Floods in the Guadalupe and San Antonio River Basins in Texas, October 1998

Severe flooding in parts of south-central Texas resulted from a major storm during October 17–18, 1998. The flooding occurred in parts of the major streams and tributaries of the San Jacinto, San Benard, Colorado, Lavaca, Guadalupe, and San Antonio River Basins. Peak gage height, peak streamflow, and documentation of the significance of the peaks were compiled for the streamflow-gaging stations where the storm caused substantial flooding. This information is available on the U.S. Geological Survey (USGS) world-wide web site at http://tx.usgs.gov/alert/oct_floods_98.html.

Most of the substantial rainfall and flooding occurred in the Guadalupe and San Antonio River Basins. This report summarizes rainfall and flood peaks in these two basins during October 1998.

Meteorology of the Storm

According to the National Weather Service (NWS) (John Patton, written commun., 1999), the meteorologic conditions that produced the storm rainfall were dominated by Hurricane Madeline in the Eastern Pacific near the tip of Baja California, and Hurricane Lester in the Eastern Pacific near Acapulco, Mexico. The hurricanes, coupled with an atmospheric trough of low pressure over the western United States, forced a very deep layer of air with high water-vapor content across Mexico and into Texas. Meanwhile, an atmospheric ridge of high pressure to the east, extending from the North Atlantic to the Yucatan Peninsula of Mexico, confined the surface and mid-level water-vapor plumes to south-central Texas.

During the morning of October 17, 1998, a strong low-level inflow of moist air traveling 23 to 35 miles per hour flowed from the Gulf of Mexico across Texas into Bexar County (fig. 1). An upper-level divergent wind pattern over south-central Texas lifted the extremely moist air mass from lower levels. Early thunderstorms slowly pushed eastward throughout the day into the prevailing moisture-rich flow.

In the early morning hours of October 17, extreme atmospheric instability over western Bexar County extending northward to Kendall County caused rapid uplift of low-level moisture, forming heavy thunderstorms. By 6 a.m., the area from western Comal County to eastern Medina County had received 4 to 6 inches of rain. By 8 a.m., 6 to 10 inches had fallen; and by late morning, this area had received about 15 inches.

By late morning on October 17, the rains extended into Hays and Travis Counties. The NWS rain gage at Wimberley (Hays County) indicated that intense rainfall began by 8 a.m. and recorded 4.5 inches by 11 a.m., 6 inches by 1 p.m., 9 inches by 4 p.m., and 11.25 inches by 8 p.m. At 11:30 p.m., the 12-inch rain collector overflowed.

Finally, by mid-day October 18, the tropical plume and intense rainfall shifted eastward to the upper Texas Coastal Plain and extended into Louisiana.

Storm Rainfall

A map of the total rainfall for the storm (fig. 1) was prepared by the NWS (John Patton, written commun., 1999). The lines of equal rainfall (isohyetals) are based on total rainfall recorded at NWS rain gages and totals determined from a bucket survey coordinated by the NWS. The bucket survey identified total rainfall from privately owned rain gages and rainfall from other

View of structures inundated by the Guadalupe River at Victoria, Tex. (From video by M.W. Sunvison, D.S. Brown, and B.L. Petri, U.S. Geological Survey.)

USGS personnel measuring streamflow discharge for flood at streamflow-gaging station 08188500 San Antonio River at Goliad. (From video by M.W. Sunvison, D.S. Brown, and B.L. Petri, U.S. Geological Survey.)

collectors. Rainfall totals less than 8 inches were documented outside the area encompassed by the 8-inch isohyetal (fig. 1) but are not discussed in this report.

The rainfall shown (fig. 1) represents total rainfall for October 17–18. However, as indicated previously, most of the rain fell in less than 24 hours. The isohyetals show two main centers of rainfall. The largest documented rainfall was in southern Hays County just south of San Marcos, where at least 30 inches was recorded. A second center, with about 22 inches of rain, was documented at a site in western Comal County. The isohyetals indicate that about 2,300 square miles in 12 counties received at least 12 inches of rain, and about 5,000 square miles in 19 counties received at least 8 inches of rain. The NWS operates and sponsors many recording rain gages in the area; however, many of the gages overflowed during the storm, thus, incremental rainfall totals are not available for much of the area with the greatest rainfall.

The available incremental rainfall data and the rainfall indicated by NEXRAD radar operated by the NWS indicate that the storm was moving from northwest to southeast, the same direction as the course of the streams in the area (John Patton, National Weather Service, oral commun., 1999). This movement most likely caused the flood peaks for some sites to be higher than if the storm had been stationary or had moved in another direction. The largest rainfall occurred in the Guadalupe River Basin, and most of the basin received 8 or more inches of rainfall.

Peak Gage Heights and Streamflow

Substantial flood peaks were documented for 27 streamflow-gaging stations operated by the USGS in the Guadalupe and San Antonio River Basins (table 1). Table 1 lists the period of record, peak gage height, and peak streamflow for the maximum known flood prior to the October 1998 flood. Also included are the peak gage height and streamflow for the October 1998 flood, along with the ratio of the October 1998 peak streamflow to the maximum known peak streamflow prior to October 1998. Eleven stations have ratios equal to or exceeding 1.0, indicating that the October 1998 flood produced the highest known peak streamflow for those stations.

The largest ratio (6.5) is for site 8, Guadalupe River at Gonzales; however, only 20 years of data are available for that station (1978–present). Perhaps the most historically significant peaks occurred at site 10, Guadalupe River at Cuero, and site 11, Guadalupe River at Victoria. The October 1998 peak streamflow was 2.6 times the previous maximum streamflow at the Victoria station. The previous maximum streamflow had been the highest since before 1833.

The recurrence period, in years, is indicated for those stations where peak-flow frequency has been estimated (Asquith and Slade, 1997). For other stations, the October 1998 peak is indicated as greater than the 100-year recurrence period where the

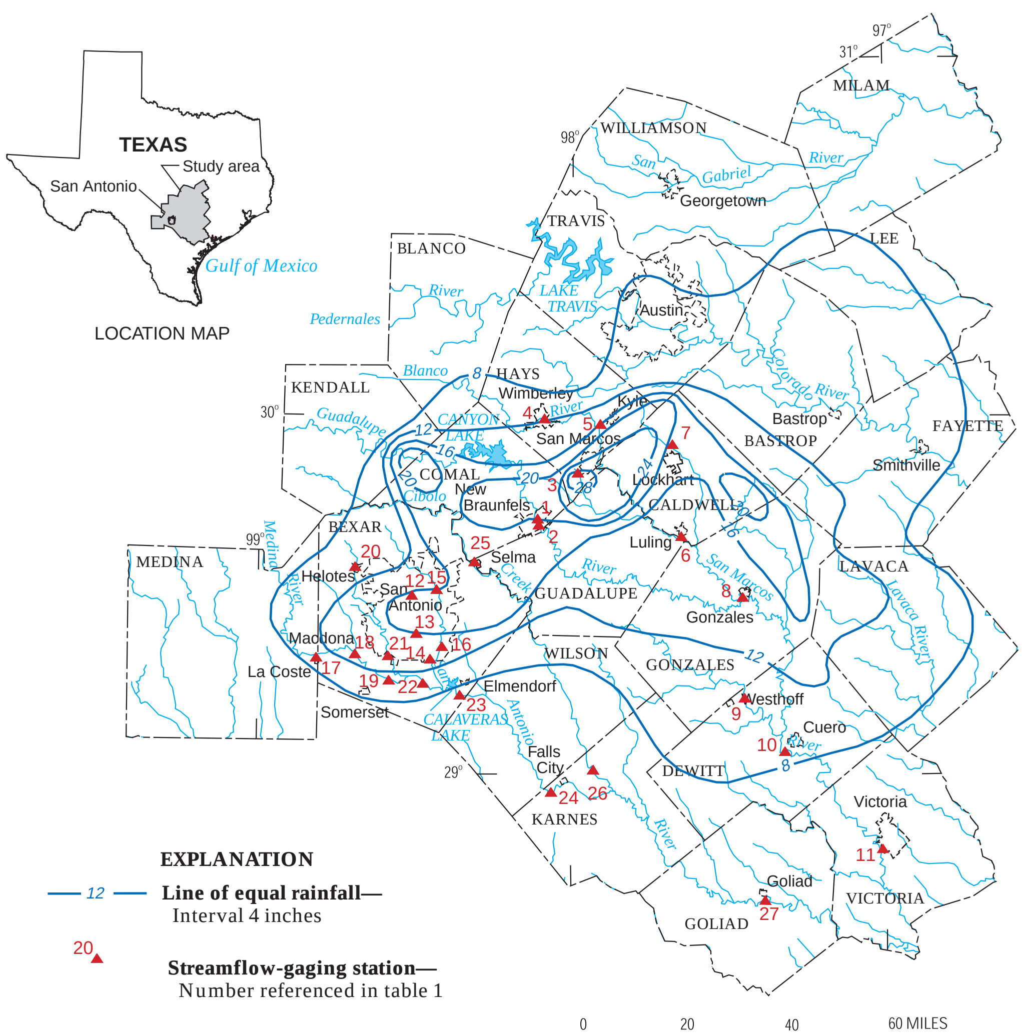

Figure 1. Total rainfall depths for October 17–18, 1998, storm in Guadalupe and San Antonio River Basins.

Table 1. Peak gage heights and streamflows during October 17–20, 1998, for selected stations in the Guadalupe and San Antonio River Basins, Texas

[mi^2, square miles; ft, feet; ft^3/s, cubic feet per second; $(ft^3/s)/mi^2$, cubic feet per second per square mile; --, no data; >, greater than]

				Previous known maximum peak data				October 17–20, 1998, maximum peak data							
Site no. (fig. 1)	Station no.	Station name	Total drainage area (mi^2)	Period of record for peak data	Date	Gage height (ft)	Streamflow (ft^3/s)	Date (month/day)	Time	Gage height (ft)	Streamflow (ft^3/s)	Ratio to previous maximum peak streamflow	Peak basin yield [$(ft^3/s)/mi^2$]	RP[1] (years)	Ratio to 100-year peak streamflow[2]
		Guadalupe River Basin													
1	08168500	Guadalupe River above Comal River at New Braunfels	1,518	1845–present	07/08/1869	[3]38	--	10/17	1745	35.57	142,000	--	93.5	100	--
					12/1913	[3]38	--	--	--	--	--	--	--	--	--
2	08169500	Guadalupe River at New Braunfels	1,652	1915–1927 1974–present	09/10/1921	28.60	56,600	10/17	--	38.54	222,000	3.9	134	>100	--
3	08170500	San Marcos River at San Marcos	47	1996–present	06/21/1997	7.73	787	10/17	1600	21.29	21,500	--	457	--	--
4	08171000	Blanco River at Wimberley	355	1869–present	05/28/1929	33.30	113,000	10/17	1415	28.50	116,000	1.0	327	100	1.06
5	08171300	Blanco River near Kyle	412	1882–present	05/1929	[3]40	139,000	10/17	1700	35.82	105,000	.8	255	50	--
6	08172000	San Marcos River at Luling	838	1859–present	1869 or 1870	[3]40.4	--	10/18	0615	41.85	206,000	--	246	>100	2.09
7	08172400	Plum Creek at Lockhart	112	1905–present	06/1936	[3]22	--	10/18	0330	23.09	47,200	--	421	>100	--
8	08173900	Guadalupe River at Gonzales	3,490	1978–present	06/05/1987	([4]--)	52,000	10/18	2100	50.44	340,000	6.5	97.4	>100	3–4
9	08175000	Sandies Creek near Westhoff	549	1864–present	07/02/1936	33.1	92,700	10/19	2000	28.80	36,200	.4	65.9	15	--
10	08175800	Guadalupe River at Cuero	4,934	1900–present	07/02/1936	[3]44.33	--	10/20	0030	50.35	473,000	--	95.9	>100	3–4
11	08176500	Guadalupe River at Victoria	5,198	1833–present	07/03/1936	31.22	179,000	10/20	1400	34.04	466,000	2.6	89.6	>100	3–4
		San Antonio River Basin													
12	08177700	Olmos Creek at Dresden Dr., San Antonio	21.2	1935–present	04/05/1991	14.38	19,700	10/17	0930	14.01	18,600	.9	877	--	--
13	08178050	San Antonio River at Mitchell St., San Antonio	42.4	1993–present	10/08/1994	7.98	5,090	10/17	1015	12.94	14,300	2.8	337	--	--
14	08178565	San Antonio River at Loop 410 at San Antonio	125	1987–present	07/15/1990	32.20	64,300	10/17	1600	32.57	79,400	1.2	635	--	--
15	08178700	Salado Creek (upper station), at San Antonio	137	1853–present	10/1913	[3]23–24	--	10/17	1600	22.40	64,400	--	470	--	--
16	08178800	Salado Creek (lower station), at San Antonio	189	1941–present	09/27/1973	28.83	13,100	10/17	1300	34.07	47,800	3.6	253	--	--
17	08180640	Medina River at La Coste	805	1987–present	05/30/1987	24.05	24,600	10/18	1300	21.30	13,400	.5	16.6	--	--
18	08180700	Medina River near Macdona	885	1982–present	05/30/1987	20.58	36,800	10/18	1945	17.39	16,300	.4	18.4	--	--
19	08180800	Medina River near Somerset	967	1971–present	07/17/1973	29.39	30,500	10/18	1515	22.70	13,500	.4	14.0	--	--
20	08181400	Helotes Creek at Helotes	15	1923–present	1927	[3]13.7	--	10/18	0115	15.21	12,600	--	840	40	--
21	08181480	Leon Creek at IH–35, at San Antonio	219	1985–present	06/22/1997	24.60	27,900	10/18	1715	29.31	93,300	3.3	426	>100	--
22	08181500	Medina River at San Antonio	1,317	1913–present	1913	[3]55	--	10/18	1600	49.45	30,000	--	22.8	--	--
23	08181800	San Antonio River near Elmendorf	1,743	1900–present	1946	[3]61	--	10/18	1200	64.20	75,000	--	43.0	>100	--
24	08183500	San Antonio River near Falls City	2,113	1875–present	09/29/1946	33.80	47,400	10/20	0600	33.60	70,000	1.5	33.1	>100	--
25	08185000	Cibolo Creek at Selma	274	1869–present	06/22/1997	29.73	69,600	10/17	1345	35.37	98,100	1.4	358	>100	1.15
26	08186000	Cibolo Creek near Falls City	827	1890–present	10/1913	[3]35	35,000	10/19	0700	39.86	47,500	1.4	57.4	>100	1.09
27	08188500	San Antonio River at Goliad	3,921	1800–present	1869	[3]>53.0	--	10/22	1230	51.78	59,200	--	14.0	--	--

[1] Recurrence period for peak streamflow from Asquith and Slade (1997).

[2] 100-year peak streamflow from Asquith and Slade (1997). Ratios not computed for peaks exceeding 100-year recurrence period for stations where peak streamflow frequency unknown, however, magnitude of peak large enough to indicate peak greater than that of 100-year recurrence period.

[3] Historical peak data from land-owner account before systematic data collection.

[4] Station at different location 1.2 miles upstream with different gage-height datum in 1987.

large magnitude of the peak makes exceedance of the 100-year recurrence period obvious (table 1). The recurrence period is not estimated for the remaining stations because the peak streamflow might have been affected by reservoirs or flood-retarding structures. The October 1998 peak streamflow equals or exceeds the 100-year recurrence period for 13 stations in the two basins.

Flood Volume in Guadalupe River Basin

The volume of runoff for site 10, Guadalupe River at Cuero, was computed for the period October 17–31, 1998, at about 1,840,000 acre-feet. Most of the runoff from the October 17–18 storm occurred at the station by the end of October. The total outflow from Canyon Lake during October 18–31 was only about 2,600 acre-feet (Tommy Hill, Guadalupe-Blanco River Authority, oral commun., 1999); thus, almost all runoff at the Cuero station originated from the basin downstream of the reservoir.

The volume of rainfall associated with the runoff at the Cuero station also was computed on the basis of the total rainfall (fig. 1). The rainfall volume in the drainage basin upstream of the Cuero station and downstream of Canyon Lake is about 2,580,000 acre-feet, which represents a mean depth of about 15.0 inches in that area. The runoff accounts for about 10.7 inches or about 71 percent of the rainfall—most of the remaining 4.3 inches of rainfall thus is attributed to depression storage (such as ponds and valleys) and infiltration.

From October 17 to 31, the change in storage in Canyon Lake was about 134,000 acre-feet, which, when added to the 2,600 acre-feet of outflow, approximates the runoff during that period from the 1,432-square-mile basin upstream of the reservoir. The maximum water elevation at Canyon Lake was about 923 feet, which is about 20 feet lower than the spillway crest at the reservoir.

Flooding in San Antonio River Basin

The largest rainfall in the San Antonio River Basin was in the upstream areas (fig. 1). However, the flood peaks at the stations on lower Cibolo Creek and the lower San Antonio River exceeded the 100-year recurrence period (table 1). Flood losses in the San Antonio River Basin were less than in the Guadalupe River Basin mostly because fewer urban areas were inundated.

Flood Losses

According to the Texas Department of Public Safety (written commun., 1999), 31 people drowned during the floods, and total property damage was estimated to be about $750 million. Forty-three counties in Texas received Presidential Disaster Declarations and thus were eligible for compensation for financial losses from the floods. Total compensation of about $188 million was provided for small businesses, individual-family grants, temporary housing, public assistance, and unemployment assistance.

Reports on Major Storms and Floods in Texas

Many storms with rainfall depths similar to and even exceeding those documented in this report have occurred throughout much of Texas—some of these storms have produced world-record rainfall rates. The USGS and other Federal and State agencies have prepared many reports documenting specific storms and floods in Texas. Two recent reports documented the June 1997 floods in south-central Texas (Raines and others, 1998) and the October 1994 floods in southeast Texas (Liscum and East, 1995). Lanning-Rush and others (1998) present references for reports documenting major storms and floods in Texas. That report also presents narratives for all known major storms and includes analyses of the areal extent of extreme rainfall depths for regions of Texas. A method to estimate rainfall depths for durations of 15 minutes to 7 days in Texas was prepared by Asquith (1998).

Many flood peaks that greatly exceed the 100-year recurrence period have occurred throughout Texas. A report presenting the greatest documented peak streamflow at many sites in Texas was prepared by Asquith and Slade (1995). That report also presents a method to estimate the maximum peak streamflow for various sizes of drainage areas for 11 regions in Texas. Asquith and Slade (1997) present a method to estimate peak streamflows for recurrence periods of 2 to 100 years for basins in Texas that are not affected by urbanization or reservoirs.

Selected abstracts and references for some of these and other USGS reports are presented on-line at http://tx.usgs.gov. The site also includes current and historic streamflow data and information for gaging stations across the State (Water Data).

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