

# Actuarial Weather Extremes Series

## Texas Floods – July 2025

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### Introduction: The Convergence of Risk Factors

This analysis focuses on the catastrophic flash floods of July 4<sup>th</sup>, 2025, in Central Texas. The floods struck overnight and in the early morning, catching many people off guard and complicating evacuation and rescue efforts. As of July 21<sup>st</sup>, 135 people, including 37 children, had perished and three were still reported missing.<sup>1</sup> Multiple counties were impacted with the most severe impacts concentrated along the Guadalupe River in Kerr County, which is the focus of this study. This is an attempt to understand the convergence of risk factors that amplified the impact.

### Understanding the Scale of the Event: Gage- and Discharge-level Data

The maps below in Figure 1 show the precipitation that fell on July 4<sup>th</sup> for Texas and, in particular, the area around Kerrville, TX. The map is made by linearly interpolating data from all stations within 750 km of Kerrville, TX. While ten inches of rain in one day is extreme by itself, this event happened over the course of only a few hours (in the early morning of July 4<sup>th</sup>). Hunt, Kerrville, and Comfort, TX are pointed out on the map, along the Guadalupe River.

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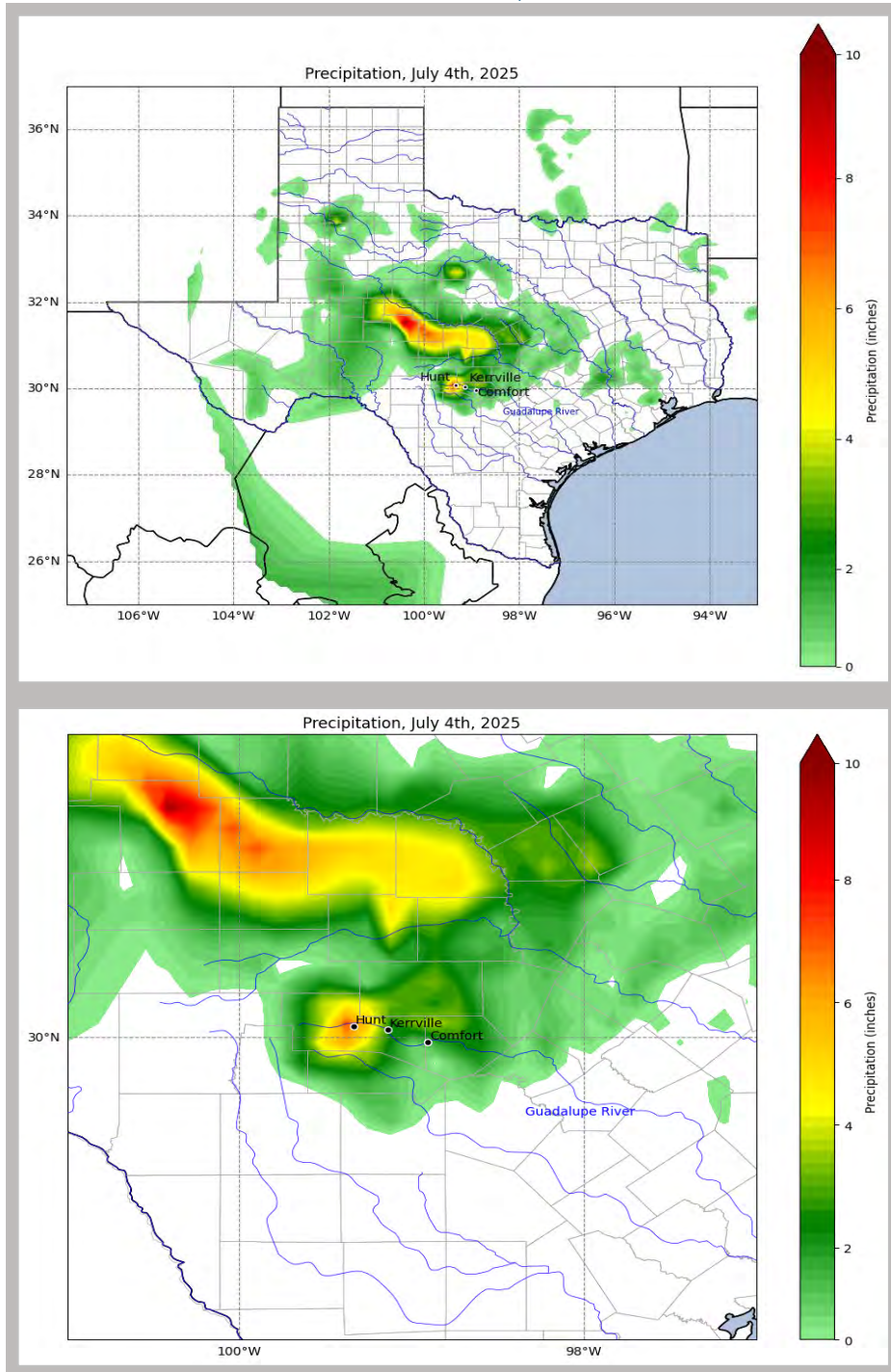
<sup>1</sup> Y. Zhuang, P. Salhotra, and M. Walker, (2025 July 20, updated July 21) "What We Know About the Floods in Central Texas," *The New York Times*, <https://www.nytimes.com/article/texas-floods-kerr-county.html>

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Figure 1

## PRECIPITATION HEATMAP FOR TEXAS FOR JULY 4, 2025



Data source: Global Historical Climatology Network, National Oceanic and Atmospheric Administration, [https://www1.ncdc.noaa.gov/pub/data/ghcn/daily/ghcnd\\_all.tar.gz](https://www1.ncdc.noaa.gov/pub/data/ghcn/daily/ghcnd_all.tar.gz). (Accessed July 12, 2025). County and river mapping provided by Texas Tech University Center for Geospatial Technology, <https://www.depts.ttu.edu/geospatial/center/TexasGISData.html> (Accessed July 12, 2025).

To study this extreme precipitation event that brought intense rainfall in a very short time span, surpassing the “Major Flood Stage” in almost all U.S. Geological Survey (USGS) monitoring locations in Kerr County, Figure 2 shows a map of these locations to enhance the reader’s spatial understanding of the area.

Figure 2  
USGS MONITORING LOCATIONS FOR KERR COUNTY



Source: National Water Dashboard, U.S. Geological Survey, <https://dashboard.waterdata.usgs.gov/app/nwd/en/?region=lower48> (Accessed July 15, 2025).

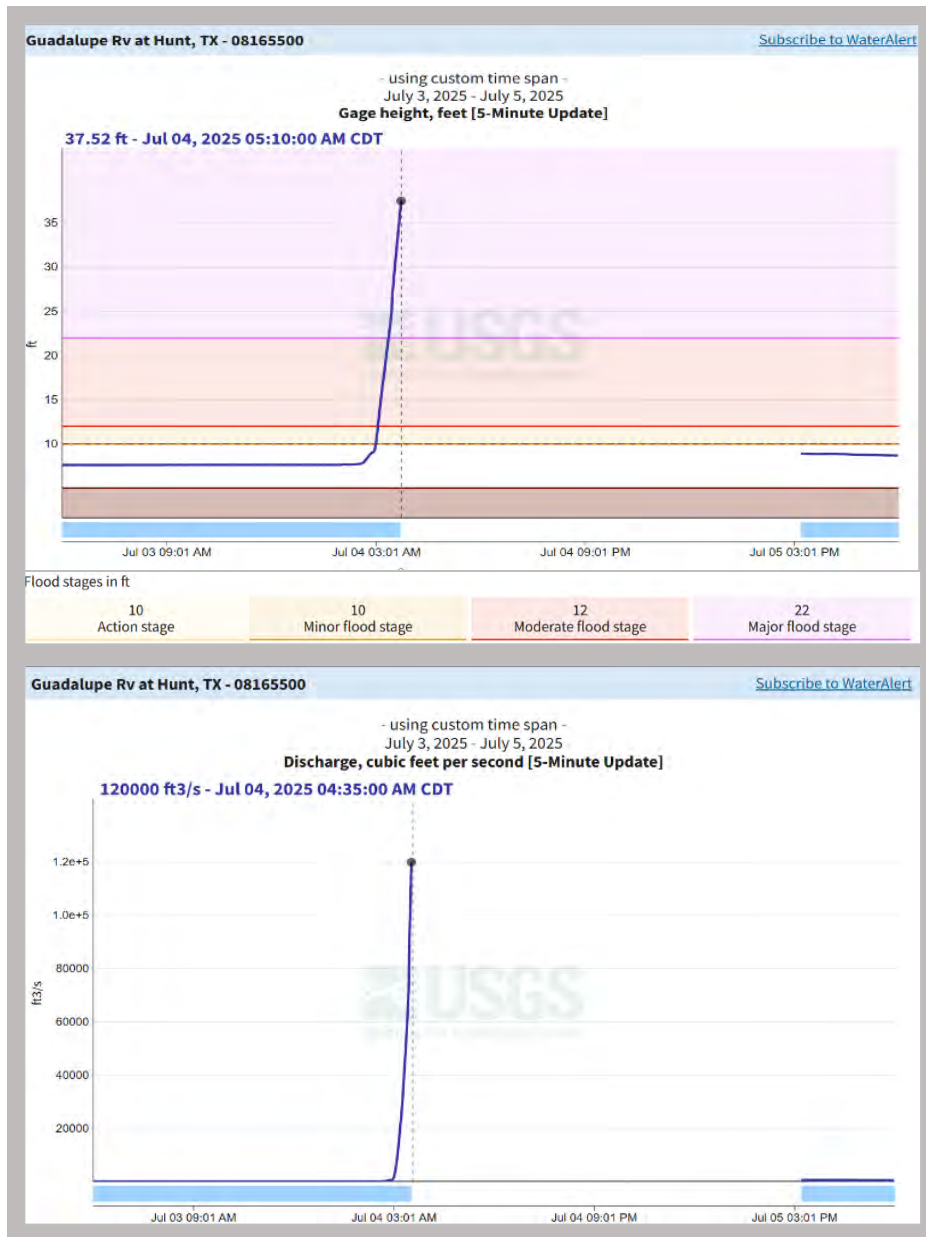
Table 1 further lists the corresponding maximum gage height and discharge levels with time stamps for each of these locations. It highlights that the event was centered close to Hunt, TX, corroborating the heatmaps above.

Table 1  
MAXIMUM GAGE HEIGHT AND DISCHARGE LEVEL FOR JULY 4, 2025

USGS Monitoring Locations	Max Gage Height (ft)	Time Stamp (CDT)	Max Discharge Level (cubic ft per sec (ft <sup>3</sup> /s))	Time Stamp (CDT)
N Fk nr Hunt, TX - 08165300	21.2	5:30 AM	28,500	4:15 AM
Hunt, TX - 08165500	37.52	5:10 AM	120,000	4:35 AM
Johnson Ck nr Ingram, TX - 08166000	12.54	6:05 AM	19,200	6:05 AM
Kerrville, TX - 08166200	34.29	6:45 AM	134,000	7:30 AM
Comfort, TX - 08167000	35.64	11:00 AM	177,000	11:00 AM

Data source: Water Data for the Nation, U.S. Geological Survey, Data Source: <https://waterdata.usgs.gov/> (Accessed July 15, 2025).

**Figure 3**  
**MAXIMUM GAGE HEIGHT AND DISCHARGE LEVEL FOR HUNT, TX FOR JULY 4, 2025**



Source: Water Data for the Nation, U.S. Geological Survey, <https://waterdata.usgs.gov/monitoring-location/USGS-08166200/> (Accessed July 15, 2025). Description of flood stage categories: National Water Prediction Service, National Oceanic and Atmospheric Administration <https://water.noaa.gov/gauges/08165500> (Accessed July 15, 2025).

The USGS River gage at Hunt (east of the confluence of North Fork and South Fork) recorded the catastrophic transformation of the river; Figure 3 shows the gage height readings went from 8 feet to 37.5 feet in three hours (2:00am to 5:10am).

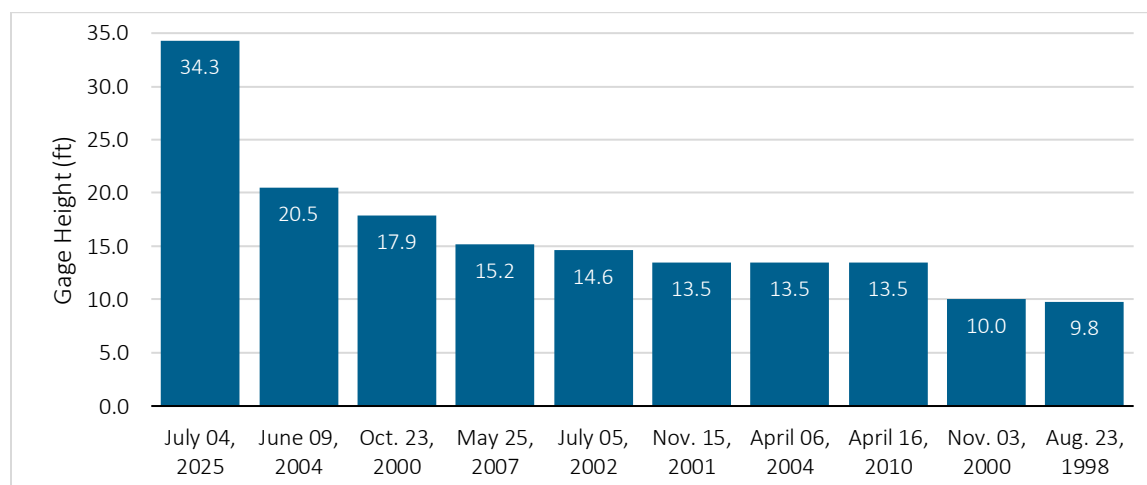
As dramatic as that is, what was significant was the exponential rate of change of discharge level - it increased almost ten times from 3:10am to 4:00am, increasing from 4,640 ft<sup>3</sup>/s to 45,000 ft<sup>3</sup>/s—for context, the discharge level at 2:00am was only 85 ft<sup>3</sup>/s. In the next 35 minutes, it increased by another 266% to 120,000 ft<sup>3</sup>/s at 4:35am, corresponding to a level of 30 feet. As noted above, in the following 30 minutes, the level rose another 7.5 feet,

however, discharge-level readings after 4:35am are not available. The scale of this change is difficult to fully grasp. In just over three hours, the river went from a nearly dry bed to a violent torrent carrying more water than the typical discharge over Niagara Falls of 100,000 ft<sup>3</sup>/s.<sup>2</sup>

Please note that the discharge level is scaling exponentially relative to the gage height. This implies that the discharge level corresponding to the 7.5 feet rise in gage height would have been tens of thousands of ft<sup>3</sup>/s higher than the last recorded 120,000 ft<sup>3</sup>/s.

**Figure 4**

**TOP 10 GAGE HEIGHT READINGS FOR GUADALUPE RV AT KERRVILLE, TX (SINCE 1997-10-02)**



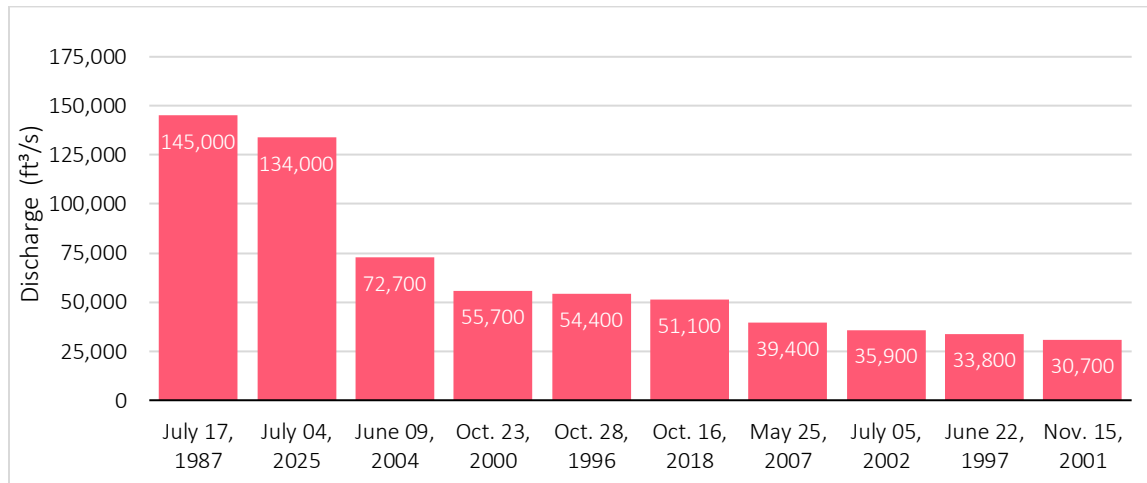
Data source: Water Data for the Nation, U.S. Geological Survey, <https://waterdata.usgs.gov/monitoring-location/USGS-08166200/> (Accessed July 10, 2025).

Figure 4 shows that the gage height in Kerrville reached unprecedented levels on July 4th, with a height of 34.3 feet being registered by the gage. Although the data only goes back to 1997 (i.e., there is no information on the 1987 flood), the river rose to more than 50% higher than at any other point in the last 27 years, and more than double the highest point in the last 20 years.

Figure 5 below shows the discharge data for Kerrville, TX. The USGS has data available going back to 1997 but also includes some data during the 1987 floods, which enables comparing the river's July 2025 discharge to the 1987 flooding event. The 134,000 ft<sup>3</sup>/s would put the Guadalupe River very close to the average current of the Ohio River in Louisville, KY on that day (about average for that location).<sup>3</sup>

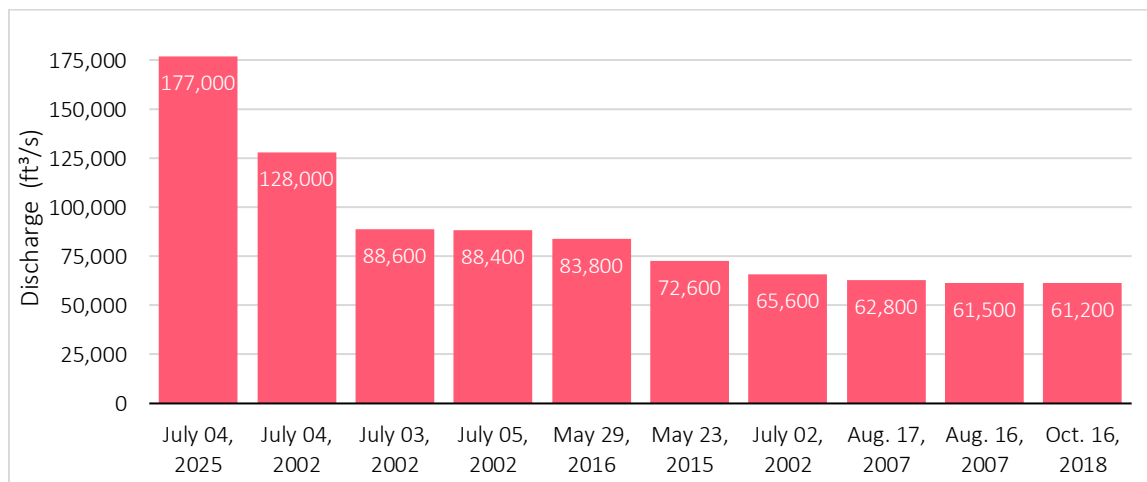
<sup>2</sup> H. Zaid, Jr., "Evaluation of Acoustic Doppler Current Profiler to Measure Discharge at New York Power Authority's Niagara Power Project, Niagara Falls, New York," U.S. Geological Survey Open-File Report 2007-1187, U.S. Geological Survey, <https://pubs.usgs.gov/of/2007/1187/>

<sup>3</sup> "Ohio River at Louisville, KY - 03294500," Water Data for the Nation, U.S. Geological Survey, <https://waterdata.usgs.gov/monitoring-location/USGS-03294500/#dataTypeId=continuous-00060-0&startDT=2025-07-04&endDT=2025-07-04> (Accessed July 16, 2025).

**Figure 5****TOP 10 DISCHARGE READINGS FOR GUADALUPE RV AT KERRVILLE, TX (LIMITED DATA BEFORE 1997)**

Data source: "Guadalupe Rv at Kerrville, TX – 08166200," Water Data for the Nation, U.S. Geological Survey, <https://waterdata.usgs.gov/monitoring-location/USGS-08166200/> (Accessed July 10, 2025 ).

Figure 6 shows how Comfort, TX (downstream from Kerrville), suffered a greater discharge as a result of having more precipitation entering the river from upstream and being at a lower elevation (gravity increasing the speed). As a result, Comfort, TX had 177,000 ft³/s of water coming through the Guadalupe River. This is about 60% of the magnitude of the Mississippi River as it flowed through St. Louis on that day (also about average for that location).<sup>4</sup>

**Figure 6****TOP 10 DISCHARGE READINGS FOR GUADALUPE RV AT COMFORT, TX (LIMITED DATA BEFORE 2002)**

Data source: "Guadalupe Rv at Hunt, TX – 08167000," Water Data for the Nation, U.S. Geological Survey, <https://waterdata.usgs.gov/monitoring-location/USGS-08167000/> (Accessed July 10, 2025).

<sup>4</sup> "Mississippi River at ST> Louis, MO – 07010000," Water Data for the Nation, U.S. Geological Survey, <https://waterdata.usgs.gov/monitoring-location/USGS-07010000/#dataTypeId=continuous-00060-0&startDT=2025-07-04&endDT=2025-07-04> (July 16, 2025).



## Risk Factors

The sections below discuss each of the risk factors whose confluence made these flash floods catastrophic.

### METEOROLOGICAL FACTORS

It all started with the remnants of Barry, a short-lived tropical storm that made landfall in Mexico on June 29<sup>th</sup> at 10:00pm CDT. It had weakened to a tropical depression before moving over land and was carrying maximum sustained winds of 35 miles per hour (55 km/h). Barry quickly dissipated as it moved inland, and the low-level circulation decayed.<sup>5</sup>

As per the forecast advisory from the National Oceanic and Atmospheric Administration (NOAA), the mid-level circulation remained.<sup>6</sup> The storm's lingering circulation continued drawing in abundant low-level moisture from the western Gulf of Mexico, bringing it inland across southern Texas. By Thursday night, this moisture appeared to be joined by significant upper-level humidity originating from the Eastern Pacific. A weather balloon launched from Del Rio, Texas, at 7:00am CDT on Friday July 4 revealed exceptionally high atmospheric moisture content, ranking as the fourth most water-laden profile observed in more than seven decades of twice-daily measurements.<sup>7</sup>

Kerr County lies in the Texas Hill Country, a region in Central Texas which largely occupies the Edward Plateau and is characterized by rugged hills, limestone and granite outcrops, and a unique karst topography. The region sits where different air masses often meet, specifically cool, dry air from the north and warm, moist air from the Gulf of Mexico. Moisture advection from the Gulf of Mexico colliding with a stalled front in Central Texas resulted in frontal lifting, a phenomenon where two air masses meet and the warm air mass is pushed upwards. Furthermore, there was moisture transport coming northward, as well, with a strong low-level jet stream (a common feature in Texas located about 5,000 feet above the surface). However, the jet was oriented to allow for maximum lift, aimed right at Hill Country.

Surface temperatures in Kerr County the night of July 4<sup>th</sup> were ~5 degrees C below average. Cooler air holds less moisture, so it saturates faster when lifted. This leads to lower cloud bases, thicker clouds, and more intense rainfall once condensation starts.

The storms were tracking from the southwest toward the northeast, essentially following the same direction as the Guadalupe river's flow. Studies have indicated that when storms travel along the course of a river, they tend to generate a more intense hydrologic response compared to those moving against the flow. In this case, the alignment between storm motion and river direction likely played a key role in amplifying the severity of the resulting flood wave.

### TOPOGRAPHY: THE TEXAS HILL COUNTRY'S ROLE IN RAINFALL INTENSIFICATION

The unique regional topography of the Texas Hill Country, also known as Flash Flood Alley, played a significant part in the intensification of rainfall and flash floods that devastated Kerr County in July 2025. The Upper Guadalupe River flows through three counties and its basin covers an area of approximately 1,427 square miles (913,280 acres) of the Texas Hill Country. It flows in a roughly easterly direction beginning in far-western Kerr County, through Kendall County and into Comal County. The basin's maximum elevation is 2,424 feet above sea level (MSL), and the

<sup>5</sup> Moderate Resolution Imaging Spectroradiometer, NASA (Accessed July 18, 2025) [https://modis.gsfc.nasa.gov/gallery/individual.php?db\\_date=2025-07-01](https://modis.gsfc.nasa.gov/gallery/individual.php?db_date=2025-07-01)

<sup>6</sup> National Hurricane Center and Central Pacific Hurricane Center, NOAA (Accessed July 18, 2025)

[https://www.nhc.noaa.gov/archive/2025/al02/al022025\\_discus.007.shtml](https://www.nhc.noaa.gov/archive/2025/al02/al022025_discus.007.shtml)

<sup>7</sup> Masters, Jeff and Bob Henson. Devastating flash floods slam Texas Hill Country; Tropical Storm Chantal heads for Carolinas. Yale Climate Connections. July 5, 2025. <https://yaleclimateconnections.org/2025/07/devastating-flash-floods-slam-texas-hill-country-tropical-storm-chantal-heads-for-carolinas/>

lowest is 822 feet MSL, giving it a relief of 1,602 feet over its 187 river-mile length.<sup>8</sup> This high relief creates big changes in elevation through hills, cliffs, and valleys that fundamentally affect how water flows, how fast rivers run, and how likely flooding can be.

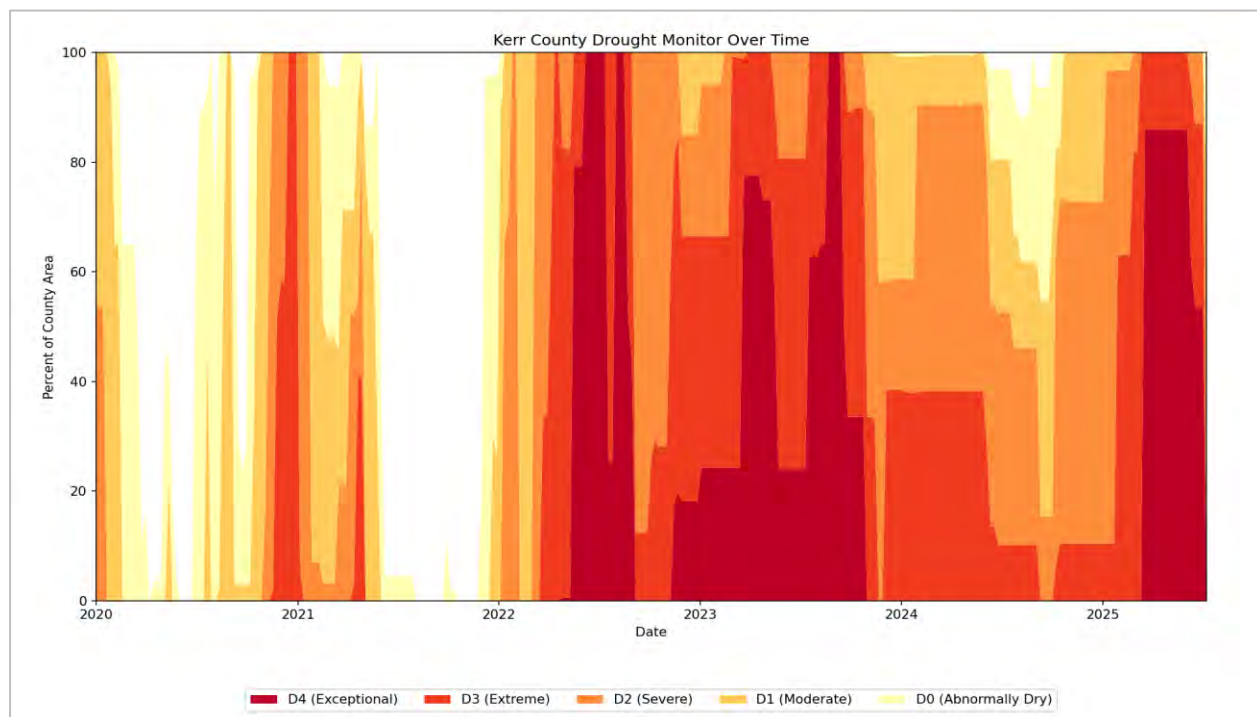
The terrain played a twin role in this disaster. First, it enhanced downpours due to orographic lift, as the moist air was forced upward by the Hill Country's elevated terrain. Some locations received 10 to 15 inches of rain in a matter of hours, four months' worth of precipitation in half a day. As the water flows through steep, hilly terrain with narrow and incised valleys, the landscape naturally channels and accelerates water movement but also restricts the excess from laterally spreading into the landscape. Water levels can rise precipitously and cause dangerous flash floods, particularly close to the creeks and rivers.

### PRIMED FOR DISASTER: THE DROUGHT THAT SET THE STAGE

Kerr County entered its fourth consecutive year of drought in 2025, with visible impacts including dry creeks and a severe wildfire season as evident in Figure 7. The drought intensified in early 2025, with Exceptional Drought (D4) expanding across the Texas Hill Country, including Kerr County.<sup>9</sup>

**Figure 7**

**WEEKLY MAP OF DROUGHT CONDITIONS IN KERR COUNTY (1/1/2020- 7/8/2025)**



Source: Drought Monitor, Water Data for Texas, Texas Water Development Board <https://www.waterdatafortexas.org/drought/drought-monitor> (Accessed July 14, 2025).

<sup>8</sup> Flatten, Charlie. The Upper Guadalupe River: Stewarding a Hill Country Icon. Hill Country Alliance. June 2017. [https://www.hillcountryalliance.org/wp-content/uploads/2017/11/GRA\\_HCA\\_UpperGuadalupe\\_LitReview.pdf](https://www.hillcountryalliance.org/wp-content/uploads/2017/11/GRA_HCA_UpperGuadalupe_LitReview.pdf) (Accessed July 9, 2025).

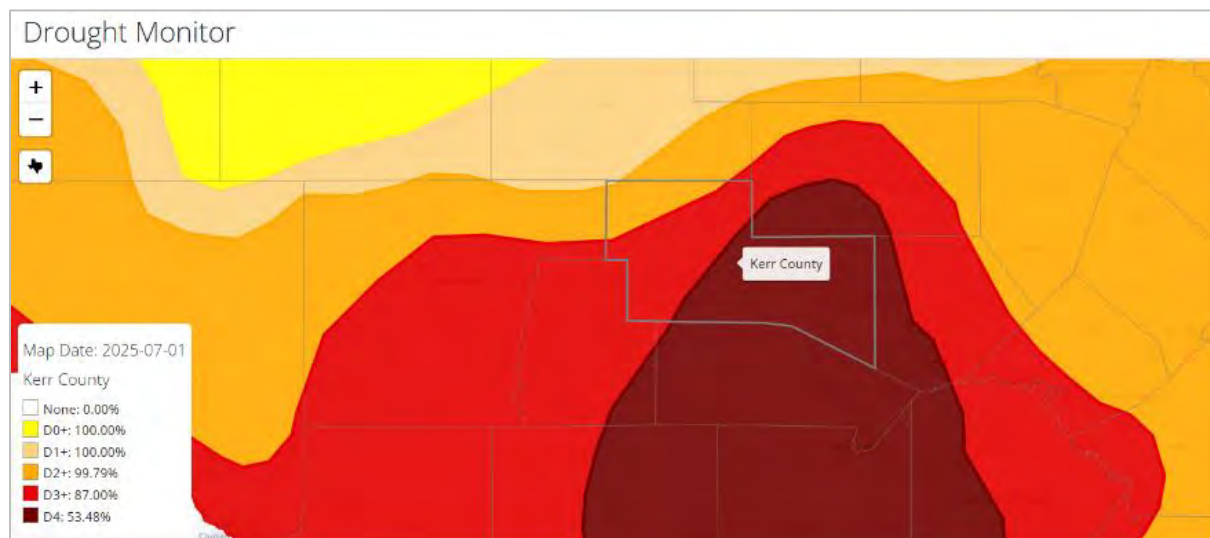
<sup>9</sup> Drought Conditions for Kerr County, National Integrated Drought Information System, National Oceanic and Atmospheric Administration, <https://www.drought.gov/states/texas/county/kerr> (Accessed July 14, 2025).



Figure 8 below shows a snapshot of the drought conditions in Kerr County as of July 1<sup>st</sup>, 2025, which indicates that virtually the entire county was experiencing at least severe drought, with over half of the county classified in the most critical drought stage ("Exceptional Drought").

**Figure 8**

**U.S. DROUGHT MONITOR MAP FOR KERR COUNTY AS OF JULY 1, 2025**



Source: Drought Monitor, Water Data for Texas, Texas Water Development Board, <https://www.waterdatafortexas.org/drought/drought-monitor?period=2025-07-01&areaType=county&areaName=Kerr> (July 14, 2025).

The drought created additional compounding factors that worsened the flood risk. Prolonged dryness caused soils to become hydrophobic (water-repellent), reducing their ability to absorb sudden rainfall and increasing the risk of rapid runoff and flash flooding rather than slow infiltration and soil rehydration. Vegetation stressed by drought had reduced ground cover due to withering or dieback, further limiting the landscape's ability to slow and absorb rainfall while amplifying runoff and erosion.

The devastating impact of the July 2025 flash floods in Kerr County was significantly amplified by preexisting drought conditions. This compound effect - drought followed by a high-intensity storm - represents a classic example of how extreme weather events can interact to produce outsized societal impacts.

## EXPOSURE

Kerr County was the epicenter of the disaster, suffering the highest loss of life. For nearly a century, the banks of the Guadalupe River and its tributaries in the Texas Hill Country have been home to a thriving summer camp tradition. The number of camps had grown from a handful in the early 20th century to more than a dozen major camps today, collectively serving thousands of children each summer. Camp Mystic, which was the worst hit, alone had about 750 campers.<sup>1</sup> With respect to the property, the actual damage from July 2025 is still being assessed, but entire subdivisions and summer camps were inundated by the rapidly rising Guadalupe River.

The First Street Foundation website lists an estimated number of properties that are likely to be impacted in a 1-in-100-year flood event, if it occurred today. The estimates suggest a higher number of properties to be at risk for urban and suburban counties, such as approximately 33,000 in Bexar, approximately 17,000 in Travis and

approximately 9,000 in Williamson. While the potential impact in rural counties may span from around 7,000 in Burnet to 225 in Mason, for Kerr County, the estimate is around 3,953 properties to be impacted.<sup>10</sup>

Cotality (formerly CoreLogic) has published their preliminary property impact analysis analyzing the wide swath of impacted areas across Central Texas. As per their initial estimates, over 38,600 residential structures were within the flood footprint of counties that were deemed eligible for individual and public assistance by the Federal Emergency Management Agency (FEMA) and may have experienced flood damage.<sup>11</sup> Of these counties, Tom Green, Travis, Kerr, Williamson, and Burnet are home to the greatest number of residential properties potentially impacted by flooding. Also, the protection gap in this region has been trending up. Just 7% of homeowners in Texas have flood insurance through the federal government, which runs the biggest flood insurance program in the country.<sup>12</sup> That percentage drops to 2% when you move inland to areas like Travis and Kerr counties, some of the hardest hit by recent floods.

In addition, catastrophic losses have been reported across traditional and specialty farms. Damage includes drowned livestock, ruined crops, destroyed infrastructure, and lost equipment. Specialty producers — like Christmas tree growers and ostrich farmers — face near-total losses. Flooded fields render fruits and vegetables unsellable and heighten future pest and disease risks. Livestock rescue and welfare remain urgent challenges, especially for vulnerable species.<sup>13,14</sup>

The following account is taken from AccuWeather:<sup>15</sup>

The preliminary estimate of total damage and economic loss ranges from \$18 billion to \$22 billion. This estimate includes impacts to homes, businesses, campgrounds and recreation facilities.

It also accounts for broader impacts, such as disruptions to supply chains, extended power outages, road closures, travel delays, projected tourism losses, infrastructure damage and the long-term costs for survivors and others impacted by the catastrophic event.

## CONCLUSION

The flash floods that struck Kerr County on July 4th, 2025, were a devastating example of how overlapping natural forces can produce catastrophic results. Though the region is no stranger to flash flooding, this event stood apart in both speed and scale. The storm developed at the intersection of unusually high atmospheric moisture, persistent low-level inflow from the Gulf, and favorable upper-level dynamics that concentrated rainfall over a small area in a short time. The terrain of the Hill Country, already well known for steep relief and narrow river valleys, amplified runoff and limited opportunities for water to spread or infiltrate. Compounding this, the area was in the grip of a multiyear drought, which had rendered soils hydrophobic and vegetation sparse, further accelerating runoff into the Guadalupe River system. The result was a sudden, violent rise in water levels, with river gauges registering flows comparable to major North American rivers and record-setting discharges in multiple locations.

<sup>10</sup> Does Kerr County have Flood Risk? First Street. [https://firststreet.org/county/kerr-county-tx/48265\\_fsid/flood](https://firststreet.org/county/kerr-county-tx/48265_fsid/flood) (Accessed July 18, 2025)

<sup>11</sup> July 2025 central Texas floods. Cotality. July 11, 2025. <https://www.cotality.com/insights/articles/july-2025-central-texas-floods> (Accessed July 18, 2025)

<sup>12</sup> McGlinchy, Audrey. As Texans start to rebuild after the floods, many face the reality of being uninsured. KUT News, Reliably Austin. July 18, 2025. <https://www.kut.org/housing/2025-07-18/austin-texas-flood-home-insurance-fema-financial-assistance> (Accessed July 21, 2025)

<sup>13</sup> Texas floods endangered livestock and damaged crops. Here's how farmers are dealing with the aftermath of the disaster. CBS News. July 11, 2025. <https://www.cbsnews.com/news/texas-floods-endangered-livestock-damaged-crops-farmers-aftermath/> (Accessed July 22, 2025)

<sup>14</sup> Terzo, Gerelyn. Texas Ag Sector Looks to Rebuild Amid Flood Devastation. Global AgInvesting. <https://globalaginvesting.com/texas-ag-sector-looks-to-rebuild-amid-flood-devastation/> (Accessed July 22, 2025)

<sup>15</sup> Potts, Jenna. Texas flash flood tragedy causes an estimated \$18 billion to \$22 billion in total damage and economic loss. AccuWeather. July 9, 2025. <https://www.accuweather.com/en/blogs-webinars/texas-flash-flood-tragedy-lives-lost-and-billions-in-damages/1792503> (Accessed July 18, 2025)



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