Floodflow in Maricopa County, Arizona—
A progress report through June 1969

By

H. W. Hjalmarson and L. L. Werho

Administrative report, February 1970

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Prepared in cooperation with the
Flood Control District
of Maricopa County

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FLOODFLOW IN MARICOPA COUNTY, ARIZONA—A PROGRESS REPORT THROUGH JUNE 1969

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Introduction

In September 1960 the Flood Control District of Maricopa County entered into a cooperative agreement with the U. S. Geological Survey for the purpose of obtaining the hydrologic information necessary for comprehensive flood-control planning. The investigation is being conducted under the immediate supervision of H. M. Babcock, district chief of the Water Resources Division in Arizona. The report summarizes the work done from September 1965 (Werho, 1967) through June 1969.

The main objectives of the investigation are (1) to determine the magnitude and frequency of floods in Maricopa County; (2) to delineate flood-prone areas, placing special emphasis on urban areas; (3) to determine the duration of flow, rate of travel of flood peaks, and channel losses; and (4) to develop precipitation-runoff relations for desert and urban watersheds.

Little hydrologic data had been collected in Maricopa County prior to this study; therefore, it was necessary to establish a network of streamflow- and precipitation-gaging stations. The data-collection network is being evaluated continuously to insure that it provides the data necessary to satisfy the objectives of the study.

Data-Collection Network

Since September 1965, the data-collection network (Werho, 1967) has been modified to improve the quantity and quality of the data. The type of instrumentation has been changed at some stations, new stations have been established, some stations have been relocated, and some stations have been discontinued. Data obtained from precipitation- and streamflow-gaging stations established during other investigations are used to supplement data collected for this study. The changes in the streamflow-gaging station network are given in table 1, and the present (June 1969) data-collection network is shown in figure 1.

Precipitation gages were installed by the Geological Survey in areas where the existing Weather Bureau network did not provide the necessary data. Two types of precipitation gages were installed—recording and nonrecording. Since 1965, however, most of the nonrecording gages have been discontinued because experience has proven them to

Table 1.--Changes in the streamflow-gaging station network from October 1965 through June 1969

[Gage number: number on figure 1; discontinued stations are not shown on figure 1]

Gage number	Gaging station	Change in instrumentation
1	Queen Creek tributary at Apache Junction, Ariz.	From continuous-record station to crest-stage gage.
5	Mesquite Creek near Mormon Flat Dam, Ariz.	Crest-stage gage discontinued.
9	Camp Creek near Sunflower, Ariz.	From continuous-record station to crest-stage gage.
13	Indian Bend Wash at McDonald Drive at Scottsdale, Ariz.	Discontinued.
14	Indian Bend Wash at Indian School Road at Scottsdale, Ariz.	Discontinued.
15	Indian Bend Wash at McDowell Road at Scottsdale, Ariz.	Discontinued.
18	Cave Creek near Cave Creek, Ariz.	From continuous-record station to crest-stage gage.
22	Agua Fria River tributary at Youngtown, Ariz.	Discontinued.
23	New River near Rock Springs, Ariz.	From flood-hydrograph recorder and crest-stage gage to continuous-record station.

Table 1. --Changes in the streamflow-gaging station network from October 1965 through June 1969—Continued

Gage number	Gaging station	Change in instrumentation
27	New River at Bell Road near Peoria, Ariz.	From flood-hydrograph recorder and crest-stage gage to continuous-record station.
28	Skunk Creek near Phoenix, Ariz.	From crest-stage gage to continuous-record station.
29	Skunk Creek (above Arizona Canal) near Peoria, Ariz.	Discontinued.
31	New River (at Olive Avenue) near Peoria, Ariz.	Discontinued.
33	Agua Fria River (at Indian School Road) near Litchfield Park, Ariz.	Discontinued.
34	Agua Fria River (at McDowell Road) near Avondale, Ariz.	Discontinued.
35	Agua Fria River (at Buckeye Road) at Avondale, Ariz.	From crest-stage gage to continuous-record station.
43	Hassayampa River near Arlington, Ariz.	From continuous-record station to crest-stage gage.
52	Rainbow Wash near Gila Bend, Ariz.	Discontinued.
60	Tortilla Creek at Tortilla Flat, Ariz.	New station; crest-stage gage installed.

Table 1. --Changes in the streamflow-gaging station network from October 1965 through June 1969—Continued

Gage number	Gaging station	Change in instrumentation
61	West Fork Sycamore Creek above McFarland Canyon near Sunflower, Ariz.	New station; continuous-record station installed.
62	Indian Bend Wash (at Thomas Road) at Scottsdale, Ariz.	New station; crest-stage gage installed.

INDEX MAP

EXPLANATION

STREAMFLOW GAGES
(FIGURE INDICATES GAGE NUMBER; SEE TABLE 1)

▲49 CONTINUOUS-RECORDING STATION INSTALLED DURING THIS INVESTIGATION

▼10 CONTINUOUS-RECORDING STATION INSTALLED DURING OTHER INVESTIGATIONS

▲36 CREST-STAGE GAGE OR FLOOD-HYDROGRAPH RECORDER INSTALLED DURING THIS INVESTIGATION

PRECIPITATION GAGES
(FIGURE INDICATES STATION NUMBER)

◇74 CONTINUOUS-RECORDING GAGE INSTALLED BY THE U.S. GEOLOGICAL SURVEY

◆35 CONTINUOUS-RECORDING GAGE INSTALLED BY THE U.S. WEATHER BUREAU

◐70 NONRECORDING GAGE INSTALLED BY THE U.S. GEOLOGICAL SURVEY

◆9 NONRECORDING GAGE INSTALLED BY THE U.S. WEATHER BUREAU

REACH WHERE FLOOD-PRONE AREAS HAVE BEEN DELINEATED

FLOOD INFORMATION FROM U.S. GEOLOGICAL SURVEY
FLOOD-PRONE AREA MAPS

BASE FROM U.S. GEOLOGICAL SURVEY

5 0 15 MILES

FIGURE 1.--MAP SHOWING LOCATIONS OF STREAMFLOW- AND PRECIPITATION-GAGING STATIONS IN AND NEAR MARICOPA COUNTY.

be ineffective. The recording gages have been continued and are providing valuable and useful data.

Preliminary Analyses

Data collected to date have been utilized for preliminary analyses of flood-frequency relations, areas prone to flooding, and precipitation-runoff relations. Analyses of data on a continuing basis are an integral part of this study and are necessary to insure that the data collected are adequate.

Flood-frequency relations. --The data collected for this study will be used to determine the frequency of floods from gaged streams and to develop countywide frequency relations that may be used in estimating floods from ungaged streams. The first step in developing frequency relations for the county is to compute the frequencies of floods of different sizes from gaged streams. Preliminary flood frequencies have been computed for most gaged streams in Maricopa County by use of a digital computer. The log-Pearson Type III distribution (Water Resources Council, 1967), which has been adopted by most government agencies as a base method for estimating flood frequencies, was used in this study.

In Maricopa County only 6 to 8 years of streamflow record are

available for most gaging stations, and the data may contain large sampling errors because of chance variations in floodflows during the short periods of record. Frequency relations computed from such short records may not be accurate enough for use in flood-control planning but do provide insight into the factors that affect the magnitude of floods.

Regional flood-frequency curves are developed from the relations between floods of different frequencies and the basin parameters, such as drainage area, slope, soil, and vegetation. Preliminary studies in Maricopa County using the multiple-regression analyses outlined by Benson (1964) have shown that drainage area is the most important basin parameter and that the other basin parameters have little if any effect on the flood-frequency relations. This hypothesis, however, is valid only for the preliminary analyses, and further evaluation of other basin parameters may show that they have definite influence on the regional flood-frequency relations.

Delineation of flood-prone areas. --The delineation of flood-prone areas by floods of different frequencies is essential for comprehensive flood-control planning; however, more data will be necessary before flood-frequency relations can be established. On the basis of available information, boundaries of areas occasionally flooded and of some

historical floods in Maricopa County have been delineated to aid in preliminary flood-control planning.

Figure 1 shows the reaches in which the flood-prone areas have been defined in Maricopa County. Areas that may be subject to occasional flooding are outlined for New River, Agua Fria River, Skunk Creek, lower Waterman Wash, and Cave Creek above the Arizona Canal; boundaries of the flood of August 1921 are outlined for Cave Creek and the flood boundaries along the Salt River are given for the large flood of 1891. The flood-prone areas have been outlined on the 7.5-minute series of topographic quadrangle maps (scale 1:24,000), which have been published and are available at offices of the U.S. Geological Survey.

Precipitation-runoff relations. --In the absence of actual runoff data it is common practice to relate runoff to precipitation, especially in the design of city storm-drainage systems. A unit hydrograph is one method used to relate runoff to precipitation. Unit-hydrograph studies have been made for the small urban drainage (0.13 square mile) upstream from the station on the Agua Fria River tributary at Youngtown; the drainage is entirely within a residential area. Satisfactory relations have been developed to estimate the flow resulting from small amounts of precipitation, which produce runoff from only the impervious area. The runoff computed using the relation is almost equal to the measured runoff; the

computed peak discharge for December 10, 1965, is only 8 percent less than the measured discharge, and the total computed volume is within 1 percent of the measured volume (fig. 2). Although a second relation for large amounts of precipitation that produce runoff from the entire watershed has been developed, it is poorly defined, and additional data are needed for large runoff events.

Flood of December 19, 1967, in the Agua Fria River Drainage Area

Hydrologic data collected during this investigation were used for the analysis of the flood of December 19, 1967, in the Agua Fria River drainage area. The flood was the result of two storms—the first storm occurred December 12-16 and the second December 17-19. The storms brought large amounts of precipitation into northern Maricopa County. The first storm deposited about 3 inches of snow in the mountains north of Phoenix; the second storm deposited some snow on December 17 and rain on December 18-19. The rain caused rapid melting of the snow, and flooding resulted. The precipitation ranged from about 4 inches at the Phoenix Weather Bureau Airport precipitation station to about 7 inches at the Rock Springs precipitation station near the Yavapai-Maricopa County line north of Phoenix (fig. 3).

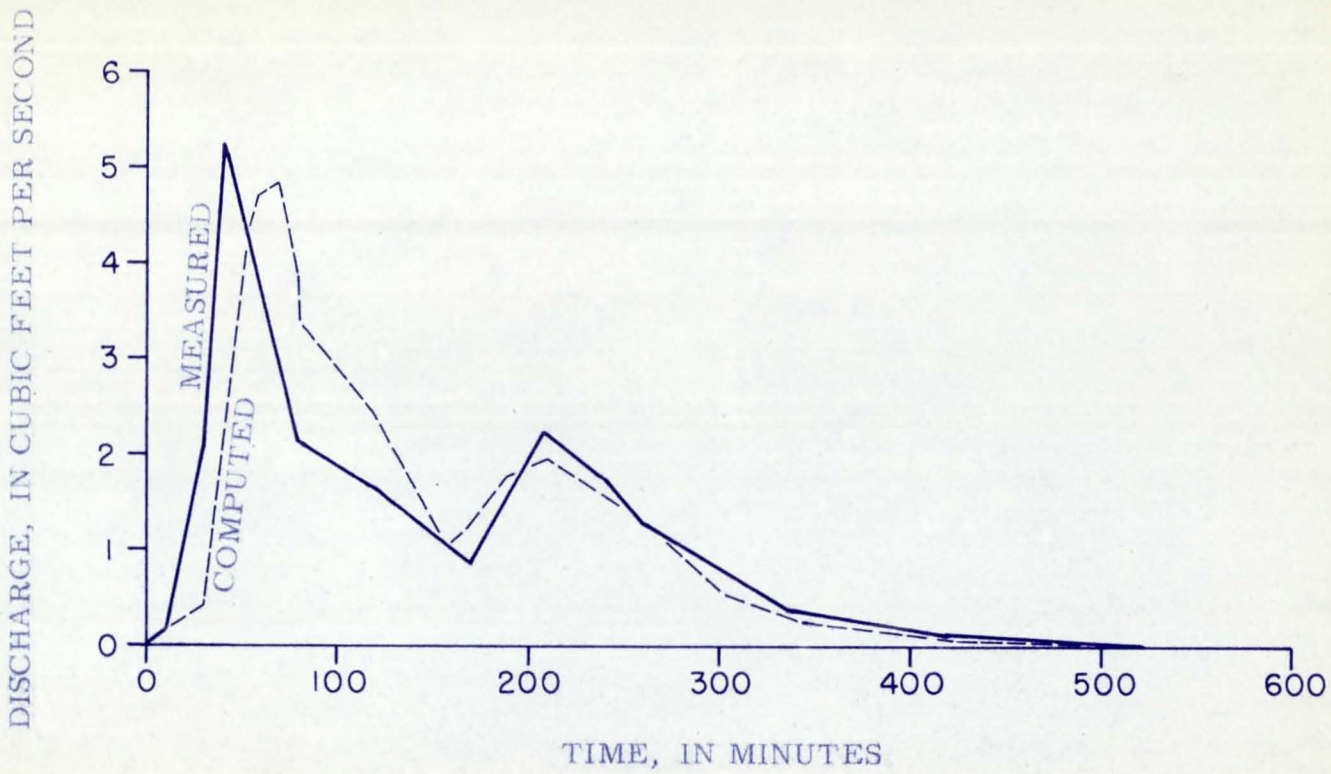
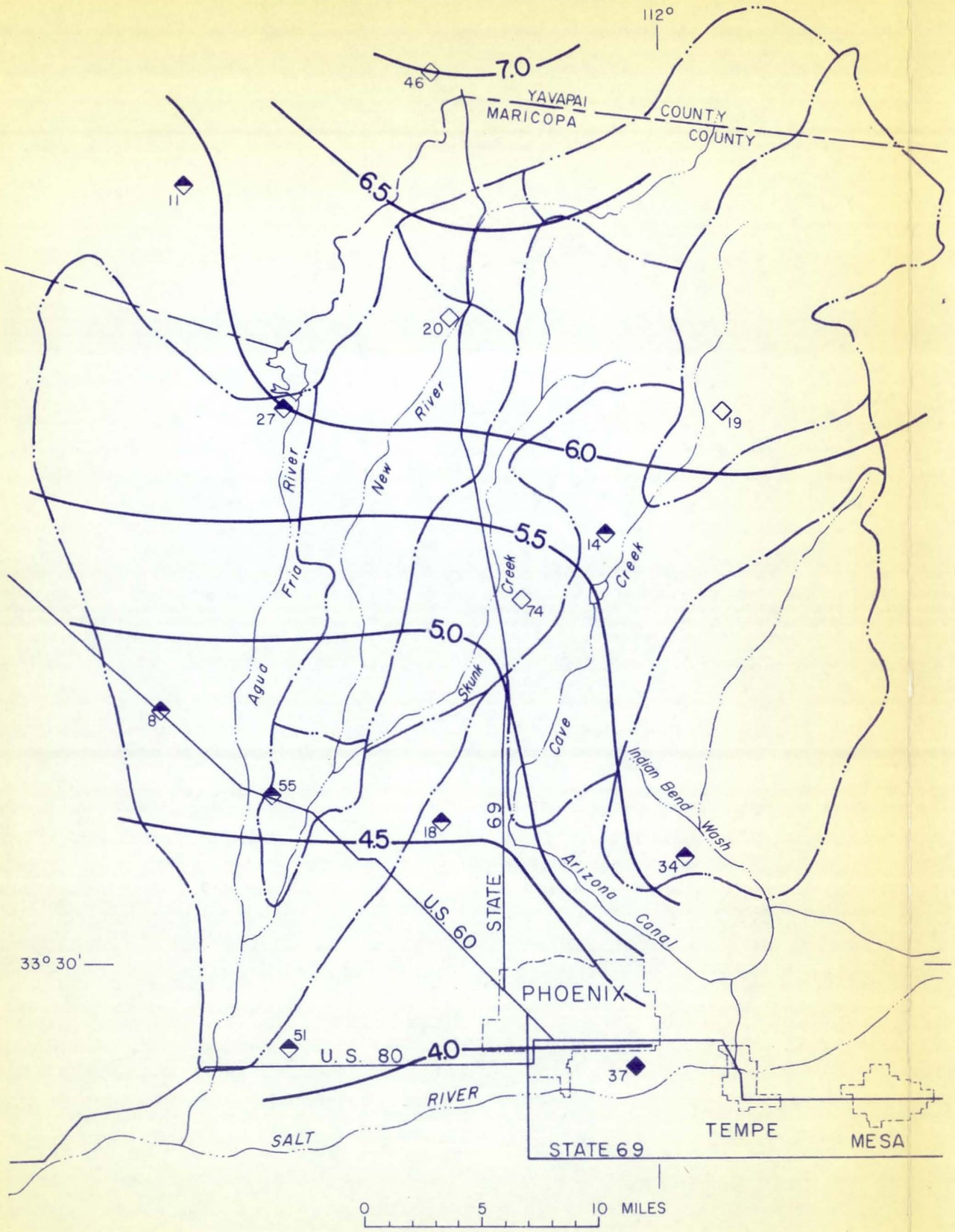


Figure 2. --Measured and computed runoff for storm event of December 10, 1965, Agua Fria River tributary at Youngtown, Ariz.



EXPLANATION

PRECIPITATION GAGES
(Figure indicates station number)

◇19
Continuous-recording gage installed by the U. S. Geological Survey

◆34
Nonrecording gage installed by the U. S. Weather Bureau

◆37
Continuous-recording gage installed by the U. S. Weather Bureau

——6.0——
Isohyetal line, showing precipitation, in inches

——··——··——··——
Boundary of drainage area

Figure 3.--Isohyets for precipitation of December 12-19, 1967, resulting in flood of December 19, 1967, in and near the Agua Fria River drainage area.

The peak discharge of the flood of December 19 is the greatest for the period of record at most of the streamflow-gaging stations north and west of Phoenix. In general the magnitude of peak discharge can be related to the maximum precipitation rate during a short period of time; the peaks of December 19 also relate to the total precipitation over the basin for December 12-19 (table 2 and fig. 4). The unit discharges—cubic feet per second per square mile—of peaks from basins that received large amounts of precipitation were greater than the unit discharges from basins that received less precipitation. The rate at which the unit discharges increased from basin to basin was greater than the rate at which the precipitation for the 8-day period increased.

Travel-time and time-of-concentration data are used in flood forecasting and flood warning. Records from continuous-recording precipitation and streamflow gages provide information on time of concentration of peak discharge. For example, the flood peak of December 19, 1967, at the New River at New River streamflow station occurred about 3 hours after the midpoint of the period of intense rainfall (fig. 5). Discharge hydrographs provide information on duration and time of travel of flood peaks—travel time for the flood peak was 7 hours from the gaging station at New River to the gaging station near Glendale (fig. 5).

Table 2.--Flood stages and discharges, December 19, 1967, north and west of Phoenix

Gage number	Gaging station	Drainage area (sq mi)	Gage height (feet)	Discharge	
				Cfs	Cfs per sq mi
12	Indian Bend Wash near Scottsdale, Ariz.	142	3.12	2,000	14.1
18	Cave Creek near Cave Creek, Ariz.	121	8.62	12,400	102
19	Cave Creek at Phoenix, Ariz.	252	4.30	†4,080	-
20	Agua Fria River tributary No. 2 near Rock Springs, Ariz.	1.0	4.08	210	210
21	Agua Fria River at El Mirage, Ariz.	‡178	4.05	*3,200	-
23	New River near Rock Springs, Ariz.	67.3	10.7	10,600	158
24	New River at New River, Ariz.	85.7	9.12	12,600	147
25	Deadman Wash near New River, Ariz.	11.1	5.52	950	84.8
27	New River at Bell Road near Peoria, Ariz.	187	13.5	14,600	78.1
28	Skunk Creek near Phoenix, Ariz.	64.6	11.7	5,900	91.3

See footnotes at end of table.

Table 2.--Flood stages and discharges, December 19, 1967, north and west of Phoenix—Continued

Gage number	Gaging station	Drainage area (sq mi)	Gage height (feet)	Discharge	
				Cfs	Cfs per sq mi
32	New River near Glendale, Ariz.	323	6.7	19,800	61.3
35	Agua Fria River at Avondale, Ariz.	‡554	12.70	20,000	36.1

†Flow originated mainly in area downstream from Cave Creek Dam; maximum rate of release from the dam was 450 cfs.

‡Drainage area below Lake Pleasant.

*Flow originated mainly in area below Lake Pleasant; maximum rate of release from the lake was 500 cfs.

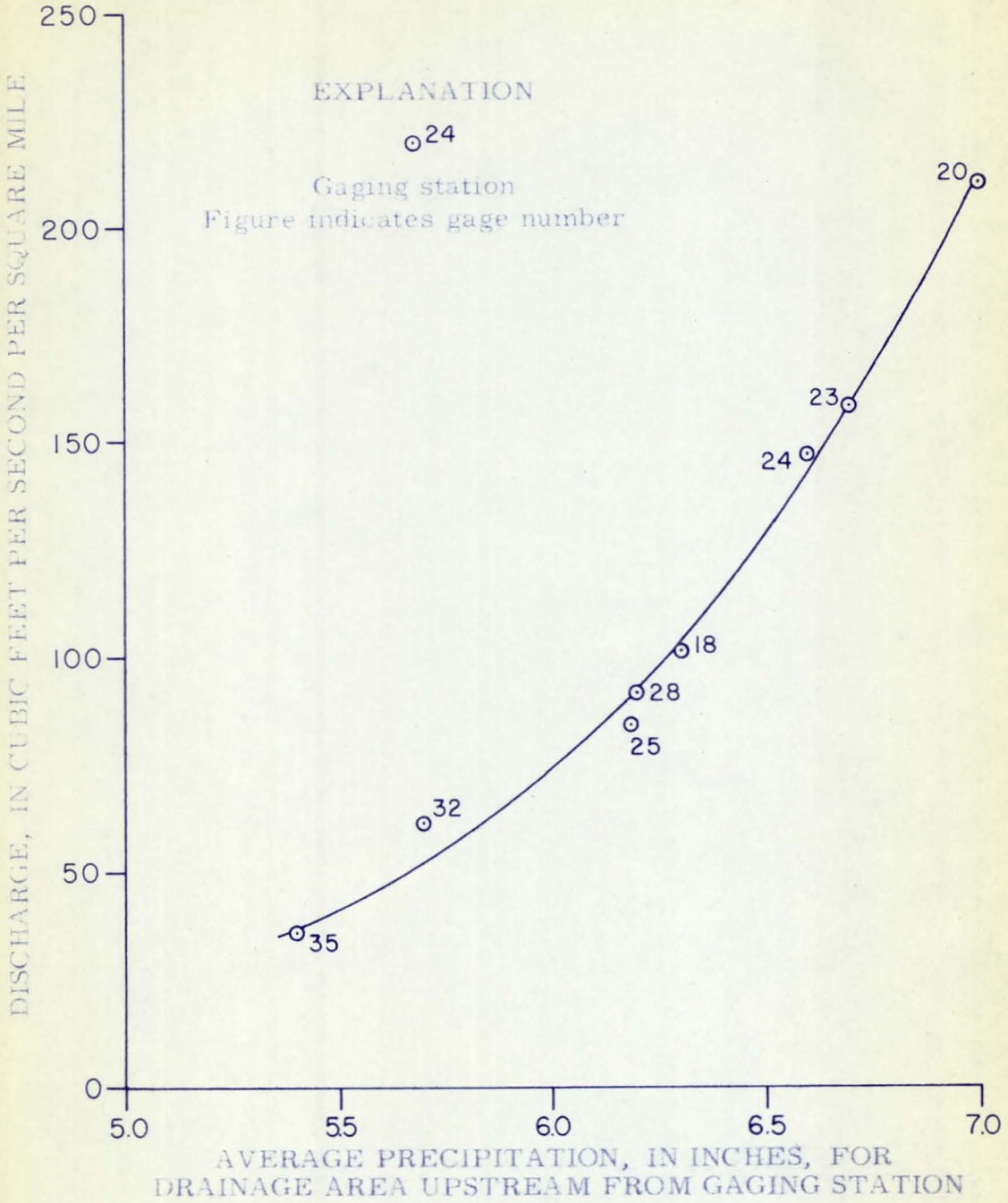


Figure 4. --Relation between precipitation of December 12-19, 1967, and unit peak discharge for flood of December 19, 1967.

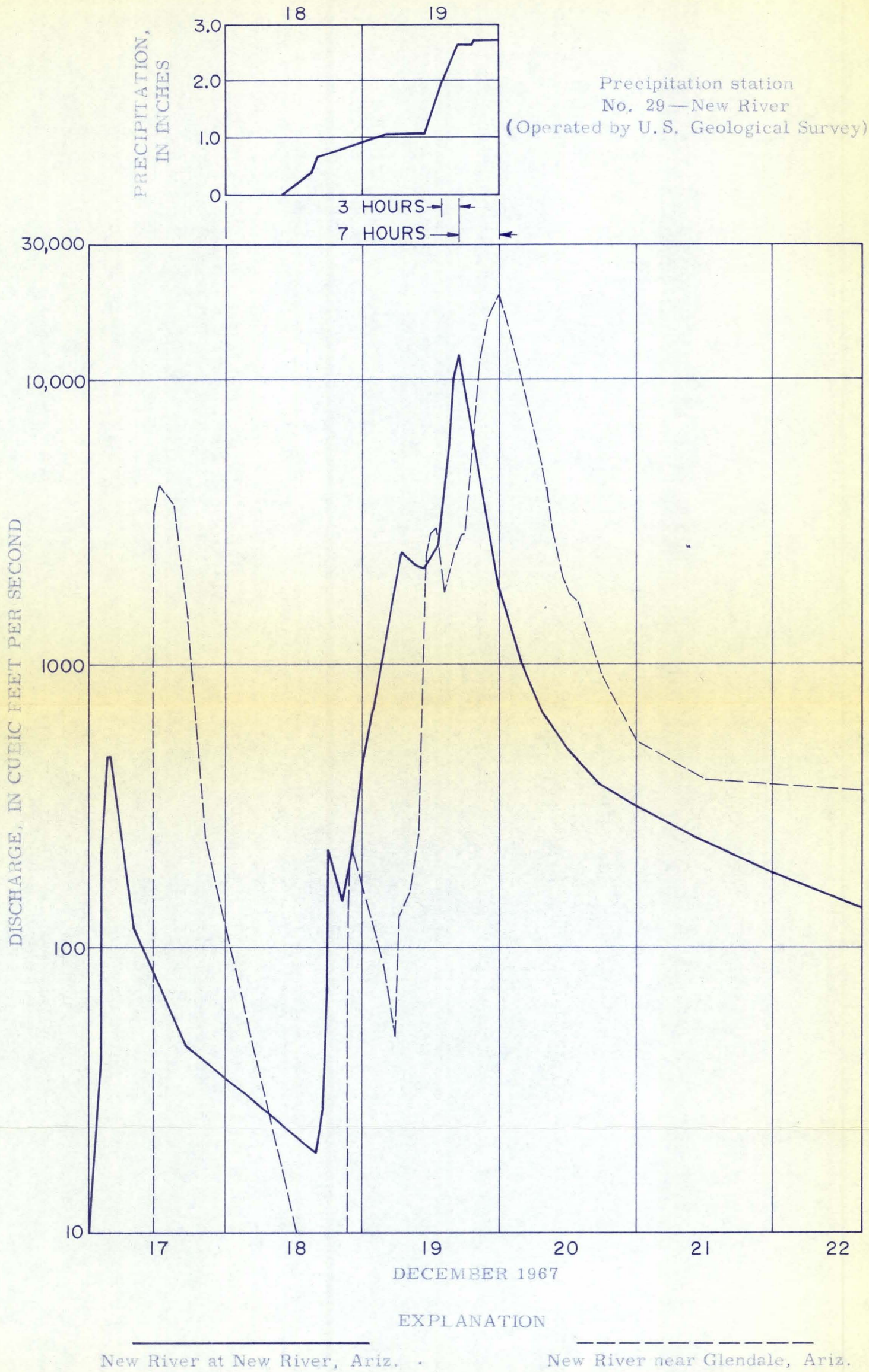


Figure 5.--Discharge hydrographs, December 17-22, for selected gaging stations.

Conclusions and Recommendations

The preliminary analyses given in this report indicate that there are not yet sufficient data available for the adequate definition of the flood-frequency relations in Maricopa County. At least 15 years of record is needed to define accurate flood-frequency relations; at the present time (1969) only 6-8 years of record are available for most gaging stations in Maricopa County. Regional flood-frequency relations are based on flood frequencies for gaged streams and on the basin parameters, such as drainage area, slope, soil, and vegetation. Preliminary studies in Maricopa County using multiple-regression analyses have shown that drainage area is the most important basin parameter and that the other basin parameters have little if any effect on the flood-frequency relations. This hypothesis, however, is valid only for the preliminary analyses, and further evaluation of other basin parameters may show that they have definite influence on the regional flood-frequency relations. On the basis of available data, boundaries of some areas in Maricopa County that are occasionally flooded have been delineated. A preliminary precipitation-runoff relation has been developed for Agua Fria River tributary at Youngtown; therefore, it has been established that precipitation-runoff relations can be developed for urban watersheds in Maricopa County.

The flood-drainage problems in many areas in Maricopa County exemplify the need for information on the effects of urbanization on runoff. Although little is known about these effects, considerable information can be gained by comparing the precipitation-runoff relations for urban and desert watersheds. In addition to the existing data-collection network, small well-instrumented networks of precipitation- and streamflow-gaging stations in urban and desert watersheds probably would furnish data adequate to define the relations. It is essential that the existing network be maintained in order to provide the necessary data for comprehensive hydrologic analyses needed in flood-control planning and design.

Literature Cited

Benson, M. A., 1964, Factors affecting the occurrence of floods in the Southwest: U.S. Geol. Survey Water-Supply Paper 1580-D, 72 p.

Water Resources Council, 1967, A uniform technique for determining floodflow frequencies: Washington, Water Resources Council, Hydrol. Comm. Bull. 15, 15 p.

Werho, L. L., 1967, Compilation of flood data for Maricopa County, Arizona, through September 1965: Arizona State Land Dept. Water-Resources Rept. 31, 36 p.