UNITED STATES DEPARTMENT OF THE INTERIOR J. A. Krug, Secretary.

GEOLOGICAL SURVEY W. E. Wrather, Director.

CIRCULAR 32 November 1948

FLOOD OF SEPTEMBER 1946 AT SAN ANTONIO, TEX.

By

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Prepared in cooperation with the
TEXAS BOARD OF WATER ENGINEERS

WASHINGTON, D. C.

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INTRODUCTION

A flood occurred in the streams in and near San Antonio, Tex., during the early morning hours of September 27, 1946, as a result of heavy rains falling during the previous night. Much property damage occurred in San Antonio and below, and four lives were lost. It is the purpose of the present report to describe this flood and its relation to the flood of September 10, 1921--the greatest of record since 1819.1/

The heavy rainfall during the night of September 26, 1946, was preceded by a moderate rain during the late afternoon of September 25, when from 1 to 3 inches fell on the drainage basins of streams that flow through San Antonio. This rainfall produced little runoff but did saturate the ground enough to increase the rate of runoff of the subsequent heavy rains. Heavy rainfall began about 8 p. m. September 26, and within a short time San Pedro Creek and its tributaries (Alazan, Martinez, and Apache Creeks) were in flood and all reached peak stages about 1 to 2 a. m. September 27. The floods in these streams caused the greater part of the damage in San Antonio. San Antonio River flows through the heart of the city, but did not overflow its banks upstream from San Pedro Creek. The fact that San Antonio River did little damage through the city can be attributed to the presence of Olmos Dam on Olmos Creek, the main tributary to the river, which held back the waters that otherwise might have caused a major flood on the stream. Considerable damage was done in the downtown area by rainwater ponded by overloaded storm sewers.

The streams flowing through San Antonio in general have small open channels and compara-

1 Ellsworth, C. E., The Floods in Central Texas in September 1921: U. S. Geol. Survey Water-Supply Paper 488, p. 53.

tively wide flood plains greatly encroached upon by residences, business buildings, and numerous bridges. San Antonio River below San Antonio has a well defined channel of small capacity and a wide flood plain. Although extensive flooding occurred downstream from the city, damages were relatively light as the flood plain is not well developed.

Immediately after the storm, the Weather Bureau obtained a great many miscellaneous records of rainfall. These data, together with records of rainfall at the Weather Bureau stations in the vicinity and an isohyetal map, were published in the Weather Bureau Hydrologic Bulletin, Lower Mississippi-West Gulf District, September 1946.

In February 1947 the Texas State Board of Water Engineers in cooperation with the Geological Survey published a report with limited distribution giving rainfall and runoff data for the storm. Analyses of rainfall-runoff relations included in that report were based on an isohyetal map furnished by the Weather Bureau and records of runoff obtained at gaging stations. In the present report the isohyetal map has been redrawn mainly to give more weight to a record of rainfall of 10.75 inches caught in a standard 8-inch gage at 201 Mulberry Street in north-central San Antonio.

ACKNOWLEDGMENTS

Base data used in this report were obtained in cooperation with the Texas State Board of Water Engineers and the Corps of Engineers, War Department. The Corps of Engineers furnished special help in obtaining field data for the computation of maximum discharges by slope-area method listed in table 4. The map showing the flooded areas in San Antonio and the statement of damages resulting from the 1946 flood are reproduced from a report on that flood prepared by the Corps of Engineers. The Engineering Department of the city of San Antonio made the surveys outlining the flooded areas and also supplied the figure for maximum elevation of stored water in Olmos reservoir. Rainfall data were furnished by the United States Weather Bureau.

RAINFALL

Records show that the heavy rainfall began about 8 p. m. September 26. Crest stages occurred about 1 to 2 a. m. September 27 in the small streams in San Antonio and in the early morning hours before daylight in those near San Antonio. It is evident that the greater part of the rain fell in the 6 or 8 hours following 8 p. m. September 26. A record obtained by a U. S. Weather Bureau recording rain gage at San Antonio Municipal Airport shows that, of the total rainfall of 6.93 inches, 6.61 inches fell between 8 p. m. September 26 and 4 a. m. September 27. The period of heaviest rainfall at this place was between 11 p. m. and 1 a. m. when 2.38 inches fell. The crest stage in San Antonio River at the gaging station at South Alamo Street bridge occurred at 2 a. m. This crest was caused by the runoff from rain falling in San Antonio below Olmos Dam.

The center of this storm (rainfall greater than 16 inches) covered an area of about 130 square miles that extended from the southern part of San Antonio south and southeast for a distance of about 20 miles. Numerous miscellaneous records of rainfall were obtained in this area. An excellent record was obtained from a standard rain gage at the State Apiculture Farm in the Calaveras Creek Basin 11 miles southeast of the San Antonio post office. This record shows that 0.55 inch fell between 6 and 10 p. m. September 26, and 16.67 inches fell between 10 p. m. and 9 a. m. the next morning. The fact that the flood crest in Calaveras Creek at a point about 2 miles below the State Apiculture Farm occurred before daylight indicates that most of this rain fell in 6 to 8 hours as at other places. The most intense rainfall reported was at the San Antonio Nursery in the southern part of the city where 4.15 inches fell during the 1-hour period 9 to 10 p. m. September 26. A total of 13.03 inches fell at this place.

The rain causing the damage to the city of San Antonio varied from 16 inches in southeastern San Antonio to about 7 inches at the headwaters of the streams that flow through the city. The rainfall in September 1921 was much heavier over the upper drainage basins of these streams than in September 1946. For the purpose of comparing the patterns of rainfall in 1921 and 1946, figure 1 and table 1, showing total rainfall over San Antonio River Basin in the vicinity of San Antonio for Sept. 8-10, 1921, are reproduced from Water-Supply Paper 488. The rainfall lines shown on figure 1 were taken from figure 1 in the account by Jarboe.2/ The following comments also come from the same source:

> Rainfall in San Antonio.- A drought of two months' duration was broken when a shower of 0.53 inch fell between 6 and 7 a. m. Sept. 8. Seventeen hours later, between 12 midnight and 1 a. m. on the 9th, steady rains began and continued until shortly after 11 p. m.--a period of about 23 hours. The crest of the flood came through the city two hours after the precipitation ended.
>
> The amounts of precipitation, as measured at the United States Weather Bureau [near the center of the city] are as follows:

	Inches
September 8, 7 a. m.	0.53
7 p. m.	.01
September 9, 7 a. m.	3.48
7 p. m.	1.90
September 10, 7 a. m.	1.46
7 p. m.	Trace
Total.	7.38

> Heavy rains shown.- Study of the accompanying map [fig. 1] shows the rapid increase of rainfall north and west of the Weather Bureau station. Two miles north, 9.50 inches were recorded, with 3 inches after 7 p. m. on the 9th, as compared to 1.46 inches at the Weather Bureau station. Further study of the map brings out the fact that approximately 3 miles north and west from the city more than 10 inches must have fallen. Between 5 and 6 miles north and west from the city's center the rainfall undoubtedly reached 14 inches over a considerable portion of the drainage area. Nine stations show 15 inches or more.
>
> The heaviest rainfall probably occurred 8 to

2 Jarboe, J. H., The San Antonio flood of Sept. 10, 1921: U. S. Weather Bureau Mo. Weather Rev. vol 49, pp. 494-496, September 1921.

10 miles northwest of San Antonio. Beyond this point the rainfall was not so heavy, as shown by the 8-inch gage located 17 miles northwest, where 10 inches were recorded.

It is possible, but hardly probable, that some sections of these drainage basins received 20 inches of precipitation in the storm preceding the flood. Two stations show this amount, but much evidence would be necessary before those familiar with rainfall data could accept the figures.

It will be noted from the last paragraph quoted above that the Weather Bureau did not accept records of rainfall amounting to 20 inches or more, although at one place, location No. 5, figure 1, 21.0 inches was measured in a standard rain gage. In the light of evidence gathered since 1921, a rainfall of 21 inches in 24 hours is not uncommon in central Texas and it is probable that the record would be accepted at this time.

The statement quoted above that "steady rains fell for a period of about 23 hours" and the distribution indicated by the record for the Weather Bureau gage at San Antonio show that although the total rain in 1921 was greater than any recorded in 1946, its intensity was less in San Antonio and probably less elsewhere than that experienced in the sections of heavy rainfall in 1946. In 1921 the greatest rainfall for a 2-hour period at the San Antonio Weather Bureau gage was 1.52 inches between 1 and 3 a. m. Sept. 9, compared with 2.38 inches for 2 hours in 1946; and the greatest rainfall for an 8-hour period was 3.53 inches for the 8 hours preceding 8 a. m. Sept. 9, compared with 6.61 inches for 8 hours in 1946. Greater peak discharge and total runoff would be expected from a rainfall of greater intensity if other factors were equal. In addition to the greater intensity of rainfall in 1946 there was considerable antecedent rain in the vicinity of San Antonio, rather large rains occurring Aug. 28, 29, Sept. 15 and 25, whereas the storm in 1921 ended a drought that had lasted for two months. Records of rainfall for Sept. 25-29, 1946, furnished in greater part by the Weather Bureau, are listed in table 2. The isohyetal map for San Antonio and vicinity (fig. 2) and the larger map covering the San Antonio River Basin above Falls City except for Medina River (fig. 3) are based largely on records of rainfall furnished by the Weather Bureau.

An inspection of figure 2 will show that a

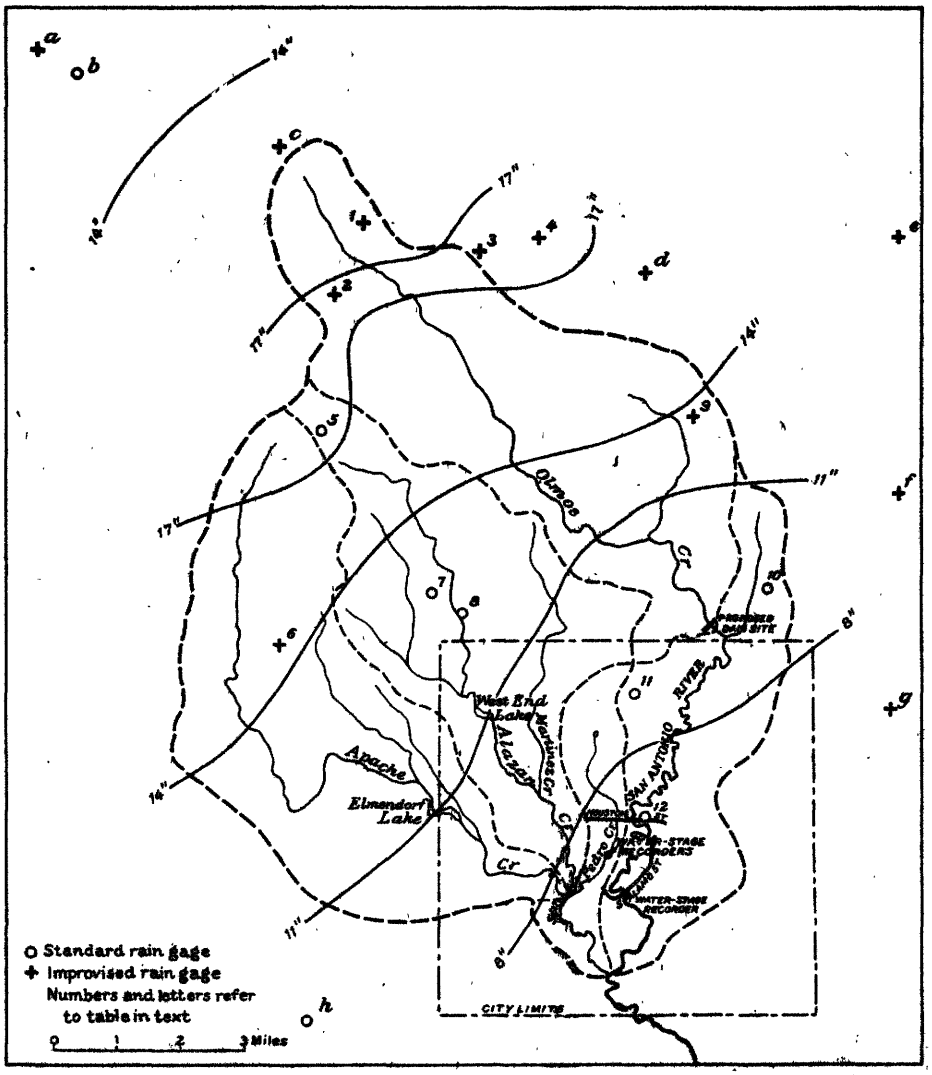

Figure 1, Map of San Antonio River and tributaries in vicinity of San Antonio, showing drainage basins and total rainfall, September 8-10, 1921.

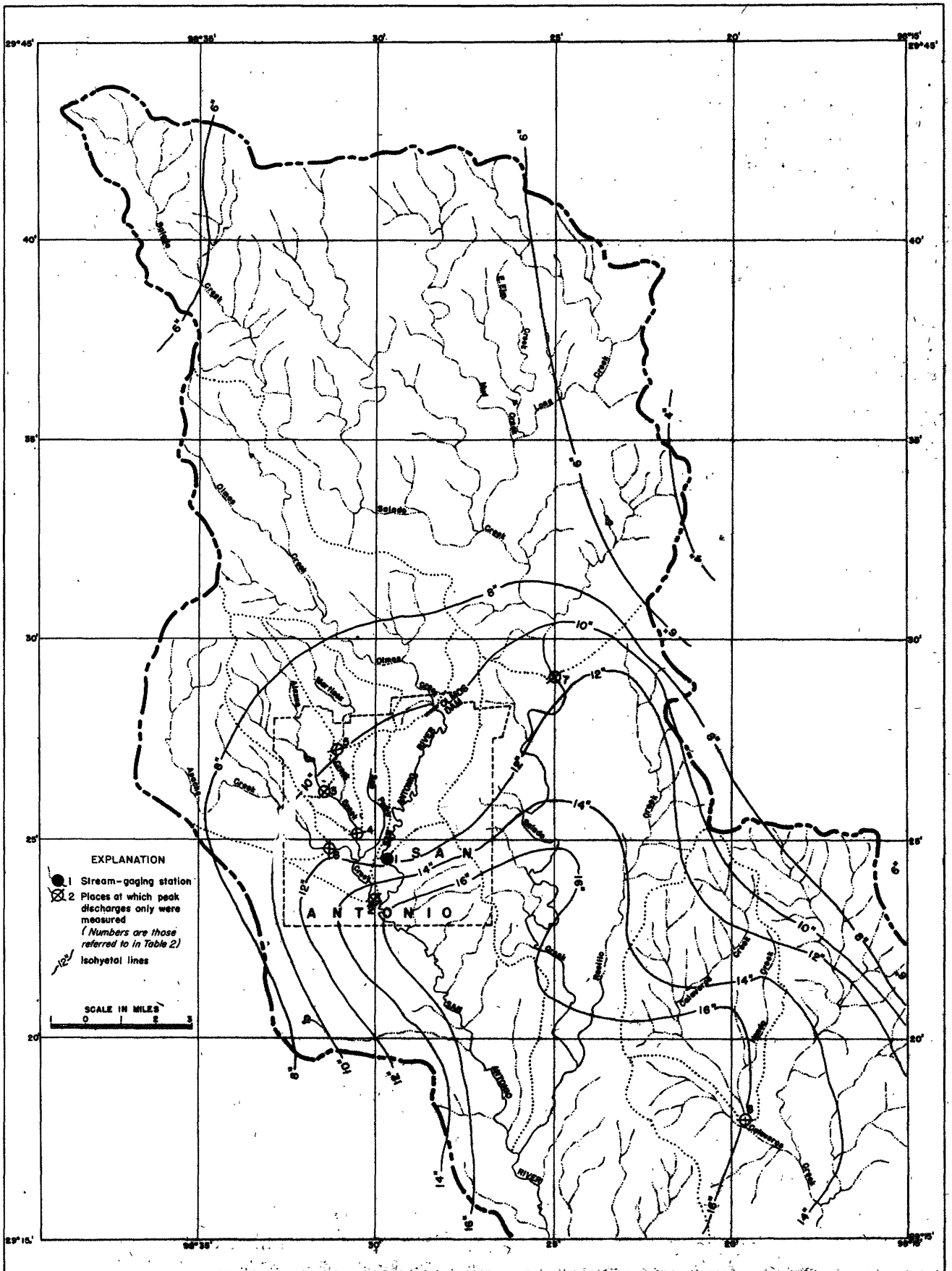

Figure 2.--Isohyetal map of part of San Antonio River Basin in vicinity of San Antonio, showing total rainfall September 26-27, 1946.

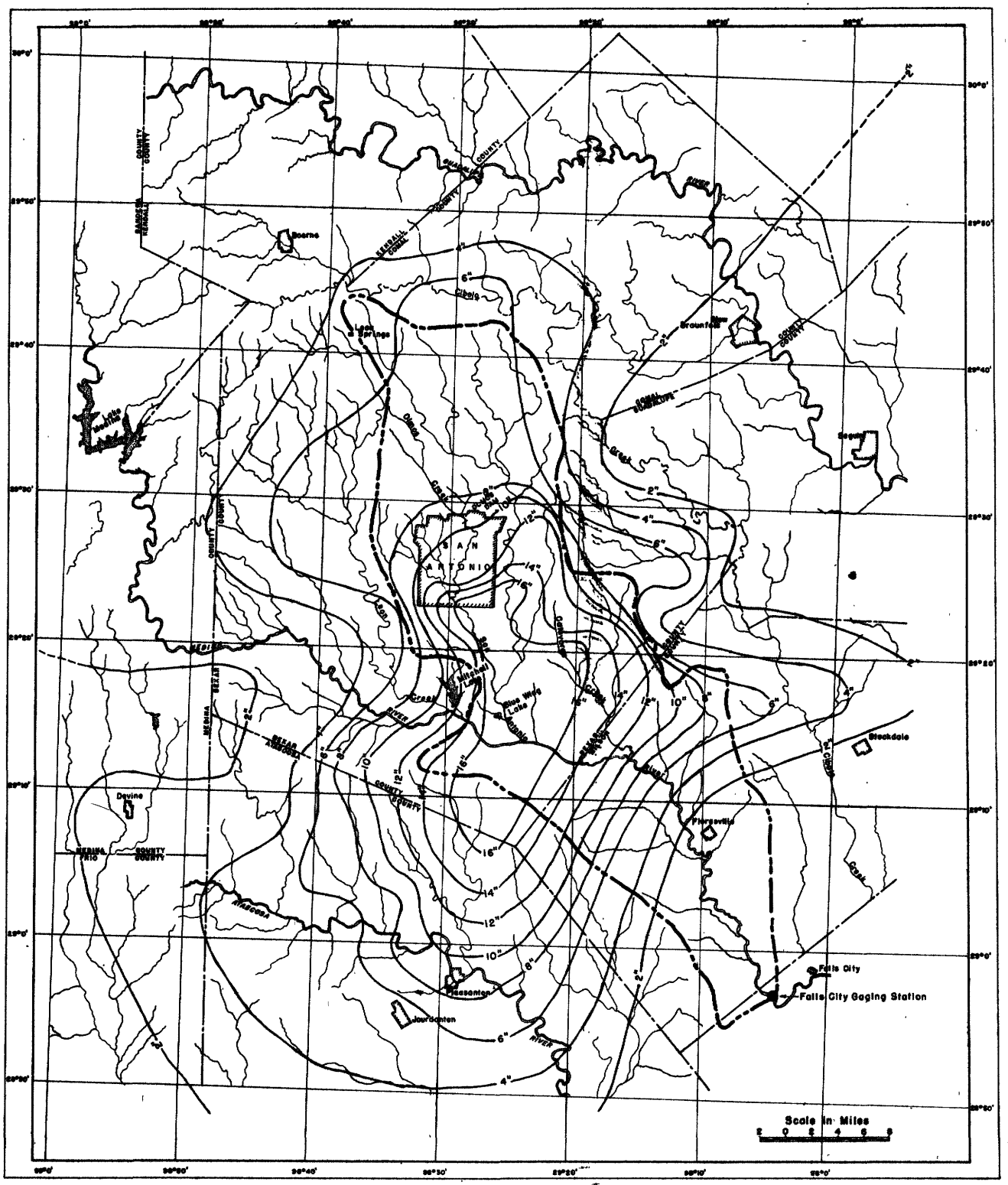

Figure 3.--Isohyetal map of storm of September 26-27, 1946, in vicinity of San Antonio.

Table 1.--Rainfall at and near San Antonio, September 7 to 10, 1921
(The locations given are those shown on fig. 1.)

Location	Inches	Period covered or details
1	15.0	Sept. 8, midnight, to Sept. 9, midnight.
2	17.5	Sept. 8, midnight, to Sept. 9, midnight.
3	20.0	Sept. 9, 7 a.m., to Sept. 10, 7 a.m.
4	18.0	Sept. 8, midnight, to Sept. 9, midnight, 17.0 inches.
5	21.0	Sept. 9, 7 a.m., to Sept. 10, 7 a.m.
6	a 25.0	Sept. 8, 7 p.m., to Sept. 9, 6 p.m., 10 inches; Sept. 9, 6 p.m., to Sept. 10, 7 a.m., 15 inches.
7	13.0	Sept. 9, 7 a.m., to Sept. 10, 7 a.m.
8	13.18	Sept. 7, midnight, to Sept. 8, 8 p.m., 0.07 inch; Sept. 8, 8 p.m., to Sept. 9, 11:30 p.m., 13.11 inches.
9	12-15	Sept. 9, 5 p.m., to Sept. 10, 7 a.m.
10	8.55	Sept. 7, 6 a.m. to 7 a.m., 0.60 inch; Sept. 8, 9 p.m. to Sept. 9, 9 a.m., 3.60 inches; Sept. 9, 9 a.m. to 4 p.m., 1.30 inches; Sept. 9, 4 p.m. to 11:30 p.m., 3.05 inches.
11	9.5	
12	6.84	
a	12.0	Sept. 8, midnight, to Sept. 9, midnight.
b	10.0	Sept. 8, midnight, to Sept. 9, 6 p.m., 6 inches; Sept. 9, 6-9 p.m., 3 inches; Sept. 9, 9-12 p.m., 1 inch.
c	15.0	Sept. 8, midnight, to Sept. 9, midnight.
d	18.0	Sept. 8, midnight, to Sept. 9, midnight.
e	10.0	Sept. 8, midnight, to Sept. 9, midnight.
f	11.0	Sept. 8, midnight, to Sept. 9, midnight.
g	7.0	Sept. 8, midnight, to Sept. 9, midnight.
h	10.14	Sept. 8, noon, to Sept. 9, noon, 4.62 inches; Sept. 9, noon, to Sept. 10, __a.m., 3.74 inches; Sept. 10, __a.m., to noon, 1.05 inches; Sept. 10, noon to evening, 0.73 inch.

a Note that Weather Bureau gives 15 inches as total for this station and not 25 inches, as shown here.

Note.- Numbered gages used by United States Weather Bureau in drawing rainfall lines shown on fig. 1. Records at lettered stations and notes regarding distribution furnished by United States Engineer Corps, Fort Sam Houston, Tex.

Table 2.--Daily rainfall, in inches, September 25-29, 1946, at points near San Antonio

Station	Lat.	Long.	September 25	26	27	28	29	Remarks
	° '	° '						
U. S. Weather Bureau								
Boerne 1/	29 49	98 45	2.17	0.11	3.51	-	0.22	
Bulverde 2/	29 45	98 27	-	.37	6.32	-	.45	
Devine 2/	29 09	98 54	-	.65	2.18	-	-	
Falls City (near) 1/	28 57	98 04	1.40	-	.70	.10	-	
Fischer's Store 1/	29 59	98 16	-	-	3.00	.75	-	
Floresville 2/	29 08	98 09	-	.75	.71	.82	-	
Goliad 1/	28 40	97 23	.83	.48	.93	-	.65	
Hindes 3/	28 43	98 47	.44	.60	.33	-	-	
Hondo 2/	29 20	99 09	-	.11	1.12	-	-	
Jourdanton 2/	28 55	98 33	.17	-	5.40	-	-	
Karnes City 1/	28 53	97 54	1.01	.78	-	-	-	
La Vernia 2/	29 22	98 06	1.53	-	2.53	.67	-	
New Braunfels 1/	29 42	98 06	1.40	.06	1.61	-	.11	
Nixon 1/	29 16	97 46	.29	.19	1.37	-	.11	
Poteet 1/	29 03	98 34	.08	.20	5.25	.08	-	
Randolph Field 3/	29 32	98 17	1.14	1.00	.99	-	-	
Riomedina 1/	29 26	98 53	.29	.24	3.05	-	-	
Runge 1/	28 53	97 43	-	.56	.65	-	.07	
San Antonio 3/	29 32	98 28	3.27	3.80	3.13	-	.06	6.61 in. fell in 8 hours following 8 p.m. Sept. 26
Seguin 3/	29 33	97 58	.79	.87	.57	.02	-	
Whitsett 1/	28 38	98 16	-	1.00	-	-	-	
Supplementary								
Adkins, 1.6 miles south of	29 23	98 15			b 4.30			15½ miles east of San Antonio
Adkins, 4 miles south of	29 20	98 15			12.5			Began 8:30 p.m. 26th, ended 6 a.m., 27th
Bergheim, 2 miles east of	29 49	98 33			c 3.20			
Converse	29 31	98 19			b 3.60			12 miles ENE of San Antonio
Converse (near)	29 31	98 22			a 5.75			Cade Juernsey Farm

See footnotes at end of table

Table 2.--Daily rainfall, in inches, September 25-29, 1946, at points near San Antonio--Continued

Station	Lat.	Long.	September 25	26	27	28	29	Remarks
Supplementary--Continued	° '	° '						
Elmendorf, 3 miles north of	29 16	98 22			b 15+			W. W. Owen dairy
Floresville, 6½ miles NW of	29 13	98 13			b 6.5			
Floresville, 9 miles NE of	29 14	98 03			b 2.5			
Leon Springs, at	29 40	98 38	.80		a 4.65	.80		Standard 8-inch gage
New Braunfels, 19 miles WNW of	29 48	98 25			3.97			Intersection of Highways U. S. 281 & Texas 46
Macdona, 2 miles north of	29 22	98 41			b 3.50			13 miles WSW of San Antonio
Pleasanton, 2 blocks south of	28 57	98 29			a 8.37	.13	.75	Dr. B. B. Gillett has 13 years record
Pleasanton, south of (at McGee Ranch)	28 53	98 24			c 4.5			
Pleasanton, 10 miles WNW of	28 59	98 39			c 5.5			At Amphion
Pleasanton, 10½ miles north of	29 07	98 30			c 15.00			
Pleasanton, 15½ miles NNW of	29 10	98 36			b 10.00			At Hamilton's Dairy
Poteet, 5 miles north of	29 07	98 36			b 8.0+			
Rossville, 1½ miles SE of	29 05	98 40			c 7.05			
Saint Hedwig	29 25	98 12			c 6.65			17½ miles east of San Antonio
Saint Hedwig	29 25	98 12			c 5.87			Do.
San Antonio:								
5½ miles south of	29 20	98 29			a 13.03			Recording gage at nursery
9 miles south of	29 18	98 29			b 12.04			Standard 8-inch gage. Began 8 p.m. 26th, ended 8 a.m. 27th.
7 miles south of	29 19	98 29			c 12.5+			
5.3 miles SSE of	29 22	98 28			b 16.45+			Began 10:30 p.m. 26th, ended 7:30 a.m. 27th
12 miles south of	29 15	98 28			c 13+			Heavy rain started 9 p.m. 26th
327 Wildrose Ave.	29 29	98 28			d 6.73			
542 E. Huisache Ave.	29 28	98 24			d 7.10			
414 Hansford Ave.	29 23	98 29			c 13.5+			
2605 Pleasanton Rd.	29 21	98 30			b 12.00			
815 4th St.	29 21	98 31			12.75+			Began 9 p.m. 26th, ended 8 a. m. 27th
152 Grapeland	29 22	98 30			b 15.61			Very heavy rain 8 - 11 p.m. 26th
436A Hot Wells Blvd.	29 22	98 27			c 15.12			
1611 Sehley	29 24	98 27			14.5+			
11 miles SE of	29 19	98 21	.31		a 17.22	.29	.02	Standard 8-inch gage at State Apiculture Farm
12½ miles east of, (at Sayers)	29 23	98 18			c 12.2			Began 8:30 p.m. 26th, ended 6 a.m. 27th
7½ miles east of	29 25	98 22			b 13.0			
5½ miles ESE of	29 24	98 24			c 16.72			Began 8 p.m. 26th, ended 5 a.m. 27th
6½ miles SE of	29 23	98 24			14.5			
5½ miles ENE of	29 27	98 24			b 12.5			
8 miles ENE of	29 29	98 23			12.4+			At Kirby
9½ miles NE of	29 31	98 22			b 5.75			Standard 8-inch gage. Rain 9 p.m. to 4 a.m.
18½ miles NNW of	29 42	98 27			b 6.0+			At Emil's Place
18½ miles north of	29 42	98 30			c 7.46			At Circle Arrow Ranch
12 miles north of	29 36	98 31			b 7.5+			
12 miles north of	29 38	98 29			6.0			On U. S. Highway 281
15 miles NNW of	29 38	98 35			4/c 3.0			At Camp Bullis
15 miles NW of	29 34	98 41			6.1			At Moonlight Tavern
15 miles NW of	29 33	98 43			c 5.8			Sleepy Hollow Ranch
18 miles WNW of	29 30	98 47			b 4.50			Culebra Store
14 miles west of	29 24	98 44			b 5.70			
14 miles SW of	29 14	98 35			c 10.70			
327 Elaine Ave.	29 25	98 35			c 8.00			
201 Dickson St.	29 22	98 25			b 14.5+			
1012 Florida St.	29 24	98 28			a 11.66			Standard 8-inch gage. 7:30 p.m. 26th to 7:30 a.m. 27th
201 Mulberry St.	29 27	98 30			a 10.75			Standard 8-inch gage

See footnotes at end of table.

Table 2.--Daily rainfall, in inches, September 25-29, 1946, at points near San Antonio--Continued

Station	Lat.	Long.	September 25	26	27	28	29	Remarks
	° ′	° ′						
Supplementary--Continued								
San Antonio:								
175 Sherwood Dr.	29 29	98 32			b 6.45/			
918 Broadbent St.	29 23	98 28			b 15.0/			
203 Jennings St.	29 23	98 31			b 13.25/			Container overflowed by 1:30 a.m. 27th
509 North St.	29 25	98 29			a 10.12			Standard 8-inch gage
at Longhorn Cement Plant	29 32	98 24			c 6.50			
733 Delmar St.	29 24	98 27			c 12.50			
at Kelly Field	29 23	98 34	1.29		b 5.80			
Saspamco	29 14	98 18			12.5/			
Seguin, 11 miles SW of	29 28	98 04			b .50			At New Berlin
Somerset	29 11	98 41			c 4.50			
Sutherland Springs	29 16	98 03			c 5.68			
Von Ormy	29 17	98 39			c 3.5			12½ miles southwest of San Antonio
Wetmore	29 34	98 25			b 7.25			10½ miles northeast of San Antonio
Zuehl	29 30	98 10	2.00		b 3.25			13 miles southwest of Seguin

1 Measured in the afternoon.
2 Measured in the morning.
3 Measured at midnight.
4 This estimated record was disregarded in favor of the good record at Leon Springs.

Note.- All records furnished by U. S. Weather Bureau except that for Leon Springs.
All distances given are from post office named.
Accuracy of supplementary records: a Excellent, b Good, c Fair, d Poor.
Amounts shown in supplementary records on Sept. 27 show total rain for storm of night of Sept. 26.
Figures for rainfall followed by plus sign (/) indicate that container used as gage overflowed.

movement of the storm's center 10 miles northwest would have produced, on the basins that drain through San Antonio, a rainfall of about 16 inches instead of 7 or 8 inches. Had this shift in the storm's center occurred, the damage to San Antonio would probably have been many times greater than that which occurred.

GENERAL FEATURES OF THE FLOOD

All streams flowing through San Antonio apparently experienced higher stages in 1921 than in 1946, except possibly in the vicinity of the junction of San Pedro, Alazan, and Apache Creeks where the maximum stage was reported to be about the same for 1921 and 1946. The maximum stage at the gage on San Antonio River at South Alamo Street bridge was 20.14 feet in 1921 and 15.32 feet in 1946. However, these stages are not comparable as the Olmos Retention Dam was built on the main tributary of San Antonio River between those dates. During the storm of September 1946 the Olmos Reservoir caught and held the runoff from 32.4 square miles. Thus the peak stage at the San Antonio River gage at San Antonio was caused by the runoff from 9.4 square miles below the dam. However, residents on Olmos Creek at Blanco Road crossing about 2½ miles above Olmos Dam pointed out highwater marks of the 1921 flood showing that flood to have been about 6 feet higher than the flood of September 1946.

In 1921 San Antonio River caused much greater damage to the business section of San Antonio than in 1946. The 1921 flood overflowed across the divide to the west and joined with San Pedro Creek. In 1946 the river did not overflow its banks through the business sections of San Antonio. On the basis of local information, Martinez Creek at Fredericksburg Road crossing was about 3 feet higher in 1921 and available evidence indicates that Alazan and Apache Creeks also were higher in 1921 than in 1946. In order to present a record of the maximum stages reached by the flood in 1946, the altitude of the crest of the flood above mean sea level is given in table 3 at the various stream-gaging stations whose records are included in this report, and at places in San Antonio where only the maximum discharges were measured. Although this flood in San Antonio River at the gaging station in San Antonio was not as great as previous floods, its comparative size increased as it entered the area of heavy rainfall below San Antonio until it reached the vicinity of Elmendorf and the mouth of Calaveras Creek, where it was many feet higher than ever known before. A tremendous flood from Calaveras Creek did much to cause record-breaking stages in the river below Calaveras. At Calaveras bridge on San Antonio River the stage in 1946 was about 12 feet higher than in 1921. At the gage near Falls City the maximum stage on Sept. 29, 1946, was 5.4 feet higher than that reached by the flood of October 1913, which was the greatest flood previously known. By the time the flood reached Goliad its crest had flattened to such an extent that it was no longer a notable flood.

The flood in San Antonio River at the mouth

Table 3.--Maximum stages in San Antonio River Basin resulting from storm of September 26-27, 1946

Location	Latitude	Longitude	Time of crest	Altitude above mean sea level
	° ' "	° ' "		Feet
Olmos Reservoir at San Antonio	29 28 20	98 28 20	Sept. 27	712
San Antonio River at Geological Survey gage at San Antonio	29 24 35	98 29 40	Sept. 27, 2 a.m.	627.6
San Antonio River at Geological Survey gage near Falls City	28 57 05	98 03 55	Sept. 29, 9 a.m.	319.3
San Antonio River at Geological Survey gage at Goliad	28 39	97 23	Oct. 2, 10 p.m.	133.8
San Pedro Creek at intersection of Flato Street and McKaskill Ave. in San Antonio	29 23 30	98 30 05	Sept. 27, about 2 a.m	607.1
Alazan Creek 600 ft. below centerline of Zarzamora St., in San Antonio	29 26 15	98 31 30	Sept. 27, 1 - 2 a.m.	658.2
Alazan Creek at centerline of San Fernando St., in San Antonio	29 25 10	98 30 30	Sept. 27, 1 - 2 a.m.	640.8
Martinez Creek at centerline of Woodlawn Ave., in San Antonio	29 27 15	98 31 15	Sept. 27, 1 - 2 a.m.	682.5
Apache Creek at centerline of Sabinas Street in San Antonio	29 24 50	98 31 20	Sept. 27, 1 - 2 a.m.	640.9
Salado Creek at Ritterman Road crossing, near San Antonio	29 29 05	98 25 00	Sept. 27, about 3 a.m.	666.8
Cibolo Creek at Geological Survey gage near Falls City	29 01	97 56	Sept. 28, 3:30 p.m.	286.8

of Medina River was sufficiently high to cause 6 feet of backwater at the gage on Medina River 5.2 miles upstream from its mouth, as determined by a current-meter measurement made of Medina River at the crest of the flood. Because of this backwater, the maximum stage at the Medina River gage was 2.3 feet higher than the stage during the flood of Aug. 29, 1946, but the maximum discharge was considerably less.

OLMOS DAM

Following the flood in September 1921 the Olmos Dam was built to provide a reservoir for flood control on Olmos Creek, the main tributary of San Antonio River above San Antonio. Its capacity according to the capacity curve is 15,500 acre-feet at elevation 728 feet, mean sea level, which is top of dam.3/ The dam is provided with six gates, the minimum dimensions of the outlet tunnel from each gate being 5 feet 9 inches wide and 7 feet 10 inches high. The elevation of the bottom of the gates is 679.53 feet.4/ The gates are left open and the reservoir empty except during periods of flood runoff when the gates are closed in order to reduce the flood crest in San Antonio River as it passes through the city. The operation of the gates during the flood of September 1946 was the responsibility of the San Antonio Fire Department.

The gates in Olmos Dam are reported by city officials to have been closed at the beginning of the storm on Sept. 26, 1946, storing the water to a maximum elevation of 712 feet above mean sea level. This represents a maximum storage of 4,500 acre-feet, according to the capacity curve previously mentioned. Release of water stored in Olmos Reservoir was begun during the morning Sept. 27, and city officials reported that releases were completed by late afternoon Sept. 28. Released water began reaching the gage on San Antonio River at South Alamo Street bridge at 8:30 a. m. on the 27th in sufficient volume to check the rather rapid recession of the stream then in progress and cause a rise in gage height from 7.35 feet to 9.45 feet at 11 a. m. The stage then fell except for minor fluctuations until essentially all released water had passed the gage by midnight on the 28th. A computation of the amount of water released from Olmos Reservoir on the basis of the continuous record of the flow of the river at the gage shows a total of 4,470 acre-feet which compares favorably with the 4,500 acre-feet shown stored in the reservoir by the capacity curve at maximum elevation of 712 feet. These data are shown graphically in figure 4.

Unfortunately for the purpose of a complete study of the flood flow from Olmos Creek, no records of the rise and fall in the water stored in Olmos Reservoir were obtained, nor are any complete records of gate operations available. Had a continuous record of the rate of rise in Olmos Reservoir been available, a complete hydrograph of the flow of Olmos Creek into the reservoir could have been developed. This hydrograph would have supplied data needed for a better study of the effectiveness of the reservoir in reducing the flood crest in the San Antonio River as it passes through the city. A complete record of the gate openings during the time the water was being released from the reservoir or a record of the rate of fall of the water level in the reservoir would have supplied data needed to compute a hydrograph of the released water.

3 Crecelius, S. F., Report of investigations preliminary to the design of Olmos Creek Detention Dam, San Antonio, Tex., 1924.

4 Plans for Olmos Creek Detention Dam, Office of Flood Prevention Engineers, San Antonio, Tex., July 1925.

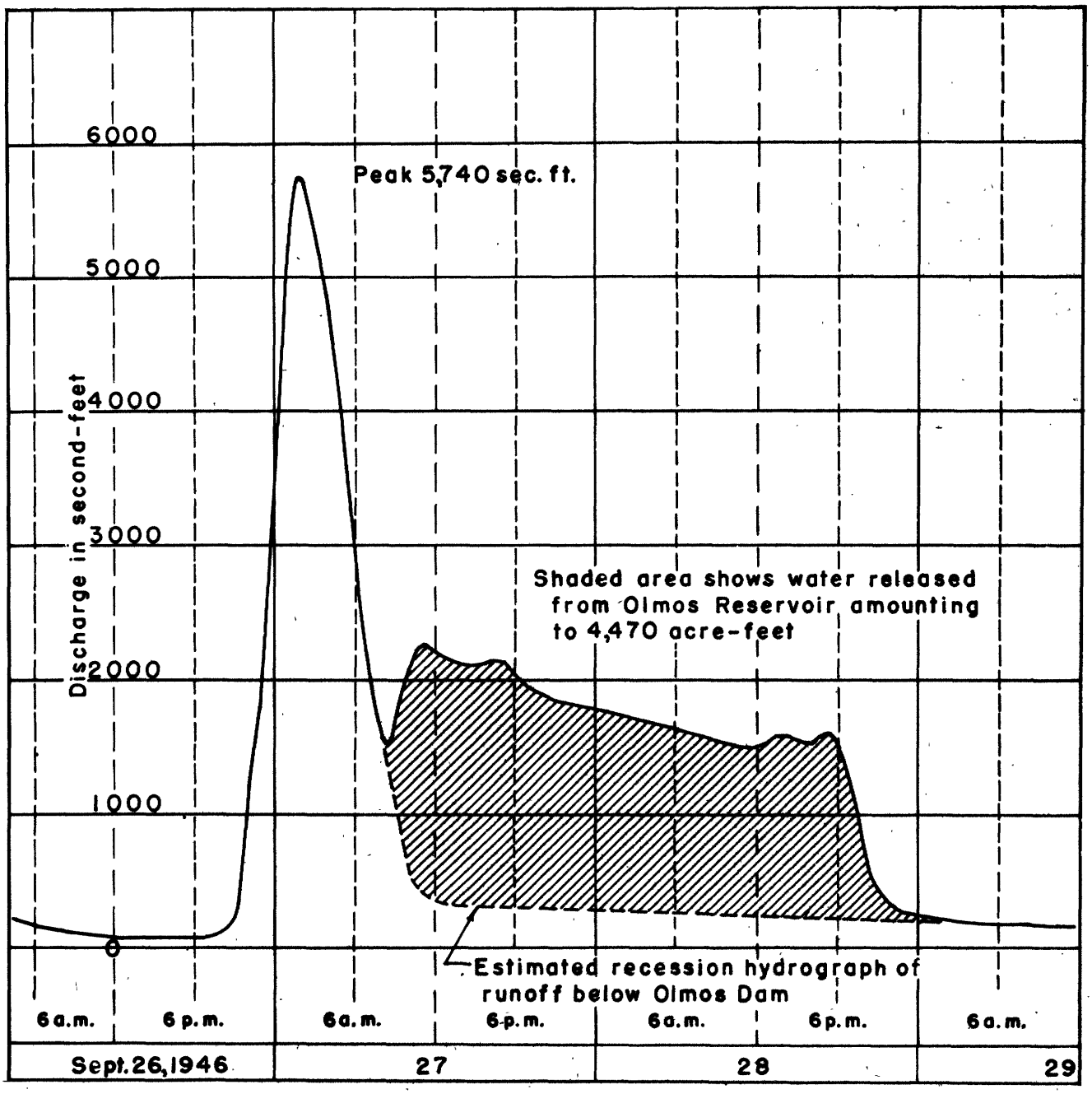

Figure 4.--Graph of discharge at stream-gaging station on San Antonio River at South Alamo Street crossing in San Antonio.

MEASUREMENTS OF PEAK DISCHARGE

In addition to the complete record of flow obtained at the gage on the San Antonio River at San Antonio, measurements of maximum discharges only were obtained by slope-area method at seven places on streams in and near San Antonio. Results of these measurements are given in table 4 and the locations are shown in figure 2. Conditions for these measurements were considered fairly good on San Pedro and Calaveras Creeks and only fair at the other sites.

Measurements of the maximum discharge of the flood of 1921 on San Pedro, Alazan and Apache Creeks are given in the report on that flood.5/ These measurements were made at or near the sites of the measurements made in 1946 and uniformly show a much greater discharge. As these measurements were made by individuals not employed by the Geological Survey, the base data are not available for comparison with the data obtained in 1946. Certainly the discharge of these streams in September 1946 was not nearly so great as that shown for 1921.

The flood in Salado Creek in September 1946 reached about the same stage as the flood in September 1921 at the place of measurement at Ritterman Road crossing about 1 mile downstream from U. S. Highway 81, according to information from local residents. The flood of 1913, the greatest known by residents of this vicinity since about 1853, reached a stage 5 or 6 feet higher than that reached by the flood in 1946.

The flood of 1946 on Calaveras Creek was particularly outstanding. Residents who had lived near the site of measurement for 60 years stated that this flood was much higher than known before. Buildings many years old were washed away. The computed maximum discharge of 58,000 second-feet was produced by an area of 24.6 square miles and amounted to a discharge of 2,360 second-feet per square mile. The rainfall over this basin varied from about 10 inches to 17 inches with an average of about 14 inches. The maximum rainfall measured for this storm was 17.22 inches at a place about 2 miles upstream from site of measurement of maximum discharge. It should be kept in mind that most of this rain fell in a period of 6 to 8 hours.

Table 4.--Maximum discharges of flood of September 27, 1946, in streams in the vicinity of San Antonio

No. on fig. 2	Streams [a]	Latitude	Longitude	Width	Area	Mean velocity	Discharge	Drainage area	Runoff
		° ′ ″	° ′ ″	(feet)	(Sq ft)	(fps)	(cfs)	(Sq miles)	(cfs per sq mile)
1	San Antonio River at gage at South Alamo Street bridge	29 24 35	98 29 40	-	-	-	5,740	b 9.4	611
2	San Pedro Creek, 1500 ft. above mouth	29 23 30	98 30 05	554	3,130	7.25	22,700	44.5	510
3	Alazan Creek above Martinez Creek, between Zarzamora and Navidad Sts.	29 26 15	98 31 30	392	1,430	4.12	5,900	8.8	670
4	Alazan Creek below Martinez Creek, between San Luis and El Paso Sts.	29 25 10	98 30 30	390	2,060	5.05	10,400	17.2	605
5	Martinez Creek, between Huisache and Woodlawn Ave.	29 27 15	98 31 15	377	1,170	3.38	3,950	6.3	627
6	Apache Creek, between Navidad and Trinity Sts.	29 24 50	98 31 20	451	2,210	3.80	8,400	21.5	391
7	Salado Creek near San Antonio, 1 mile below U. S. Highway 81 crossing	29 29 05	98 25 00	566	5,680	8.80	50,000	161	311
8	Calaveras Creek near Elmendorf, 4,000 ft. below Hondo Creek	29 18 00	98 19 40	867	9,060	6.40	58,000	24.6	2,360

a Names of streams agree with those given in Water-Supply Paper 488, p. 8, The Floods in Central Texas in September, 1921, by C. E. Ellsworth, and supersede those given on U. S. Geological Survey Topographic Map, San Antonio Quad., 1901-1903.

b Area between Olmos Dam and the gage.

Note.- All discharges, except that for San Antonio River, were measured by slope-area method. Figures for width, area, and mean velocity were obtained by averaging two cross sections. Discharge for San Antonio River was obtained from rating curve extended above 2,200 second-feet.

5 Ellsworth, C. E., The Floods in Central Texas in September 1921: U. S. Geol. Survey Water-Supply Paper 488, p. 43.

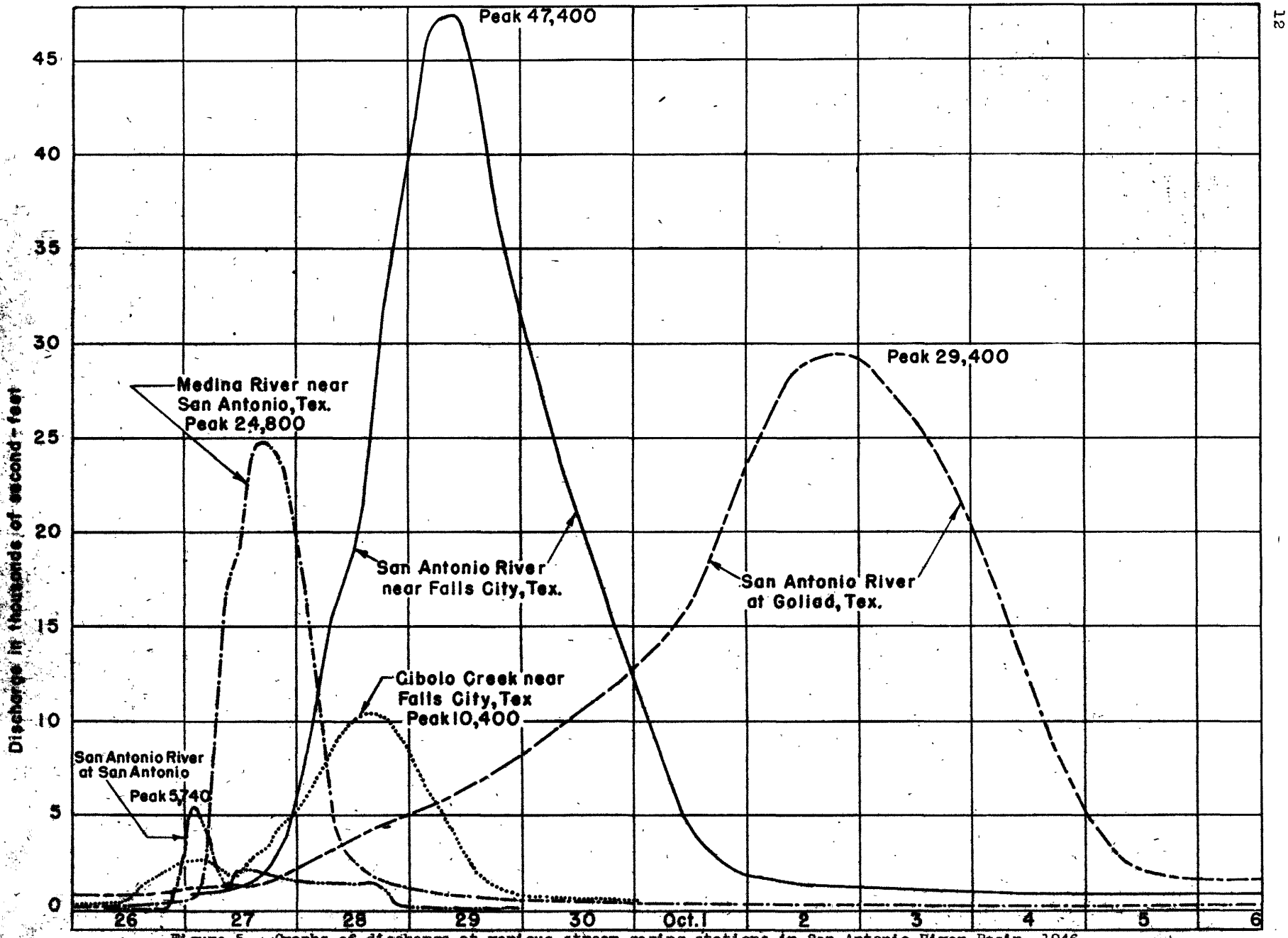

Figure 5.-- Graphs of discharge at various stream-gaging stations in San Antonio River Basin, 1946.

STAGES AND DISCHARGES AT GAGING STATIONS IN SAN ANTONIO RIVER BASIN

On the following pages are presented stage and discharge records at all gaging stations in San Antonio River Basin particularly affected by this storm. These records consist of a station description, a table of daily mean discharges and daily and total runoff for the flood period, and a table of discharges at indicated times during the flood in sufficient detail for a reasonably reliable delineation of the hydrograph.

The tables showing stage and discharge at indicated times are designed to present the rise and recession of the flood in detail, as the rate of rise and fall is usually so rapid that daily mean values do not define the hydrograph adequately. Hydrographs of discharge plotted from these tables are shown in figure 5.

San Antonio River at San Antonio

Location.- Lat. 29°24'35", long. 98°29'40", at South Alamo Street Bridge in San Antonio, Bexar County, 2.1 miles upstream from San Pedro Creek. Datum of gage is 612.3 feet above mean sea level, datum of 1929.

Drainage area.- 42 square miles (1946 revision).

Gage-height record.- Water-stage recorder graph.

Discharge record.- Stage-discharge relation defined by current-meter measurements up to 2,200 second-feet and extended above to 5,740 second-feet. Gage heights used to half-tenths between 2.7 and 4.9 feet; hundredths below and tenths above these limits.

Maxima.- 1946: Discharge, 5,740 second-feet 2 a. m. Sept. 27 (gage height, 15.32 feet).
1915-29, 1939-46: Discharge, 15,300 second-feet Sept. 10, 1921 (gage height, 20.14 feet, from floodmark), by slope-area method.
Flood of July 5, 1819 equalled or exceeded that of Sept. 10, 1921.

Remarks.- Olmos Reservoir (capacity, 15,500 acre-feet) about 8½ miles above station stored all flood water, amounting to 4,500 acre-feet, during night of Sept. 26. This water was released Sept. 27-28, after crest from natural runoff below dam had passed.

Mean discharge, in second-feet, and runoff, in acre-feet, 1946

Day	Second-feet	Acre-feet
September		
26	330	655
27	2,690	5,340
28	1,370	2,720
29	180	357
30	158	313
Runoff, Sept. 26-30		9,380

Gage-height, in feet, and discharge, in second-feet, at indicated time, 1946

Hour	Feet	Second-feet	Hour	Feet	Second-feet	Hour	Feet	Second-feet
Sept. 26			Sept. 27--Con.			Sept. 28--Con.		
1 a.m.	4.10	514	6 a.m.	10.95	3,060	4 p.m.	7.47	1,530
4	2.68	217	7	9.00	2,100	5:30	7.66	1,610
11	1.87	99	8:30	7.37	1,500	7	6.58	1,230
3 p.m.	1.73	81	10	8.85	2,020	8	5.15	810
7	1.74	82	11	9.42	2,280	9	3.85	454
8:30	2.10	130	1 p.m.	9.10	2,140	10	3.22	310
9	2.90	254	3	8.95	2,100			
10	6.50	1,200	5	9.14	2,140	Sept. 29		
11	8.16	1,800	7	8.65	1,950	1 a.m.	2.65	212
12	11.90	3,580	9	8.33	1,830	8:30	2.50	188
						11	2.39	171
Sept. 27						8 p.m.	2.35	165
1 a.m.	14.50	5,220	Sept. 28			11	2.36	166
2	15.32	5,740	1 a.m.	8.07	1,760			
3	14.75	5,410	6	7.78	1,640			
4	14.05	4,890	11:30	7.45	1,500	Sept. 30		
5	12.65	4,000	2 p.m.	7.64	1,570	6 a.m.	2.32	161
						12 p.m.	2.28	155

San Antonio River near Falls City

Location.- Lat. 28°57'05", long. 98°03'55", at highway bridge 0.9 mile upstream from Scared Dog Creek and 3.6 miles southwest of Falls City, Karnes County. Datum of gage is 285.5 feet above mean sea level, datum of 1929.

Drainage area.- 2,071 square miles (1946 revision).

Gage-height record.- Water-stage recorder except for Sept. 26, 1946, when record was uncertain and Sept. 29, when recorder was submerged and record obtained by levels to floodmarks and to stakes set at intervals by gage observer.

Discharge record.- Stage-discharge relation defined by current-meter measurements. Gage heights used to half-tenths between 3.0 and 4.4 feet; hundredths below and tenths above these limits.

Maxima.- 1946: Discharge, 47,400 second-feet 9 a. m. Sept. 29 (gage height, 33.80 feet).
1925-46: Discharge, 18,500 second-feet July 6, 1942; gage height, 22.3 feet June 13, 1935, affected by backwater.
Flood of October 1913 reached a stage of 28.36 feet, from information supplied by local residents.

Remarks.- Flow at high stages affected by natural storage in wide flood plain.

Mean discharge, in second-feet, and runoff, in acre-feet, 1946

Day	Second-feet	Acre-feet	Day	Second-feet	Acre-feet
September			October		
26	552	1,090	1	5,340	10,590
27	1,830	3,630	2	1,380	2,740
28	21,100	41,850	3	1,040	2,060
29	42,200	83,700	4	925	1,830
30	21,300	42,250			
Runoff, Sept. 26 to Oct. 4					189,700

Gage-height, in feet, and discharge, in second-feet, at indicated time, 1946

Hour	Feet	Second-feet	Hour	Feet	Second-feet	Hour	Feet	Second-feet
Sept. 26			Sept. 29			Sept. 30--Con.		
1 a.m.	1.85	424	2 a.m.	32.90	43,200			
1 p.m.	2.05	546	4	33.50	46,000	12 p.m.	15.45	12,200
			6	33.72	46,900			
Sept. 27			8	33.78	47,400	Oct. 1		
1 a.m.	2.43	798	9	33.80	47,400	2 a.m.	13.90	10,900
6	2.66	973	10	33.78	47,400	4	12.40	9,540
12 m.	3.05	1,320	12 m.	33.65	46,400	6	10.65	8,040
4 p.m.	3.50	1,760	2 p.m.	33.30	45,000	8	8.75	6,690
8	4.70	2,980	4	32.60	42,000	10	7.10	5,340
10	5.65	3,920	6	31.70	38,400	12 m.	5.88	4,220
12	7.70	5,840	8	31.00	36,000	4 p.m.	5.05	3,300
			10	30.25	33,600	8	4.00	2,260
Sept. 28			12	29.40	31,400	12	3.65	1,910
2 a.m.	10.50	7,960						
4	13.60	10,600	Sept. 30			Oct. 2		
6	16.40	13,200	2 a.m.	28.60	29,400	6 a.m.	3.28	1,560
8	18.70	15,500	4	27.80	27,600	12 m.	3.07	1,320
10	20.45	17,200	6	26.95	25,900	6 p.m.	2.93	1,210
12 m.	21.90	18,700	8	26.03	24,100	12	2.87	1,150
2 p.m.	23.85	20,900	10	25.00	22,600			
4	26.55	25,200	12 m.	24.00	21,200	Oct. 3		
6	28.95	30,300	2 p.m.	22.75	19,700	12 m.	2.72	1,020
8	30.35	34,200	4	21.40	18,200	12 p.m.	2.68	989
10	31.20	36,700	6	19.90	16,700			
12	32.05	39,500	8	18.45	15,200	Oct. 4		
			10	17.00	13,800	12 m.	2.60	925
						12 p.m.	2.54	880

San Antonio River at Goliad

Location.- Lat. 28°39', long. 97°23', at bridge on State Highway 29, 1.3 miles southeast of courthouse in Goliad, Goliad County, and 10 miles upstream from Manahuilla Creek. Datum of gage is 91.1 feet above mean sea level, datum of 1929, Houston supplementary adjustment of 1943.

Drainage area.- 3,918 square miles (1946 revision).

Gage-height record.- Water-stage recorder graph.

Discharge record.- Discharges obtained from loop curves defined by current-meter measurements. Gage heights used to half-tenths between 3.7 and 4.8 feet; hundredths below and tenths above these limits.

Maxima.- October 1946: Discharge, 29,400 second-feet at 10 p. m. Oct. 2 (gage height 42.67 feet). 1924-28, 1939-46: Discharge, 33,800 second-feet July 9, 1942 (gage height 44.9 feet). Floods of October 1913 and June 15, 1935, reached about the same stage as that of July 9, 1942.

Remarks.- Flow at high stages affected by natural storage in wide flood plain.

Mean discharge, in second-feet, and runoff, in acre-feet, 1946

Day	Second-feet	Acre-feet	Day	Second-feet	Acre-feet	Day	Second-feet	Acre-feet
September			October			October--Con.		
26	820	1,630	1	17,000	33,720	5	2,510	4,980
27	1,440	2,860	2	27,800	55,140	6	1,590	3,150
28	3,760	7,460	3	25,500	50,580	7	1,460	2,900
29	6,490	12,870	4	12,500	24,790			
30	10,300	20,430						
Runoff, Sept. 26 to Oct. 7								220,500

Gage-height, in feet, and discharge, in second-feet, at indicated time, 1946

Hour	Feet	Second-feet	Hour	Feet	Second-feet	Hour	Feet	Second-feet
Sept. 26			Sept. 29--Con.			Oct. 3--Con.		
6 a.m.	6.33	725	8 p.m.	24.86	7,520	4 p.m.	40.95	24,300
12 m.	6.23	706	12	25.92	8,170	8	40.10	22,600
3 p.m.	6.36	744				12	38.90	20,200
6	6.65	782						
9	7.48	763	Sept. 30					
12	8.40	1,160	4 a.m.	27.00	8,920	Oct. 4		
			8	28.02	9,620	4 a.m.	37.50	17,800
Sept. 27			12 m.	29.00	10,400	8	35.80	15,400
3 a.m.	9.06	1,330	4 p.m.	29.92	11,100	12 m.	33.20	12,200
6	9.32	1,370	8	30.70	11,900	4 p.m.	30.36	9,750
9	9.06	1,330	12	31.50	12,800	8	27.20	7,450
12 m.	8.65	1,210				12	23.86	5,330
2 p.m.	8.60	1,210	Oct. 1					
4	9.00	1,300	4 a.m.	32.35	13,600	Oct. 5		
6	9.80	1,490	8	33.30	14,800	4 a.m.	20.28	3,620
8	10.80	1,750	12 m.	34.55	16,200	8	16.90	2,600
10	11.80	2,030	4 p.m.	36.05	18,500	12 m.	14.34	2,100
12	12.66	2,260	8	37.60	21,000	4 p.m.	12.70	1,860
			12	39.00	23,400	8	11.79	1,750
Sept. 28						12	11.37	1,680
4 a.m.	14.20	2,680	Oct. 2					
8	15.65	3,080	4 a.m.	40.20	25,400	Oct. 6		
12 m.	17.05	3,870	8	41.15	27,600	6 a.m.	10.95	1,630
4 p.m.	18.12	4,320	12 m.	41.85	28,900	12 m.	10.64	1,580
8	19.10	4,700	6 p.m.	42.50	29,300	6 p.m.	10.39	1,550
12	20.04	5,080	10	42.67	29,400	12	10.18	1,500
			12	42.65	29,200			
Sept. 29						Oct. 7		
4 a.m.	20.98	5,480	Oct. 3			12 m.	9.95	1,460
8	21.93	5,920	6 a.m.	42.30	27,600	12 p.m.	9.81	1,440
12 m.	22.82	6,360	12 m.	41.63	25,900			
4 p.m.	23.80	6,900						

Medina River near San Antonio

Location.- Lat. 29°15', long. 98°28', at bridge on U. S. Highway 281, 5.2 miles upstream from mouth, and 9 miles south of San Antonio, Bexar County.

Drainage area.- 1,225 square miles (587 square miles is above dam forming Medina Lake).

Gage-height record.- Water-stage recorder graph.

Discharge record.- Stage-discharge relation defined by current-meter measurements. Discharges obtained from loop curve above 3,000 second-feet because of backwater from San Antonio River. For balance of period gage heights used to half-tenths between 3.3 and 5.4 feet, hundredths below and tenths above these limits. Shifting-control method used Sept. 26-27, below 3,000 second-feet.

Maxima.- September 1946: Discharge, 24,800 second-feet 4 to 5 p. m. Sept. 27 (gage height, 41.57 feet, affected by backwater from San Antonio River.)
1939 - August 1946: Discharge, 31,800 second-feet Aug. 29, 1946 (gage height, 39.23 feet). Maximum stage known, about 55 feet in 1912 (prior to construction of Medina Dam, 60 miles upstream), from information by State Highway Department.

Remarks.- All flow during this flood period from runoff below Medina Dam. Records good except those above 3,000 second-feet which are fair.

Mean discharge, in second-feet, and runoff, in acre-feet, 1946

Day	Second-feet	Acre-feet	Day	Second-feet	Acre-feet
September			September--Con.		
26	126	250	30	414	821
27	15,900	31,540	October		
28	5,730	11,370	1	321	637
29	756	1,500	2	268	532
Runoff, Sept. 26 to Oct. 2					46,650

Gage-height, in feet, and discharge, in second-feet, at indicated time, 1946

Hour	Feet	Second-feet	Hour	Feet	Second-feet	Hour	Feet	Second-feet
Sept. 26			Sept. 27--Con.			Sept. 28--Con.		
4 a.m.	3.22	87	12 m.	39.05	19,100	12 p.m.	11.58	1,170
7	3.26	90	1 p.m.	40.25	21,500			
9	3.75	130	2	40.95	23,300	Sept. 29		
11	4.30	185	4	41.55	24,800	6 a.m.	10.17	870
12 m.	4.27	185	5	41.57	24,800	12 m.	9.37	722
4 p.m.	3.62	120	6	41.47	24,700	5 p.m.	8.95	645
9	3.36	98	8	40.80	24,200	6	8.80	620
10	3.67	124	10	39.05	22,900	12	8.17	512
12	5.80	378	12	36.00	20,200			
Sept. 27						Sept. 30		
1 a.m.	6.74	541	Sept. 28			6 a.m.	7.81	456
2	6.87	558	2 a.m.	32.50	17,000	12 m.	7.48	405
3	10.00	1,130	4	28.90	13,200	6 p.m.	7.23	370
4	11.50	1,460	6	24.90	8,350	12	7.12	352
5	18.00	3,040	8	21.65	5,050			
6	25.20	7,400	10	19.35	3,450	Oct. 1		
7	31.50	11,500	12 m.	17.60	2,680	12 m.	6.89	321
8	35.50	14,400	2 p.m.	16.05	2,240	12 p.m.	6.67	294
9	37.35	16,400	4	14.80	1,960			
10	38.23	17,700	6	13.77	1,690	Oct. 2		
11	38.70	18,500	8	12.82	1,450	12 m.	6.47	268
						12 p.m.	6.35	254

Cibolo Creek near Falls City

Location.- Lat. 29°01', long. 97°56', at bridge on State Highway 123, 6.5 miles northeast of Falls City, Karnes County, and 9 miles upstream from mouth. Datum of gage is 264.3 feet above mean sea level, datum of 1929, Houston supplementary adjustment of 1943.

Drainage area.- 831 square miles.

Gage-height record.- Water-stage recorder graph.

Discharge record.- Stage-discharge relation defined by current-meter measurements. Gage heights used to half-tenths between 2.8 and 4.8 feet; hundredths below and tenths above these limits.

Maxima.- September 1946: Discharge, 10,400 second-feet 3:30 p. m. Sept. 28 (gage height, 22.52 feet).
1930 - August 1946: Discharge, 33,600 second-feet July 6, 1942 (gage height, 34.48 feet).
Flood in October 1913 reach a stage about one-half foot higher than that of July 6, 1942.

Remarks.- The upper part of the Cibolo Creek Basin, having an area of about 280 square miles, does not produce much surface runoff because much of the surface flow enters sink holes and caverns in the Glen Rose and Edwards limestones.

Mean discharge, in second-feet, and runoff, in acre-feet, 1946

Day	Second-feet	Acre-feet	Day	Second-feet	Acre-feet
September			October		
26	872	1,730	1	282	559
27	2,970	5,890	2	187	371
28	8,760	17,380	3	145	288
29	3,540	7,020	4	124	246
30	501	994			
Runoff, Sept. 26 to Oct. 4					34,480

Gage-height, in feet, and discharge, in second-feet, at indicated time, 1946

Hour	Feet	Second-feet	Hour	Feet	Second-feet	Hour	Feet	Second-feet
Sept. 26			Sept. 27--Con.			Sept. 29--Con.		
2 a.m.	2.15	100	12 p.m.	17.02	5,300	12 p.m.	5.95	780
3	2.17	102						
6	1.99	84	Sept. 28			Sept. 30		
8	1.97	82	2 a.m.	17.93	5,930	6 a.m.	5.21	594
9	2.00	85	4	18.90	6,760	12 m.	4.62	470
10	2.60	150	6	19.87	7,700	6 p.m.	4.25	405
12 m.	4.80	510	8	20.78	8,600	12	4.00	360
2 p.m.	6.65	926	10	21.58	9,460			
4	8.00	1,320	12 m.	22.13	10,000	Oct. 1		
6	9.10	1,680	2 p.m.	22.45	10,300	12 m.	3.53	282
8	10.05	1,990	3	22.52	10,400	12 p.m.	3.17	221
10	10.85	2,280	4	22.52	10,400			
12	11.45	2,510	6	22.35	10,300	Oct. 2		
			8	21.97	9,900	12 m.	2.92	187
Sept. 27			10	21.33	9,130	12 p.m.	2.72	164
2 a.m.	11.82	2,670	12	20.50	8,300			
3	11.86	2,710				Oct. 3		
4	11.81	2,670				12 m.	2.56	145
5	11.69	2,630	Sept. 29			12 p.m.	2.42	129
6	11.40	2,510	2 a.m.	19.57	7,400			
8	10.31	2,100	4	18.62	6,490			
10	9.25	1,710	6	17.52	5,650	Oct. 4		
11	9.05	1,650	8	16.20	4,750	12 m.	2.37	124
12 m.	10.25	2,060	10	14.63	3,840	12 p.m.	2.28	114
2 p.m.	11.75	2,670	12 m.	12.82	3,070			
4	12.90	3,110	2 p.m.	10.65	2,210	Oct. 5		
6	13.80	3,480	4	8.45	1,450	12 m.	2.28	114
8	15.52	4,320	6	7.38	1,140	9 p.m.	2.23	88
10	16.16	4,750	9	6.49	900	12	2.69	161

The drastic reduction in peak discharge at Goliad from that at Falls City was due to temporary storage in wide flood plain between these stations. San Antonio River also has a wide flood plain above Falls City. The rainfall pattern indicates that the maximum discharge in the river probably occurred just below the mouth of Calaveras Creek, about 30 miles above Falls City, and probably was greatly in excess of the 47,400 second-feet measured at Falls City.

RAINFALL AND RUNOFF

Analyses of the rainfall for the night of Sept. 26, 1946, and the runoff records have been made for three areas: Olmos Creek above Olmos Dam, San Antonio River Basin between Olmos Dam and the gage at South Alamo Street bridge, and San Antonio River Basin above the gage near Falls City but excluding the basin of Medina River above the gage near San Antonio. These analyses have been made for the purpose of showing the relation between storm rainfall and the resulting direct runoff. The differences between rainfall and runoff give an indication of the volume of water retained in the drainage basins; this retention is an important factor in flood control and other problems.

For the purpose of this study the rainfall during the night of September 26 and the resulting direct runoff were used. The total runoff shown in the discharge tables for San Antonio River at San Antonio and near Falls City was adjusted for antecedent flood runoff and base flow. The total rainfall for the Olmos Creek Basin and for the San Antonio River Basin above San Antonio was measured on the isohyetal map (fig. 2). The rainfall on the basin above Falls City gage was measured on the map in figure 3.

Records at the San Antonio Weather Bureau station show that a rainfall of 3.27 inches fell in late afternoon September 25. This rain produced only small rises in the streams but no doubt conditioned the soil to cause greater maximum discharges and total runoff from the rain that began about 26 hours later.

The rainfall for the night of Sept. 26, 1946, over Olmos Creek Basin above Olmos Dam varied from about 6 to about 10 inches, and the average was 7.4 inches. Runoff from this area of 32.4 square miles, as obtained from capacity curve for Olmos Reservoir, was 4,500 acre-feet, or a depth of 2.6 inches. This shows that the retention averaged 4.8 inches. Olmos Creek Basin is 11 miles long above Olmos Dam with an average width of slightly less than 3 miles. It heads in the southern edge of the Edwards Plateau at an elevation of about 1,050 feet. Elevation of the stream bed at Olmos Dam prior to construction of the dam was about 670 feet. The upper part of the basin is crossed by a number of faults in the geological structure which may permit the entrance of some surface flow into underground reservoirs. The area is entirely rural except for a very small part just above the dam. A small part of the area is in cultivation but the much greater part is in pasture land and covered with brush and timber. The topography is rolling to hilly.

The rainfall on San Antonio River Basin between Olmos Dam and the gage at South Alamo Street bridge varied from about 10 to about 11 inches and the average was 10.5 inches. Storm runoff from this area of 9.4 square miles was 3,520 acre-feet, as measured at the gage, representing total flow Sept. 26-30 of 9,380 acre-feet (less 4,470 acre-feet measured as water released from Olmos Reservoir, and less 1,390 acre-feet antecedent flow and base flow from springs). The net runoff amounts to a depth of 7.0 inches, leaving a retention of 3.5 inches. This is largely an urban area and includes a large part of the main business section of San Antonio. The elevation of the stream bed at Olmos Dam is about 670 feet and at the gage, 612 feet. The distance between these places, following the meanderings of the channel, is 8½ miles.

The average rainfall over the San Antonio River Basin above Falls City, exclusive of the area in the Medina River Basin above gage near San Antonio, was 8.7 inches. Storm runoff from this area of 846 square miles as measured at the gage near Falls City for the period September 26 to October 4, 1946, was 134,000 acre-feet, equivalent to a depth of 3.0 inches, leaving a retention of 5.7 inches. Within this basin the rainfall was 16 inches or more over an area of 105 square miles, more than 12 inches over 258 square miles, more than 8 inches over 409 square miles, and more than 4 inches over 690 square miles. The average annual rainfall over this basin is about 28 inches. The headwater streams originate in and drain some 60 square miles of the Edwards Plateau. They are crossed by a number of fault zones in their upper reaches where part of the surface flow may be taken into underground reservoirs. However, possible diversion of surface flow would have very small effect on the rainfall-runoff relation under study as nearly all of the rain fell below the faulted zone.

DAMAGES

The direct damages that were caused by the flood of September 1946 on San Antonio River and its tributaries are estimated at $3,636,330 as shown below:

Within City of San Antonio		
San Antonio River..	$ 117,700	
Martinez, Alazan, Apache, and San Pedro Creeks.....	2,488,630	
		$2,606,330
Outside City of San Antonio		
San Antonio River..	880,000	
Tributaries.....	150,000	
		1,030,000
Total direct damages.....		$3,636,330

The above figures do not include indirect damages nor damages due to ponded rainwater caused by inadequate storm sewers. Indirect damages include losses resulting from the interruption of traffice and communications, the interruption to normal business and commerce, wage loss, and the relief and care of flood victims and their rehabilitation.

Map showing 1946 and 1921 flooded areas in San Antonio

A map of the city of San Antonio, figure 6, is included in this report to show the extent of the flood plains of the floods of Sept. 10, 1921, and Sept. 27, 1946. The flooded area in 1921 is outlined only within the original city limits, whereas the area for 1946 is outlined for some distance upstream and downstream. It will be noted that in 1921 the flood waters of the San Antonio River covered a much greater area than in 1946.

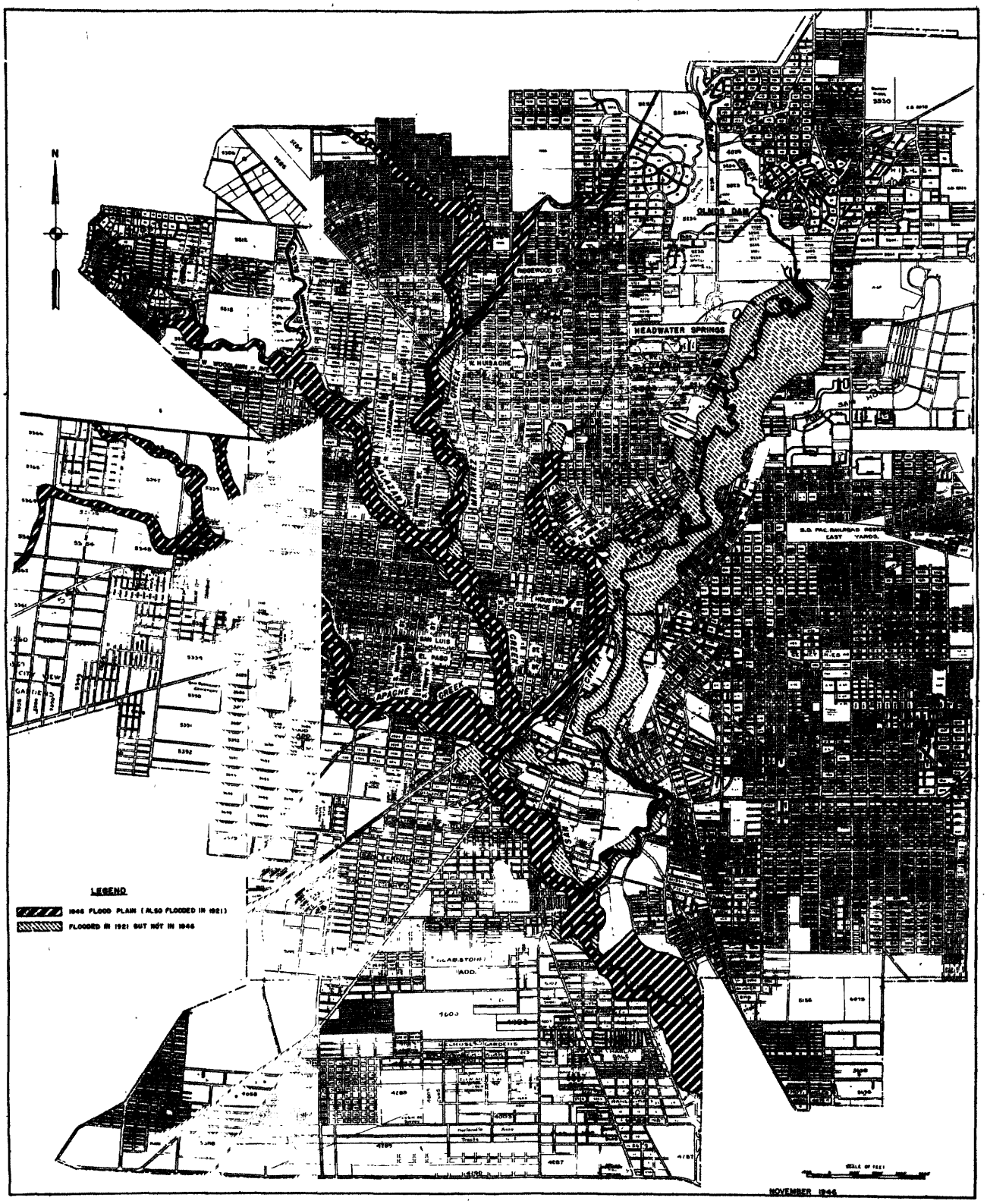

Figure 6.--Map of San Antonio, showing 1946 and 1921 flood plains.

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