15-77	1,600	ES
1946	09-17-46	2,310		1978	03-02-78	18,000	
1947	08-08-47	6,000		1979	12-18-78	9,600	
1954	00-00-54	0		1980	02-20-80	17,000	
1956	00-00-56	0		1981	07-10-81	4,800	
1964	07-12-64	4,000	ES	1983	03-03-83	2,520	
1965	09-02-65	9,280		1984	09-10-84	26,700	
1966	09-13-66	3,210		1985	12-28-84	848	
1967	09-00-67	1,150		1986	11-26-85	2,740	
1968	12-19-67	4,800		1987	11-18-86	714	
1969	09-13-69	650		1988	08-27-88	6,820	
1970	09-05-70	[1]47,500		1989	01-04-89	1,210	

[1]Highest since 1916.

MAGNITUDE AND PROBABILITY OF INSTANTANEOUS PEAK FLOW
BASED ON PERIOD OF RECORD 1939-47, 1964-81, 1983-89

DISCHARGE, IN FT^3/S, FOR INDICATED RECURRENCE INTERVAL IN YEARS, AND EXCEEDANCE PROBABILITY, IN PERCENT

2	5	10	25	50	100†
50%	20%	10%	4%	2%	1%
2,670	7,180	12,200	21,500	31,300	43,900

WEIGHTED SKEW (LOGS)= 0.10
MEAN (LOGS)= 3.43
STANDARD DEV. (LOGS)= 0.50

† Reliability of values in column is uncertain, and potential errors are large.

BASIN CHARACTERISTICS

MAIN CHANNEL SLOPE (FT/MI)	STREAM LENGTH (MI)	MEAN BASIN ELEVATION (FT)	FORESTED AREA (PERCENT)	SOIL INDEX	MEAN ANNUAL PRECIPITATION (IN)	RAINFALL INTENSITY, 24-HOUR 2-YEAR (IN)	RAINFALL INTENSITY, 24-HOUR 50-YEAR (IN)
84.9	58.4	3,190	5.2	1.72	16.9	2.2	4.3

~~44~~
~~58~~
590

DVSTAT - DAILY VALUES STATISTICAL PROGRAM

JAN

STATION ID - 09516500
HASSAYAMPA RIVER NR MORRISTOWN, ARIZ

HIGHEST MEAN VALUE AND RANKING FOR THE FOLLOWING NUMBER OF CONSECUTIVE DAYS
FOR PERIOD OCT TO SEP

WATER YEAR RANGE	1		3		7		15		30		60		90		120		183	
1939 1939	1200	2	431	2	249	3	137	3	70.6	4	37.4	4	25.0	4	18.7	4	12.5	4
1940 1940	20.0	7	15.0	7	8.36	7	5.20	7	3.30	7	2.25	8	2.27	8	2.07	8	1.53	8
1941 1941	2050	1	1500	1	1114	1	696	1	354	1	455	1	349	1	265	1	180	1
1942 1942	10.0	8	4.33	8	3.00	8	3.00	8	2.73	8	2.45	7	2.32	7	2.16	7	1.83	7
1943 1943	733	3	252	5	112	5	79.5	5	39.7	5	21.4	5	14.3	5	10.7	5	7.07	5
1944 1944	494	4	257	4	159	4	105	4	85.3	3	55.8	3	39.0	3	29.9	3	20.5	3
1945 1945	494	5	423	3	239	2	192	2	124	2	76.3	2	52.3	2	39.7	2	27.1	2
1946 1946	273	6	136	6	60.0	6	29.6	6	19.5	6	17.1	6	11.9	6	8.89	6	5.90	6

DVSTAT - DAILY VALUES STATISTICAL PROGRAM

STATION ID - 01516500
NASSAYAMPA RIVER NR MORRISTOWN, ARIZ.

ANNUAL AND/OR SEMI-ANNUAL VALUES

MEAN VALUE AND RANKING FOR
PERIOD INCLUDED IN HIGH-VALUE ANALYSIS
(OCT-SEP)

WATER YEAR RANGE			
1939	1939	9.09	4
1940	1940	.86	8
1941	1941	93.9	1
1942	1942	1.10	7
1943	1943	3.96	5
1944	1944	11.5	3
1945	1945	14.1	2
1946	1946	3.68	6

Appendix C

HEC-1 Output

```
****************************************
*                                      *
*   FLOOD HYDROGRAPH PACKAGE  (HEC-1)  *
*           SEPTEMBER 1990             *
*            VERSION 4.0               *
*                                      *
*  RUN DATE  11/09/1991  TIME  13:24:12 *
*                                      *
****************************************
```

```
****************************************
*                                      *
*   U.S. ARMY CORPS OF ENGINEERS       *
*   HYDROLOGIC ENGINEERING CENTER      *
*         609 SECOND STREET            *
*      DAVIS, CALIFORNIA 95616         *
*          (916) 756-1104              *
*                                      *
****************************************
```

```
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

100YR Event

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

  1           ID        TATUM RANCH/DESERT FLOWER - "FANS 5 & 6" (FAN8A.O)
  2           ID        RAINFALL DISTRIBUTION : SCS TYPE IIa
  3           ID        100 YEAR RAINFALL = 4.65 " (per NOAA ATLAS)
  4           ID        LAG TIMES: CORPS OF ENGINEERS LAG EQUATION
  5           ID        CURVE NUMBERS: RANGE 80 TO 84
  6           ID                VEGETATION: FAIR
  7           ID                SOIL TYPES: B, C & D
  8           ID        DEPTH AREA REDUCTION FACTORS(PER NOAA HYDRO-40)
  9           ID        AREA(SQMI)      %
 10           ID        ---------------------
 11           ID         0             1.0
 12           ID         1             0.99
 13           ID         2             0.98
 14           ID         3             0.97
 15           ID         4             0.965
 16           ID        ---------------------
              *DIAGRAM
 17           IT      10                     300
 18           IO       5       0
 19           JR    PREC   1.000    0.99   0.980   0.970   0.965

 20           KK    S5A1
 21           KM    SUB BASIN 5A1
 22           KM    SCS TYPEIIA DISTRIBUTION PER PARADISE VALLEY FAN TERRACE, CONCEPT
 23           KM    DRAINAGE STUDY
 24           IN      30
 25           PB    4.65
 26           PC     0.0   .0050  0.0090  0.0100  0.0130  0.0190  0.0210  0.0280  0.0320  0.0440
 27           PC  0.0570  0.1000  0.6600  0.7450  0.7760  0.8000  0.8160  0.8300  0.8400  0.8500
 28           PC  0.8610  0.8680  0.8780  0.8840  0.8910  0.9000  0.9050  0.9120  0.9190  0.9230
 29           PC  0.9300  0.9340  0.9390  0.9440  0.9500  0.9580  0.9610  0.9630  0.9690  0.9710
 30           PC  0.9740  0.9790  0.9810  0.9850  0.9890  0.9910  0.9930  0.9960    1.00
 31           BA    0.43
 32           LS              82
 33           UD    0.59

 34           KK    S5A2
 35           KM    SUB BASIN 5A2
 36           BA    0.94
 37           LS              80
 38           UD     .76

 39           KK      C1
 40           KM     COMBINE 5A1 & 5A2
 41           HC      2.

 42           KK    MAIN
 43           KM     FLOW DIVERSION OUT OF WASH 5
 44           DT   DIV5
 45           DI       0      17      74     204     531    1083    2690
 46           DQ       0      10      44     121     361     794    2050
```

SA1+SA2 = #15 for FCD
0.43 + 0.94 =
1.3 + = S15 FCD
S15 is considered under stream 2 calibration
FCD.

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

  47          KK      R1
  48          KM      BOTTOM WIDTH = 40': V BAR= 5 fps
  49          RS       7    ELEV      10
  50          RC     .06    .035     .06   20380     .02
  51          RX      34      37      77      80     120     123     163     166
  52          RY      16      13      13      10      10      13      13      16

  53          KK    S5A3      1475
  54          KM    SUB BASIN 5A3
  55          BA    1.77        1.69
  56          LS              84
  57          UD     .79

  58          KK   WASH5
  59          HC       2                                   1430
                                                           1440
                                                           1470
                                                                  1.43
                                                                  1.89
                                                                  0.30
                                                                  3.62
  60          KK     S6A
  61          KM    SUB BASIN 6A
  62          BA    3.54        — 3.62   1430+
                                          1440
                                          1470
  63          LS              81
  64          UD    1.05

  65          KK     S6B - 1390S
  66          KM    SUB BASIN 6B
  67          BA    0.43      0.43
  68          LS              84
  69          UD    0.58

  70          KK    S6C1    1380
  71          KM    SUB BASIN 6C1
  72          BA    1.00      0.93
  73          LS              81
  74          UD    0.72

  75          KK      R2
  76          KM      BOTTOM WIDTH = 30': V BAR= 7 fps
  77          RS       3    ELEV      10
  78          RC     .06    .035     .06   13940     .02
  79          RX      39      42      82      85     115     118     158     161
  80          RY      16      13      13      10      10      13      13      16

  81          KK    S6C2    = 1390N
  82          KM    SUB BASIN 6C2
  83          BA     .57      0.56
  84          LS              82
  85          UD     .67                                   7.31    7.23

  86          KK  WASH6C
  87          KM     COMBINE FOR WASH 6C
  88          HC       2
  89          ZZ
```

SCHEMATIC DIAGRAM OF STREAM NETWORK

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

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

   20        S5A1
                .
                .
   34           .        S5A2
                .          .
                .          .
   39          C1............
                .
                .
   44           .------->   DIV5
   42        MAIN
                V
                V
   47          R1
                .
                .
   53           .        S5A3
                .          .
                .          .
   58       WASH5............
                .
                .
   60           .         S6A
                .          .
                .          .
   65           .          .         S6B
                .          .          .
                .          .          .
   70           .          .          .       S6C1
                .          .          .          V
                .          .          .          V
   75           .          .          .         R2
                .          .          .          .
                .          .          .          .
   81           .          .          .          .        S6C2
                .          .          .          .          .
                .          .          .          .          .
   86           .          .          .     WASH6C............
```

(***) RUNOFF ALSO COMPUTED AT THIS LOCATION

```
****************************************
*                                      *
*   FLOOD HYDROGRAPH PACKAGE  (HEC-1)  *
*           SEPTEMBER 1990             *
*            VERSION 4.0               *
*                                      *
*  RUN DATE  11/09/1991  TIME  13:24:12 *
*                                      *
****************************************
```

```
****************************************
*                                      *
*    U.S. ARMY CORPS OF ENGINEERS      *
*    HYDROLOGIC ENGINEERING CENTER     *
*          609 SECOND STREET           *
*       DAVIS, CALIFORNIA 95616        *
*           (916) 756-1104             *
*                                      *
****************************************
```

```
                    TATUM RANCH/DESERT FLOWER - "FANS 5 & 6" (FAN8A.O)
                    RAINFALL DISTRIBUTION : SCS TYPE IIa
                    100 YEAR RAINFALL = 4.65 " (per NOAA ATLAS)
                    LAG TIMES: CORPS OF ENGINEERS LAG EQUATION
                    CURVE NUMBERS: RANGE 80 TO 84
                           VEGETATION: FAIR
                           SOIL TYPES: B, C & D
                    DEPTH AREA REDUCTION FACTORS(PER NOAA HYDRO-40)
                    AREA(SQMI)      %
                    --------------------
                     0            1.0
                     1            0.99
                     2            0.98
                     3            0.97
                     4            0.965
                    --------------------

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

   IT          HYDROGRAPH TIME DATA
                      NMIN          10  MINUTES IN COMPUTATION INTERVAL
                     IDATE      1    0  STARTING DATE
                     ITIME        0000  STARTING TIME
                        NQ         300  NUMBER OF HYDROGRAPH ORDINATES
                    NDDATE      3    0  ENDING DATE
                    NDTIME        0150  ENDING TIME
                    ICENT           19  CENTURY MARK

                 COMPUTATION INTERVAL     .17 HOURS
                      TOTAL TIME BASE   49.83 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

   JP          MULTI-PLAN OPTION
                     NPLAN           1  NUMBER OF PLANS
```

```
JR          MULTI-RATIO OPTION
                RATIOS OF PRECIPITATION
                1.00       .99       .98       .97       .96
```

PEAK FLOW AND STAGE (END-OF-PERIOD) SUMMARY FOR MULTIPLE PLAN-RATIO ECONOMIC COMPUTATIONS
FLOWS IN CUBIC FEET PER SECOND, AREA IN SQUARE MILES
TIME TO PEAK IN HOURS

OPERATION	STATION	AREA	PLAN		RATIOS APPLIED TO PRECIPITATION RATIO 1	RATIO 2	RATIO 3	RATIO 4	RATIO 5
					1.00	.99	.98	.97	.96
HYDROGRAPH AT									
+	S5A1	.43	1	FLOW	451.	444.	437.	429.	426.
				TIME	6.50	6.50	6.50	6.50	6.50
HYDROGRAPH AT									
+	S5A2	.94	1	FLOW	767.	754.	741.	728.	721.
				TIME	6.67	6.67	6.67	6.67	6.67
2 COMBINED AT									
+	C1	1.37	1	FLOW	1176.	1156.	1136.	1116.	1107.
				TIME	6.50	6.50	6.50	6.50	6.67
DIVERSION TO									
+	DIV5	1.37	1	FLOW	867.	851.	836.	820.	812.
				TIME	6.50	6.50	6.50	6.50	6.67
HYDROGRAPH AT									
+	MAIN	1.37	1	FLOW	309.	305.	301.	296.	294.
				TIME	6.50	6.50	6.50	6.50	6.50
ROUTED TO									
+	R1	1.37	1	FLOW	283.	279.	275.	271.	270.
				TIME	7.33	7.33	7.33	7.33	7.33
			** PEAK STAGES IN FEET **						
			1	STAGE	11.10	11.09	11.08	11.07	11.07
				TIME	7.33	7.33	7.33	7.33	7.33
HYDROGRAPH AT									
+	S5A3	1.77	1	FLOW	1662.	1636.	1610.	1585.	1572.
				TIME	6.67	6.67	6.67	6.67	6.67
2 COMBINED AT									
+	WASH5	3.14	1	FLOW	1677.	1651.	1625.	1598.	1585.
				TIME	6.67	6.67	6.67	6.67	6.67
HYDROGRAPH AT									
+	S6A	3.54	1	FLOW	2388.	2348.	2309.	2270.	2251.
				TIME	7.00	7.00	7.00	7.00	7.00
HYDROGRAPH AT									
+	S6B	.43	1	FLOW	493.	485.	478.	470.	466.
				TIME	6.50	6.50	6.50	6.50	6.50
HYDROGRAPH AT									
+	S6C1	1.00	1	FLOW	878.	864.	849.	835.	828.
				TIME	6.67	6.67	6.67	6.67	6.67
ROUTED TO									

```
+                R2      1.00    1   FLOW        839.    824.    809.    795.    787.
                                    TIME        6.83    6.83    6.83    6.83    6.83

                                ** PEAK STAGES IN FEET **
                                1   STAGE      12.52   12.50   12.47   12.44   12.43
                                    TIME        6.83    6.83    6.83    6.83    6.83

HYDROGRAPH AT
+               S6C2     .57    1   FLOW        550.    541.    532.    523.    518.
                                    TIME        6.50    6.50    6.50    6.50    6.50

 2 COMBINED AT
+             WASH6C    1.57    1   FLOW       1309.   1287.   1265.   1243.   1232.
                                    TIME        6.83    6.83    6.83    6.83    6.83


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

```
****************************************
*                                      *
*   FLOOD HYDROGRAPH PACKAGE  (HEC-1)  *
*            SEPTEMBER 1990            *
*             VERSION 4.0              *
*                                      *
*  RUN DATE  11/09/1991  TIME  13:24:36 *
*                                      *
****************************************
```

```
****************************************
*                                      *
*    U.S. ARMY CORPS OF ENGINEERS      *
*    HYDROLOGIC ENGINEERING CENTER     *
*          609 SECOND STREET           *
*       DAVIS, CALIFORNIA 95616        *
*           (916) 756-1104             *
*                                      *
****************************************
```

```
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

2 Year Event

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

  1           ID        TATUM RANCH/DESERT FLOWER - "FANS 5 & 6" (FAN8F.O)
  2           ID        RAINFALL DISTRIBUTION : SCS TYPE IIa
  3           ID        2 YEAR RAINFALL = 2.1 " (per NOAA ATLAS)
  4           ID        LAG TIMES: CORPS OF ENGINEERS LAG EQUATION
  5           ID        CURVE NUMBERS: RANGE 63 TO 69  AMC I
  6           ID                VEGETATION: FAIR
  7           ID                SOIL TYPES: C & D
  8           ID        DEPTH AREA REDUCTION FACTORS(PER NOAA HYDRO-40)
  9           ID        AREA(SQMI)      %
 10           ID        --------------------
 11           ID         0            1.0
 12           ID         1            0.99
 13           ID         2            0.98
 14           ID         3            0.97
 15           ID         4            0.965
 16           ID        --------------------
              *DIAGRAM
 17           IT      10                    300
 18           IO       5       0
 19           JR    PREC   1.000    0.99   0.980   0.970   0.965

 20           KK    S5A1
 21           KM    SUB BASIN 5A1
 22           KM    SCS TYPEIIA DISTRIBUTION PER PARADISE VALLEY FAN TERRACE, CONCEPT
 23           KM    DRAINAGE STUDY
 24           IN      30
 25           PB    2.10
 26           PC     0.0   .0050  0.0090  0.0100  0.0130  0.0190  0.0210  0.0280  0.0320  0.0440
 27           PC  0.0570  0.1000  0.6600  0.7450  0.7760  0.8000  0.8160  0.8300  0.8400  0.8500
 28           PC  0.8610  0.8680  0.8780  0.8840  0.8910  0.9000  0.9050  0.9120  0.9190  0.9230
 29           PC  0.9300  0.9340  0.9390  0.9440  0.9500  0.9580  0.9610  0.9630  0.9690  0.9710
 30           PC  0.9740  0.9790  0.9810  0.9850  0.9890  0.9910  0.9930  0.9960    1.00
 31           BA    0.43
 32           LS             65
 33           UD    0.59

 34           KK    S5A2
 35           KM    SUB BASIN 5A2
 36           BA    0.94
 37           LS             63
 38           UD     .76

 39           KK      C1
 40           KM     COMBINE 5A1 & 5A2
 41           HC      2.

 42           KK    MAIN
 43           KM     FLOW DIVERSION OUT OF WASH 5
 44           DT   DIV5
 45           DI       0      17      74     204     531    1083    2690
 46           DQ       0      10      44     121     361     794    2050
```

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

  47          KK      R1
  48          KM      BOTTOM WIDTH = 40': V BAR= 5 fps
  49          RS       7    ELEV      10
  50          RC     .06    .035     .06   20380     .02
  51          RX      34      37      77      80     120     123     163     166
  52          RY      16      13      13      10      10      13      13      16

  53          KK    S5A3
  54          KM    SUB BASIN 5A3
  55          BA    1.77
  56          LS              69
  57          UD     .79

  58          KK   WASH5
  59          HC       2

  60          KK     S6A
  61          KM    SUB BASIN 6A
  62          BA    3.54
  63          LS              64
  64          UD    1.05

  65          KK     S6B
  66          KM    SUB BASIN 6B
  67          BA    0.43
  68          LS              68
  69          UD    0.58

  70          KK    S6C1
  71          KM    SUB BASIN 6C1
  72          BA    1.00
  73          LS              65
  74          UD    0.72

  75          KK      R2
  76          KM      BOTTOM WIDTH = 30': V BAR= 7 fps
  77          RS       3    ELEV      10
  78          RC     .06    .035     .06   13940     .02
  79          RX      39      42      82      85     115     118     158     161
  80          RY      16      13      13      10      10      13      13      16

  81          KK    S6C2
  82          KM    SUB BASIN 6C2
  83          BA     .57
  84          LS              66
  85          UD     .67

  86          KK  WASH6C
  87          KM     COMBINE FOR WASH 6C
  88          HC       2
  89          ZZ
```

SCHEMATIC DIAGRAM OF STREAM NETWORK

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

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

   20        S5A1
                .
                .
   34           .        S5A2
                .           .
                .           .
   39         C1............
                .
                .
   44           .------->   DIV5
   42        MAIN
                V
                V
   47         R1
                .
                .
   53           .        S5A3
                .           .
                .           .
   58      WASH5............
                .
                .
   60           .         S6A
                .           .
                .           .
   65           .           .        S6B
                .           .          .
                .           .          .
   70           .           .          .       S6C1
                .           .          .          V
                .           .          .          V
   75           .           .          .         R2
                .           .          .          .
                .           .          .          .
   81           .           .          .          .       S6C2
                .           .          .          .          .
                .           .          .          .          .
   86           .           .          .     WASH6C............
```

(***) RUNOFF ALSO COMPUTED AT THIS LOCATION

```
****************************************
*                                      *
*   FLOOD HYDROGRAPH PACKAGE  (HEC-1)  *
*           SEPTEMBER 1990             *
*            VERSION 4.0               *
*                                      *
* RUN DATE  11/09/1991  TIME  13:24:36 *
*                                      *
****************************************
```

```
****************************************
*                                      *
*   U.S. ARMY CORPS OF ENGINEERS       *
*   HYDROLOGIC ENGINEERING CENTER      *
*         609 SECOND STREET            *
*      DAVIS, CALIFORNIA 95616         *
*          (916) 756-1104              *
*                                      *
****************************************
```

```
                    TATUM RANCH/DESERT FLOWER - "FANS 5 & 6" (FAN8F.O)
                    RAINFALL DISTRIBUTION : SCS TYPE IIa
                    2 YEAR RAINFALL = 2.1 " (per NOAA ATLAS)
                    LAG TIMES: CORPS OF ENGINEERS LAG EQUATION
                    CURVE NUMBERS: RANGE 63 TO 69
                            VEGETATION: FAIR
                            SOIL TYPES: C & D
                    DEPTH AREA REDUCTION FACTORS(PER NOAA HYDRO-40)
                    AREA(SQMI)      %
                    --------------------
                     0            1.0
                     1            0.99
                     2            0.98
                     3            0.97
                     4            0.965
                    --------------------

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

    IT        HYDROGRAPH TIME DATA
                     NMIN         10  MINUTES IN COMPUTATION INTERVAL
                    IDATE     1    0  STARTING DATE
                    ITIME       0000  STARTING TIME
                       NQ        300  NUMBER OF HYDROGRAPH ORDINATES
                   NDDATE     3    0  ENDING DATE
                   NDTIME       0150  ENDING TIME
                   ICENT          19  CENTURY MARK

              COMPUTATION INTERVAL     .17 HOURS
                   TOTAL TIME BASE   49.83 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

    JP        MULTI-PLAN OPTION
                    NPLAN          1  NUMBER OF PLANS
```

```
JR          MULTI-RATIO OPTION
                RATIOS OF PRECIPITATION
              1.00       .99       .98       .97       .96
```

PEAK FLOW AND STAGE (END-OF-PERIOD) SUMMARY FOR MULTIPLE PLAN-RATIO ECONOMIC COMPUTATIONS
FLOWS IN CUBIC FEET PER SECOND, AREA IN SQUARE MILES
TIME TO PEAK IN HOURS

					RATIOS APPLIED TO PRECIPITATION				
OPERATION	STATION	AREA	PLAN		RATIO 1	RATIO 2	RATIO 3	RATIO 4	RATIO 5
					1.00	.99	.98	.97	.96
HYDROGRAPH AT									
+	S5A1	.43	1	FLOW	11.	10.	10.	9.	9.
				TIME	6.83	6.83	6.83	6.83	6.83
HYDROGRAPH AT									
+	S5A2	.94	1	FLOW	14.	13.	12.	11.	11.
				TIME	7.17	7.17	7.17	7.17	7.17
2 COMBINED AT									
+	C1	1.37	1	FLOW	24.	22.	21.	19.	19.
				TIME	7.00	7.00	7.00	7.00	7.00
DIVERSION TO									
+	DIV5	1.37	1	FLOW	14.	13.	12.	11.	11.
				TIME	7.00	7.00	7.00	7.00	7.00
HYDROGRAPH AT									
+	MAIN	1.37	1	FLOW	10.	9.	9.	8.	8.
				TIME	7.00	7.00	7.00	7.00	7.00
ROUTED TO									
+	R1	1.37	1	FLOW	7.	6.	6.	6.	6.
				TIME	9.33	9.33	9.33	9.33	9.33
			** PEAK STAGES IN FEET **						
			1	STAGE	10.06	10.06	10.05	10.05	10.05
				TIME	9.33	9.33	9.33	9.33	9.33
HYDROGRAPH AT									
+	S5A3	1.77	1	FLOW	79.	76.	73.	70.	68.
				TIME	7.00	7.00	7.00	7.00	7.00
2 COMBINED AT									
+	WASH5	3.14	1	FLOW	79.	76.	73.	70.	68.
				TIME	7.00	7.00	7.00	7.00	7.00
HYDROGRAPH AT									
+	S6A	3.54	1	FLOW	56.	52.	49.	46.	45.
				TIME	7.50	7.50	7.50	7.50	7.50
HYDROGRAPH AT									
+	S6B	.43	1	FLOW	19.	18.	17.	17.	16.
				TIME	6.67	6.67	6.67	6.67	6.83
HYDROGRAPH AT									
+	S6C1	1.00	1	FLOW	23.	22.	21.	20.	19.
				TIME	7.00	7.00	7.00	7.00	7.00
ROUTED TO									

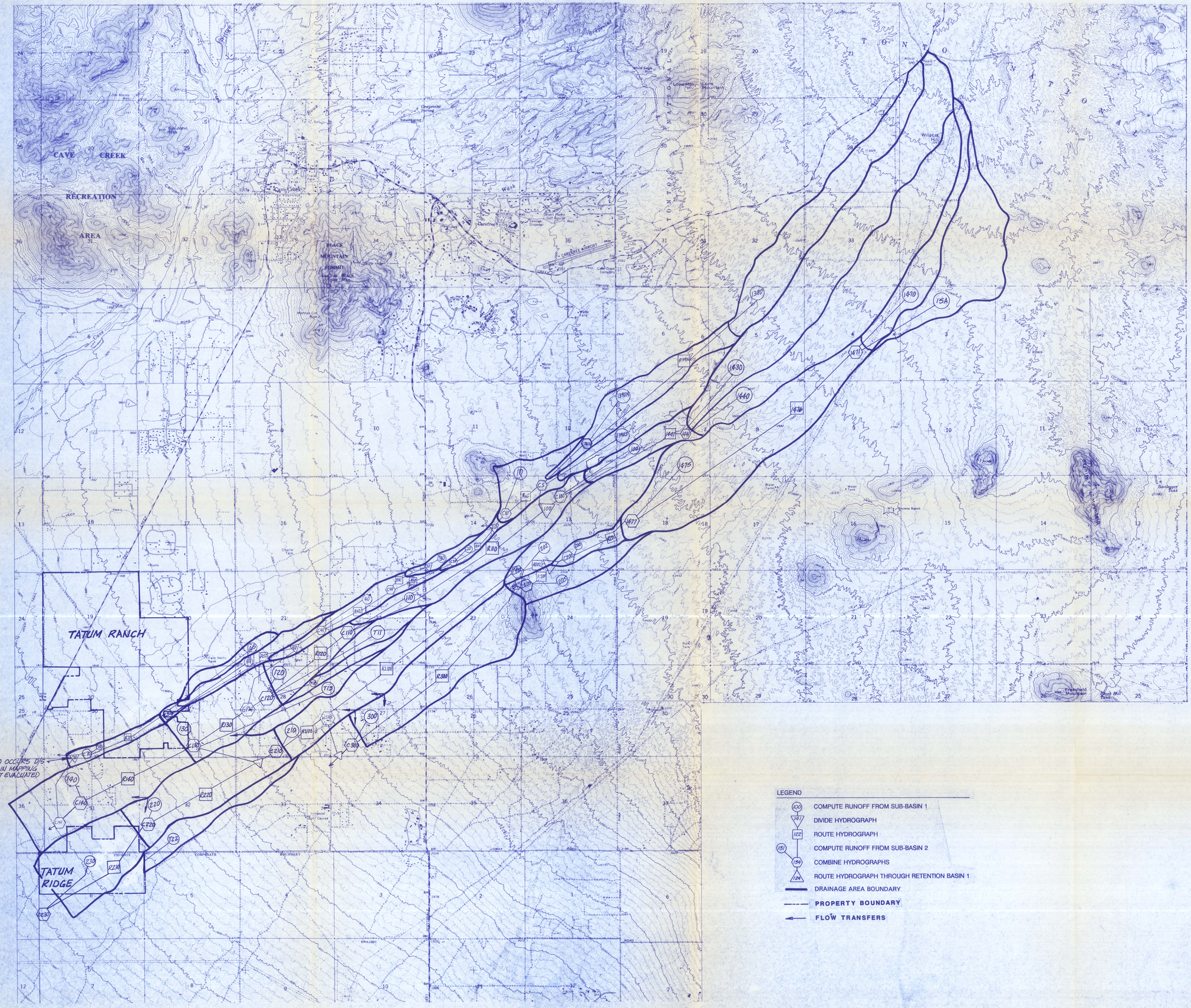
```
+                R2      1.00    1   FLOW        16.     15.     14.     13.     13.
                                    TIME       8.50    8.50    8.50    8.67    8.67

                                ** PEAK STAGES IN FEET **
                                1   STAGE      10.19   10.18   10.17   10.16   10.15
                                    TIME       8.50    8.50    8.50    8.67    8.67

HYDROGRAPH AT
+               S6C2     .57    1   FLOW        17.     16.     15.     14.     14.
                                    TIME       6.83    6.83    6.83    6.83    6.83

 2 COMBINED AT
+             WASH6C    1.57    1   FLOW        23.     22.     21.     19.     19.
                                    TIME       8.17    8.17    8.17    8.17    8.17


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



DRAINAGE AREA BOUNDARIES

PLATE 1

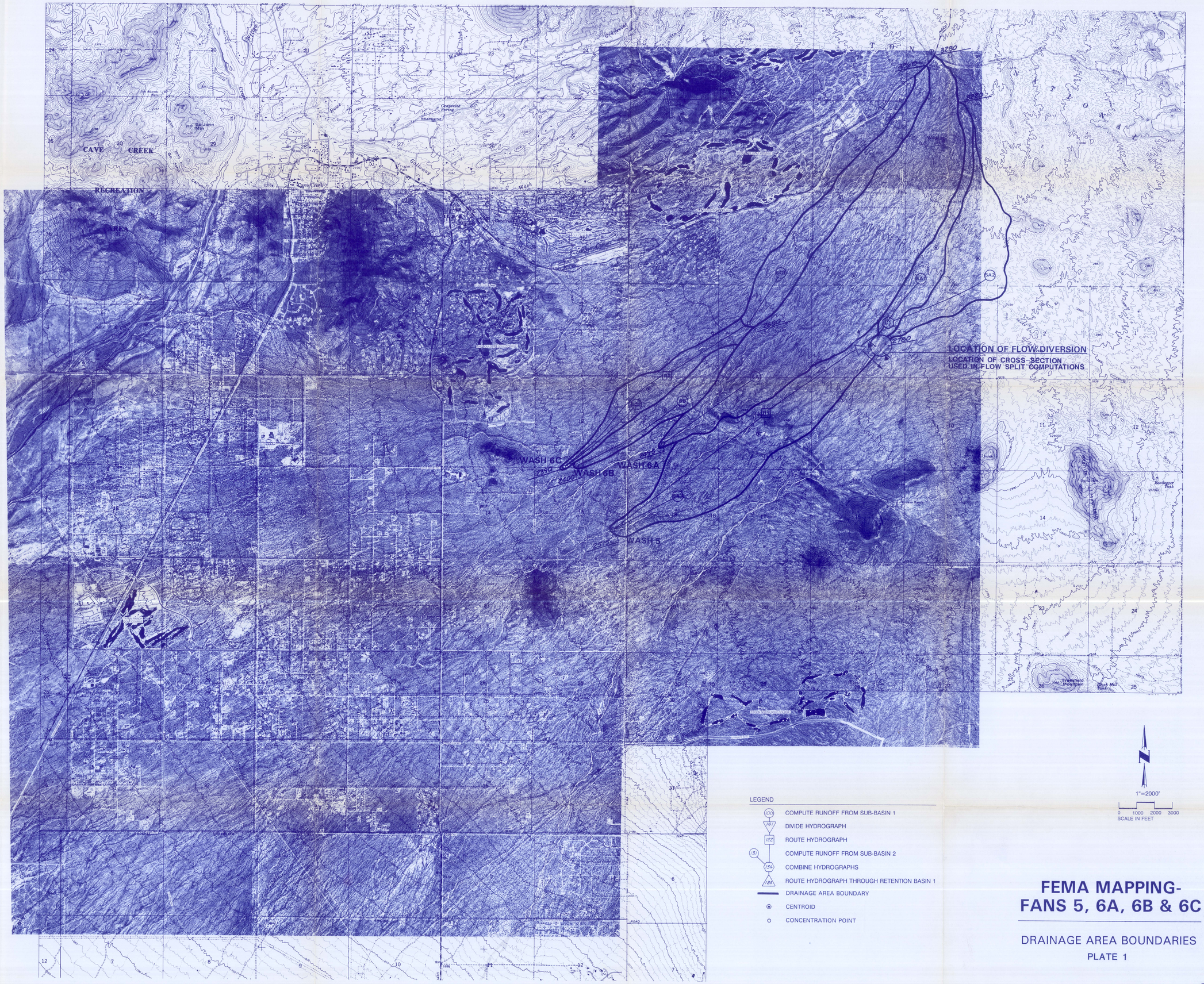
JOB # 93-0064-11 (1)

CYL

PRELIMINARY FIRM MAP

(JULY 9, 1991)

PLATE 2



FEMA MAPPING-
FANS 5, 6A, 6B & 6C

DRAINAGE AREA BOUNDARIES

PLATE 1

CYL