FLOOD OF OCTOBER 1983 AND HISTORY OF FLOODING ALONG THE SAN FRANCISCO RIVER, CLIFTON, ARIZONA

By H.W. Hjalmarson

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CONVERSION FACTORS

For readers who prefer to use metric (International System) units rather than inch-pound units, the conversion factors for the terms used in this report are listed below:

Multiply inch-pound unit	By	To obtain metric unit
inch (in.)	25.4	millimeter (mm)
foot (ft)	0.3048	meter (m)
mile (mi)	1.609	kilometer (km)
square mile (mi^2)	2.590	square kilometer (km^2)
foot per second (ft/s)	0.3048	meter per second (m/s)
cubic foot per second (ft^3/s)	0.02832	cubic meter per second (m^3/s)

Sea level: In this report "sea level" refers to the National Geodetic Vertical Datum of 1929 (NGVD of 1929)—A geodetic datum derived from a general adjustment of the first-order level nets of both the United States and Canada, formerly called "Sea Level Datum of 1929."

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TABLES

1.0 INTRODUCTION

THE HYDROLOGIC CHARACTERISTICS OF THE FLOOD OF OCTOBER 1983 AND HISTORIC FLOODS ALONG THE SAN FRANCISCO RIVER, CLIFTON, ARIZONA, ARE DESCRIBED IN THIS SECTION

On October 1, 1983, Clifton, Arizona, had the largest flood in its history of destructive floods. The flood-warning sirens sounded, but residents had no time to escape with their belongings. The next day, an even larger flood peak overtopped the banks of the San Francisco River and residents again had to flee for their lives. The residents have tenaciously occupied the river's land in a costly and losing battle against the river. Several floods since at least 1891 have overtopped the banks of floodwalls along the river and damaged or destroyed homes and businesses.

Clifton, Arizona, is located in central Greenlee County in east-central Arizona. The San Francisco River flows through Clifton toward its confluence with the Gila River. Clifton, which is a community of 4,000 residents, lies on the narrow flood plain of the San Francisco River in a V-shaped canyon. Data were collected on flood characteristics and urban development to gain information about floods and flood hazards in Clifton. The entire San Francisco River basin in Arizona and New Mexico is included in the study area. The data from this study are intended to help planners, engineers, hydrologists, local residents, and other interested individuals to understand the nature of flooding in Clifton and the consequences of encroachment on the flood plains of the San Francisco River. This report was prepared in cooperation with the U.S. Army Corps of Engineers and the U.S. Bureau of Reclamation.

This report describes the flood characteristics and the history of flooding along the San Francisco River at Clifton. (See figure 1.0-1.) The flood of October 1-2, 1983, is documented in detail. The largest known floods are summarized here by using photographs, reports, and newspaper articles.

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ABSTRACT

Clifton, Arizona, has received major damage from floods at least 12 times since the town was settled in 1870. Residents built floodwalls along the main channel of the San Francisco River, filled in flood-plain areas, and raised buildings and roads in an effort to protect homes and businesses. Although the floodwalls provide protection during low and medium flows, they provide little protection during large flows. During the flood of October 1-2, 1983, floodwaters overtopped the floodwalls and inundated flood plains. The peak discharge of 90,900 cubic feet per second on October 2, 1983, was the largest peak since 1870 and has a recurrence interval of 75 years. The 2,766-square-mile basin of the San Francisco River is steep and has a large topographic relief, especially in the vicinity of Clifton. Intense orographic rainfall from winter storms results in rapid runoff in the San Francisco River basin. Flood routing and hydrograph analyses indicate that runoff from the southern part of the San Francisco River basin produced many large peaks at Clifton.

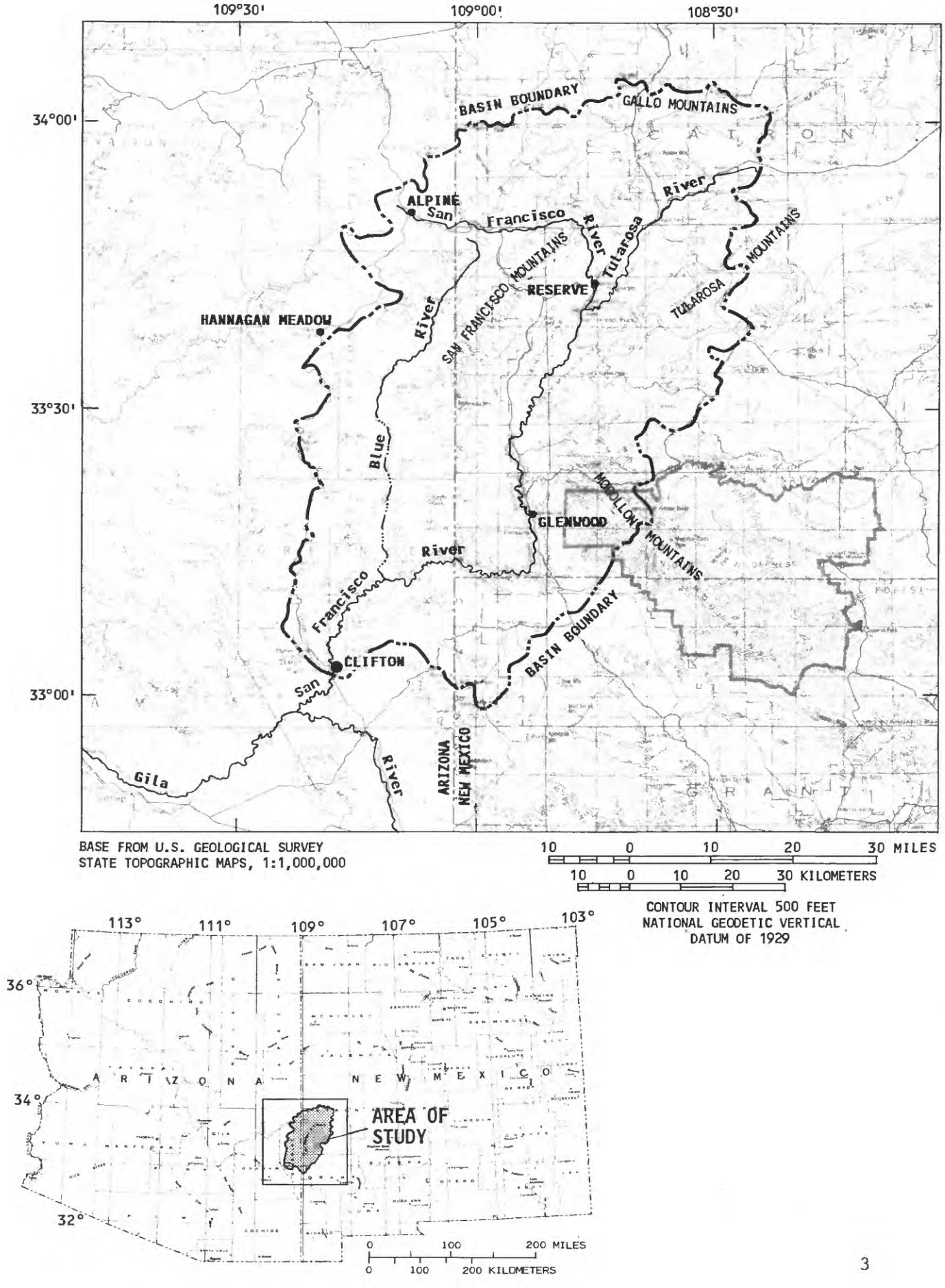


Figure 1.0-1--Area of study in Arizona and New Mexico.

2.0 HYDROLOGIC SETTING

2.1 Flooding

DEVELOPMENT IN CLIFTON DANGEROUSLY CLOSE TO THE CHANNEL OF THE SAN FRANCISCO RIVER

Clifton, Arizona, lies along the narrow flood plains on both sides of the San Francisco River and at the base of high steep cliffs that are composed of bedrock (figs. 2.1-1 and 2.1-2). The town's name probably is a shortening of "Cliff Town." Development also extends along Chase Creek and in small areas of generally flat ground above the cliffs. Development in Clifton began in the early 1870's when copper mining began in the area. In addition to the steep cliffs, another distinguishing characteristic of the Clifton area is the dangerously close proximity of the development to the large channel of the San Francisco River.

The San Francisco River drains 2,766 mi^2 of steep, rugged terrain. Because the soils are thin and the slopes are steep, runoff from heavy rains rapidly reaches the tributary streams. Rapidly rising floodflow at Clifton may occur within 1 to 2 hours after intense rainfall in the watershed. Floodwater laden with pine trees, boulders, and silt can pass through the town with a tremendous destructive force.

Clifton is one of the best examples of a community in the southwestern United States that frequently receives major damage by flooding. Many lives have been lost and many homes and businesses destroyed by floods in the San Francisco River and Chase Creek.

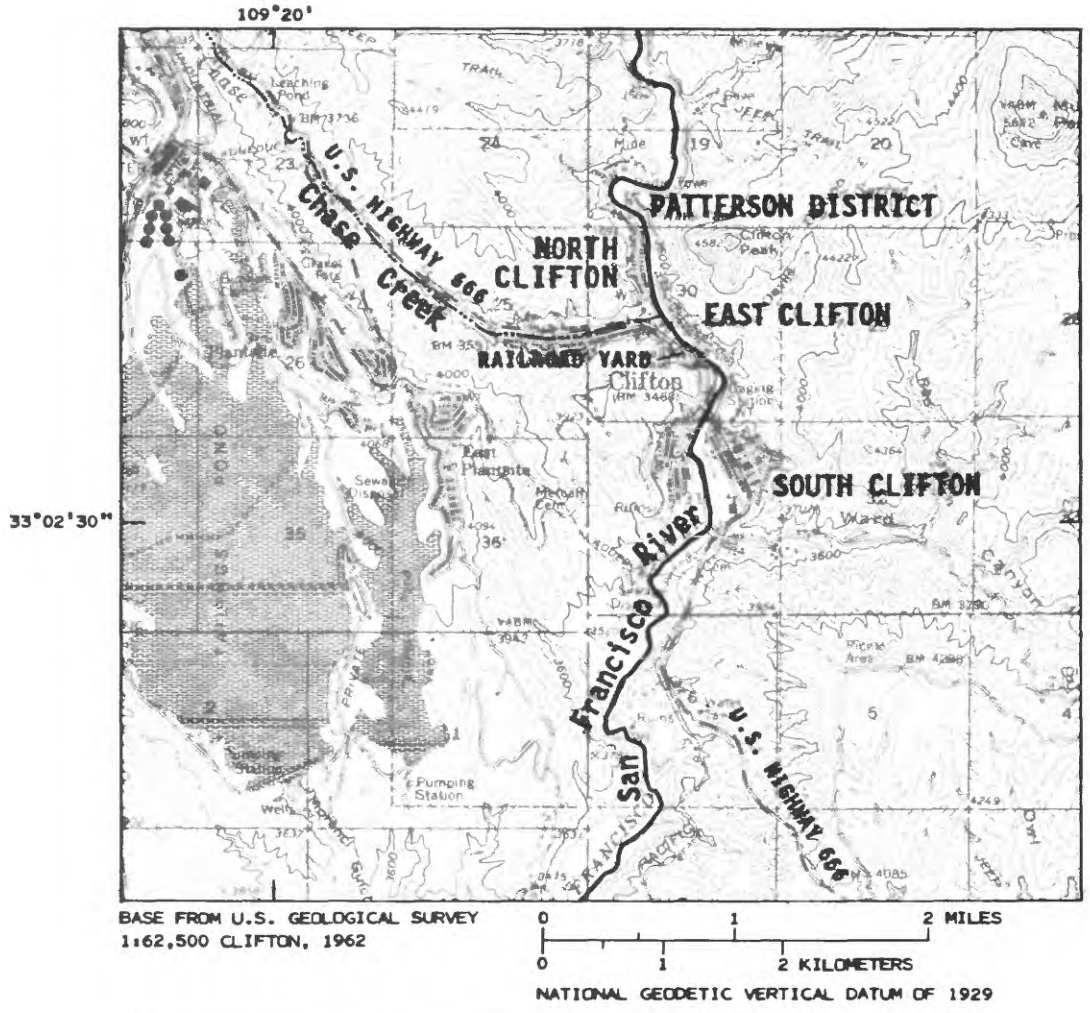


Figure 2.1-1--The San Francisco River, Chase Creek, and Clifton, Arizona.

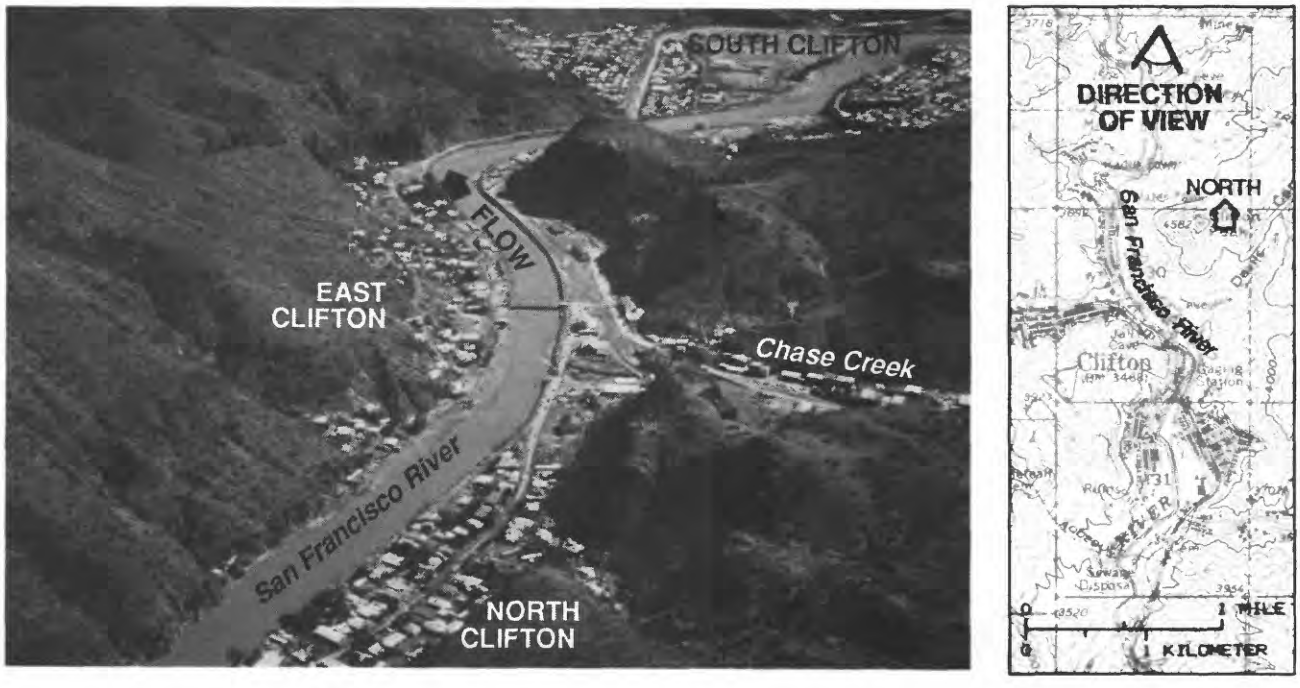


Figure 2.1-2--Aerial view of Clifton, Arizona. Photograph was taken on October 5, 1983.

2.2 Changes Made in the Channel and Flood Plain

FLOODWALLS WERE CONSTRUCTED ALONG THE MAIN CHANNEL OF THE SAN FRANCISCO RIVER AND FLOOD-PLAIN AREAS WERE FILLED IN A FEW FEET AFTER THE FLOOD OF DECEMBER 4, 1906

Floodwalls form the banks of the San Francisco River throughout much of Clifton (figs. 2.2-1 and 2.2-2). Close examination of the walls reveals a history of the community's relation with the river. After the flood of December 4, 1906, the residents considered abandoning the town but decided instead to build floodwalls along the river banks (Patton, 1945, p. 120). In some places, floodwalls were raised an additional 2 ft after the flood of 1916. Recent repairs and additions to the floodwalls are visible. After the flood of October 1-2, 1983, raising the floodwalls was considered again, especially in south Clifton.

When the floodwalls were constructed, large amounts of fill were placed on the flood plains behind the floodwalls. In the railroad depot area, about 3.5 ft of fill was added after the 1906 flood. In east Clifton, opposite the mouth of Chase Creek, a house and street were raised 3 ft by fill. Downstream from U.S. Highway 666 where slag was dumped on the flood plain, the channel is more confined now than it was in 1900. The large amount of fill in the flood-plain areas probably has not reduced the channel capacity substantially because the main channel is now hydraulically more efficient.

The capacity of the channel upstream from Chase Creek along north Clifton is almost the same now as it was in 1906. The left bank is mostly bedrock, and the floodwall along the right bank generally follows the natural bank. The cross-sectional area of the main channel generally is unchanged.

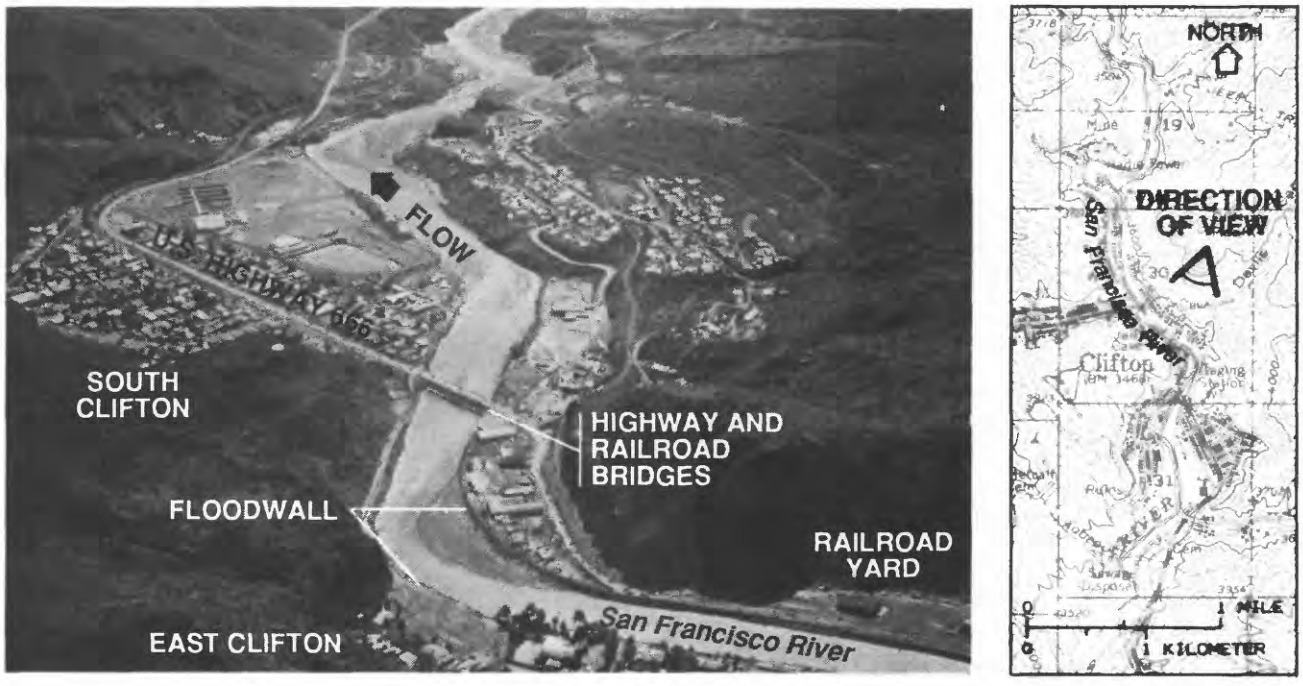


Figure 2.2-1--Floodwalls along the main channel of the San Francisco River. Photograph was taken on October 5, 1983.

Figure 2.2-2--Floodwalls at Bridge Street along the main channel of the San Francisco River. Photograph was taken on December 1, 1930. Photograph from the files of the U.S. Geological Survey; source unknown.

2.3 Bridges

BRIDGE TO PATTERSON DISTRICT DESTROYED AND RAILROAD BRIDGE DAMAGED DURING OCTOBER 1983 FLOOD

In 1891, a single-truss railroad bridge with a trestle on each side was located at bridge site 1 (figs. 2.3-1 and 2.3-2). This bridge may have been destroyed by floodwater but its fate is uncertain because of unclear and conflicting reports. The construction date of the present railroad bridge, which has two trusses, is not known; however, the date on the bridge is 1901. Two sources indicate that the old railroad bridge (fig. 2.3-1) was destroyed by a flood in 1905 or 1906 and that the present bridge was built later; however, photographs reportedly taken in 1906 show the present railroad bridge. The center pier of the bridge at site 1 was damaged during the flood of October 1-2, 1983. In 1918, a highway bridge was constructed next to the railroad bridge connecting south Clifton at Coronado Avenue. The present highway bridge on U.S. Highway 666 replaced the 1918 bridge in 1960.

In 1906, a wagon bridge was constructed at Bridge Avenue (bridge site 2). In 1918, the bridge was relocated to bridge site 3 and was destroyed during the flood of October 1-2, 1983. A new bridge was built at site 2.

The railroad bridge at site 1 causes a reduction in the hydraulic conveyance of floodwater when the stage is high enough to submerge the stringers and deck. Large amounts of debris lodge on the bridge during major floods, and the floodwater backs up and spills over the floodwall into south Clifton. The bridge at Bridge Street, site 2, probably has not caused substantial backwater.

The first two pedestrian bridges in Clifton were located across the San Francisco River at each end of east Clifton (fig. 2.3-1). The bridges were a swinging type and were damaged or destroyed during the flood of 1891.

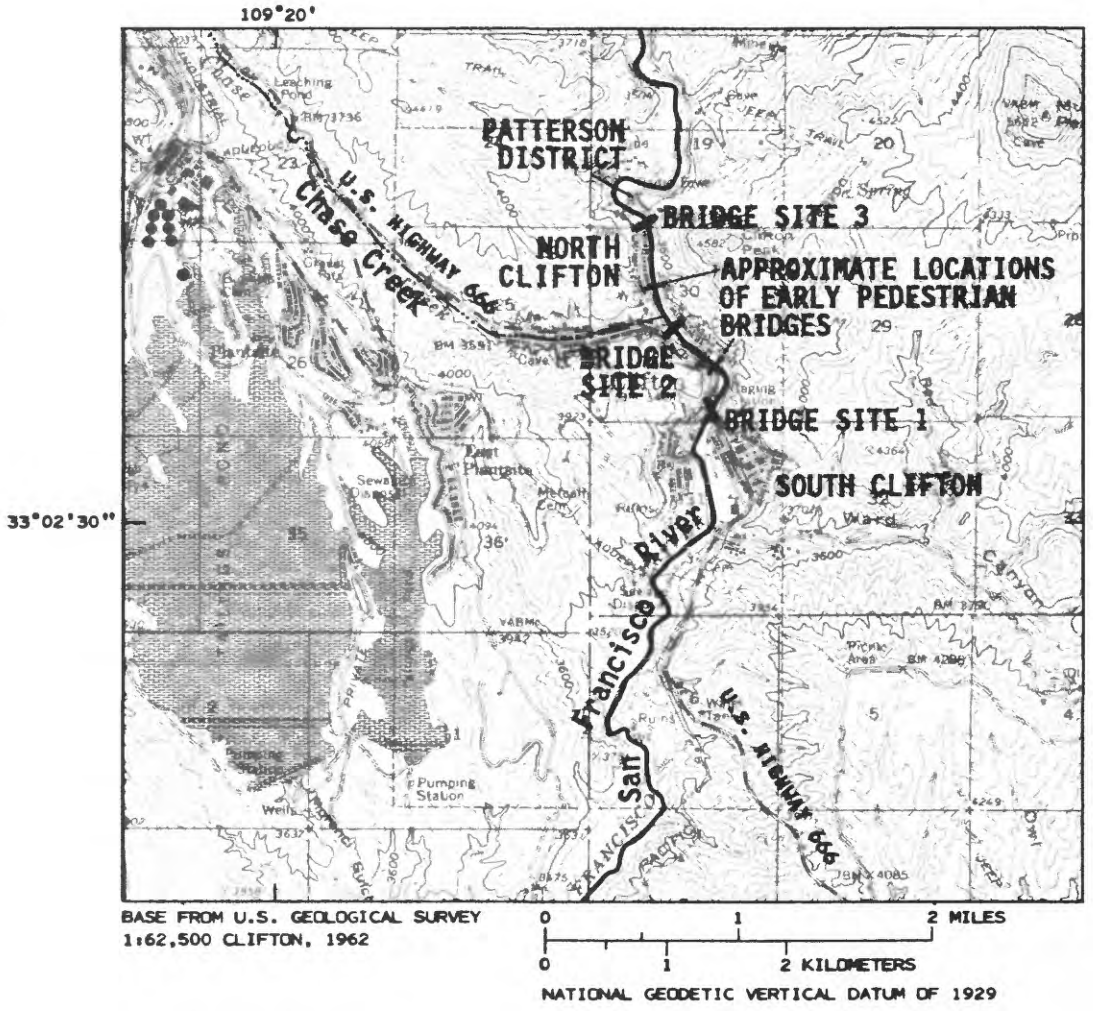


Figure 2.3-1--Location of historic and present bridge sites in Clifton, Arizona, and in the Patterson District.

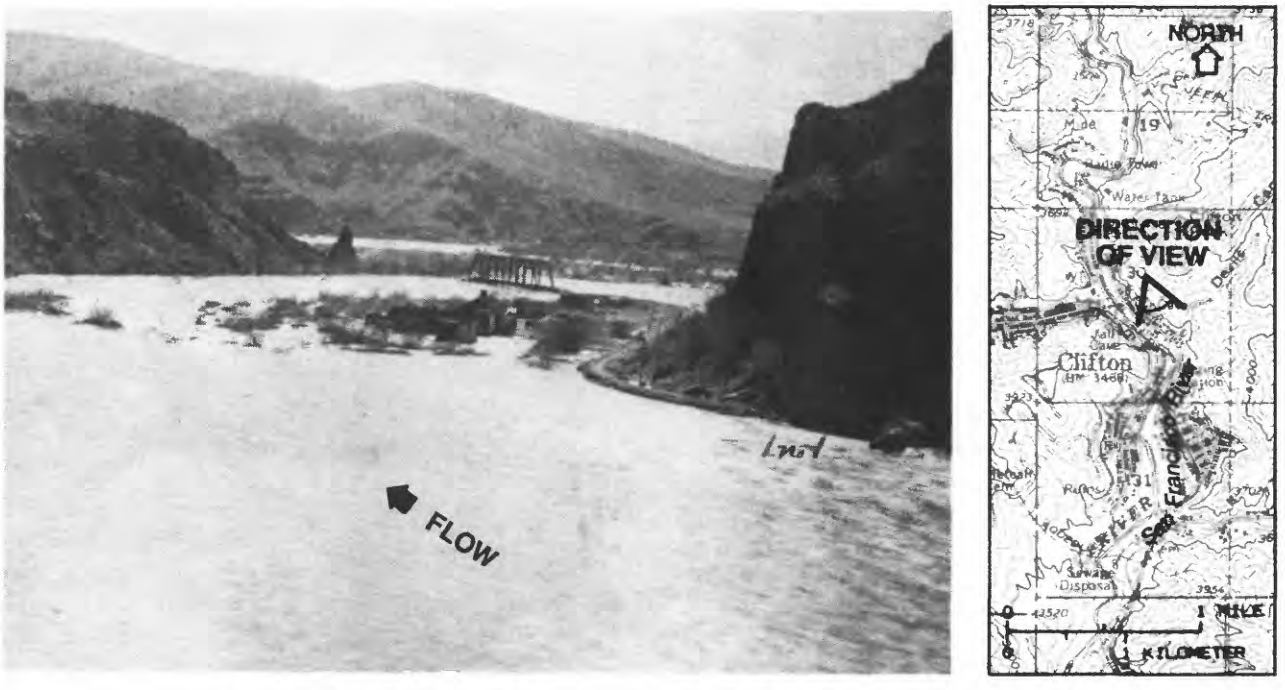


Figure 2.3-2--Flood of February 1891 at bridge site 1. No. 1 indicates location of building before the flood. Photograph from the files of the U.S. Geological Survey; source unknown.

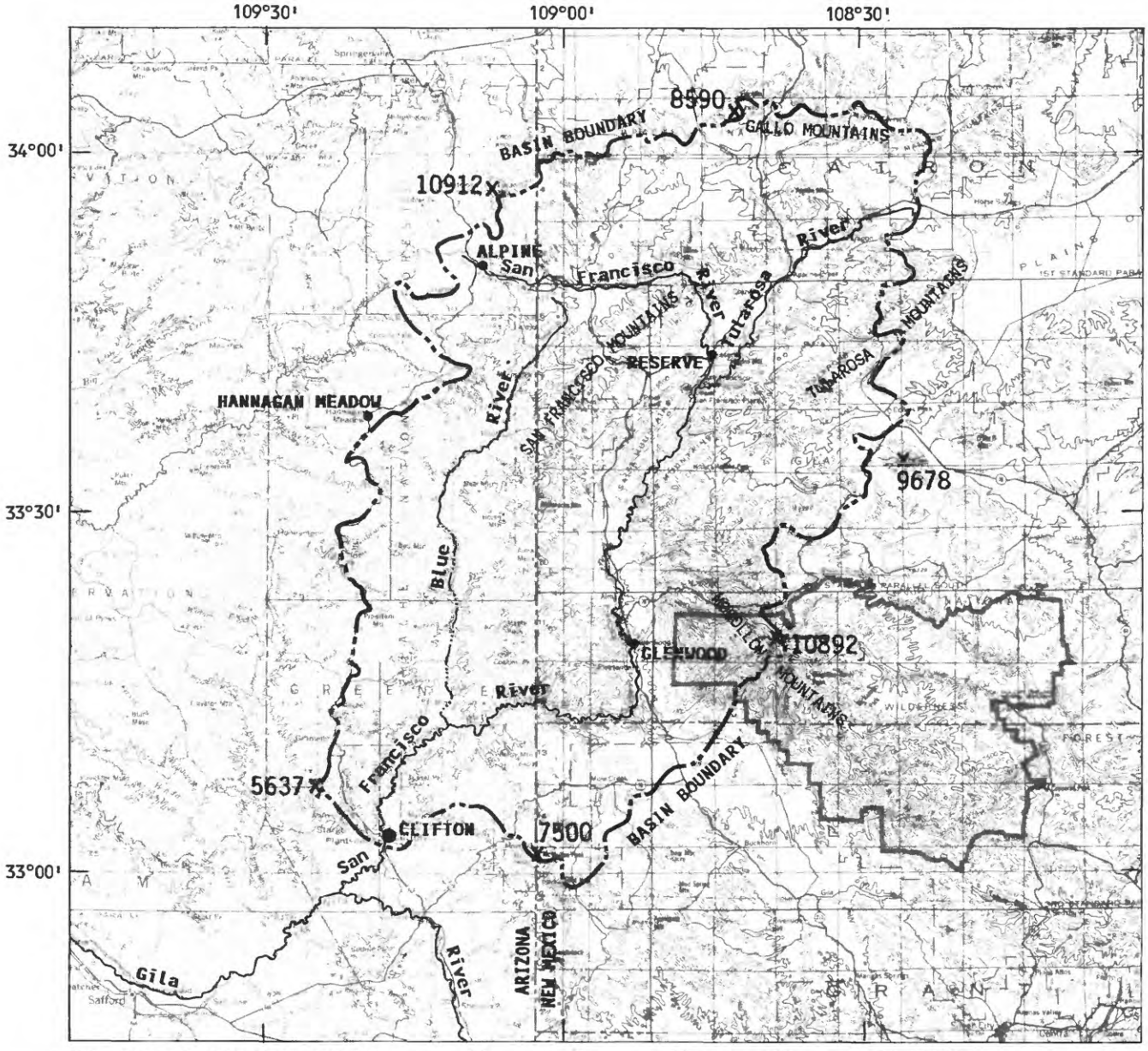
2.4 Basin Characteristics

THE SAN FRANCISCO RIVER BASIN IS RUGGED AND STEEP WITH A HIGH RELIEF THAT CAN INTERACT OROGRAPHICALLY WITH SOUTHERLY MOIST AIR TO PRODUCE INTENSE RAINFALL

The San Francisco River basin above Clifton is mountainous with steep rugged slopes and a high topographic relief. Most of the headwater area of the 2,766-square-mile basin is above 7,500 ft with a maximum altitude of nearly 11,000 ft above sea level (fig. 2.4-1). The channel of the San Francisco River at Clifton is about 3,450 ft above sea level. Most of the surrounding terrain in the Clifton area ranges in altitude from 4,000 to more than 7,000 ft. Major tributaries to the San Francisco River are the Blue River, which has a southward-trending drainage, and the Tularosa River, which heads along the Continental Divide and flows in a southwesterly direction. The San Francisco River basin drains to the south.

Downstream from Blue River to the mouth, the gradient of the 20-mile-long channel is 0.4 percent with an average width of 300 to 400 ft during floodflow. The average Manning's "n" roughness coefficient is about 0.040 for the main channel in this reach. Upstream from Glenwood, New Mexico, some reaches of the San Francisco River are not confined and floodwater can spread over wide flood-plain areas. The channel of the Blue River and the channel of the San Francisco River downstream from Glenwood, New Mexico, are confined between steep mountains and have intermittent small flood-plain areas. Much of the basin is covered by fir, pine, and pinyon-juniper forests, and the lower slopes are sparsely covered by brush and grass.

Average annual precipitation in the basin ranges from about 12 to more than 30 in.; about half of this precipitation occurs during the summer. At higher altitudes, much of the precipitation is snow that can accumulate to depths of several feet. Occasionally, warm winter rain falling on the snow over most of the basin results in some major flooding at Clifton. Much of the summer rainfall is generated by intense local thunderstorms, which may result in flash floods. Occasionally, persistent tropical surges of moist air from the south and southwest produce intense rainfall for a few hours, causing major floods.



E X P L A N A T I O N

10912x ALTITUDE OF SELECTED MOUNTAIN PEAKS NEAR THE BASIN BOUNDARY

Figure 2.4-1--Topography of the San Francisco River basin, Arizona and New Mexico.

3.0 FLOOD OF OCTOBER 1-2, 1983

RECORD FLOODING OVERTOPPED FLOODWALLS ALONG THE BANKS OF THE SAN FRANCISCO RIVER IN CLIFTON AND RAMPAGING FLOODWATERS SEVERELY DAMAGED OR DESTROYED HOMES AND BUSINESSES

More that 3 in. of rain had fallen in 2 days at Clifton when the San Francisco River overtopped the floodwalls at about 1400 hours on Saturday, October 1, 1983. Tim Miller, a student at Clifton High School, said, "There was little time to grab much more than an armful of clothes before heading for high ground. The town's flood whistle sounded, and the evacuation was underway" (Brinkley-Rogers and Lawler, 1983, p. 5A). All the floodwalls along the banks of the main channel were overtopped as the floodwater rose from nearly 60,000 ft^3/s to a record peak of almost 90,000 ft^3/s in a little more than 4 hours. The floodwaters receded during the morning of October 2, but the river started to rise again at 0600 hours. At 0945 hours, the river crested at an even larger record peak of 90,900 ft^3/s (figs. 3.0-1 and 3.0-2).

In some places on the flood plains, flood depths reached nearly 9 ft, which was 4 ft higher than the maximum peaks of earlier floods. Several buildings were swept away. Large amounts of debris were deposited on the flood plains, and as much as 7 ft of mud was deposited in some homes as the river left "a sea of mud behind" (Beal, 1983, p. 14). As the velocity of the rapidly moving floodwater that overtopped the floodwalls decreased, large amounts of silt and debris were deposited in the developed areas shoreward of the walls.

Although the flood destroyed 90 homes and 41 businesses, no loss of life or serious injury occurred. Several lives had been lost in previous floods of lower magnitude. The flood-warning sirens that were installed after the flood of 1972 and the efforts of the police to evacuate residents probably prevented the loss of life.

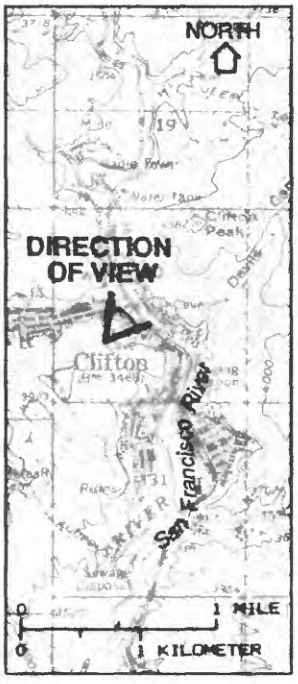
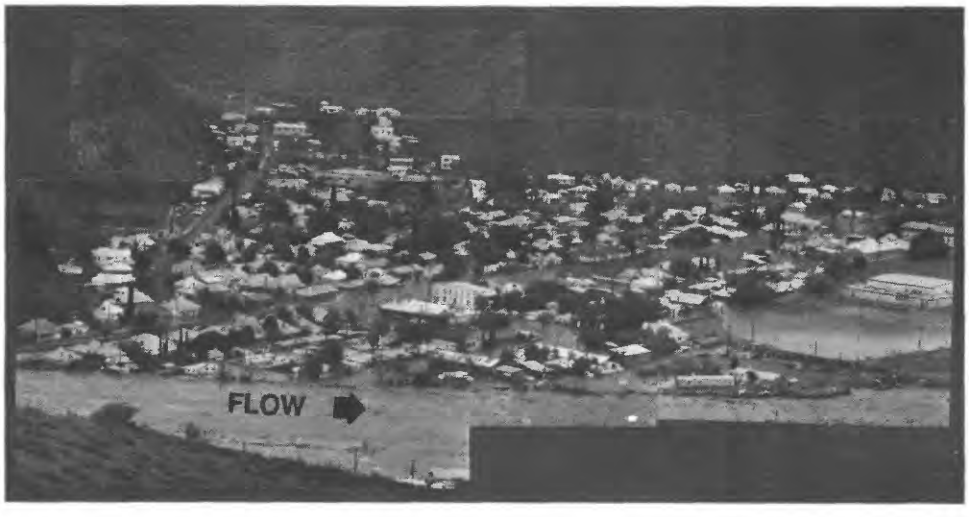


Figure 3.0-1--Bridge site 2 at Bridge Street, October 2, 1983. Discharge was at least 80,000 cubic feet per second. Photograph was taken between 0930 and 1000 hours. Photograph courtesy of John F. Hancock, Morenci, Arizona.



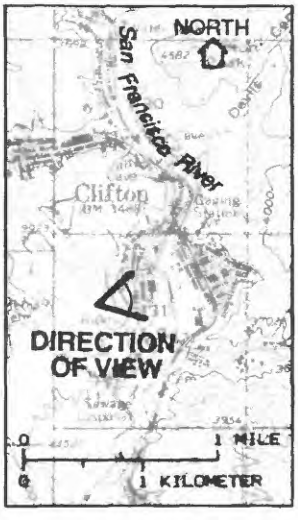


Figure 3.0-2--San Francisco River at south Clifton, October 2, 1983. Photograph courtesy of John F. Hancock, Morenci, Arizona.

3.0 FLOOD OF OCTOBER 1-2, 1983 (Continued)

3.1 The Storm

HEAVY RAINFALL OF NEARLY 6 TO AS MUCH AS 10 INCHES OCCURRED IN THE SAN FRANCISCO RIVER BASIN

During late September 1983, tropical storm Octave was located off the tip of Baja California at the same time that a high-altitude low-pressure trough existed over the western conterminous United States. As a result, Octave moved across Arizona in a northerly to northeasterly direction with large quantities of moisture. In southeastern Arizona, rainfall ranged from 3 in. to more than 11 in. during September 28 through October 3 with two periods of intense rainfall. In the San Francisco River basin, most of the rainfall occurred during September 28 through October 2. More than 6 in. of rainfall occurred in the larger river basins in southeastern Arizona.

The largest amount of rain fell in the San Francisco River basin upstream from Clifton, Arizona. A total storm rainfall of 11.30 in. was recorded at the U.S. Geological Survey precipitation station in the Blue River basin. North of Clifton, rainfall increased along the steep southwest-facing mountain slopes that produced an orographic effect on the northeastward-moving moisture. The amount of rainfall decreased in the upper San Francisco River basin where the mountain slopes are not as steep and the relief is not as great (fig. 3.1-1).

Small quantities of rain fell on September 27 and 28 and most of September 29. At 1600 hours on September 29, intense rainfall began in the San Francisco River basin; one period of flood-producing rain started at 0200 hours on October 1 and one at 0400 hours on October 2. The time distribution of rainfall recorded at the U.S. Geological Survey station at Clifton and Blue River show a similar time pattern (fig. 3.1-2). Starting at 0200 hours on October 1 after 4 days of about 2.5 to 4.5 in. of moisture, intense rainfall occurred simultaneously on the entire San Francisco basin.

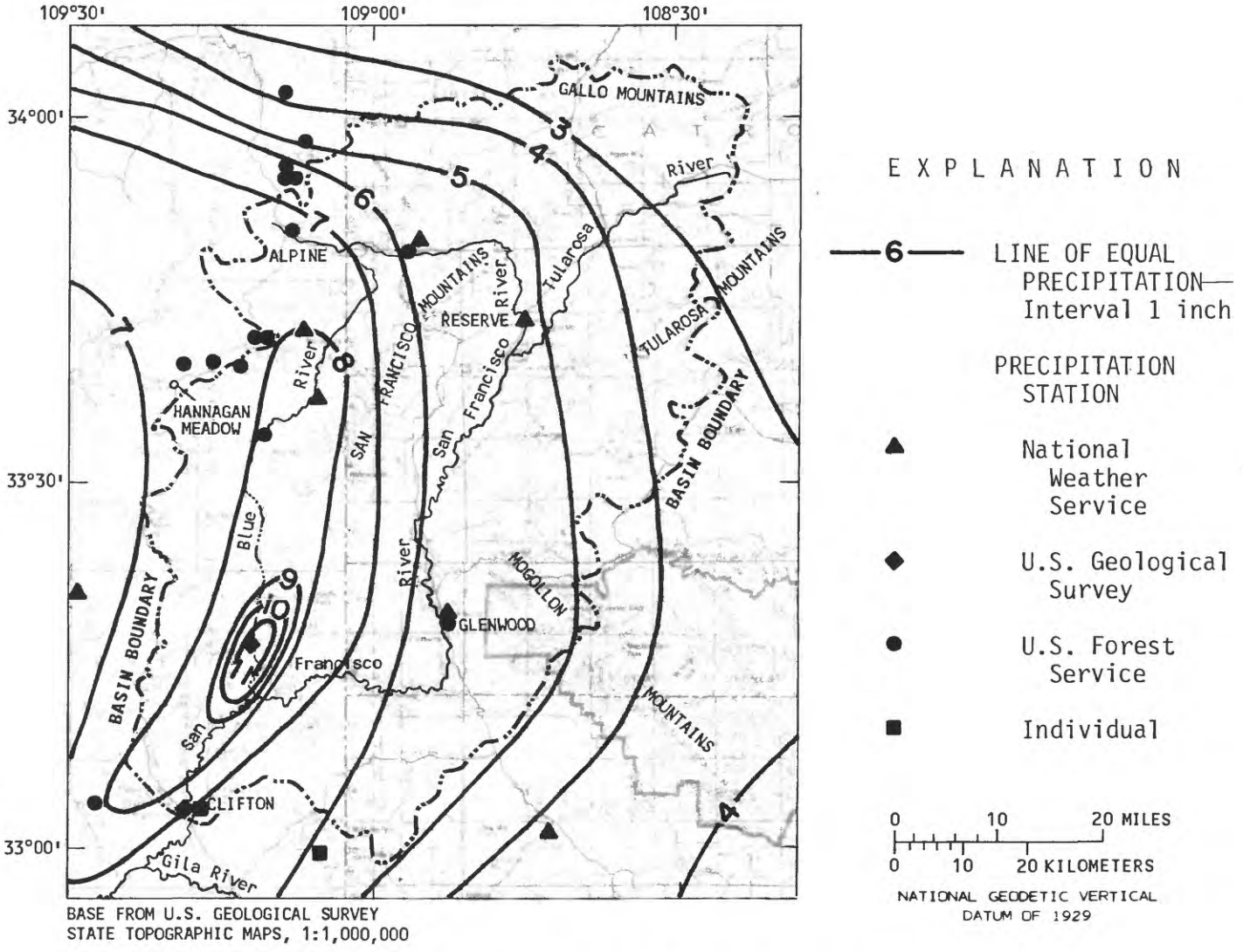


Figure 3.1-1--Storm rainfall in the San Francisco River basin, Arizona and New Mexico, September 27 to October 3, 1983.

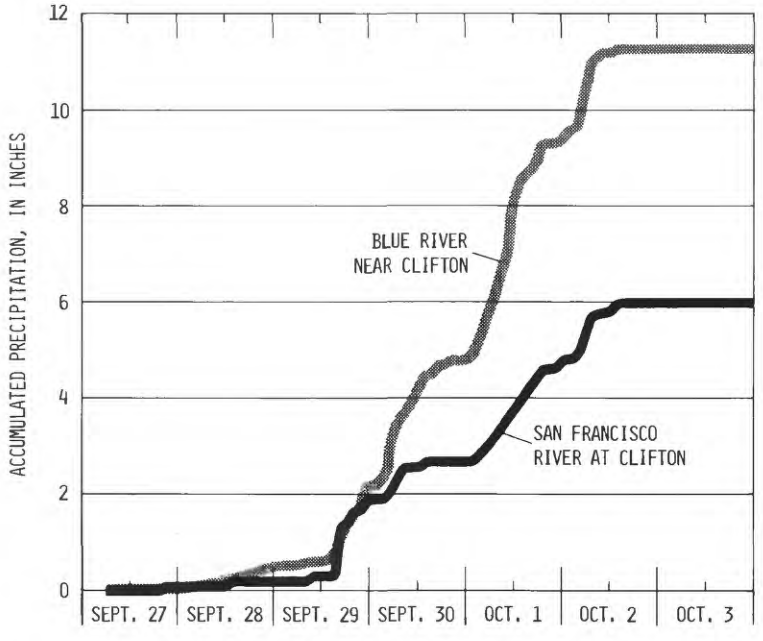


Figure 3.1-2--Rainfall data from precipitation stations, Blue River near Clifton, Arizona, and San Francisco River at Clifton, Arizona, September 27 to October 3, 1983.

3.2 Runoff

UNPRECEDENTED FLOOD PEAKS OCCUR AT STREAMFLOW-GAGING STATIONS ON THE SAN FRANCISCO RIVER NEAR GLENWOOD, NEW MEXICO, AND AT CLIFTON, ARIZONA

In the San Francisco River basin, the San Francisco River and Blue River were flowing bankfull on September 30, 1983. The soil in the basin was wetted by the earlier rains, and conditions were favorable for large amounts of runoff. On October 1, 1983, runoff started almost simultaneously throughout the basin in response to the increasing amounts of rain and, by 1200 hours, the major streams were flooding. At the streamflow-gaging station on Blue River near Clifton, the discharge increased from 6,730 ft^3/s to a peak discharge of 24,300 ft^3/s during a 3-hour period. Throughout most of October 1, the discharge at the gaging stations on the San Francisco River near Reserve, Alma, and Glenwood, New Mexico, steadily increased (fig. 3.2-1). At 1900 hours on October 1, the discharge peaked at 28,600 ft^3/s at San Francisco River near Glenwood, New Mexico, gaging station. Runoff from the area between the gaging station and Clifton, Arizona, caused the river to rise at Clifton. The discharge at Clifton increased from 32,700 ft^3/s at 1200 hours to a peak of 89,600 ft^3/s at 1615 hours. As the floodwaters from local runoff above Clifton receded, floodwater from the area above Glenwood, New Mexico, arrived at Clifton about 2400 hours on October 1.

On the morning of October 2, 1983, the channel of the San Francisco River from Alma, New Mexico, to Clifton, Arizona, was still flooded when runoff began again throughout the basin. At the gaging station near Glenwood, New Mexico, the San Francisco River started to rise at 0600 hours and the flow peaked at 37,000 ft^3/s at 1115 hours. The peak discharge at the Blue River near Clifton gaging station was 23,500 ft^3/s at 0700 hours. Downstream at Clifton, discharge of the San Francisco River increased 38,000 ft^3/s in less than 4 hours to a record peak of 90,900 ft^3/s at 0945 hours.

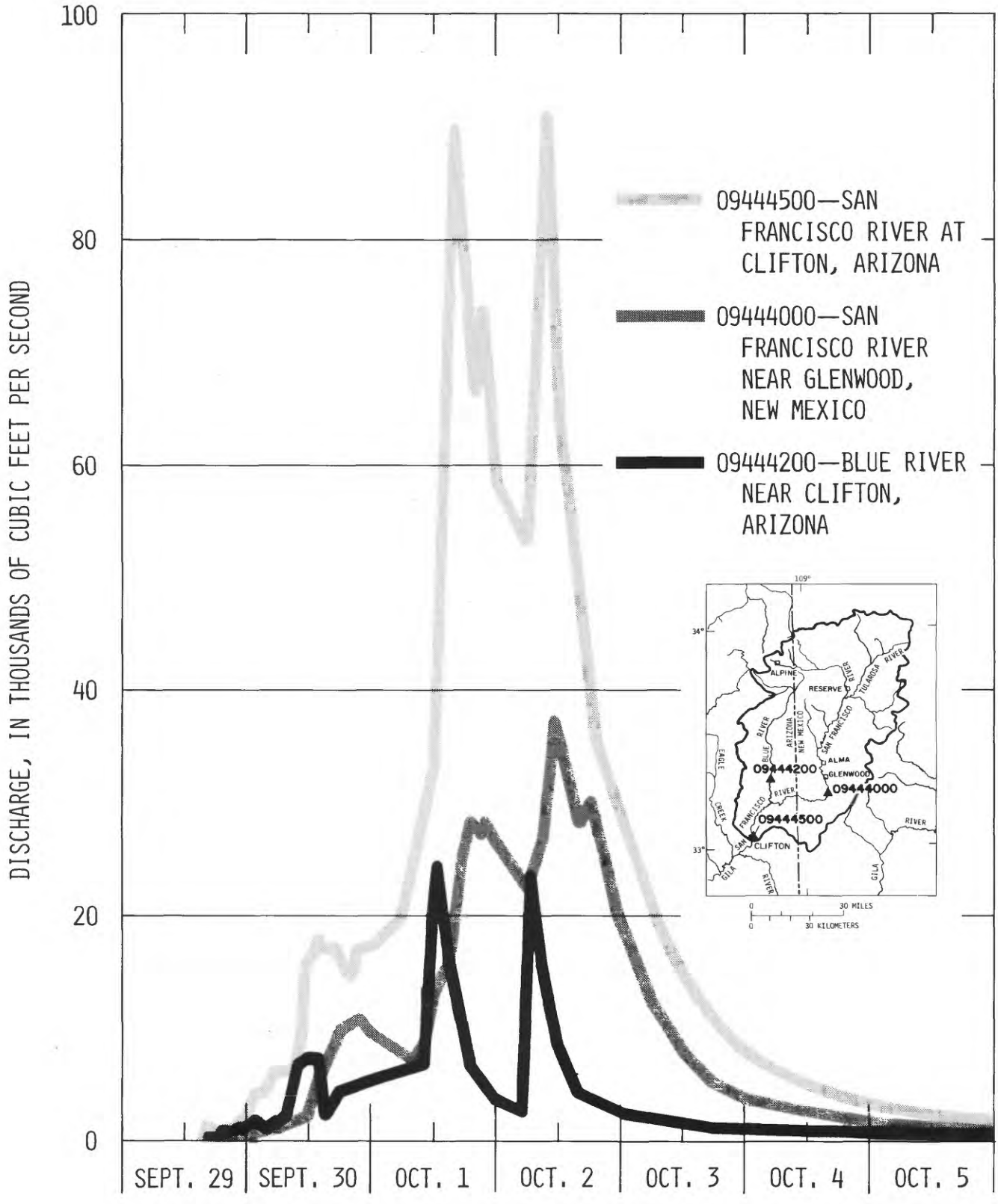


Figure 3.2-1--Discharge from selected gaging stations on the San Francisco River, Arizona and New Mexico, September 29 to October 5, 1983.

3.0 FLOOD OF OCTOBER 1-2, 1983 (Continued)

3.2 Runoff (Continued)

3.2.1 Flood Routing

FLOOD ROUTING AND HYDROGRAPH ANALYSIS INDICATE THAT A SIGNIFICANT AMOUNT OF FLOODFLOW WAS FROM LOCAL RUNOFF

The discharge hydrographs for the Blue River near Clifton, Arizona; San Francisco River near Glenwood, New Mexico; and San Francisco River at Clifton, Arizona, indicate that the peak at Clifton occurred before the peak at Glenwood and after the peak on the Blue River near Clifton, Arizona. Also, the peak discharge at Clifton was considerably more than the sum of the peak discharges at Blue River near Clifton and San Francisco River near Glenwood, New Mexico. A substantial amount of local inflow occurred from the 607-square-mile area between Clifton and the upstream gages at Blue River near Clifton and San Francisco River near Glenwood, New Mexico. The hydrograph of local discharge is useful for defining the runoff characteristics of the basin and, in particular, for defining the lag time between rainfall and runoff. A flood-warning system using rainfall data may increase the response time for evacuation and may result in a lower loss of life and property. Flood routing was used to define the discharge hydrograph for local runoff.

A hydrograph for local runoff can be defined by (a) determining the discharge at Clifton from routing of floodflow at the gaging stations Blue River near Clifton, Arizona, and San Francisco River near Glenwood, New Mexico, and (b) subtracting the routed discharge from the total observed discharge to yield local runoff. Hourly discharges at the gaging stations are routed to the confluence of the rivers by use of a flow-routing method (Doyle and others, 1983). At the confluence of the Blue and San Francisco Rivers, the routed discharges are combined, and the resultant hourly discharges are routed to Clifton (fig. 3.2.1-1 and table 3.2.1-1).

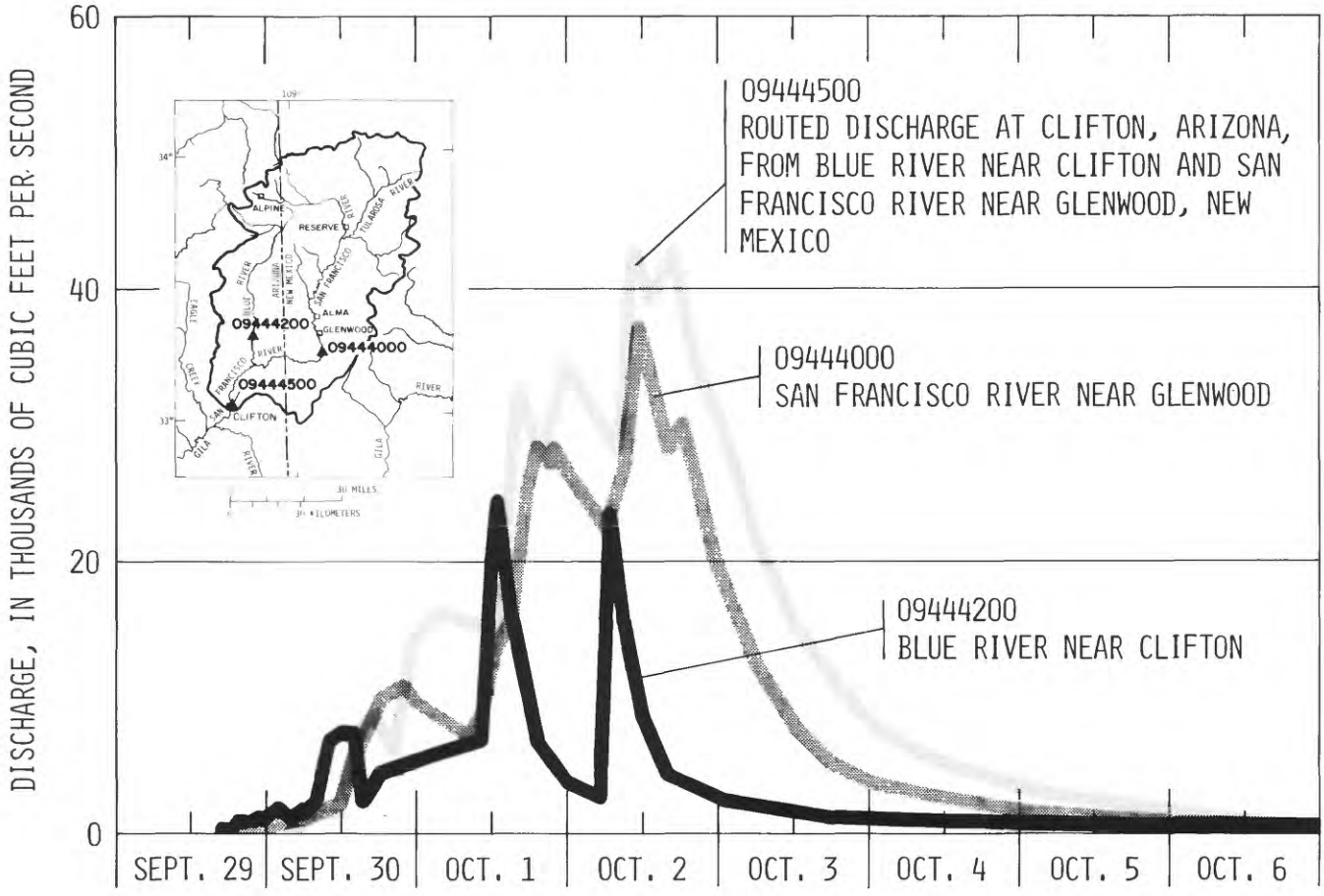


Figure 3.2.1-1--Routed discharge from Blue River near Clifton, Arizona, and San Francisco River near Glenwood, New Mexico, to Clifton, Arizona, September 29 to October 6, 1983.

Table 3.2.1-1.--Routed discharge at San Francisco River at Clifton, Arizona

[Routed discharge is the composite of observed discharge at San Francisco River near Glenwood, New Mexico, and Blue River near Clifton and does not include intervening local flow. Routed discharge for October 3-5, 1983, is adjusted to more closely agree with observed discharges to give a smooth recession. Discharge is in cubic feet per second]

Time	Discharge	Time	Discharge	Time	Discharge
Sept. 30		Oct. 1—Con.		Oct. 3	
0100	0	1600	31,000	0600	21,000
0300	0	1700	31,600	1200	15,000
0500	170	2000	26,900	1800	11,000
0600	640	2400	34,000	2400	7,800
1000	1,510	Oct. 2			
1200	1,520	0600	29,200	Oct. 4	
1600	7,690	0800	27,800	0600	6,100
1800	8,400	0900	31,700	1200	5,000
2100	5,750	1000	40,900	2400	3,320
2400	14,100	1100	42,500		
		1300	38,500	Oct. 5	
Oct. 1		1700	41,900	0600	2,800
0400	16,000	2000	34,300	1200	2,530
1300	14,600	2400	30,000	2400	1,780

The equation for routing of hourly discharges for steady-state flow conditions (simplest form) is

$$Q_L = Q_C - (Q_B + Q_G), \quad (1)$$

where

Q_L = computed discharge from local runoff, San Francisco River at Clifton (table 3.2.1-2),

Q_C = discharge, San Francisco River at Clifton (fig. 3.2.1-2), and

Q_B and Q_G = simulated discharge at Clifton from Blue River near Clifton and San Francisco River near Glenwood, New Mexico (fig. 3.2.1-2).

The hydrograph for computed local discharge shows that a large part of the peak discharge resulted from runoff from the area downstream from the two gaging stations (Q_B and Q_G) (fig. 3.2.1-2). The peak from computed local discharge (58,600 ft^3/s at 1600 hours) on October 1, 1983, combined with the peak from Blue River to produce nearly all the peak discharge (89,600 ft^3/s at 1615 hours) at Clifton. Computations show that 63 percent of the peak discharge was from local runoff. On October 2, 1983, the peak from computed local discharge was 55 percent of the record peak of 90,900 ft^3/s at Clifton.

The flood-warning system for Clifton that was recently initiated by the Flood Warning Office of the Arizona Department of Water Resources is based on the routing of floodwater from telemetered data obtained from U.S. Geological Survey gaging stations on the San Francisco River near Glenwood, New Mexico, and Blue River near Clifton, Arizona. To improve the flood warning for evacuation of the flood-plain areas of Clifton, telemetered rainfall data for the area of local runoff was identified for potential flood-hazard mitigation (U.S. Federal Emergency Management Agency, 1983, p. 17 and 18). On the basis of flood routing (Doyle and others, 1983), a substantial increase of discharge from local runoff precedes the floodwater from upstream areas by 1 to 2 hours. On October 1, 1983, a sharp peak from local runoff occurred 1 hour before the sharp peak flow arrived from Blue River. On October 2, another peak from local runoff occurred about 2 hours before the peak flow from Blue River reached Clifton. Thus, solely on the basis of basin-runoff characteristics, the lead time of the present warning system could be increased by at least 1 hour for a similar flood. A lead time of about 3 hours is possible, however, using rainfall and runoff data from precipitation stations in the local drainage area.

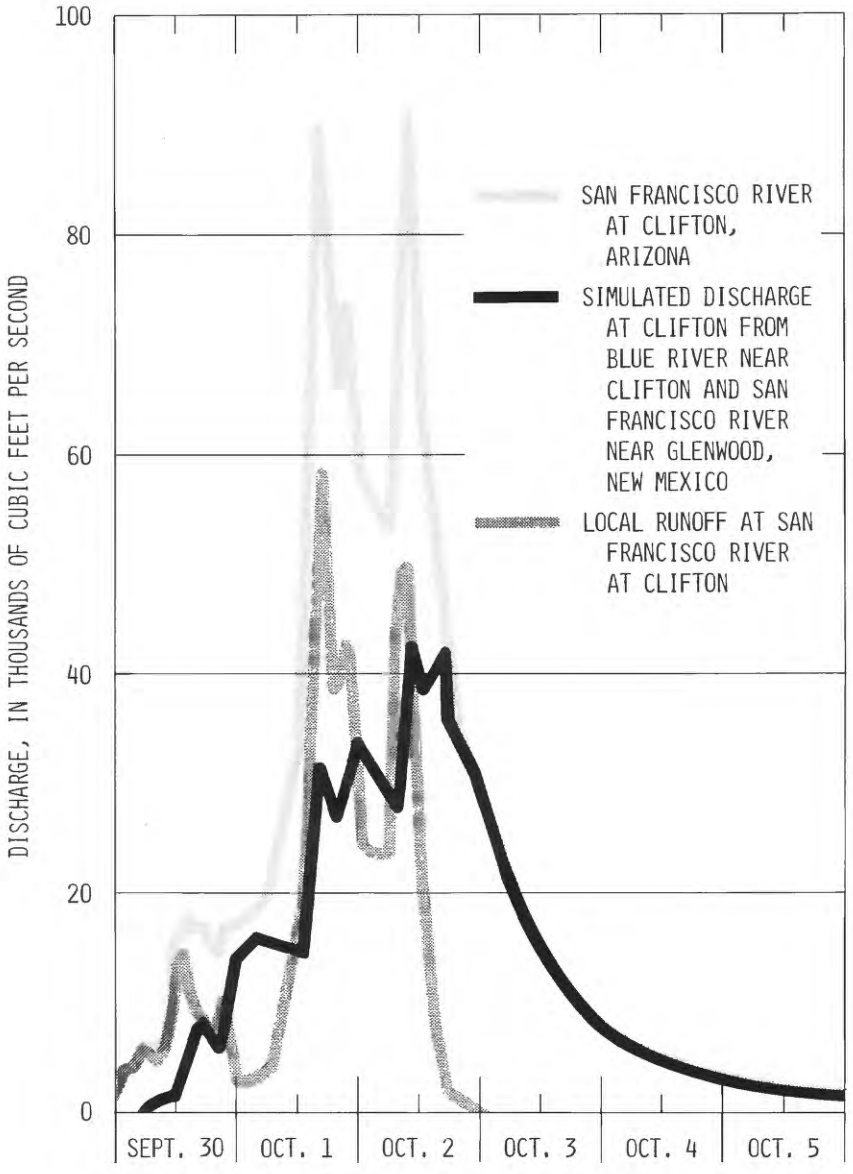


Figure 3.2.1-2--Observed, simulated, and computed local discharge, Clifton, Arizona, September 30 to October 5, 1983.

Table 3.2.1-2--Computed discharge from local runoff, San Francisco River at Clifton, Arizona, September 30 to October 2, 1983

[Discharge is in cubic feet per second]

Time	Discharge	Time	Discharge	Time	Discharge	Time	Discharge
Sept.30		Sept. 30—Con.		Oct. 1—Con.		Oct. 2—Con.	
0100	2,390	2000	7,930	1000	13,400	0600	23,600
0130	3,610	2100	10,850	1200	18,100	0700	34,000
0330	3,970	2200	7,390	1500	48,200	0800	44,000
0500	5,050	2400	2,700	1600	58,600	0900	49,700
0800	4,530			1800	42,300	1000	50,000
1000	7,130	Oct. 1		1900	38,100	1200	24,200
1100	8,580	0100	2,350	2200	42,100	1400	14,200
1200	14,200	0300	2,390	2400	24,500	1600	5,000
1300	15,000	0400	2,600			1800	2,000
1500	10,200	0600	4,100	Oct. 2		2400	0
1900	6,750	0800	8,900	0300	23,600		

3.2 Runoff (Continued)

3.2.2 Flood Frequency and Magnitude

THE PEAK DISCHARGE OF THE FLOOD OF OCTOBER 2, 1983, COULD BE EXCEEDED ON THE AVERAGE OF ONCE EVERY 75 YEARS

The peak discharge of 90,900 ft^3/s on the San Francisco River at Clifton, Arizona, on October 2, 1983, has a recurrence interval of 75 years (fig. 3.2.2-1). This discharge probably is the largest at this site since 1870. A discharge of at least this magnitude has a 1.3-percent chance of occurring in any given year.

Large floods on the San Francisco River generally occur during the winter period, September to May, as a result of extensive tropical-moisture and frontal-type storms. A winter annual peak of 30,000 ft^3/s has nearly a 9-percent chance of being exceeded in any year, but a summer annual peak of the same magnitude, as a result of intense convective stream activity, has less than a 2-percent chance of being exceeded in any year (fig. 3.2.2-1). Examination of the annual peaks also indicates that large annual peaks are more likely to occur in the winter (fig. 3.2.2-2).

Floods generally are defined in terms of recurrence interval and frequency of occurrence. Conventional flood-frequency curves are commonly used (fig. 3.2.2-1). Established methods for defining frequency curves are used by Federal agencies and many State and local authorities (U.S. Water Resources Council, 1981). Log-Pearson Type III frequency distributions for annual, summer, and winter populations were used for the San Francisco River at Clifton.

This analysis used 74 years (1911-84 water years) of systematic annual peaks that are based on records of streamflow at the San Francisco River at Clifton (fig. 3.2.2-2) and estimates (1918-26 water years) that are based largely on records of streamflow at Gila River at head of Safford Valley, near Solomon, Arizona. Four historic peak discharges in 1891, 1905, 1906, and 1907 also were used. The flood of 1891 was considered the highest from about 1870 to 1891 on the basis of reports of flooding (Patton, 1945, p. 115; Burkham, 1970, p. 21). The single-population frequency relation was compared to a composite-frequency relation based on summer and winter populations, and no significant difference was observed (fig. 3.2.2-1). The curves are related by the formula

$$P_A = P_S + P_W - P_S P_W, \qquad (2)$$

where

P_A = probability of exceedance of an annual peak during any year,

P_S = probability of exceedance of a summer peak during any year, and

P_W = probability of exceedance of a winter peak during any year.

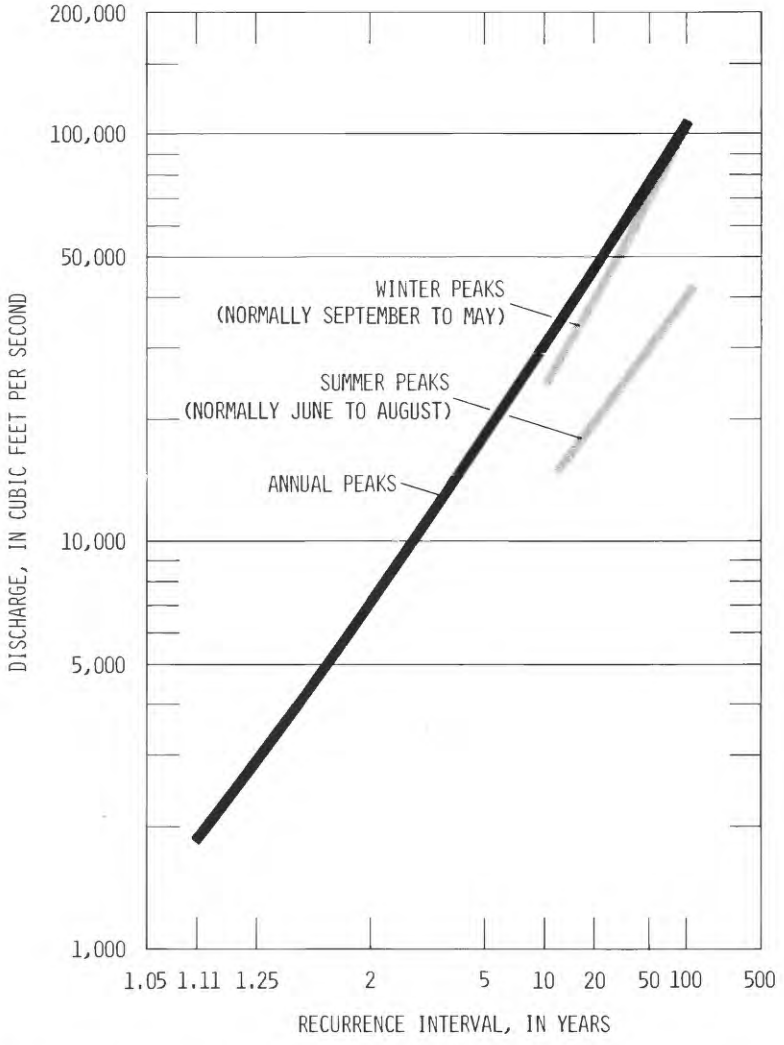


Figure 3.2.2-1--Frequency curves of annual, summer, and winter floods, San Francisco River at Clifton, Arizona.

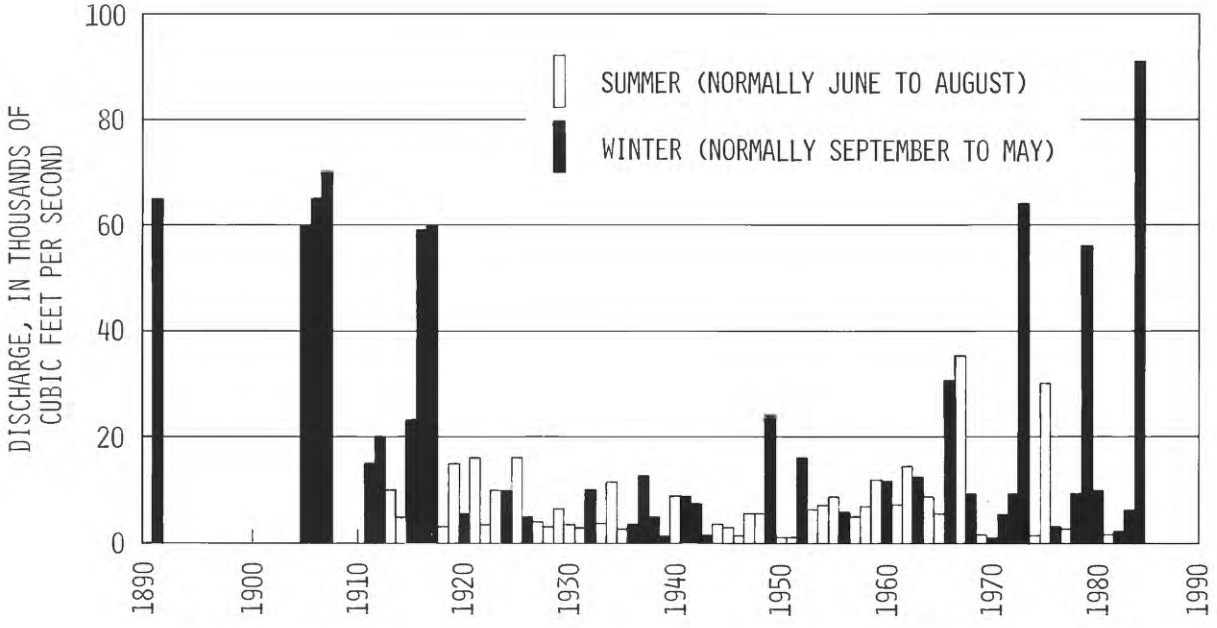


Figure 3.2.2-2--Annual peak discharges, San Francisco River at Clifton, Arizona.

3.0 FLOOD OF OCTOBER 1-2, 1983 (Continued)

3.3 Flood Boundaries and Elevation

3.3.1 General Area

FLOODWATER SPILLS OVER FLOODWALLS AND INUNDATES FLOOD PLAINS AT RECORD DEPTHS

Flood boundaries and elevations shown in figure 3.3.1-1 were determined from 119 transit-stadia surveyed floodmarks, aerial and ground photographs taken during and after the flood, and field mapping that was done after the flood. The elevations are referenced to sea level. The survey was referenced to the gaging station on the downstream side of the right pier at bridge site 1; the datum of the gaging station is at an elevation of 3,436.16 ft.

All the buildings in the Patterson District were inundated during the flood of October 1-2, 1983. In the north Clifton area, the floodwater was 3 to 4 ft above the top of the floodwall from bridge site 3 at the north end of the area downstream to Chase Creek (fig. 2.3-1). All the homes in north Clifton between the toe of the mountain and the river were inundated. In the railroad yard area, the water was 5.4 ft above the floor of the northeastern room of the old railroad depot; at the historic railroad engine display just south of the jail, the water was 3.8 ft above the east track. In the east Clifton area, almost all the buildings along Park Street had water above floor level; at the old Central Hotel, the water was 7.6 ft above the floor. The floodwall along east Clifton was overtopped and provided little protection to structures. In the south Clifton area, floodwater spilled over the floodwall near U.S. Highway 666 and became ponded because outflow through a small ditch was restricted by the flooded San Francisco River.

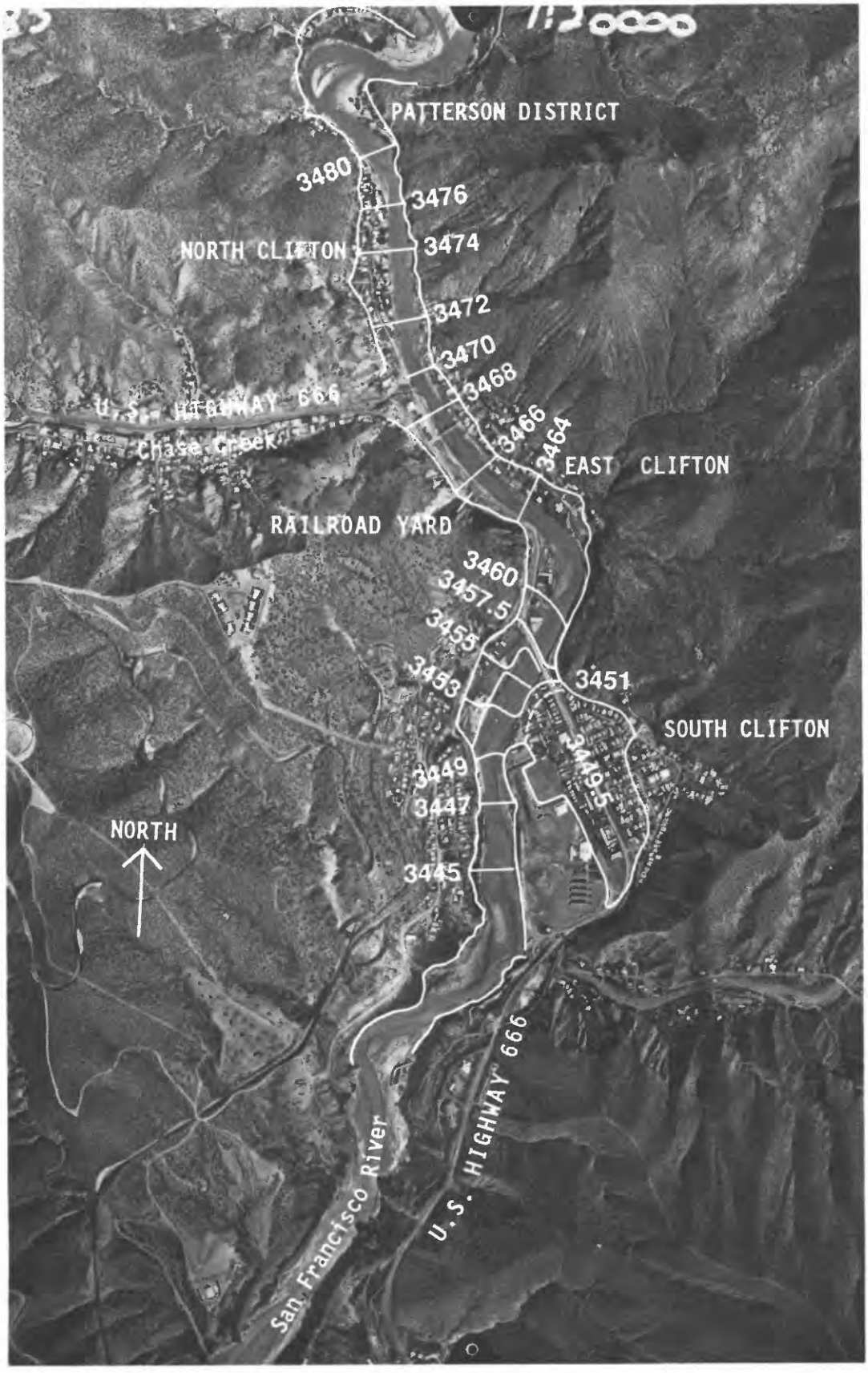


Figure 3.3.1-1--Flood elevations and boundaries at Clifton, Arizona. Photograph was taken on October 7, 1983. Photograph by Cooper Aerial Surveys.

3.3 Flood Boundaries and Elevation (Continued)

3.3.2 U.S. Highway 666 and South Clifton

FLOODWATERS OF THE SAN FRANCISCO RIVER INUNDATE U.S. HIGHWAY 666 AND DEPOSIT LARGE AMOUNTS OF SILT AND DEBRIS IN THE AREA

On October 1, 1983, the floodflow of the San Francisco River increased from 32,700 ft^3/s at 1200 hours to more than 80,000 ft^3/s at 1600 hours. Floodwaters overtopped the right bank at U.S. Highway 666 about 0.3 mi upstream from bridge site 1. Water covered the flood plain on the right bank and flowed down Highway 666 to the bridge (figs. 3.3.2-1, 3.3.2-2, and 3.3.2-3). Flow over the highway continued for about 3 hours. Downstream from the bridge, the flood-plain flow spilled over the steep bank into the main channel for about 1,200 ft.

On October 2, 1983, a peak discharge of 90,900 ft^3/s occurred at 0945 hours. During this peak, water flowed over the highway on the right bank for at least 1 hour. Peak discharge over the highway embankment to the right of bridge site 1 was 7,200 ft^3/s. Flow crossed the embankment at a 45° angle.

On the left bank upstream from the bridge, the floodwater overtopped a masonry retaining wall (figs. 3.3.2-1, 3.3.2-2, and 3.3.2-4). Downstream from the bridge, a concrete floodwall was also overtopped. Most of south Clifton was inundated. The water, trapped behind the floodwalls, became ponded at an elevation of 3,449.5 ft. About 2,700 ft of U.S. Highway 666 was inundated in south Clifton. Large amounts of silt and debris were deposited in the area. Flow velocities were too small to cause erosion along the highway.

U.S. Highway 666 was closed at 1500 hours, October 1, 1983, and reopened on October 4, 1983. In order to reopen the highway, silt and debris that included large trees had to be removed after the ponded floodwater in south Clifton slowly drained back into the San Francisco River.

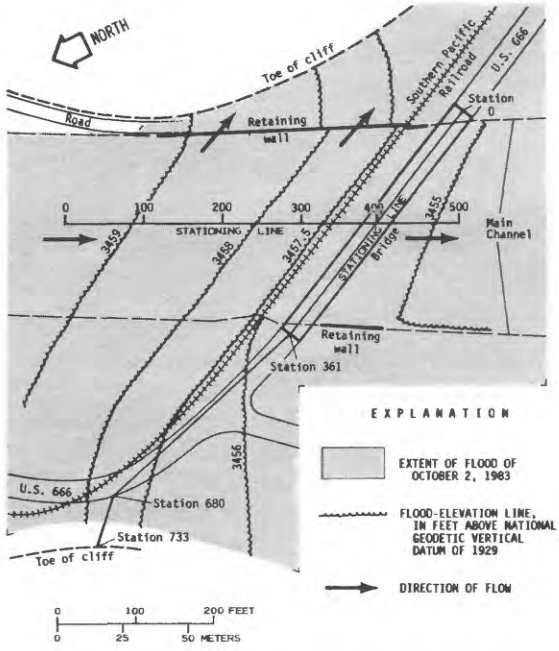


Figure 3.3.2-1--Flood boundary and elevation at bridge site 1, San Francisco River at Clifton, Arizona.

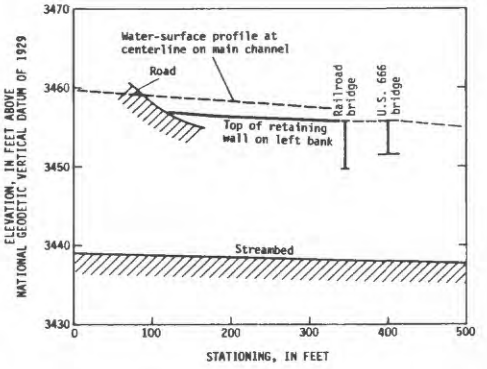


Figure 3.3.2-2--Profile of the San Francisco River at bridge site 1, Clifton, Arizona.

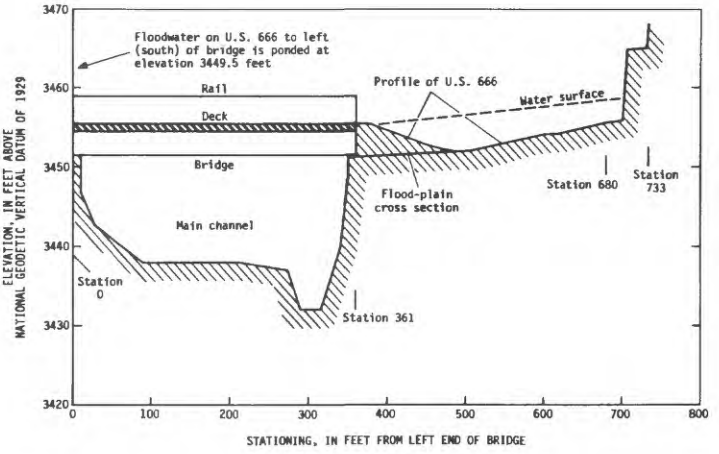


Figure 3.3.2-3--Cross section of the San Francisco River at bridge site 1, Clifton, Arizona.

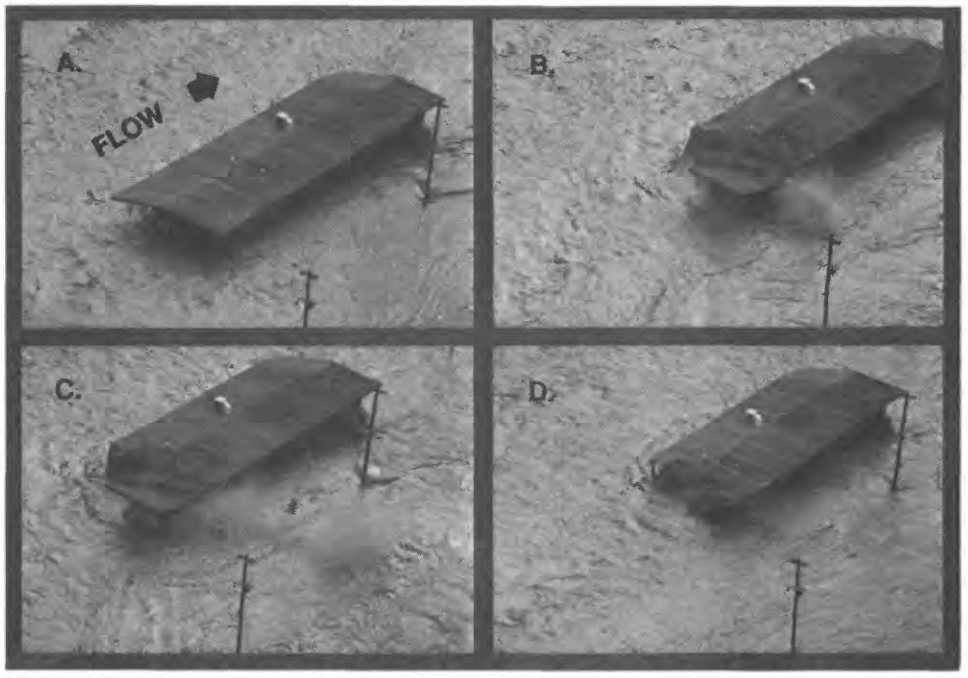
Figure 3.3.2-4--Bridge site 1 about 0900 hours, October 2, 1983. Discharge was about 75,000 cubic feet per second. Photograph courtesy of John F. Hancock, Morenci, Arizona.

3.4 Flood Damage

NEARLY ALL HOMES AND BUSINESSES ON THE FLOOD PLAIN OF THE SAN FRANCISCO RIVER ARE DAMAGED OR DESTROYED

The flood of October 1-2, 1983, probably caused the most damage to structures in Clifton's history. The flood of 1891 covered the town from mountain to mountain; many buildings were washed away, the railroad track was moved, and the rails were twisted. On June 9, 1903, a tailings dam in Chase Creek basin broke and many homes were swept away; at least 13 lives were lost. On December 4, 1906, the tailings dam in Chase Creek basin broke again and caused an estimated $1 million in damages to structures; at least 18 lives were lost. Before the flood of October 1-2, 1983, the most damaging flood on the San Francisco River in this century was on October 20, 1972; flooding of 105 homes and 24 businesses caused an estimated $1,360,000 in damages (U.S. Army Corps of Engineers, 1979, p. 12).

On October 5, 1983, President Reagan declared Arizona a major disaster area, making the town of Clifton eligible for public and private assistance. About 130 homes and businesses had been washed away or damaged (figs. 3.4-1 and 3.4-2). Nearly 240 other buildings received major damage, and about 60 buildings received minor damage. Of the 126 businesses in the community, 84 percent received some damage—41 were destroyed, 57 had major damage, and 8 had minor damage. The cost for repairs including debris removal, shoulder repair, and sidewalk replacement along U.S. Highway 666 was about $200,000. The estimated total damage in Clifton was $9.5 million.



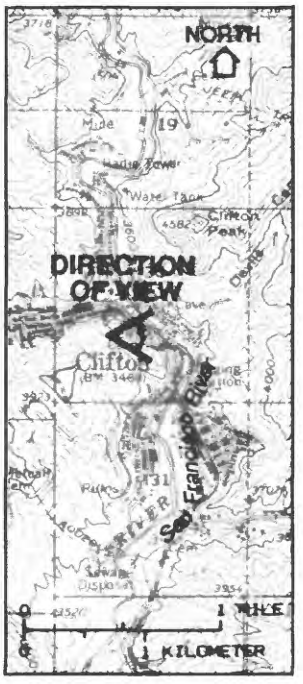
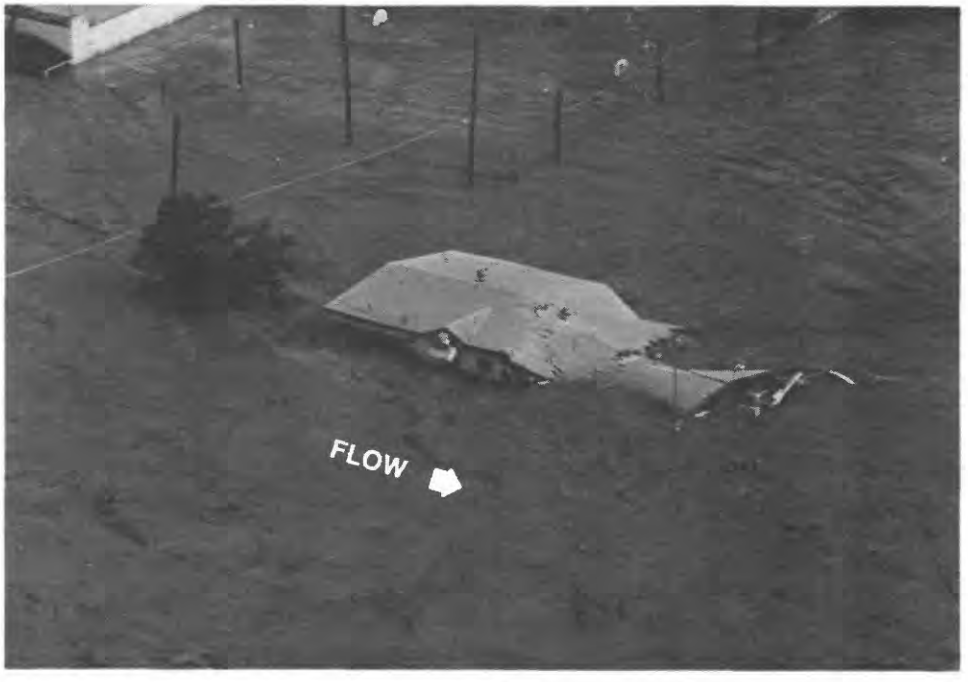


Figure 3.4-1--Structural failure of railroad freight depot, October 2, 1983. Photographs taken between 0930 and 1000 hours. Time interval between photographs was only a few seconds. Discharge was at least 80,000 cubic feet per second. Photographs courtesy of John F. Hancock, Morenci, Arizona.



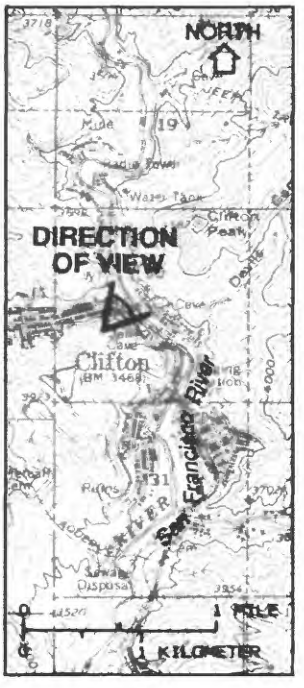


Figure 3.4-2--Inundation of Riley's Drug Store in east Clifton, October 2, 1983. Photograph taken between 0930 and 1000 hours. Discharge was at least 80,000 cubic feet per second. Photograph courtesy of John F. Hancock, Morenci, Arizona.

4.0 HISTORY OF FLOODS

CHARACTERISTICS OF PAST FLOODS DEFINED BY EXAMINATION OF HISTORIC PHOTOGRAPHS OF FLOODS, NEWSPAPER ARTICLES, ACCOUNTS BY LOCAL RESIDENTS, MEASUREMENTS OF FLOOD DEPTH, AND RECORDS OF STREAMFLOW

Much of the information on the history of large floods was obtained from photographs taken during and after the floods of February 1891, December 1906, and January 1916; newspaper articles; interviews of local residents; and several flood measurements. This information provided a means of estimating historic flood discharges and of comparing early floods with recent floods at several places in Clifton. Fairly definite comparisons were made between the floods of 1906, 1916, 1972, and 1983, although conditions changed largely because of the addition of floodwalls and the filling of the flood plains.

Floodwater has overtopped the banks of the San Francisco River and damaged homes and businesses in Clifton at least 12 times since the town was settled in 1870. Early accounts of floods indicate that earlier damaging floods occurred in the early 1870's, 1880, 1885, and possibly 1890 before the severe flood of 1891. The flood of 1880 cut a new channel on a flood plain and isolated several homes. A note penciled on the back of a photograph on file at the Arizona Historical Society states that a railroad bridge at bridge site 1 was damaged by a flood in 1885. Although information is insufficient to estimate the stage or discharge of these early floods, the flood of February 21, 1891, appears to be the largest of these historic floods.

The 1891 flood extended from mountain to mountain and inundated nearly all of Clifton. Buildings were washed away, and the railroad was greatly damaged. A larger flood occurred on December 3, 1906 (see fig. 4.0-1 for a photograph of this flood or possibly an earlier flood). Eighteen lives were lost, and damages were estimated at $1 million. Some of the loss of life and damage was from flooding along Chase Creek.

Two large floods occurred in 1916 (fig. 4.0-2) and were followed by a long period of small floods until October 20, 1972. Throughout Clifton, the stage of the flood of October 1972 was higher than the stage of the two 1916 floods. In the Patterson District, the flood of October 1972 was about 1 ft lower than the flood of 1906. The slope in water surface through the town, however, was greater during the 1906 flood than that during the 1972 flood. At bridge site 2, the stages for the two flood peaks are approximately equal; however, at bridge site 1, the 1906 flood was about 2 to 2.5 ft lower than the 1972 flood.

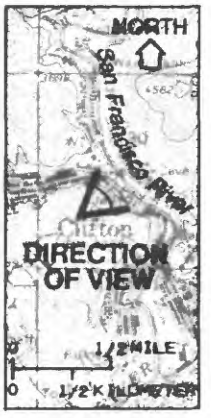
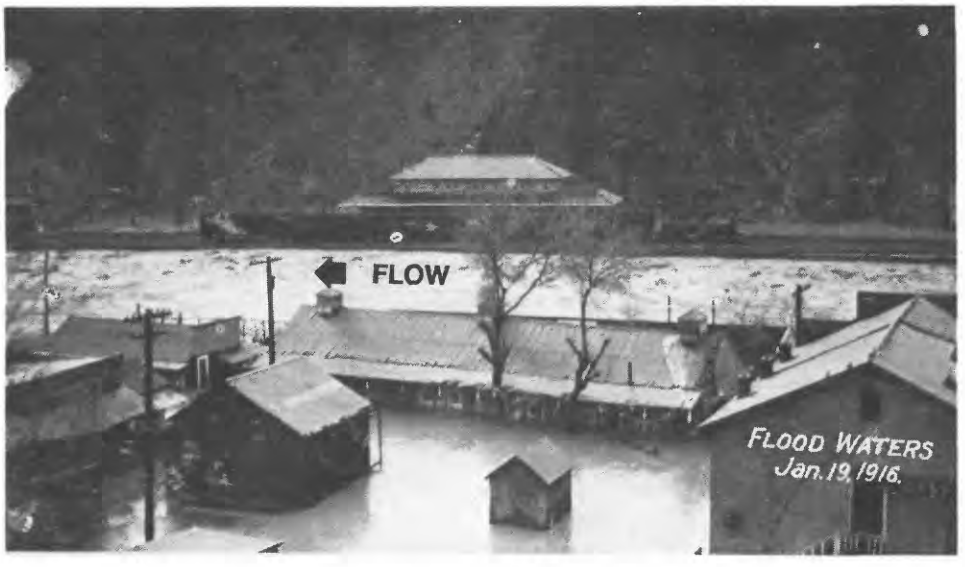


Figure 4.0-1--A flood in 1905 or 1906 in the San Francisco River, east Clifton, Arizona. The bridge on the left was built in 1905 and the houses on the right were replaced by the railroad depot before 1916. Photograph courtesy of the Arizona Historical Society.



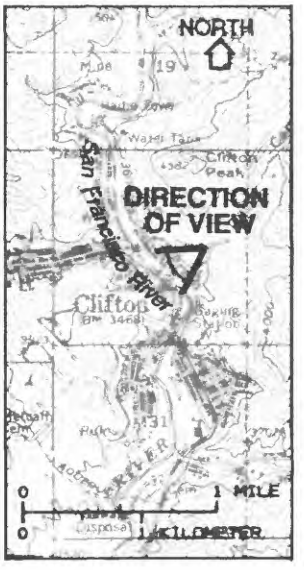


Figure 4.0-2--Railroad depot during flood of January 19, 1916, San Francisco River, Clifton, Arizona. Photograph from the files of the U.S. Geological Survey; source unknown.

4.0 HISTORY OF FLOODS (Continued)

4.1 Records of Floodflow

A SYSTEMATIC RECORD OF ANNUAL MAXIMUM DISCHARGE FOR THE 1911 TO 1984 WATER YEARS AND FOR HISTORIC PEAKS DURING 1891 AND 1905-07 HAS BEEN DETERMINED FROM STREAMFLOW RECORDS AND OTHER SOURCES

The record of streamflow of San Francisco River at Clifton began in the 1911 water year and continues to the present (1985 water year) except for periods of no operation in 1911, 1912, and 1913 and from August 1918 to June 1927. The first annual maximum discharge was determined for the peak of December 20, 1914 (table 4.1-1). To obtain a continuous record of maximum discharge since records began, missing peaks were estimated. Several of the annual peaks were determined from floodmarks using stage-discharge relations.

For the 1919 to 1926 water years, the peaks were estimated from records of streamflow at the gaging station Gila River at head of Safford Valley, near Solomon, Arizona. The records for this station, which is located downstream on the Gila River, indicate that the peaks during this period were low. The peaks were estimated from a poorly defined correlation of later peaks (1927-73). A well-defined maximum probable flow for each peak was obtained. Actual peak discharges probably are equal to or less than the values estimated. Estimated discharges are less than 15,000 ft^3/s for the 8 years, and any errors are assumed to have little effect on characterizing floods at Clifton. The peak discharges for the floods of 1891 and 1905-07 were estimated because of the historic value of these large floods. The analyses of data are on file at the offices of the U.S. Geological Survey, Tucson, Arizona.

Table 4.1-1.--Annual and historic peak discharges, 1891-1984, San Francisco River at Clifton, Arizona

Date	Water year	Discharge[1] by rank, in cubic feet per second
Systematic record		
October 2, 1983.....	1984	90,900
October 20, 1972.....	1973	64,000
October 14, 1916.....	1917	60,000
January 19, 1916.....	1916	59,000
December 19, 1978.....	1979	56,000
August 12, 1967.....	1967	[2]34,700
December 23, 1955.....	1966	30,500
September 9, 1975.....	1975	30,000
January 13, 1949.....	1949	24,100
December 20, 1914.....	1915	23,000
March 10, 1912.....	1912	20,000
August 1921.....	1921	[3]16,000
September 1925.....	1925	[3]16,000
January 19, 1952.....	1952	15,800
March 7, 1911.....	1911	15,000
August 1919.....	1919	[3]15,000
September 26, 1962.....	1962	14,300
February 8, 1937.....	1937	12,400
October 18, 1962.....	1963	12,200
January 12, 1960.....	1960	11,800
August 26, 1934.....	1934	11,700
August 28, 1959.....	1959	11,600
July 1913.....	1913	10,000
August 1923.....	1923	[3]10,000
December 1924.....	1924	[3]10,000
February 10, 1932.....	1932	10,000
Estimated historic peak discharges[4]		
December 3, 1906.....	1907	70,000
February 21, 1891.....	1891	65,000
November 27, 1905.....	1906	65,000
January 10, 1905.....	1905	60,000

[1]Peaks less than 10,000 cubic feet per second not shown.
[2]Largest summer peak of record.
[3]Estimated on the basis of records of streamflow at Gila River at head of Safford Valley, near Solomon, Arizona.
[4]Occurred before systematic record began.

4.2 Comparison of Floods

4.2.1 North Clifton

ELEVATION OF FLOOD CRESTS FOR HISTORIC FLOODS ESTIMATED IN PLACES IN NORTH CLIFTON

Photographs during or shortly after flooding in 1906 (probable year), 1916, 1972, and 1983 were taken along Frisco Street in north Clifton (figs. 4.2.1-1 to 4.2.1-3; arrows in these photographs point to the same house at 145 Frisco Street) and are used here as an example of how historic flood information was related. The house at 145 Frisco Street is in the photographs; with the aid of a magnifying viewer, a line can be seen in the early photographs that appears to be a high-water mark (fig. 4.2.1-2). In the 1906 picture, a man is holding a cane horizontally at about the level of the apparent mark, which is about 0.6 ft below the top of the porch rail (fig. 4.2.1-2). The 1972 flood was 0.8 ft below the top of the rail (fig. 4.2.1-3), and the October 1983 flood was 1.2 ft above the rail. The January 1916 flood appears to have covered about one step of the porch and was probably about 2 ft below the 1906 and 1972 floods. The high-water mark from the flood of 1916 was on a fence that no longer exists. Transit-stadia surveys of floodmarks for the 1972 and 1983 floods were made in north Clifton. The floodmarks for early floods were tied to these surveys, and a record of flood-crest elevations was compiled (table 4.2.1-1).

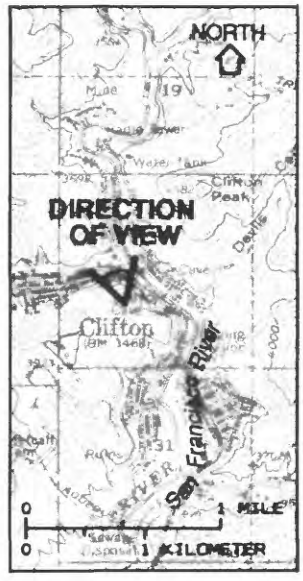


Figure 4.2.1-1--Flood of October 2, 1983, along Frisco Street, Clifton, Arizona. Photograph courtesy of John F. Hancock, Morenci, Arizona. Note that arrow on photographs indicates same house.

Figure 4.2.1-2--Frisco Street, 1905 or 1906. Man in center of photograph is holding a cane at the high-water mark. Photograph from the files of the U.S. Geological Survey; source unknown.

Figure 4.2.1-3--Frisco Street, November 21, 1972. Man's outstretched arms indicate the high-water mark from the flood of October 1972. Photograph from the files of the U.S. Geological Survey; source unknown.

Table 4.2.1-1.--Elevations of major flood crests at 145 Frisco Street, Clifton, Arizona, 1891-1983

Date	Approximate elevation by rank, in feet above NGVD of 1929	Date	Approximate elevation by rank, in feet above NGVD of 1929
October 2, 1983....	3,473.5	January 10, 1905...	3,469
December 3, 1906...	3,472	January 19, 1916...	3,469
October 20, 1972...	3,471.5	October 14, 1916...	3,469
February 21, 1891..	3,471	December 19, 1978..	3,469
November 27, 1905..	3,471		

4.0 HISTORY OF FLOODS (Continued)

4.2 Comparison of Floods (Continued)

4.2.2 East Clifton

A RECORD OF FLOOD CRESTS AT THE CENTRAL HOTEL IS AVAILABLE

Peak stages are available for the flooding of the Central Hotel during the floods of 1906, 1916, 1972, and 1983; references to peaks of floods in 1891 and 1905 are also available (fig. 4.2.2-1 and table 4.2.2-1). Comparability of these flood peaks may be limited because of the effects of the added floodwalls along the river channel. The depth of the floodwater in the Central Hotel for the 1906 flood was 1.9 ft higher than that for the October 1916 flood, which was more than 1 ft deep (The Copper Era, October 13, 1916). Newspaper accounts indicate that the October 1916 flood was a few inches higher than the January 1916 flood. The stage at the hotel probably did not represent the stage in the river channel because the flow in the channel for the January 1916 flood was just barely over the floodwall. The 1972 flood was 4.4 ft deep and the 1983 flood was nearly 8 ft deep in the Central Hotel.

The Central Hotel is a short distance downstream from the site of the old Clifton Hotel. The hotels were at about the same elevation, and observed flood depths at the Clifton Hotel can be compared with flood depths at the Central Hotel. The water surface of the November 1905 flood was up to the windows of the Clifton Hotel or about 1 ft lower than that of the December 1905 flood. Newspaper accounts indicate that the November 1905 flood was equal to the flood of 1891 in the Central Hotel area. The crest of the December 1906 flood was 4 ft deep at the Clifton Hotel or about 1 ft higher than the December 1905 flood, and the first floor of the Central Hotel was inundated with water and mud. The flood of January 1916 was 0.7 ft deep in the Clifton Hotel (The Copper Era, January 21, 1916).

Figure 4.2.2-1--Flooding of the San Francisco River at the Central Hotel on Park Avenue in east Clifton, Arizona, October 2, 1983. Photograph courtesy of John F. Hancock, Morenci, Arizona.

Table 4.2.2-1.--Elevations of major flood crests at the Central Hotel in east Clifton, Arizona

Date	Approximate elevation by rank, in feet above NGVD of 1929
October 2, 1983.....	3,467
October 20, 1972.....	3,463.6
December 3, 1906.....	[1]3,463
February 21, 1891.....	[1]3,462
November 27, 1905.....	[1]3,462
October 14, 1916.....	3,460.5
January 19, 1916.....	3,460

[1]Estimated from observations at the site of the Clifton Hotel.

4.0 HISTORY OF FLOODS (Continued)

4.3 Runoff and Flood-Travel Characteristics

INITIAL RISE OF THE SAN FRANCISCO RIVER DURING MAJOR FLOODS AT CLIFTON IS A RESULT OF RUNOFF FROM BLUE RIVER AND SMALL TRIBUTARIES

Newspaper accounts, Senate Document 436 (65th Congress, 3rd Session, 1919), and streamflow records show that the initial rise of the San Francisco River at Clifton during major floods is the result of flooding on Blue River and (or) small tributaries to the San Francisco River just upstream from Clifton. Peaks from the Blue River precede those from the San Francisco River upstream from the mouth of Blue River by 3 to 12 hours, and peaks from the small tributaries between the Blue River and Clifton precede or nearly coincide with peaks on the Blue River. The initial rise generally occurs at night, and flood stage is reached in the early morning hours. Time of peaks and other incidental information is summarized in table 4.3-1.

Table 4.3-1--Time of crests for major floods on the San Francisco River at Clifton, Arizona

Date	Hour	Remarks
Feb. 22, 1891	Not determined	Information not available.
Jan. 10, 1905	Not determined	Information not available.
Feb. 17, 1905	0100 to 0300	Rain fell below 7,000 ft; snow fell above 7,000 ft. On Feb. 16, rain fell slowly and steadily and increased to a downpour in afternoon. River almost bankfull by dark when evacuation began. River rose 2 ft from 2400 hours on Feb. 16 to 0100 hours on Feb. 17. Temperature dropped suddenly at 0100 hours; rain changed to snow. Stage leveled off immediately and dropped 2 hours later.
Nov. 27, 1905	0900 and 1400-1800	Two peaks occurred. First peak probably from Blue River; second peak from San Francisco River above Blue River. Gentle rain began on afternoon of Nov. 26 and lasted until daylight on Nov. 27. River began to overflow about 0400 hours on Nov. 27, and rose until 0900 hours. Dropped for a few hours. Rose again about 1400 hours and stayed constant for several hours. Second peak was 1 ft above first peak.
Dec. 2-3, 1906	2400-1200	San Francisco River rose for 2 days before flooding. Evacuation began on Dec. 2. By evening, many houses were flooded. For a 12-hour period from 2400 hours, Dec. 2, to 1200 hours, Dec. 3, stream fluctuated in several crests.
Jan. 16, 1916	1300-1400	San Francisco River rose gradually Jan. 15 and 16. On Jan. 16, river was 10 ft deep at 1000 hours, 14 ft deep at 1200 hours, and 15.6 ft deep about 1300 hours. Water barely went over floodwall. Velocity was 18.9 ft/sec at slope area.
Oct. 14, 1916	0400-0700	Crest passed Base Line Ranger Station on Blue River at 2230 hours on Oct. 13 and arrived at Clifton at 0400 hours on Oct. 14. Floodwave traveled nearly 30 mi in 5.5 hours. Crest of San Francisco River below Tularosa Creek occurred at same time as crest in Clifton.
Dec. 23, 1965	1000	Peak of 30,300 ft^3/s came from area downstream from San Francisco River near Glenwood, New Mexico, and Blue River above Clifton gages. Peak at Glenwood, New Mexico, was 3,860 ft^3/s at 1100 hours, Dec. 23. Peak at Blue River above Clifton gage was less than 9,380 ft^3/s; time unknown.
Aug. 12, 1967	0600	Rain began about 2200 hours, Aug. 11. Intense rain for several hours. Clifton had 2.3 in. of rain in 2 hours. Upstream areas reported as much as 4 in. Crest came just before daylight. Water was backing up into streets through drains. Peak was 34,700 ft^3/s. Some sandbagging was done.
Oct. 20, 1972	0330 to 0400	At gage, Blue River above Clifton, peak was 30,000 ft^3/s at 0130 hours, Oct. 20. Peak was highest known since settlement of valley in 1885 and probably exceeded the 1891 flood. At Glenwood, New Mexico, peak was 34,100 ft^3/s at 0630 hours, Oct. 20. Flash-flood warnings issued on Oct. 19. By that evening flooding was predicted because Blue River was flooding. Thirty families evacuated from Clifton. People began to return home about 2400 hours; however, flow started over floodwall in north Clifton about 0300 hours and inundated north Clifton by 0330 hours. (Instantaneous peak at gage was reportedly at 0300 hours. This may have been too early.) Velocity was 15.3 to 17.7 ft/sec at slope area past north Clifton.
Sept. 9, 1975	0030	Peak was 30,000 ft^3/s. Flow was 3 ft deep on U.S. Highway 666 along west side of bridge just upstream from railroad bridges. Floodwater that backed up through drains on both sides of river did not go over floodwalls. Peak at Blue River above Clifton gage was 25,500 ft^3/s at 2130 hours, Sept. 8. Peak at gage at San Francisco near Glenwood, New Mexico, was 10,300 ft^3/s at 0300 hours, Sept. 9.
Dec. 19, 1978	0300	Peak on Blue River was 24,500 ft/s at 2100 hours, Dec. 18. Peak at Glenwood, New Mexico, was 20,500 ft^3/s at about 2300 hours, Dec. 18. The peak of 56,000 ft^3/s at Clifton came mostly from the area downstream from the Blue River above Clifton and San Francisco near Glenwood gages. Local runoff combined with runoff from Blue River to produce the peak at Clifton.

5.0 SUMMARY

FLOODS OF AT LEAST THE MAGNITUDE OF THE FLOOD OF OCTOBER 1983 HAVE A 1.3-PERCENT CHANCE OF OCCURRING IN ANY GIVEN YEAR ON THE SAN FRANCISCO RIVER AT CLIFTON, ARIZONA

The flood of October 1983 is the greatest recorded flood in Clifton and is considered the largest peak discharge since at least 1870 (fig. 5.0-1). The estimated recurrence interval for the peak discharge of 90,900 ft^3/s is 75 years. A flood of at least this magnitude has a 1.3-percent chance of occurring in any given year.

Flood routing and hydrograph analysis for the flood of October 1983 and other large floods indicate that many large peaks at Clifton are the result of local runoff. Local runoff occurs downstream from the gaging stations at Blue River near Clifton, Arizona, and San Francisco River near Glenwood, New Mexico. This area of the San Francisco River basin is steep with V-shaped canyons, and runoff is rapid with little attenuation of peaks. In October 1983, floodwaters of the San Francisco River at Clifton rose rapidly on the flood plains within 3 hours after the occurrence of intense rain.

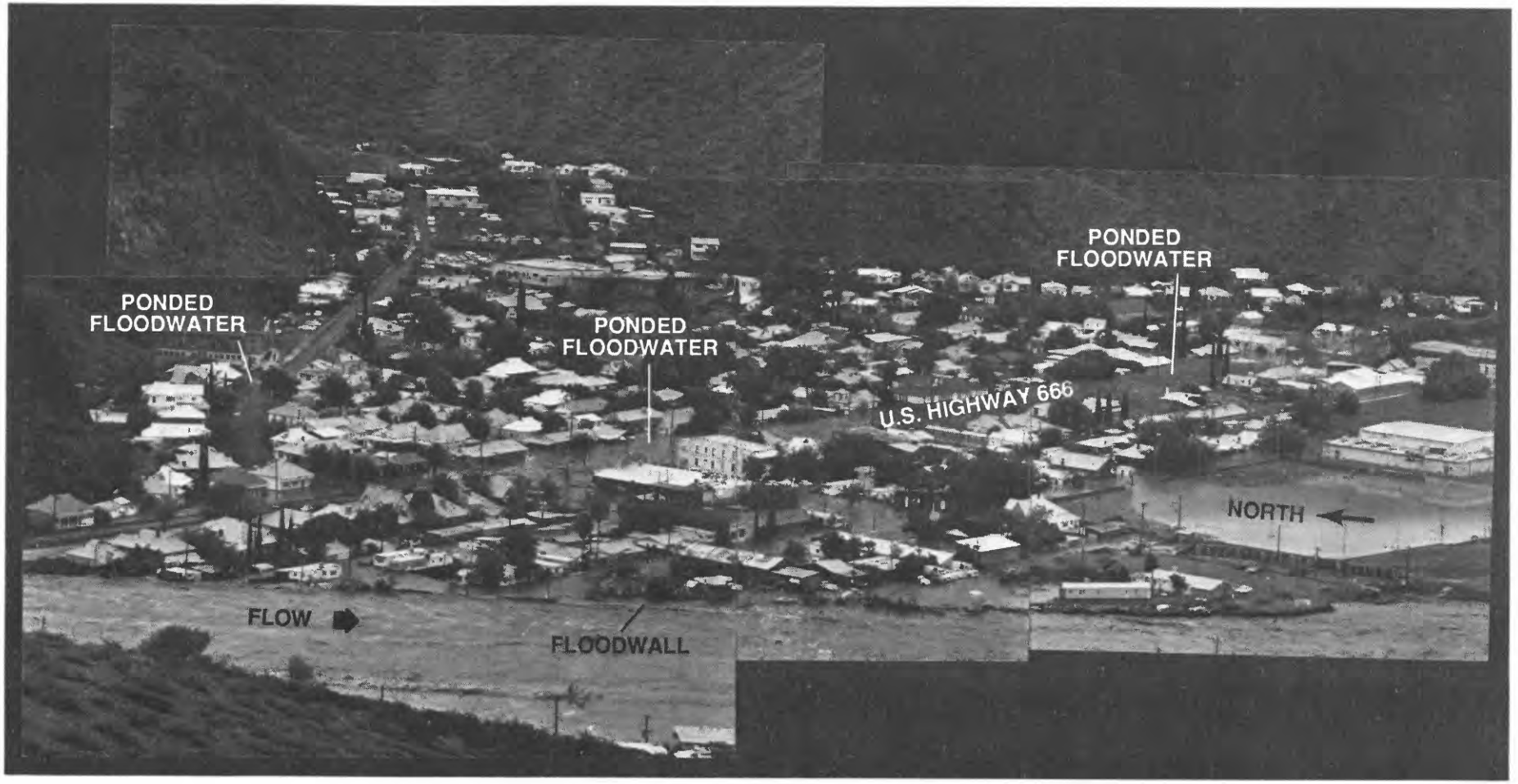


Figure 5.0-1--Flooding in the San Francisco River, south Clifton, October 2, 1983. Floodwaters that overtopped the floodwall became ponded. Most of the structures in the center and foreground were inundated above the first floor. Photograph courtesy of John F. Hancock, Morenci, Arizona.

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