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RAIN BY THE CUBIT

The Great Southeast Texas Flood of 1994

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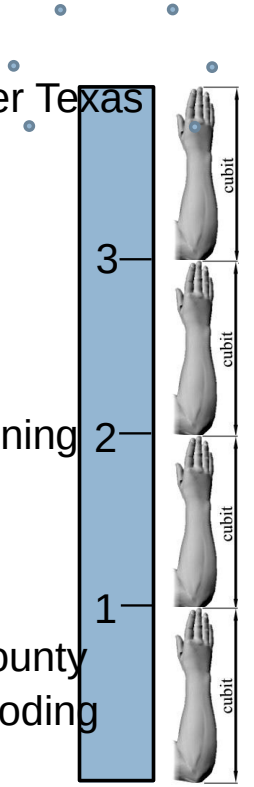
LLanite

Llanite is found only in the vicinity of Llano, Texas. Although Llanite is an igneous rock, co-author Duane Barrett will always associate it with water!

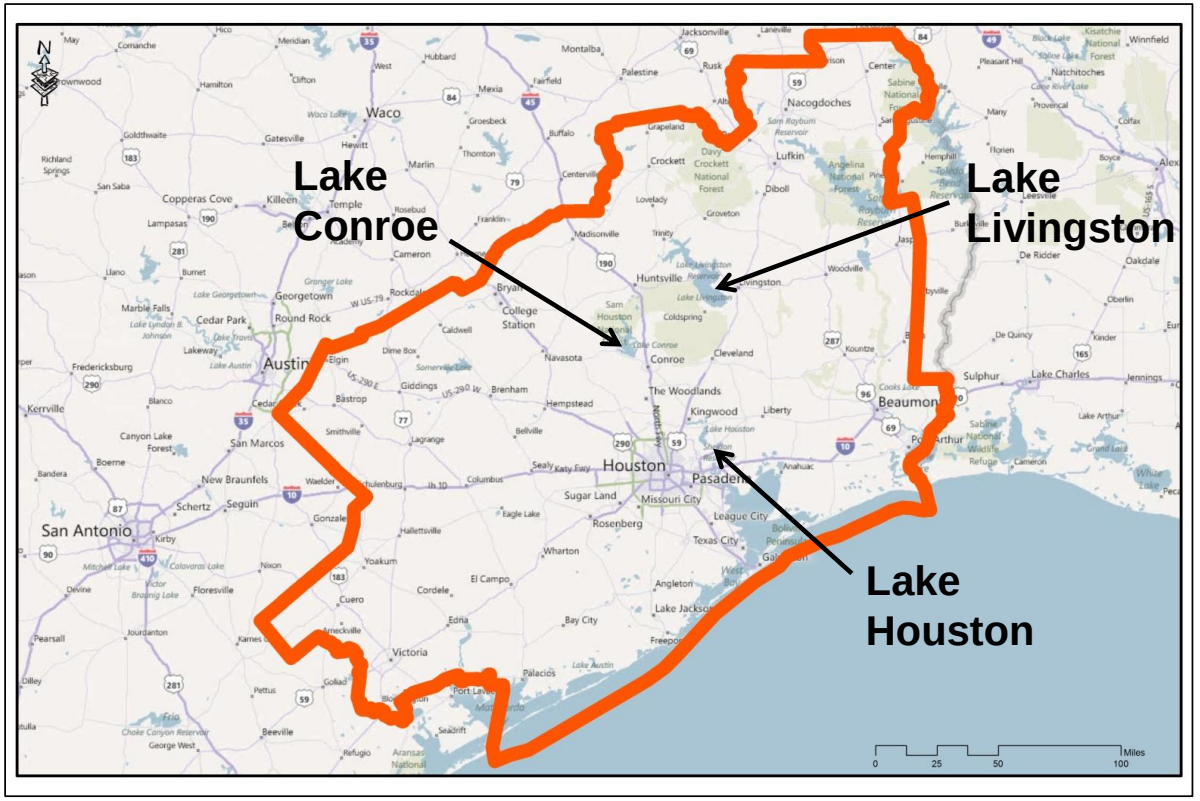
General Timeline

- **October 15, 1994 (Saturday)**
  - Pacific Hurricane Rosa Meets a Gulf Coast Warm Front Over Texas
  - Rainfall Begins
- **October 16, 1994 (Sunday)**
  - Rainfall Abates in the Early Morning
  - Begins to Rebuild and Intensify in the Evening
- **October 17, 1994 (Monday)**
  - Large Cell Develops Southwest of Waller, Texas - Early Morning
  - Flooding Overtops U.S. Highway 290 near Waller
  - HCFCD Mobilizes Flood ALERT Activities
- **October 18, 1994 (Tuesday)**
  - Jet Stream Southward & Heavy Rainfall Comes to Harris County
  - Most Bayous and Creeks in Harris County Report Major Flooding
- **October 19, 1994 (Wednesday)**
  - Aerial Reconnaissance Conducted Across Harris County
  - The Sun Appears!



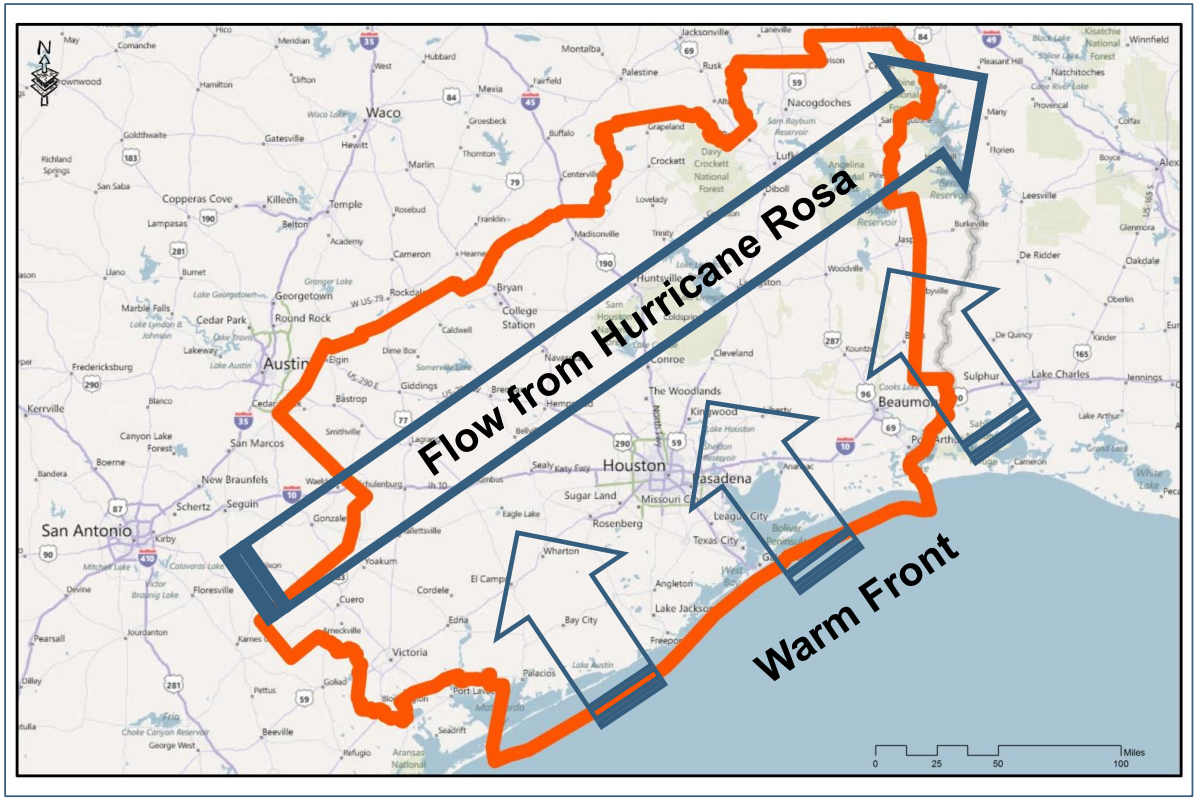
Geography

The 1994 flood affected a huge geographic area covering 38 counties in southeast Texas. The map at right illustrates the extent of the affected area, which is roughly the size of the state of Maine.



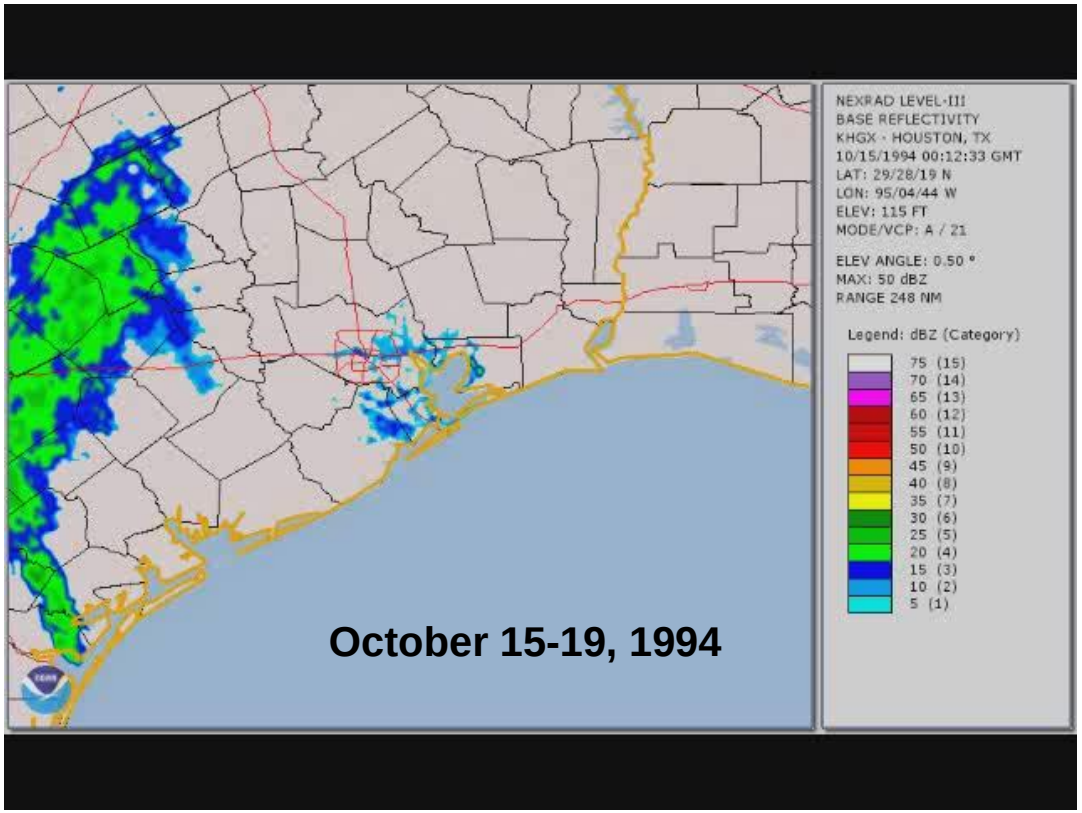
Meteorology

Remnants of Pacific Hurricane Rosa interacted with a warm front from the Gulf of Mexico, creating a boundary along within which rainfall events were entrained.



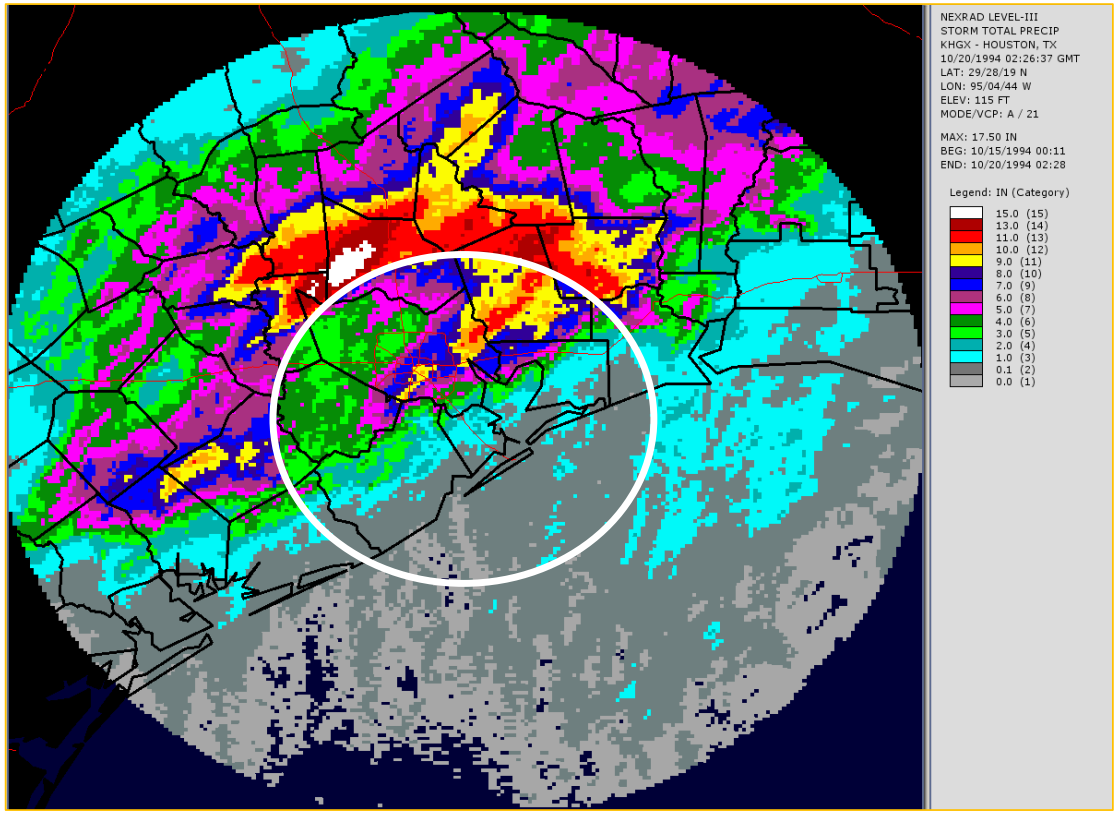
A Real “Texas Flood”

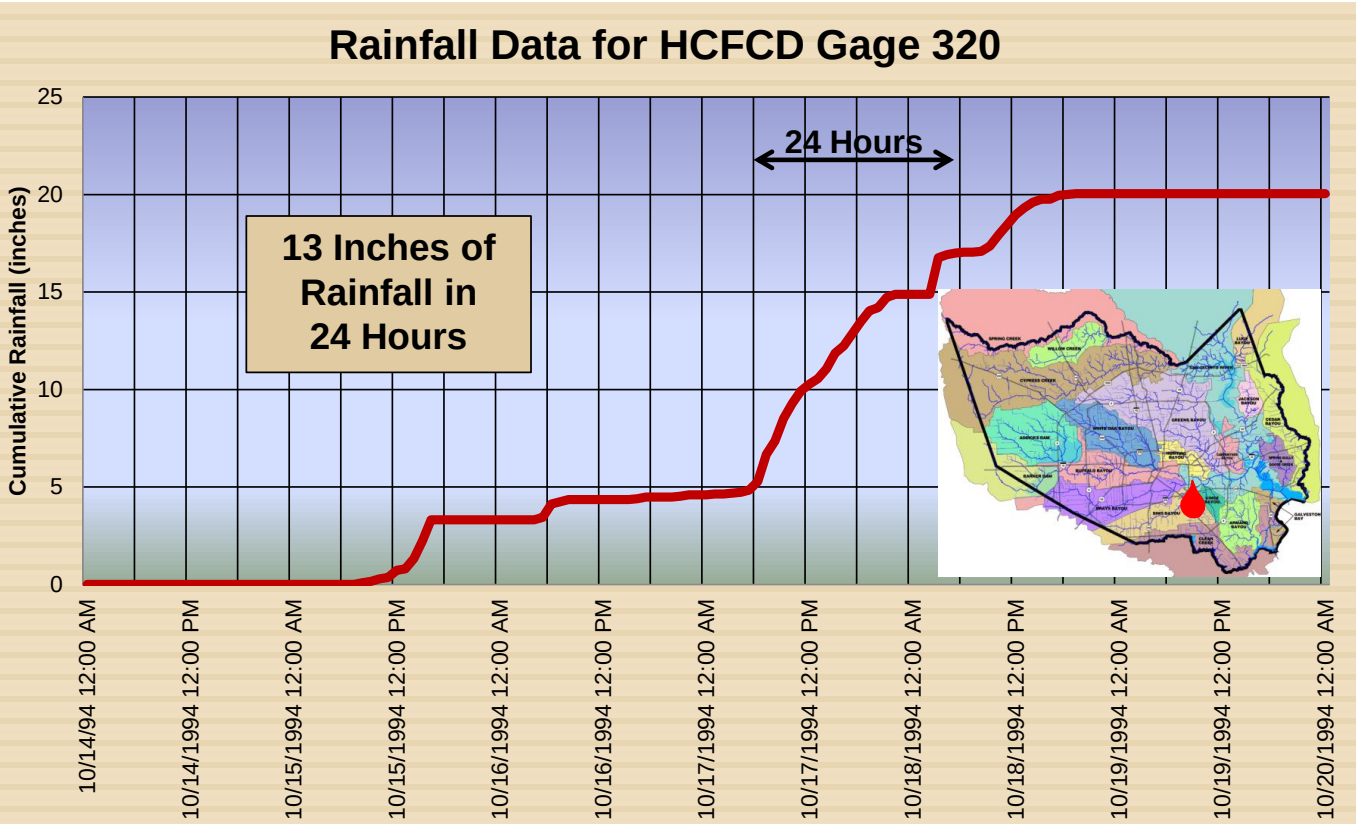
The song “Texas Flood” by Stevie Ray Vaughan provides an appropriate musical backdrop for this amazing video created from radar images of the 1994 event.



Rainfall Totals

Rainfall totals of over 20 inches were recorded at 4 gages within Harris County. More than 15 inches was recorded at 18 gages. Finally, more than 10 inches was recorded at 34 gages!





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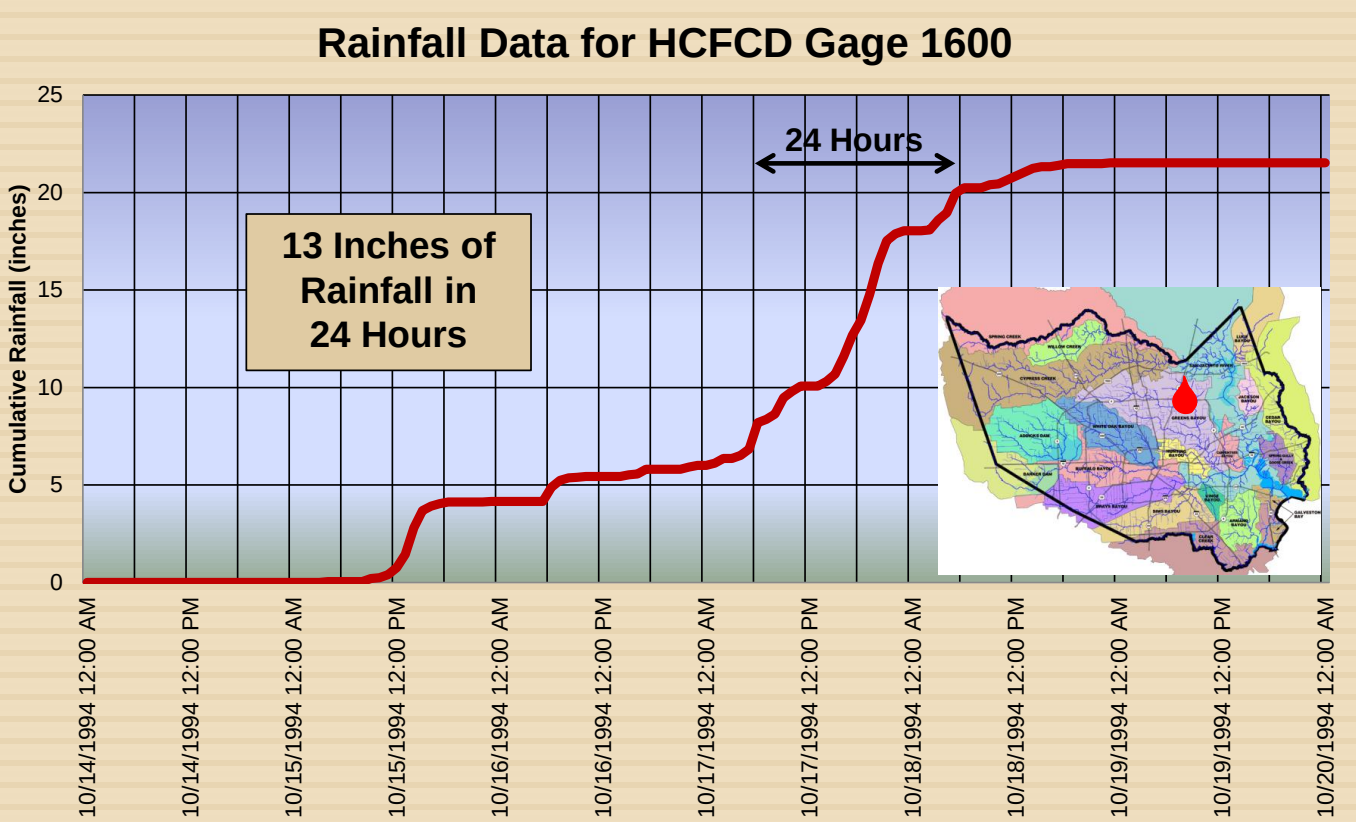
Rainfall Data - HCOEM Gage 320

Berry Bayou at Forest Oaks Drive



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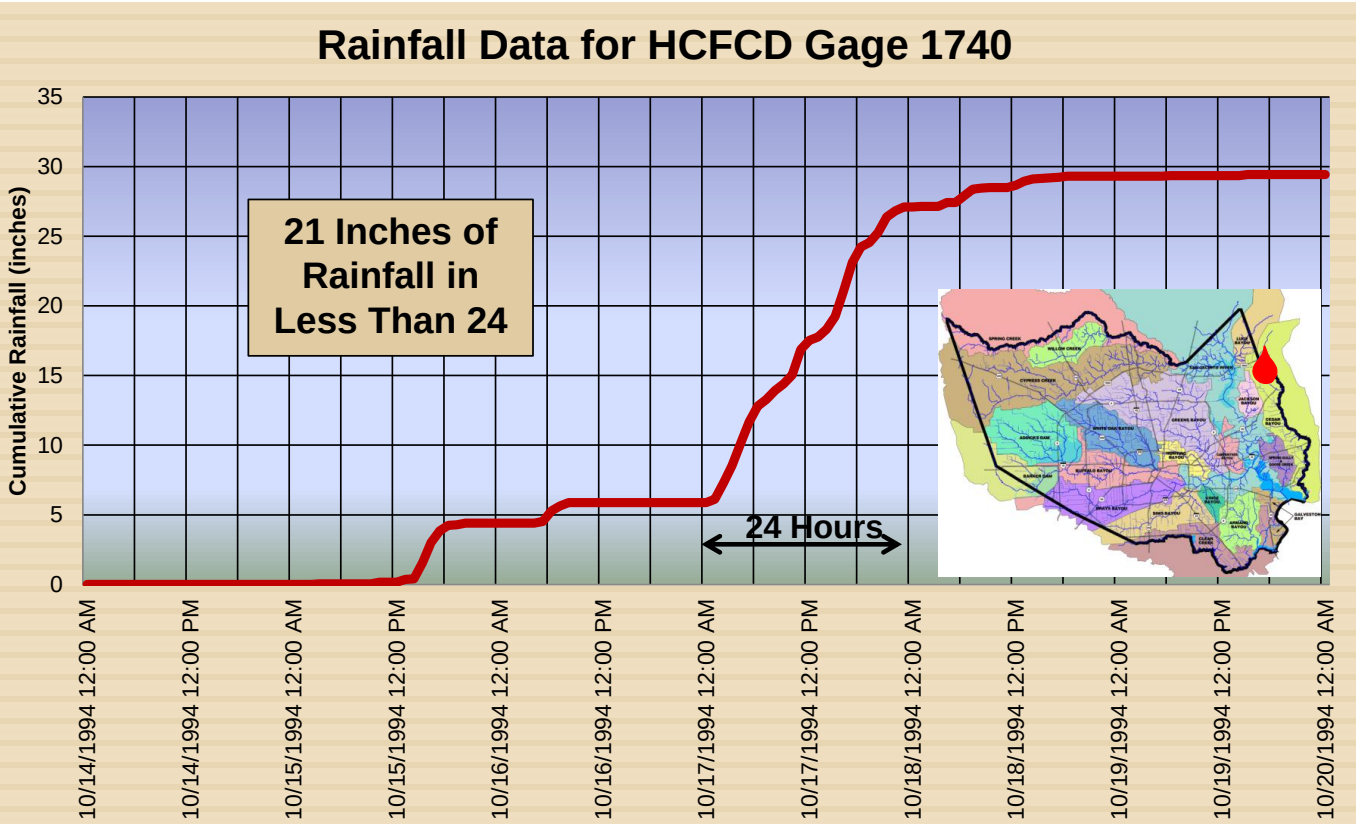
Rainfall Data - HCOEM Gage 1600

Greens Bayou at Mount Houston Road



10 Rainfall Data - HCOEM Gage 1740

Cedar Bayou at U.S. Highway 90

Watershed-Wide Rainfall

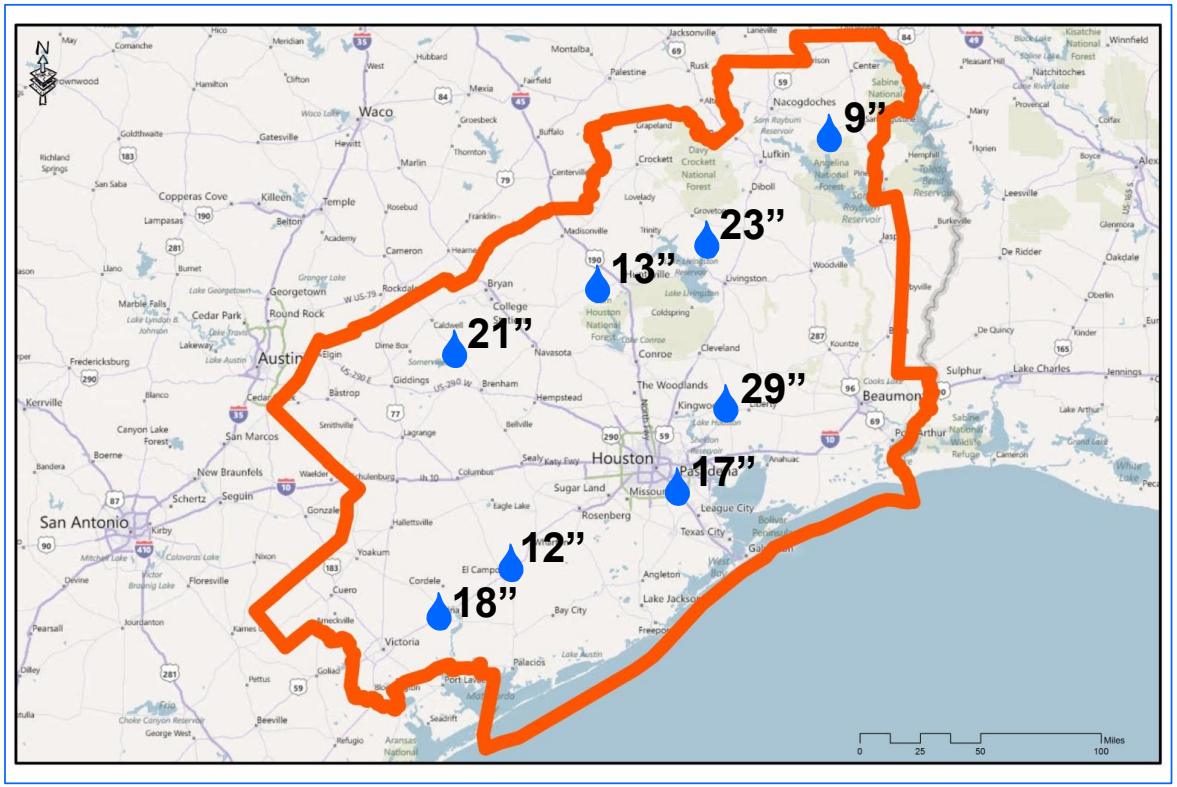
The storm event of October 1994 produced staggering rainfall amounts, especially considering the size of the area affected.

Source: Steve Johnson, P.E.

- **The average rainfall depth over the 2,880-square mile San Jacinto River watershed was 19.5 inches.**
- **The 1% annual chance rainfall 4-day rainfall is 14.9 inches.**
- **A total of 1.9 million acre-feet of runoff passed through Lake Houston.**
- **The average runoff over the watershed was 12.7 inches.**

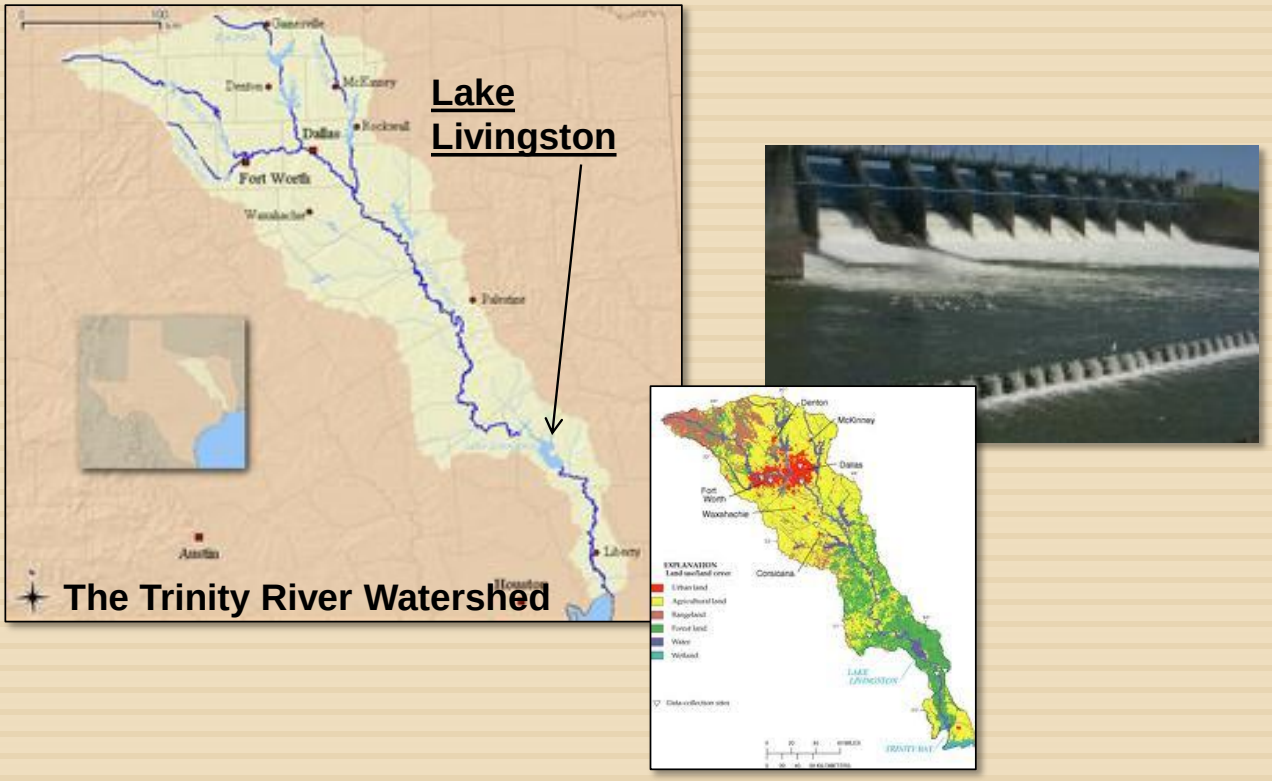
Area-Wide Rainfall

Rainfall was heavy over the entire 38-county area affected by the storm, as evidenced by the figure at right. The area affected measures roughly 300 miles x 170 miles.



Reservoirs React

In response to the heavy rainfall over their respective watersheds, water levels in Lakes Conroe, Houston, and Livingston rose rapidly, and spillways went into operation.



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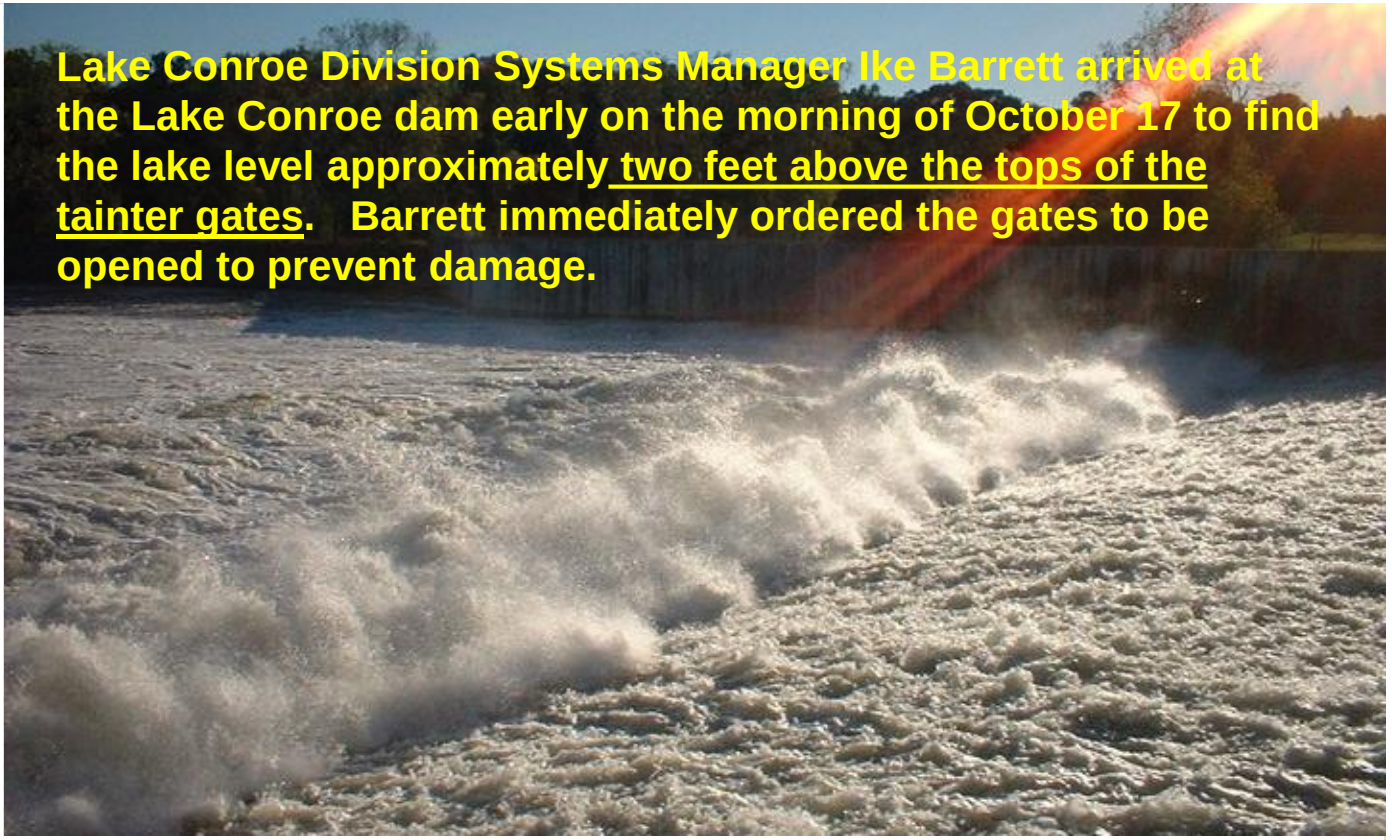
Lake Livingston

Watershed Area = 16,600 square miles at Lake Livingston

The Lake Livingston discharge reached a maximum of 110,600 cfs . The maximum lake level was 134.38 ft, 3.38 feet above the normal pool elevation of 131.00 ft. All this despite that the storm affected only the lower portion of the watershed! (Images: USGS, TRA)



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Lake Conroe

Watershed Area = 448 square miles

Lake Conroe reached a maximum level of 205.88 feet (4.88 feet above the normal conservation pool of 201.00 ft). A peak discharge of 56,000 cfs was recorded a short distance downstream of the dam. (Photo: SJRA)

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Lake Houston

The Lake Houston discharge reached a maximum value of 359,000 cfs with a corresponding lake elevation of 52.8 feet, 8.3 feet above the crest elevation of the 3,160-foot long overflow spillway. (Photo: HCFCD)

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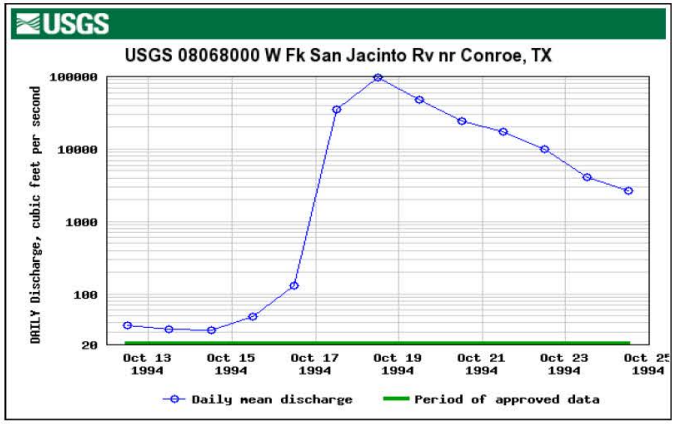
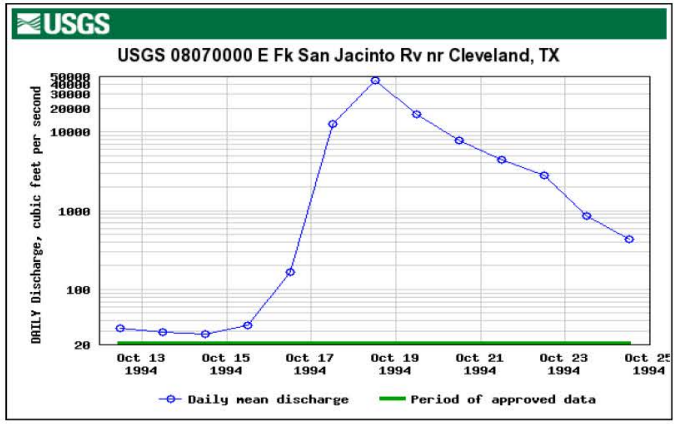
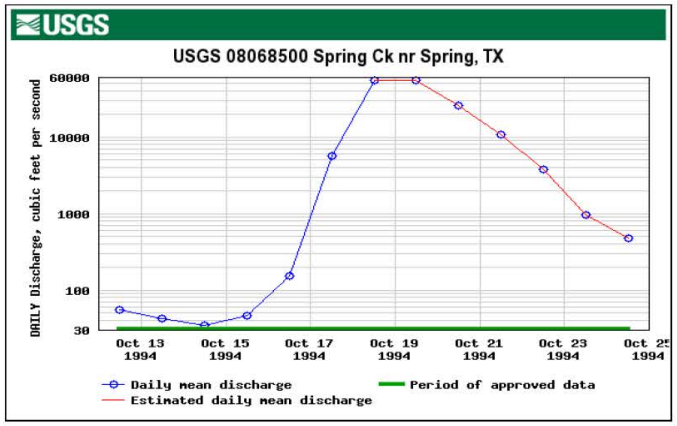
Lake Houston

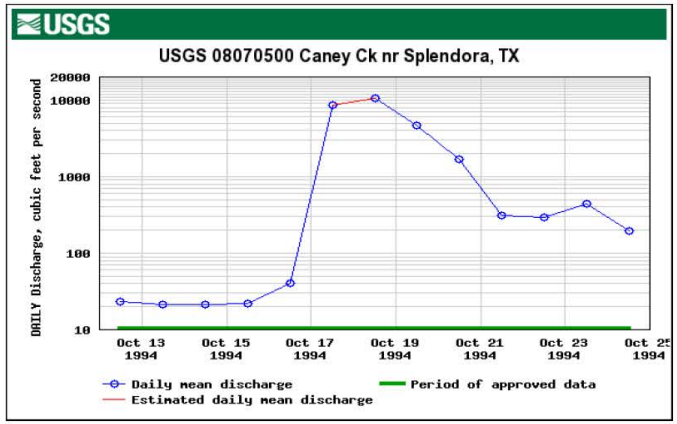
Lake Houston Gated Section of Spillway (Photo: HCFCD)

Rivers and Creeks Rise









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Cypress Creek Overflows

Cypress Creek overflowed its banks, sending thousands of acre-feet of storm water cross-country to the Addicks and Barker Reservoir watersheds and inundating thousands of acres of land. (Photo: HCFCD)

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Cypress Creek

Inverness Forest Levee on Cypress Creek at the Hardy Toll Road (Photo: HCFCD)

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Northgate Crossing Levee

Maximum flood levels along Spring Creek exceeded FEMA 1% annual chance values by 4.0 to 4.5 feet. The Northgate Crossing levee was overtopped on October 18, 1994. This is one of only two levee systems in Harris County. (Photo: HCFCD)

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Northgate Crossing Levee

Northgate Crossing Levee and Pump House (Photo: HCFCD)

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West Fork of the San Jacinto River

West Fork San Jacinto River at U.S. 59 (Photo: HCFCD)

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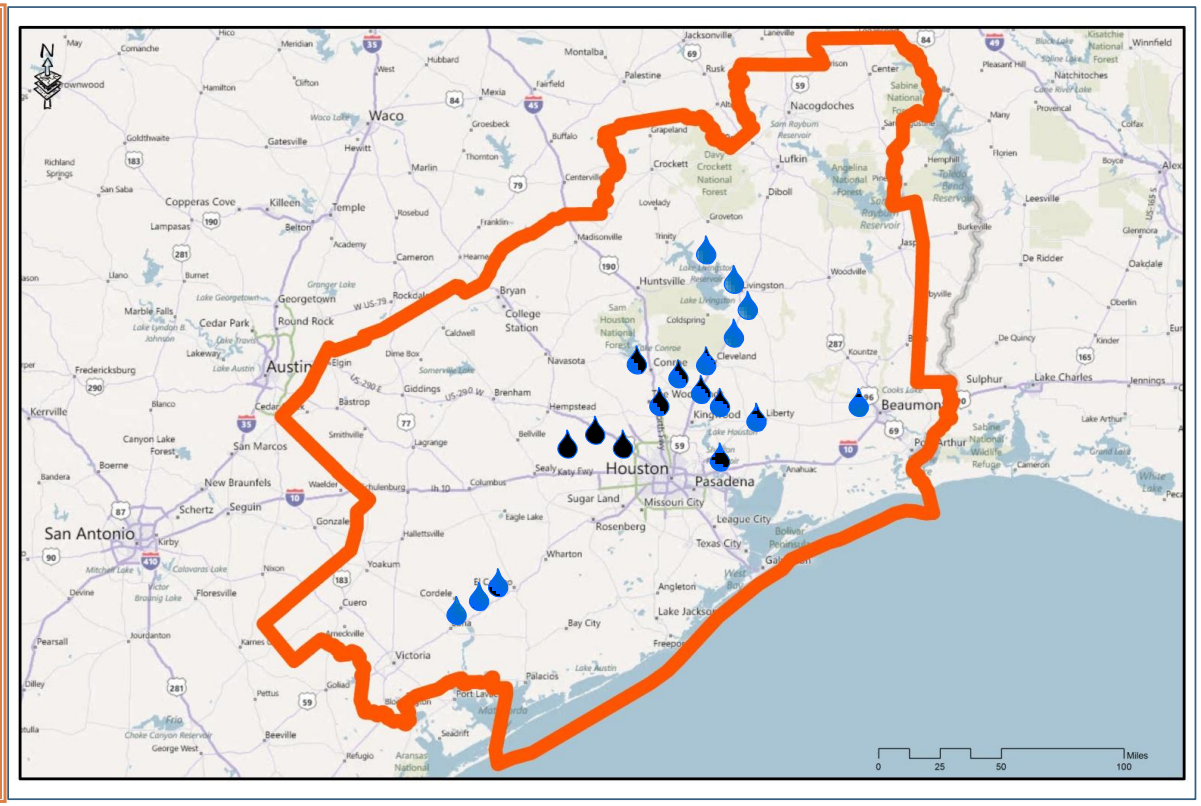
Lower San Jacinto River

San Jacinto River at I-10 (Photo: HCFCD)

Record Stream Flows

Stream flows in excess of 1% annual chance values were recorded at 19 USGS gages within the affected area! New historical maxima were recorded at 25 of 43 stations!



Peak Discharge Comparisons

The 1994 flood produced peak flows on the San Jacinto and Lavaca Rivers that exceeded historical maxima from much larger watersheds .

Location	Drainage Area (sq mi)	Peak Discharge (cfs)	Peak Discharge (cfs/sq mi)
San Jacinto River D/S Lake Houston	2,880	360,000	125
Lavaca River at Edna, TX	817	150,000	184
Spring Creek at Riley-Fuzzel Rd.	420	78,800	188
Trinity River at Liberty, TX	17,500	135,000	7.7
Brazos River at Richmond, TX	45,100	300,000	6.7

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Photos

Banana Bend/Rio Villa Area Below Lake Houston (Photo: HCFCD)

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Photos

Apartments in Forest Cove Area (Photo: HCFCD)

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Photos

Little Cypress Creek at Cypress-Rose Hill Road (Photo: HCFCD)

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Photos

Toys-R-Us on U.S. 59 at West Fork San Jacinto River (Photo: HCFCD)

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Photos

U.S. 59 North Bound Feeder Road at West Fork San Jacinto River (Photo: HCFCD)

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Photos

Power Line Near the Upper End of Lake Houston on the West Fork of the San Jacinto River (Photo: HCFCD)

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Photos

Cypress Creek at Aldine-Westfield (Photo: HCFCD)

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Photos

West Fork San Jacinto River Near Lake Houston (Photo: HCFCD)

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Photos

Forest Cove Area near the West Fork San Jacinto River (Photo: HCFCD)

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Photos

Cypress Creek at Huffmeister Road (Photo: HCFCD)

37 Pea Gravel

Pea Gravel is found everywhere. Although this small stone is used primarily in gardening, co-author Andy Yung will always associate it with the massive flood of 1994!

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The San Jacinto River Fire (October 20th)

Breakage of pipelines across the river led to a fire that sent plumes of black smoke hundreds of feet into the air. (Photo: *Houston Chronicle*)

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Photos

San Jacinto River Shortcut across Banana Bend/Rio Villa Meander. This is near the location of exposed pipelines; note burned trees. (Photo: HCFCD)

Conclusions

- **Extreme rainfall events will continue to occur.**
- **Are they "acts of God" that may be ignored, or should they be considered when establishing flood protection requirements?**
- **The adoption of criteria that exceed FEMA minimum requirements should be considered by communities to guard against severe events.**
- **Design of critical facilities should consider such extreme events.**
- **We must study and learn from these events.**
- **Improvements in predictive technology and warning systems must continue in order to reduce the loss of life that occurs during such extreme weather events.**

References

Public Agencies

- U.S. Geological Survey (USGS)
- National Oceanic & Atmospheric Administration (NOAA)
- Harris County Flood Control District (HCFCD)
- San Jacinto River Authority (SJRA)
- Trinity River Authority (TRA)
- Harris County Office of Emergency Management (HCOEM)

Private Sources

- The *Houston Chronicle*
- Steve Johnson, P.E., CFM