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# Terrain and timing conspired to cause 'horrifying' Texas rainfall

*Texas Hill Country is prone to flooding, and climate change is making it more common.*

**Dinah Voyles Pulver**
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Texas Hill Country is no stranger to extreme flooding. In the rugged, rolling terrain it's known for, heavy rains collect quickly in its shallow streams and rivers that can burst into torrents like the deadly flood wave that swept along the Guadalupe River on July 4.

The Guadalupe has flooded more than a dozen times since 1978, according to the U.S. Geological Survey, but the Independence Day flood is among the worst in its

history. The raging river claimed more than 70 lives, officials said on July 6, and rescue workers were still searching for missing children.

Several factors came together at once – in one of the worst possible locations – to create the "horrifying" scenario that dropped up to 16 inches of rainfall in the larger region over July 3-5, said Alan Gerard, a recently retired storm specialist with the National Oceanic and Atmospheric Administration.

Hill Country, the region in Central and South Central Texas, also is known colloquially as "flash flood alley," for its propensity for fast and furious flooding when extreme rain falls, Gerard, who is now CEO of weather consulting company Balanced Weather said. As bountiful moist air from the Gulf of America, renamed from the Gulf of Mexico, moves over the steep hills, it can dump heavy rains.

On July 4, rain was falling at 3-4 inches per hour, with some locations recording a deluge of up to 7 inches of rain in just three hours, the National Weather Service said. Seven inches of rain is nearly 122 million gallons of water per square mile. Over 7 square miles that's enough water to fill the AT&T Stadium, home of the Dallas Cowboys.

The Guadalupe River skyrocketed more than 20 feet in a matter of hours in several locations as it rushed downstream toward Kerrville, a city of 24,000.

## What caused the Texas flooding?

Terrain and timing were the biggest factors in the storms, said Gerard and Victor Murphy, a recently retired National Weather Service meteorologist in Texas.

Thunderstorms that began on July 3 and continued through the morning of July 4 dropped as much as 10.33 inches of rain near Ingram, Texas, and widespread

amounts between 3 to 7 inches in more than a half-dozen counties across the south-central part of Texas.

Because of the region's proximity to the Gulf, it gets "very high rainfall rates," especially in the summer months, Gerard said.

"The Gulf is warmer than normal and disturbances moving through that flow can focus thunderstorm activity on a particularly area," he said. On July 4, it was a case of everything focusing in "exactly the wrong place."

An upper level disturbance in the atmosphere tapped into a deep plume of tropical moisture left over from Tropical Storm Barry, which made landfall in Mexico on June 29, Gerard said. It didn't help that the storms that formed on Independence Day moved in the same direction as the Guadalupe River, which only added to the rain flowing off the terrain.

Hill Country is a “semi-arid area with soils that don’t soak up much water, so the water sheets off quickly and the shallow creeks can rise fast,” Hatim Sharif, a hydrologist and civil engineer at the University of Texas at San Antonio wrote in a July 5 post on The Conversation.

The escarpment is a line of cliffs and steep hills created by a geologic fault, Sharif said. "When warm air from the Gulf rushes up the escarpment, it condenses and can dump a lot of moisture. That water flows down the hills quickly, from many different directions, filling streams and rivers below."

A weather balloon remotely launched by the weather service Del Rio in West Texas, showed near-record moisture in the upper atmosphere, Murphy said. With that enormous amount of moisture serving as fuel, the winds hitting the escarpment in West Texas served as a kind of match that started the storms.

“Once the storms get going, they’re self-sustaining," Murphy said. That's also why it continued to rain and flood in the region on July 5.

## What role did climate change play in the Texas flood?

Warming temperatures over land and especially in the Gulf are stoking extreme rainfall events more often in an arc across the United States, from Texas up into the Northeast, extreme storm experts tell USA TODAY. The region has always seen occasional extreme rains, but today they occur more often, according to weather service data.

Air holds 7% more water for every 1.8 degree Fahrenheit rise in temperature. Waters in the Gulf are often 3, 4 or 5 degrees warmer than normal. At one point this year, sea surface temperatures in the Gulf off the coasts of Texas and Louisiana were more than 8 degrees above normal.

"As has been shown time and time again, event after event, climate change is leading to wetter, more extreme precipitation events," Kevin Reed, an associate provost for climate and sustainability programming at Stony Brook University, previously told USA TODAY.

Out of 140 years of U.S. weather records, more than half of the standing 24-hour rainfall totals have been set in the past 30 years.

## Why is Texas flooding?

A guide to Texas State Parks makes it clear flash floods are common and life-threatening.

"In hilly terrain, flash floods can strike with little or no advance warning," the guide advises. "Be aware of changes in the weather and seek higher ground

early."

"Never camp on low ground next to streams, bottoms of canyons or deep arroyos since a flash flood can catch you while you're asleep," it states.

Texas as a whole leads the nation in flood deaths, "and by a wide margin," Sharif said. “Many of those flood deaths have been in Hill Country."Flooding occurred in the Hill Country on July 4-5, 2002, when six days of rain had dropped between 40-45 inches of rain in the region. The Guadalupe reached a record height at the Canyon Dam. Seven people died in flash flooding and damage was estimated at $250 million.

*(This story has been updated to add new information.)*

*Dinah Voyles Pulver, a national correspondent for USA TODAY, writes about climate change, violent weather and other news. Reach her at dpulver@usatoday.com or @dinahvp on Bluesky or X or dinahvp.77 on Signal.*