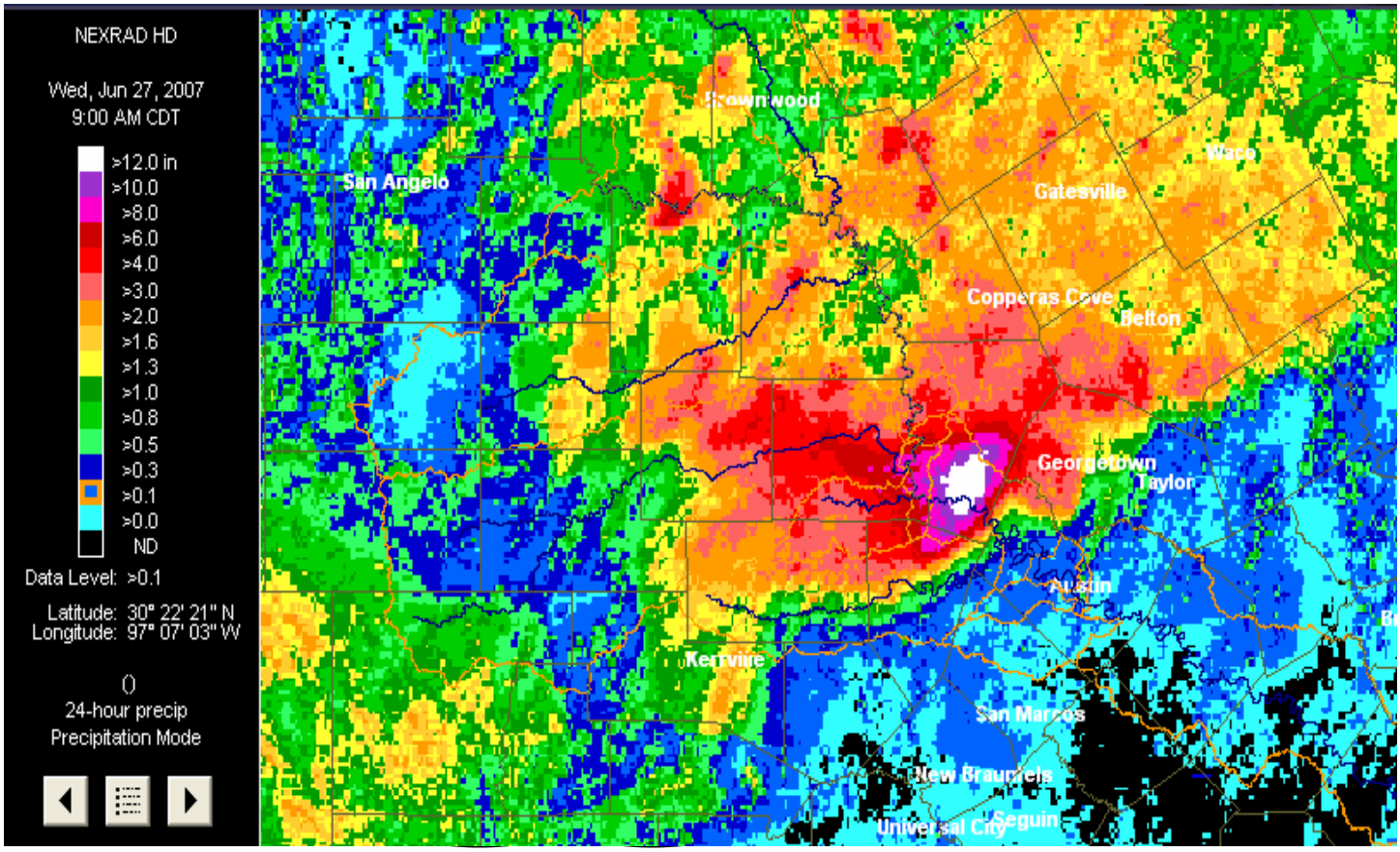
Summer 2007 Flood Report

LCRA Water Services River Operations Center



NEXRAD image of the June 27 storm that triggered the Summer 2007 Flood

Executive Summary

The Summer 2007 Flood was unexpected, sudden, severe and a great test of LCRA assets, both in terms of facilities and people.

This event demonstrated the value of remote-controlled floodgates at Starcke Dam, dedicated floodgate hoists at Wirtz Dam, a refined computer simulation model to forecast flood conditions with greater accuracy, a higher state of readiness, and depth at key positions. Communications continued to improve as a result of this event, as did relationships with other agencies that work with LCRA during flood emergencies.

The greatest intensity of rainfall was in the Marble Falls area. The peak flow on Hamilton Creek surpassed that of the previously documented extreme peak discharge set in 1936. The worst flooding occurred in Marble Falls and the headwaters of Lake Travis, qualifying the area for federal disaster assistance.

The Summer 2007 Flood did not break the severe drought of 2006. Actually, the drought had ended before then, thanks to rains earlier that spring which filled lakes Buchanan and Travis. But public attention was riveted by the June 27 rain event. The public became more aware of floods and droughts, and of the value of the Highland Lakes to the people of the lower Colorado River basin.

Flood Facts:

- Rainfall intensity near Marble Falls (18 inches in 6 hours) was in excess of a 500-year event, based on depth-duration-frequency analysis.
- Unit-peak discharge on Hamilton Creek, 722 cubic feet per second (cfs) per square mile, exceeded the historical record. Unit-peak flow was even higher on Backbone Creek in Marble Falls.
- Lake Travis reached its fifth highest level: 701.52 feet above mean sea level (msl).
- LCRA received so many hits on its Flood Summary page on the LCRA web site, that the method of generating graphics had to be changed to keep up with demand.

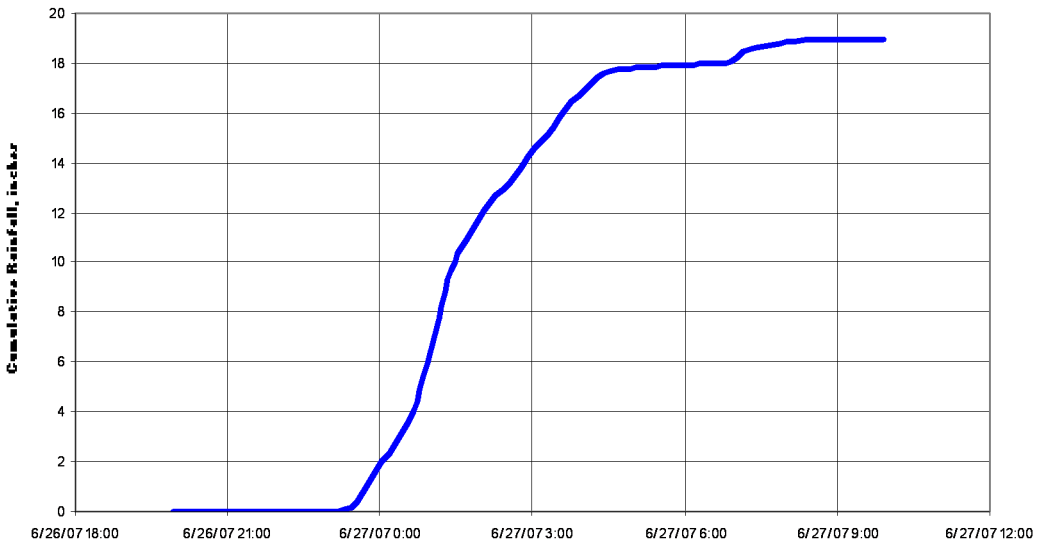
After 18 months of drought, wet weather in the spring of 2007 filled Lake Travis. Then the flood hit in June 2007.

Weather Pattern

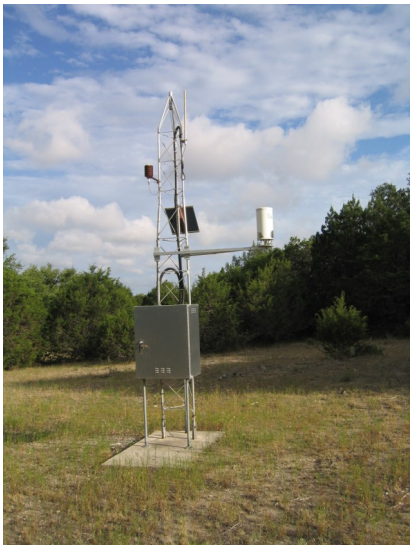
The phenomenally heavy rain event on June 27 was part of an unusually wet weather pattern that began in May and lasted into early August. During that time, a trough of low pressure in the middle and upper atmosphere over Texas was surrounded by ridges of high pressure to the east and west. Atmospheric disturbances tracking south from the Plains states interacted with a rich supply of moisture off the Gulf of Mexico. The May to August period was one of the wettest on record. These rains filled the conservation pool of Lake Travis.

On June 26, a complex of thunderstorms developed in the unstable atmosphere over Central Texas. Late that night, the storms reached Llano, Burnet and northwestern Williamson counties. The storms entrained a very warm, moist flow of air off the Gulf of Mexico (low-level Jet). The intersection of the Jet with outflow in the upper atmosphere caused the storm complex to stall. Rainfall intensity increased as individual storms repeatedly moved over the same areas. Heavy rain began to fall after midnight.

Hydromet Rain Gauge
Marble Falls 6 ENE



Hydromet Gauge
Marble Falls 6 ENE



Between 11 p.m. on June 26 and 5 a.m. on June 27, the storms moved slowly east across southern Burnet County with heavy rain. Between 12:45 a.m. and 2 a.m., the rainfall intensity became extremely heavy over southeastern Burnet County. An LCRA tipping-bucket rain gauge located six miles east-northeast of Marble Falls captured the intensity of this extremely heavy rain, at one point measuring nearly 2 inches of rain in 15 minutes.

Rainfall continued at a rate of about 3 inches per hour for 6 hours. This amount of rain in such a short time ranks among some of the highest rain rates ever observed in Texas. The very heavy rain around Marble Falls began to recede, with most of the rain ending around 5 a.m.

The core of the heaviest rain occurred across southern Burnet County near the City of Marble Falls and areas just to the east.

Here, totals of 14 to 18 inches were recorded. The highest total of rain measured during the event was 19.06 inches at the Marble Falls 6 ENE Hydromet station. Approximately 18 inches of rain fell in a six hour period. That rate of rainfall intensity exceeded the 500-year return frequency for Central Texas.

For much of the region, the summer of 2007 ended up being one of the wettest and coolest on record.

Rainfall Distribution

In the watersheds feeding directly into the Highland Lakes, the June 27 rainfall totals were very impressive. The storm reached its full intensity in the early morning of June 27, with rainfall rates as high as two inches in 15 minutes. The Marble Falls area received as much as 18 inches of rain in six hours. Many gauges in southern Burnet County, north and south from the Colorado River, measured more than 8 inches of rain on June 27.

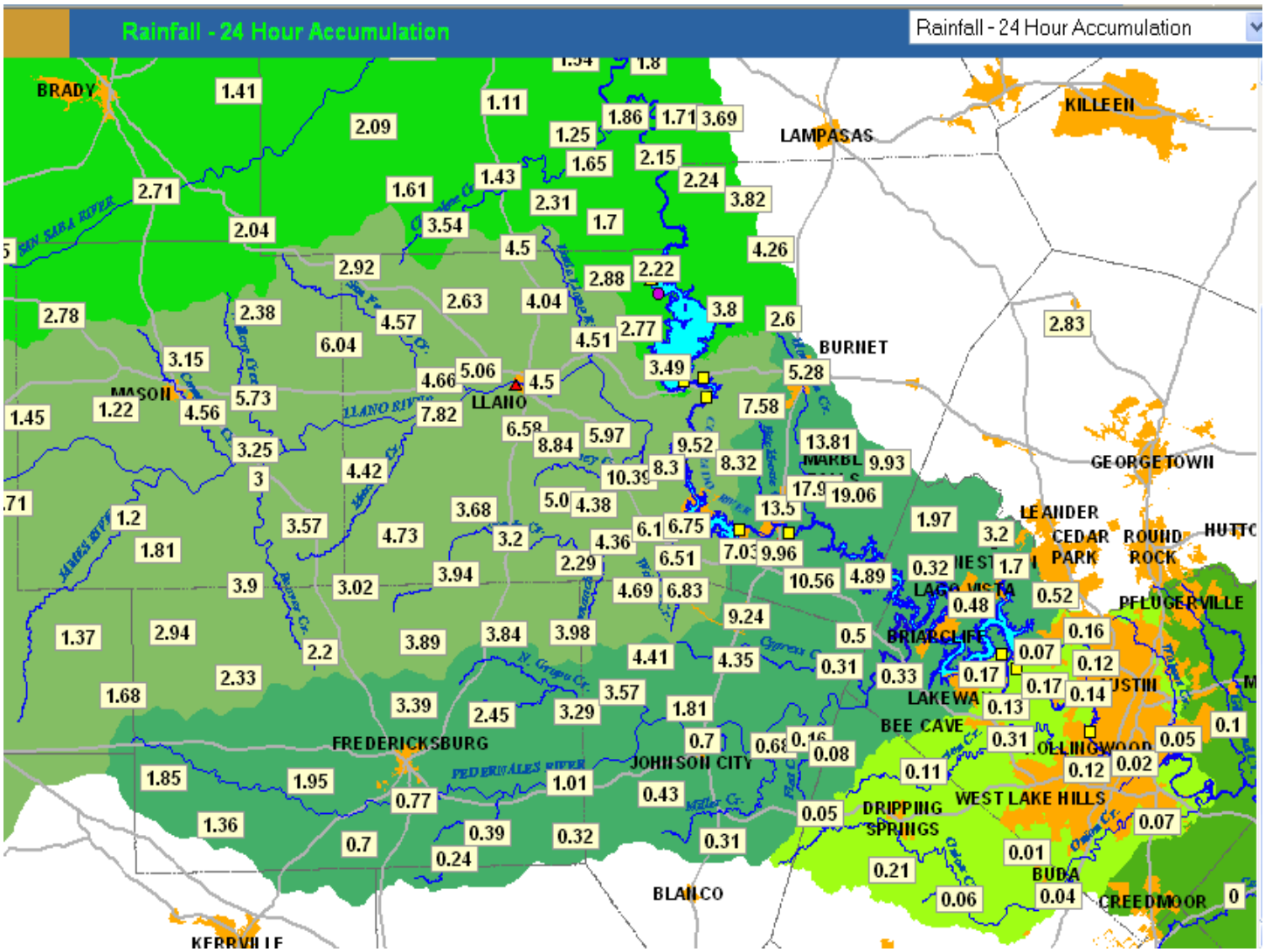
In the Lake LBJ watershed, rainfall totals were less than three inches west of Mason, from 3 to 5 inches between Mason and Llano, and from 5 to 10.5 inches between Llano and Lake LBJ. The pattern was higher rainfall at locations closer to the lakes.

In the Pedernales River watershed, there were lesser rainfall totals than the Llano River watershed, from less than 0.5 to 4.5 inches.

LCRA uses this rainfall data in two ways: as direct input to estimates of runoff resulting from heavy rainfall, and as an adjustment to radar rainfall estimates. Radar covers the area uniformly and fills the gaps between rainfall gauges, and the rainfall gauges provide data that refines the map of rainfall distribution.

The following figure, showing the 24-hour rainfall accumulation on June 27, can be compared to the gauge-adjusted radar rainfall distribution shown in the NEXRAD image on Page 1. This gridded data is used as input to LCRA's flood simulation models. The models accurately predict rates of flow in streams and rise of lake levels through time.

The area around Marble Falls received 18 inches of rain in six hours.



Streamflow

Many bridges were washed out and many homes and businesses were flooded in Marble Falls.

Intense rainfall in southern Burnet County caused tributaries in the area to rise rapidly. Most of the runoff entering the north side of Lake Travis came from Hamilton Creek with a watershed of 84 square miles. The peak flow on Hamilton Creek was approximately 56,000 cfs, exceeding the previously documented peak discharge that occurred in 1936 (USGS, WRI Report 96-4072). Incredibly, the FM 1431 bridge over Hamilton Creek was undamaged by the event despite massive scouring in the floodway. That water entered the headwaters of Lake Travis.

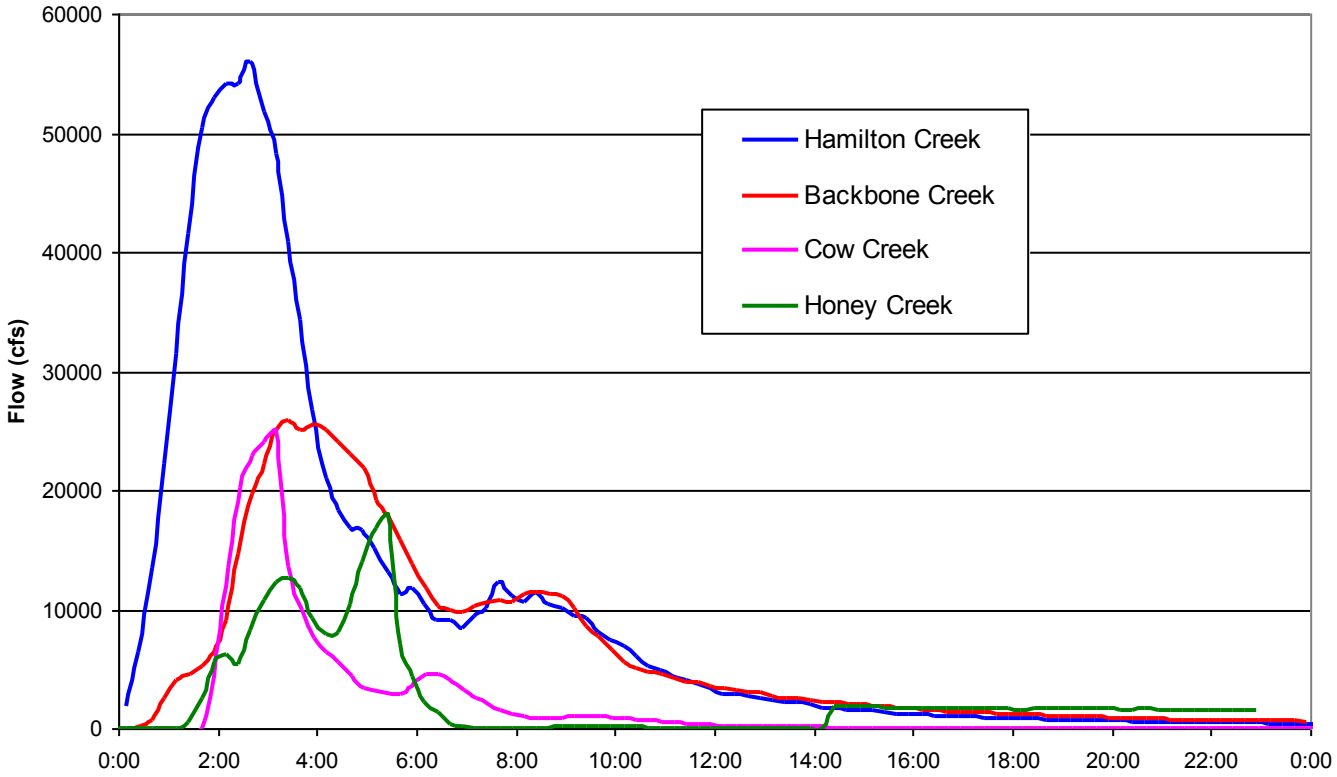
Backbone Creek near Marble Falls has a contributing watershed of 35 square miles. The estimated peak flow on Backbone Creek was 26,000 cfs. The flow on Backbone Creek combined with Whitman Branch and caused extensive flood damage in the City of Marble Falls. Many bridges were washed out, and many homes and businesses were flooded. That water flowed into Lake Marble Falls, then into Lake Travis.

Further east of Marble Falls along FM 1431, there was significant flooding of ranchland on Sycamore, Camp and Hickory Creeks.

Cow Creek near Lago Vista experienced devastating peak flows where the stream washed out FM 1431 on the north side of Lake Travis. Cow Creek had a peak flow of approximately 25,000 cfs from a watershed of 46 square miles. There were two fatalities attributed to the flood in that area.

Flood damages in southern Burnet County qualified for federal disaster assistance.

Tributaries upstream from Lake Travis - June 27, 2007



Streamflow (continued)

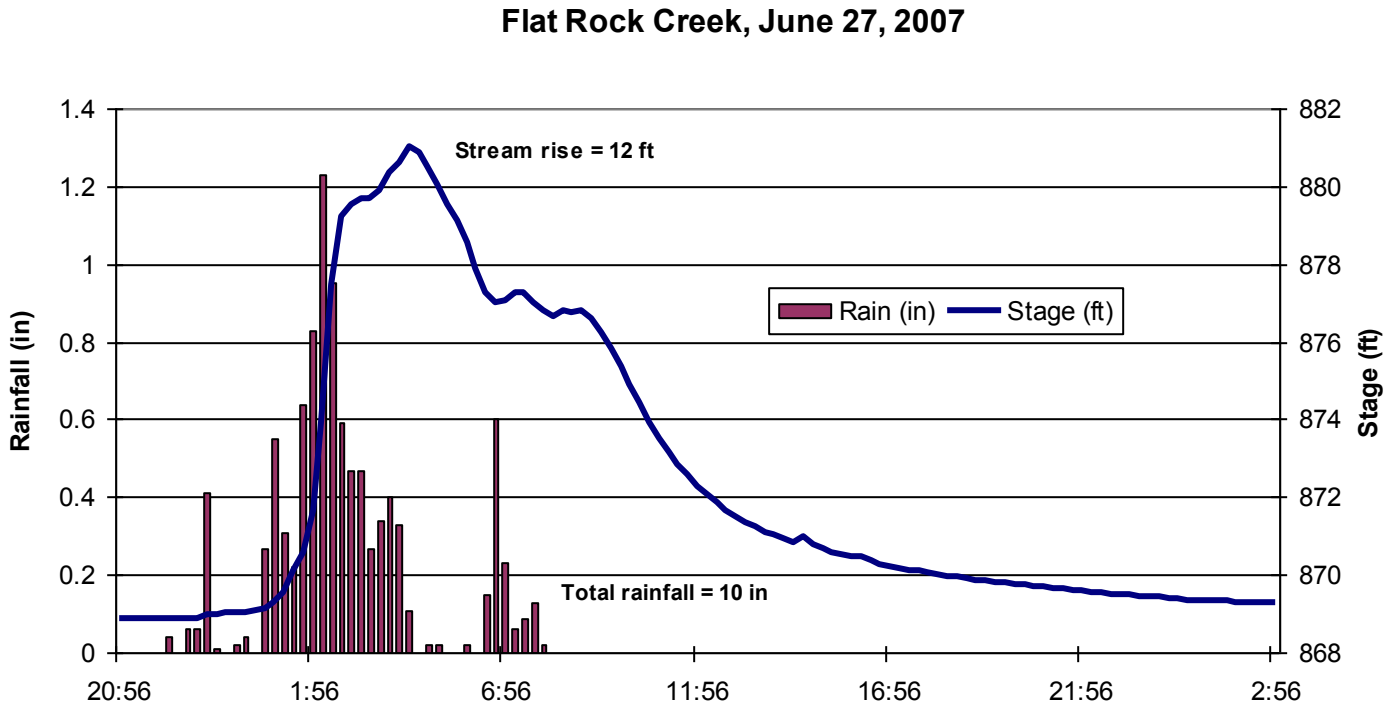
South of Marble Falls, tributaries to the Highland Lakes also had high flows. In the early morning hours on June 27, Little Flat Rock Creek quickly rose at State Highway 71 and U.S. Highway 281, flowing over the highway at both crossings. There was a 12-foot rise on Flat Rock Creek at the Hydromet gauge at FM 2147.

Flat Rock Creek came within a few feet of flooding the Huber underground mine south of Marble Falls. Just downstream, the flood caused damage to the bridge crossing on the road leading to Starcke Dam.

To the east along the south side of Lake Travis, Double Horn Creek experienced similar conditions and washed out a county road crossing on the south side of Lake Travis.

Peak flow on the Llano River was about 69,000 cfs, which was less than a 5-year flood magnitude (USGS WRI Report 96-4307). The peak flow on the Pedernales River at Johnson City reached 18,000 cfs. These rivers are typically large contributors to floods in the Texas Hill Country, but in this case most of the water came from other tributaries.

Washout of FM 2147 at Double Horn Creek southeast of Marble Falls

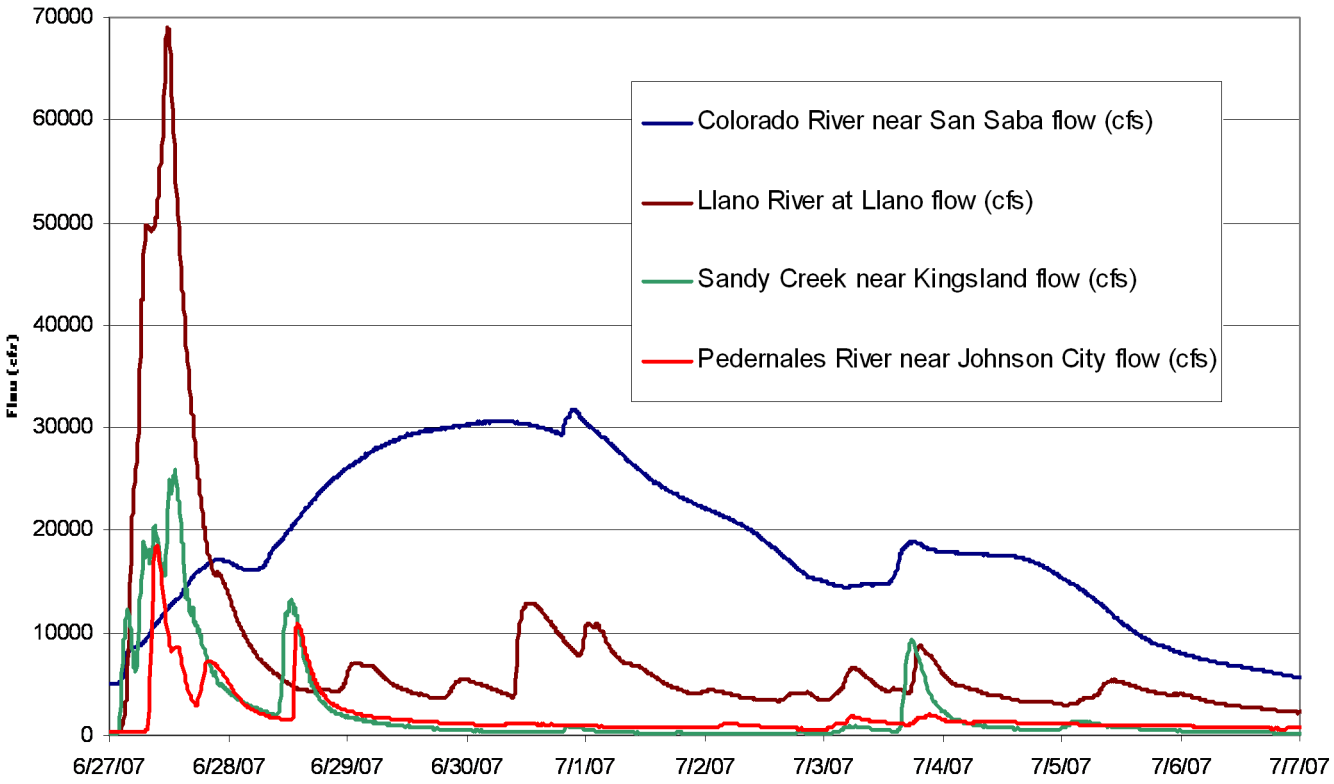


Streamflow (continued)

Rainfall events totaling 7-10 inches also occurred in Brown County.

Prior to the flood in the Marble Falls area on June 27, rainfall totaling 7-10 inches also occurred in Brown County in the preceding ten days. These heavy rains caused discharge from Lake Brownwood, operated by Brown County Water Improvement District No. 1, into Pecan Bayou upstream from Lake Buchanan on two separate occasions. Lake Brownwood rose above the level of the spillway on June 17, receded and then rose again to a level of 4 feet over the spillway on June 29. The first event was short-lived, but the second event carried much more volume of water downstream on Pecan Bayou over several weeks. Due to low stream gradient in that area, inflows into Lake Buchanan steadily increased to a peak of 31,000 cfs on July 1. The inflows took several weeks to recede as the level of Lake Buchanan rose. Just when runoff from the major storm in Marble Falls was being passed into Lake Travis, LCRA staff was also managing a flood upstream from Lake Buchanan, eventually requiring four floodgates plus full generation to pass flood waters through Buchanan Dam. That water was passed through intermediate Dams into Lake Travis. This operation was done without worsening the damage in Marble Falls.

Colorado River Upstream Gauges



Streamflow (continued)

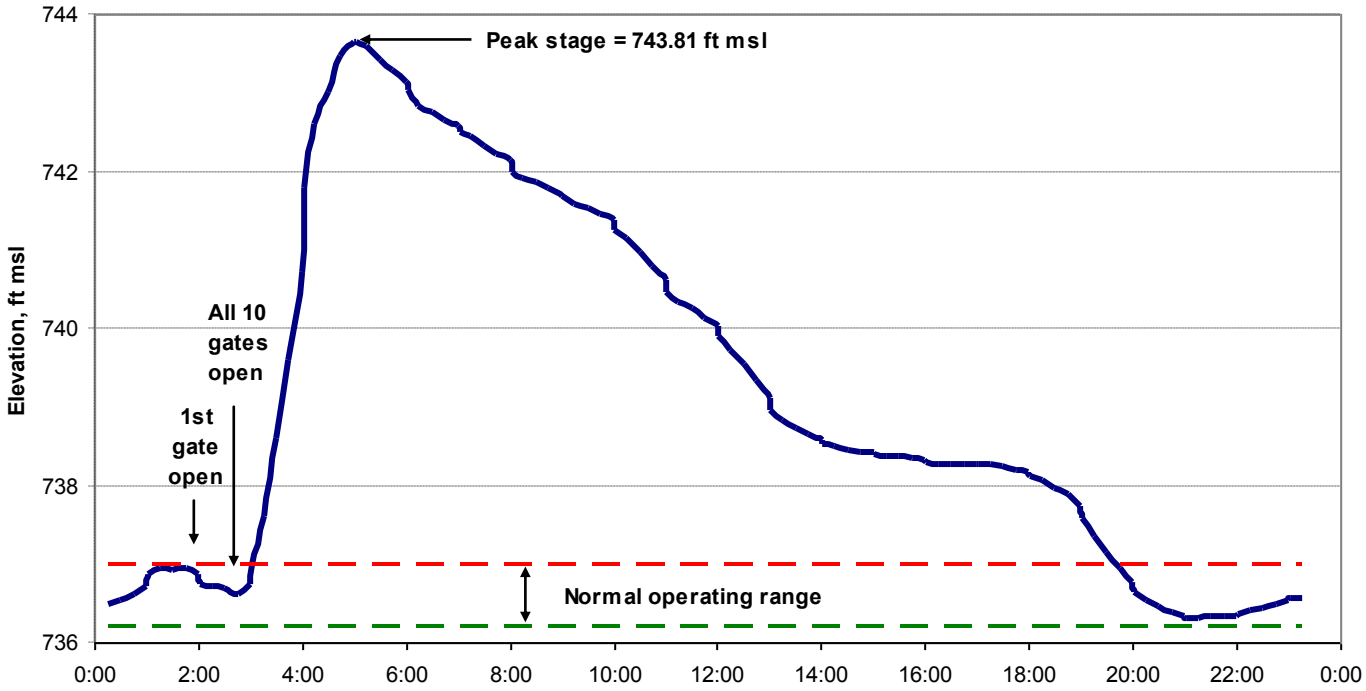
The following table shows the calculation of unit-peak discharge, which is a measure of storm runoff intensity, as peak flow per square mile of contributing watershed. Cow Creek near Lago Vista had a high unit-peak discharge of 542 cfs per square mile (sq.mi.). By comparison, the highest intensity of runoff was in the Marble Falls area. The June 2007 unit-peak discharge on Hamilton Creek of 722 cfs/sq.mi surpassed that of the record of 434 cfs/sq.mi set in 1936. The unit-peak discharge on Backbone Creek was even higher (867 cfs/sq.mi), indicating the intensity of runoff that caused so much damage in Marble Falls.

June 2007 Unit-Peak Discharge

Stream Gauge Location	Peak Flow Rate (cfs)	Gauged Drainage Area (sq.mi.)	Unit-Peak Discharge (cfs/sq.mi.)
Llano River near Llano	69,000	4,197	16.4
Pederales River near Johnson City	18,389	901	20.4
Cow Creek near Lago Vista	24,939	46	542
Hamilton Creek near Marble Falls	55,954	77.5	722
Backbone Creek near Marble Falls	26,000	30	867

The following figure shows how the level of Lake Marble Falls responded to extremely high rates of inflow from Flat Rock Creek, Backbone Creek and Lake LBJ. The lake rose 7 feet despite full generation and all 10 floodgates being open.

Lake Marble Falls at Starcke Dam
June 27, 2007



Lake Operations

Starcke Dam access road, damaged by flooding on Flat Rock Creek

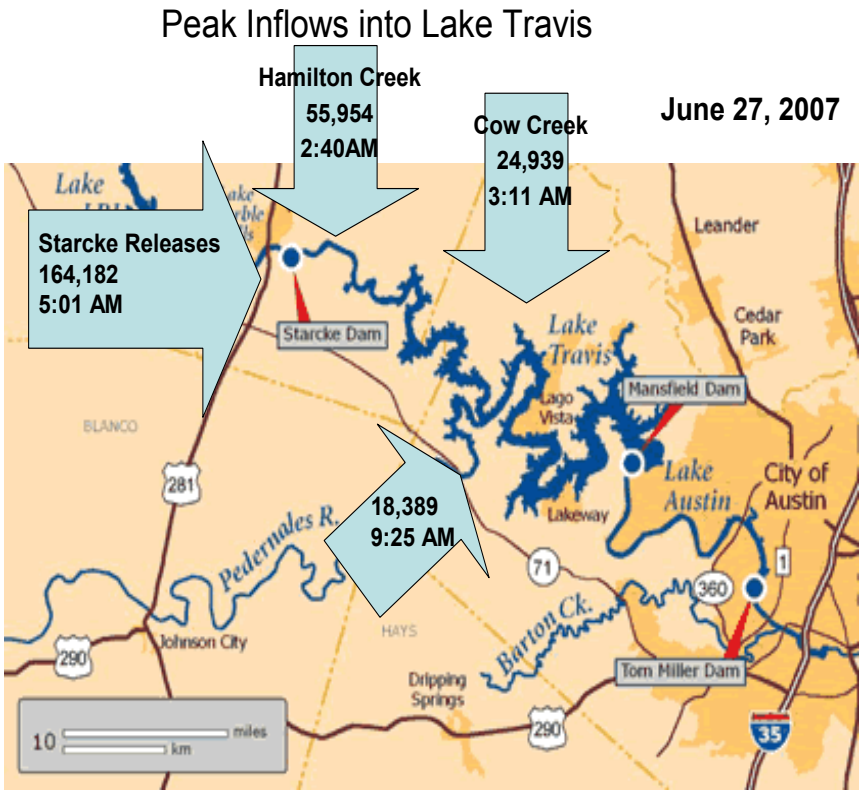
LCRA managed the flood that resulted from the June 27 storm with a combination of forecast modeling and lake level control using hydrogeneration and floodgate operations, with consideration of downstream river levels in accordance with rules of the U.S. Army Corps of Engineers. Discharge by hydrogeneration was already in progress when the event began. The intensity of this storm required floodgate operations in the very early hours of the event.

The Hydro Operations Control Center (HOCC) called out operators to Wirtz Dam and Starcke Dam in the early morning hours of June 27. Operators had difficulty getting to the dams because of flooded roads and hazardous driving conditions. Two operators reached Starcke Dam just before the access road was damaged by flooding on Flat Rock Creek (see photo upper left).

The first floodgate was opened at Starcke Dam at 1:40 a.m.. Floodgate operations were initiated at Wirtz Dam at 2:14 a.m., and one floodgate was fully open by 2:28 a.m.. Due to the flash flooding on Backbone Creek and Flat Rock Creek, Lake Marble Falls rose above its upper operating level of 737 feet msl around 2:45 a.m.. Two floodgates at Wirtz Dam and all 10 floodgates at Starcke Dam were open by 3:00 a.m.. Four floodgates were open at Wirtz Dam by 3:07 a.m.. Lake Marble Falls continued to rise and peaked at 743.81 feet msl at 5:00 a.m. and then began to recede as the water was passed into Lake Travis (see graph below).

The peak inflows into Lake Travis on June 27 are shown below. The graphic does not reflect ungauged inflows.

The intensity of this storm required floodgate operations in the very early hours of the event.



The total inflow volume to Lake Travis was estimated at 1.0 million acre-feet. All of that water was eventually passed downstream over several weeks because the conservation pool at Lake Travis was full. If Mansfield Dam did not exist, the estimated peak flow on the Colorado River through Austin would have been 269,000 cfs; instead it was 28,700 cfs. Just for reference, a flow of 269,000 cfs would inundate the City of Austin's Hike and Bike Trail and raise Lady Bird Lake to a level just below the Congress Avenue Bridge. Proper operation of Mansfield Dam kept that from happening.

Lake Travis Flood Management

U.S. Army Corps of Engineers (USACE) rules govern the operation of Mansfield Dam at levels above the conservation pool, providing specific guidance on reservoir elevation and corresponding discharge during floods.

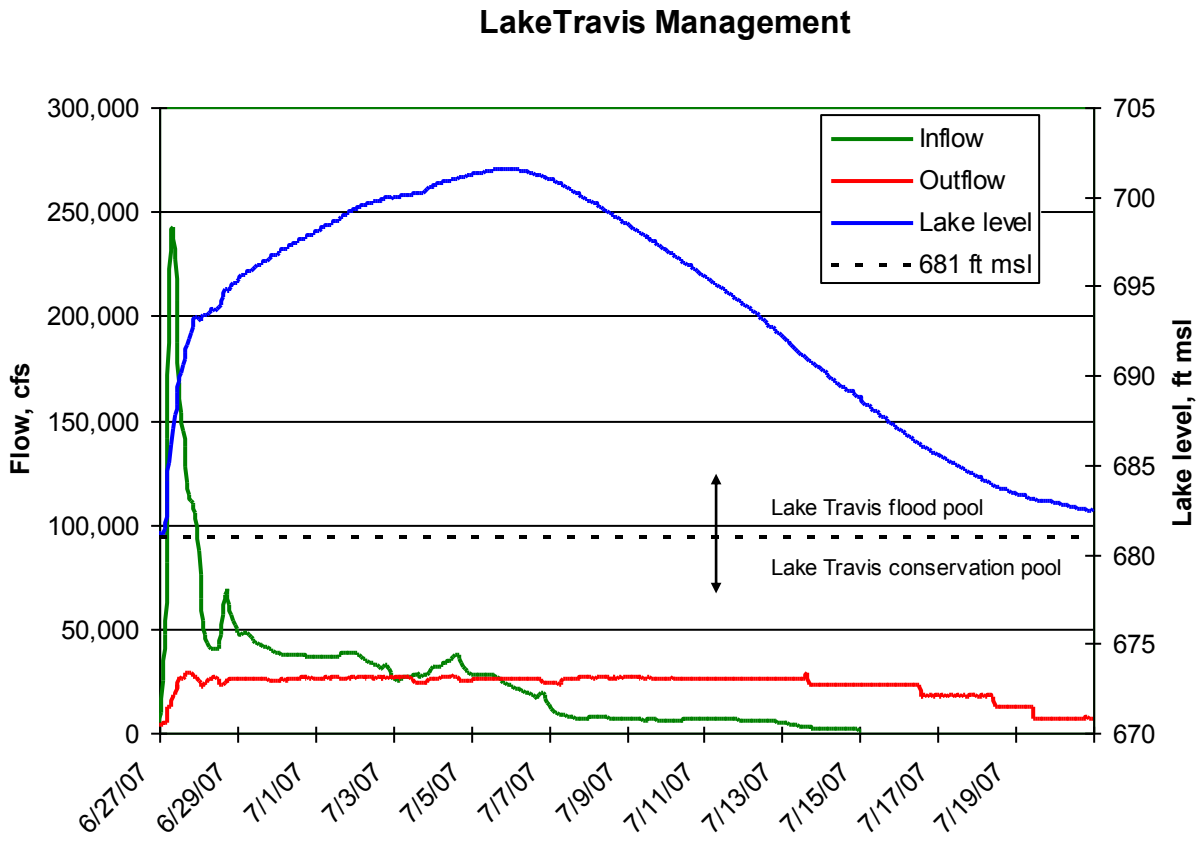
At midnight on June 27, the level of Lake Travis was barely in the flood pool at 681.13 feet msl, with hydrogeneration releases of 3,800 cfs. Heavy rain began to fall about midnight. At 3 a.m., with a forecast of 685 feet msl, hydrogeneration at Mansfield Dam was increased to nearly 5,000 cfs in accordance with USACE flood control regulations. At 5 a.m., with a forecast that Lake Travis would exceed 685 feet msl, LCRA opened the first floodgate at Mansfield Dam in accordance with USACE regulations. The second floodgate was opened at 7 a.m., the third floodgate at 9 a.m., and the fourth and final floodgate at 11 a.m.. Floodgates at Tom Miller Dam were opened in combination with hydrogeneration to pass floodwaters through Lake Austin. Releases past the Austin gauge were kept under 28,700 cfs in order to meet USACE controls on stage in the lower river.

The initial surge of inflows from heavy rainfall on the areas around lakes LBJ, Marble Falls and Travis caused a rapid rise on Lake Travis from about 681 feet msl to about 693 feet msl on the first day of the flood. Over the next several days, the level of Lake Travis continued to rise as runoff from the farther reaches of the basin and from additional rain storms continued to flow into the lake. Releases from Mansfield Dam were at the maximum allowed by USACE regulations.

Lake Travis crested July 6 at 701.52 feet msl, more than 20 feet into the flood pool, with four floodgates open. As the lake slowly receded, the last floodgate at Mansfield Dam was closed on July 19. LCRA continued to release floodwaters from Lake Travis through hydrogeneration at Mansfield Dam. Lake Travis was gradually brought down to 681 feet msl by August 14.

Releases from Mansfield Dam were at the maximum allowed by USACE regulations.

The following graph shows how the inflow to Lake Travis caused the lake level to rise to 701.52 feet msl, then recede to near 681 feet msl as water was released. The stair-step pattern of outflow indicates the four flood gates that LCRA opened at Mansfield Dam at the beginning of the flood, then closed one by one as the lake level receded.



Four floodgates were used at Buchanan Dam and Mansfield Dam, leaving both lakes full at the end of the flood.

Upper Highland Lakes Management

LCRA conducts flood management on the upper Highland Lakes in accordance with a 1990 agreement with the Federal Emergency Management Agency (FEMA).

The first floodgate at Buchanan Dam was opened on June 27 at 1:00 pm. The level of Lake Buchanan rose to 1019.47 feet msl on June 28. Flows on the Colorado River near San Saba peaked at 31,800 cfs on June 30. Releases from Lake Buchanan were matched or kept less than the rates of inflow and did not exceed 22,000 cfs. Four floodgates and full hydrogeneration were used to bring the lake level down to elevation 1,018 feet msl, the conservation pool level for that time of year as set in the 1990 FEMA agreement.

The level of Inks Lake was more than 1 foot over the spillway from June 27 through July 6 while gate operations continued at Buchanan Dam.

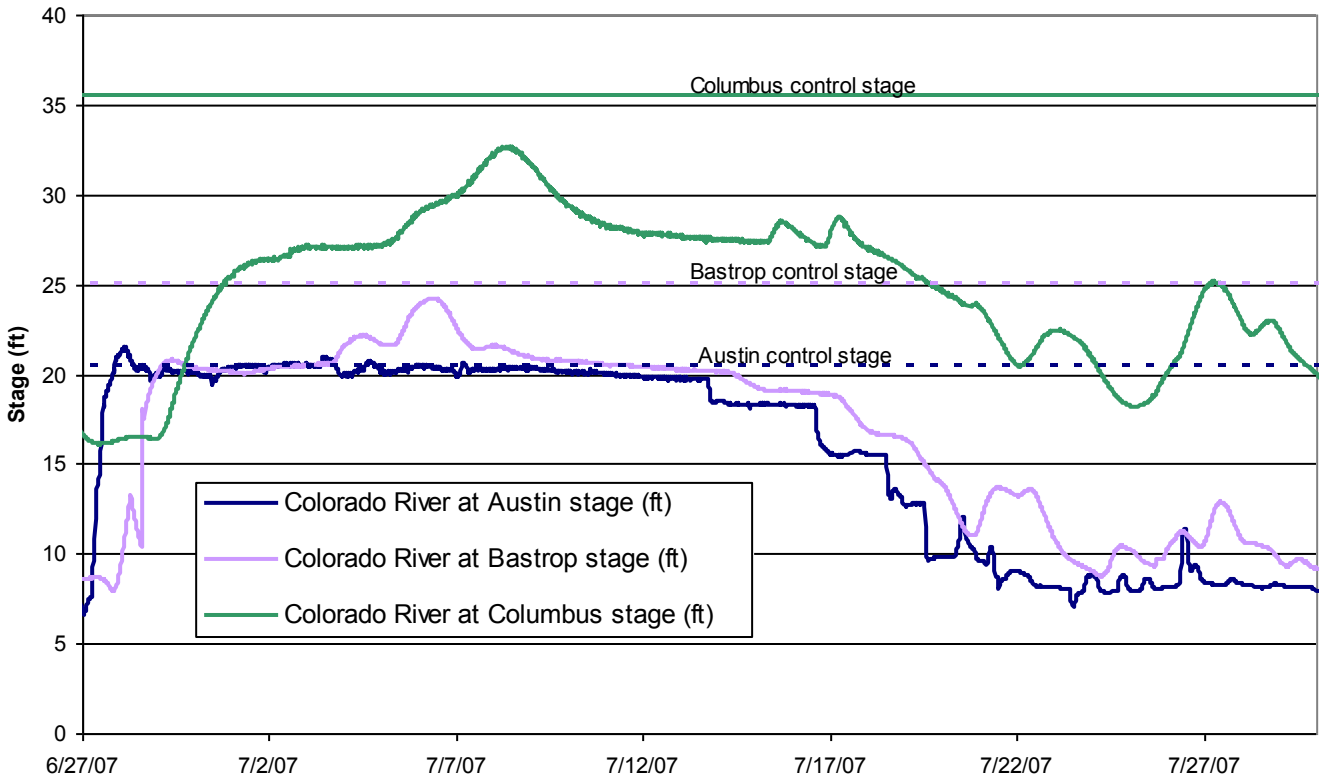
Lake LBJ rose to 825.88 feet msl by 3:15 a.m. on June 27 before gate operations brought the lake level under control and eventually lowered the lake to a minimum of 823.12 feet msl later the same day. Lake LBJ was maintained slightly below its normal operating range throughout much of the flood as large volumes of water from the Pecan Bayou and Llano River watersheds continued to flow through the system.

Downstream Flood Management

It was necessary to adjust floodgate releases from Tom Miller Dam several times due to precipitation and runoff in the Barton Creek watershed that would have otherwise exceeded the USACE control stages at Austin, Bastrop and Columbus.

The following figure shows the measured stage levels during the flood event and limits set by the USACE at control gauges downstream from Austin. As shown, releases from Lake Travis were kept in range of these control stage levels.

Colorado River Downstream Gauges



Magnitude of Record Floods

Largest Flood Events, Measured by Volume At Mansfield Dam or Austin Dam	Volume (acre-feet)
1. The 1936 Flood (Sept. 15 to Oct. 20) Twenty days of rain (30 inches) swept away business and farms in West Texas. The Colorado River crested at 31.4 feet at Austin and remained in or near flood stage for three weeks, cutting the city in two. This flood occurred prior to completion of the Highland Lakes Dams.	3,258,000
2. The 1957 Flood (May 1 to June 30) A basin-wide series of floods broke the Drought of Record. LCRA opened floodgates at Mansfield Dam for the first time. It was also the first time that meteorologists used radar, adapted from World War II military equipment, to detect severe weather and warn residents. **Lake Travis peak:** 707.38 feet msl on May 18 – the second-highest peak. **Floodgates open at Mansfield Dam:** 6 (still a record).	2,700,000
3. The 1938 Flood (July 19 to Aug. 14) The first flood since LCRA completed Buchanan Dam. It confirmed the need to heighten Mansfield Dam (under construction), and resulted in what became LCRA's Hydromet system of rain and streamflow gauges. **Floodgates open at Buchanan Dam: 22.**	2,028,000
4. The 1922 Flood (May 1 to 3) Runoff from basinwide storms resulted in floodwaters 5 to 10 miles wide in Wharton.	1,998,000
5. The 1935 Flood (June 12 to 20) Noted for the historic image of the houseboat going over the old Austin Dam, this basinwide flood caused record rises on the Llano River as well as the Colorado River at Austin.	1,526,000
6. The Christmas Flood (Dec. 20, 1991, to Jan. 2, 1992) This was the first major flood for LCRA to make extensive use of its Hydromet electronic rainfall and streamflow monitoring system. Several downstream communities had water levels that exceeded the 1935 Flood. **Lake Travis peak:** 710.44 feet msl on Dec. 25, 1991 – the all-time highest peak. **Floodgates open at Mansfield Dam: 5**.	1,172,000
7. The Fourth of July Flood (July 4 to 22, 2002) The Guadalupe River bore the brunt of the storms, but the Highland Lakes received enough rain to trigger floodgate operations. Growth of hydrilla in Lake Austin complicated floodgate releases at Mansfield Dam. **Lake Travis peak:** 693.47 feet msl on July 7 – seventh all-time highest peak. **Floodgates open at Mansfield Dam: 4.**	1,118,081
8. The 1913 Flood (Dec. 1 to 13) Floodwaters caused the Colorado and Brazos rivers to merge 65 miles wide between Columbus and Bay City.	1,105,000
9. The Summer 2007 Flood (June 27 to July 13) Most likely to be remembered for the 19-inch "rain bomb" that hit Marble Falls – and the second time Lake Travis was closed to recreation over the July Fourth holiday in a decade (the lakes were closed for 17 days). **Lake Travis peak:** 701.52 feet msl on July 6 – 5th all-time highest peak. **Floodgates open at Mansfield Dam: 4.**	1,012,135
10. The 1952 Flood (Sept. 1 to 20) A respite in the middle of the Drought of Record, this flood was a workout for the recently completed Wirtz and Starcke Dams. One 15-inch storm resulted in a record 57-foot rise in Lake Travis within 14 hours. **Lake Travis peak:** 677.73 feet msl on Sept.11. **Floodgates open at Mansfield Dam: 0.**	934,000
11. (Honorable Mention): The Summer 1997 Flood (June 21 to 30) This flood was noted for raising Lake Travis to a near-record high, scouring a hole in the bed of Lake Marble Falls, and producing near-record flows on the Llano River. **Lake Travis peak:** 705.11 feet msl on June 26 – third all-time highest peak. **Floodgates open at Mansfield Dam: 4.**	832,000

Damage from flash flooding on Whitman Branch in Marble Falls

Summary

The rain event that began in the early hours of Wednesday, June 27 fell on wet soils and swollen lakes and streams causing heavy flooding in southern Burnet County. Rain totals over 19 inches were recorded near Marble Falls in the headwaters of Lake Marble Falls and Lake Travis.

Estimated peak flow on Hamilton Creek was 56,000 cfs on June 27. Smaller streams north and south of the Colorado River also experienced high flows. By July 5, Lake Travis rose to a peak of 701.52 feet msl, its highest level since June 1997. Lake Buchanan reached 1019.47 feet msl on July 7.

This event produced approximately 1.0 million acre-feet of floodwater and ranked ninth in terms of volume produced for flood events since 1913. This event mainly affected the Highland Lakes region with only trace amounts of rain received in the lower basin.

The rainfall experienced over the Hamilton Creek watershed was in excess of a 500-year rainfall event for the area. This storm event will be remembered as the "rain bomb" that hit Marble Falls.

The mission of the Lower Colorado River Authority (LCRA) is to provide reliable, low-cost utility and public services in partnership with our customers and communities and to use our leadership role and environmental authority to ensure the protection and constructive use of the area's natural resources.

LCRA is a Texas conservation and reclamation district operating with no taxing authority.

For more information, see www.lcra.org/water

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