North Texas Flash Flood Characteristics

Ted Ryan and Stacie Hanes

1. Introduction

Flash flooding kills more people annually than any other type of severe weather. There are numerous social, educational, and political issues that contribute to the high fatality rates associated with flash flooding. According to the American Meteorology Society (AMS), flash flooding is a "flood that rises and falls quite rapidly with little or no advance warning, usually as the result of intense rainfall over a relatively small area." But what does that mean? How much rain over how big of an area constitutes a flash flood? Forecasters, the public, the media, storm spotters, and law enforcement officials all have ideas about whether a situation is a flash flood or not. It is ultimately up to National Weather Service (NWS) forecasters to classify whether an event is a flash flood. *Storm Data,* issued by the National Climatic Data Center, is the official publication for severe weather events. Flash flooding was first documented in *Storm Data* in 1995.

Unlike other severe weather events, such as tornadoes and hail, flash flooding can be caused and exacerbated by high population densities and poorly planned urban infrastructure. This makes flash flooding a unique warning and forecasting challenge as forecasters must take into account more than just meteorological factors. That is why this database, which identifies the most dangerous locations in north Texas, can be a crucial piece of information for issuing effective warnings. In addition, findings from this study may be incorporated into warning templates, thereby strengthening the public's perception of danger and hopefully saving lives.

2. Methodology

a. Database

A database containing all flash floods which appeared in *Storm Data* from January 1995 through December 2007 was compiled. The date and time of the floods as well as any narrative text was noted. The number of fatalities, injuries, high water rescues, and the amount of damage was also recorded. This data was used to make charts mapping the frequency of flash flooding by month, time of day, gender, age, and location or activity. The results are located in section 3.

b. Maps *(Maps for each county are located in P:\FlashFloodStudy\countymaps\)*

Available reports from the database were plotted onto county maps in order to find locations that frequently flooded or were associated with high water rescues or fatalities. Because some of the flash flooding reports contained no specific information, they were unable to be plotted. For example, vague reports citing "countywide flooding" were essentially useless for this study. Secondly, if a single flash flood event report contained multiple specific locations of flooding across the county, all of these locations were plotted on the map. For these reasons, county maps should not be used as a way to gauge overall frequency of flooding because reports from some counties had considerably less detail than reports from other counties. Finally, only one mark was made for each fatality and high water rescue *event* to avoid skewing the map results if a single event was responsible for dozens of high water rescues and multiple fatalities associated with the same vehicle. It is our hope that common places of flooding would be identified so that they could be used in warning decision-making and in follow up verification questions to local emergency officials.

3. Results

a. Flash Flood Frequency by Month and Average Rainfall (1995-2007)

The average monthly rainfall was calculated for the CWA as a whole by using data from 80 ASOS and COOP sites between 1995 and 2007. The monthly averages are plotted by the blue dashed line in Figure 1. It should be noted, that the 13 year rainfall average does not match the standard 30 year rainfall mean for the months of April and June. The 13 year average indicated the month of June was the wettest, but this is due to record flooding events in 2004 and 2007 skewing the results. Another anomaly in recent years was that the average rainfall in the month of April was less than that of March.

As shown in Figure 1, flash flood event were most common during the months of May and June, which not surprisingly were the wettest months in the 13 year average. The frequency of flash flooding events tends to follow the monthly rainfall trend for the months of January through September. During the first half of the year, frequency of flood events increased substantially as the average rainfall increased. The exception is the month of April, when flash flood events decreased slightly as rainfall also decreased.

In July and August, a subtropical high typically occupies the upper levels of the atmosphere over north Texas, suppressing convection and producing the lowest rainfall averages of the year. Warm summertime temperatures allow for strong evapotransporation with antecedent soil moisture usually at its lowest levels of the year in the mid to late summer months.

Flash flooding events continue to remain low in October and November despite average monthly rainfall increasing to similar values seen in spring. However, it is interesting to note that in December and January average rainfall decreases, but flash flood events increase. This may be due to vegetation becoming dormant during the winter months and not soaking up as much rain water as well as cooler temperatures leading to less evaporation.

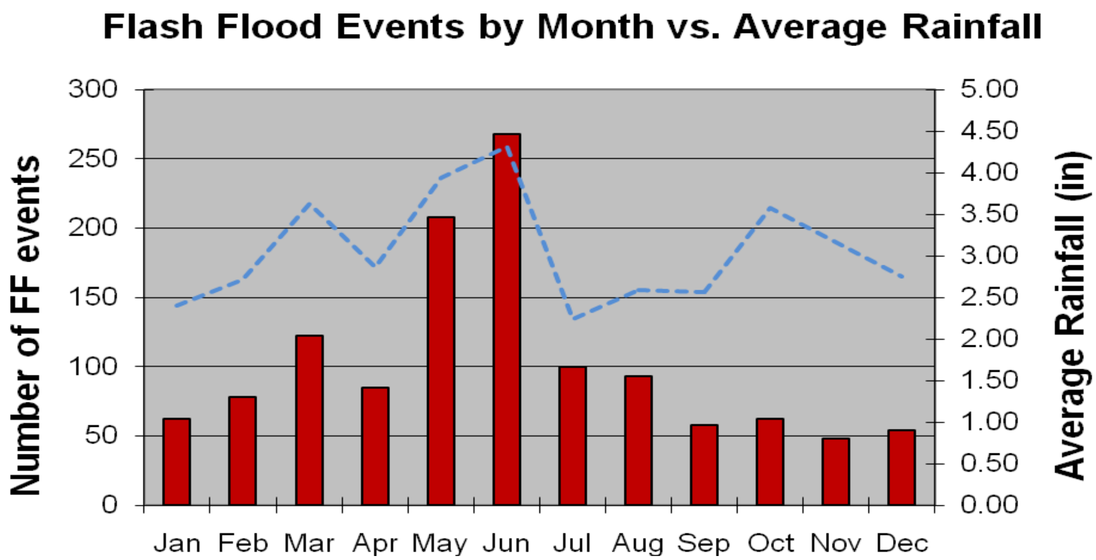


Figure 1. The average number of flash flood events per month are in red bars, while the average monthly rainfall is mapped with a blue dashed line. (1995-2007)

b. Flash Flood Frequency by Time of Day

The chart in Fig. 2 shows the frequency of flash flood events according to the time of day in CST. There are three peaks which stand out in this chart, from 1 AM to 3 AM, from 9 AM to 10 AM, and from 7 PM to 10 PM. Obviously peaks would have some correlation to the diurnal convective cycle. However, the mid-morning and evening peaks may be a reflection of more commuters on the roads and therefore more flash flood events being reported. The small peak between 1 AM and 3 AM is interesting and could also have something to do with a lag time of flooding after a diurnal convective increase during the evening hours.

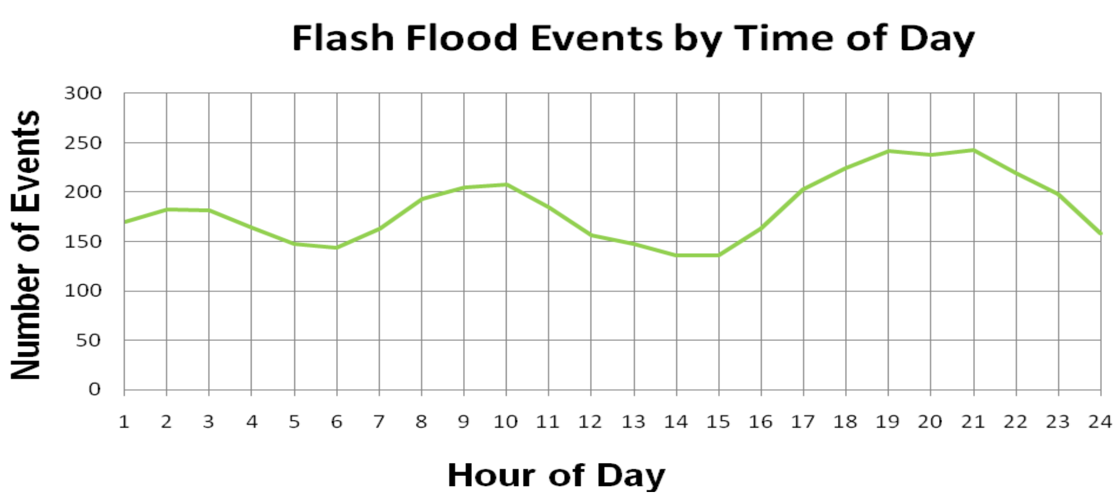


Figure 2. Flash flood events charted by local time.

c. Fatalities by location or activity

According to Figure 3, in the overwhelming number of flash flood fatality cases, victims either drove into flooded areas and drowned in their cars or drowned after abandoning stalled vehicles. Unfortunately, in *Storm Data*, the latter is sometimes categorized as "in water" instead of "in vehicle." This data is hard to pick apart with some reports providing few details. In a few instances, the vehicles were swept from roadways which were flooded, causing the inhabitants to drown. These instances would also be categorized as "in vehicle." The second highest category found the victims "in water" which usually means the victim entered the water purposefully and was swept away. In a small number of cases, the victims were in boats which capsized.

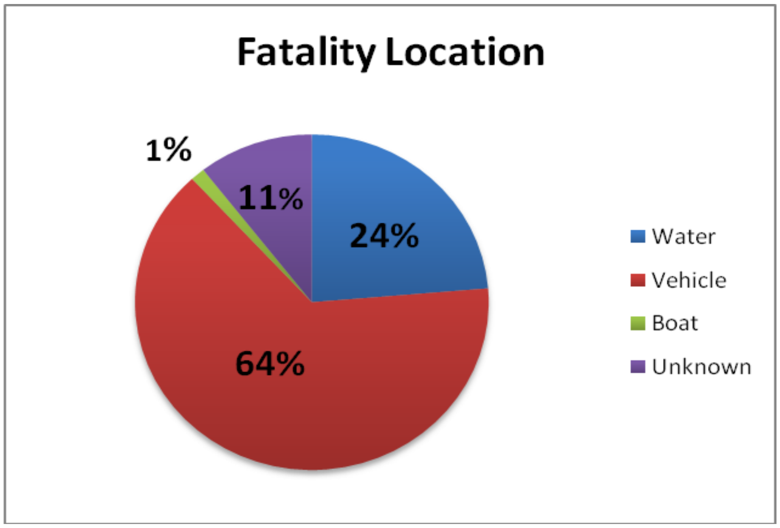


Figure 3. Flash flood fatality location with red indicating the death occurred in a vehicle, blue representing in water, green representing in a boat, and purple indicating unknown location.

d. Fatality frequency by age

Flash flood fatality data was broken down into age groups (Fig. 4). At particular risk is the 0-9 year old group. A cursory look at the flash flood narratives within *Storm Data* shows a disturbing trend which is confirmed in our research: many parents ignore flash flood warnings and barricades, often driving around them and placing their lives and the lives of the children at risk. Young children are not able to escape this situation, but their parents often are. Another reason for the high percentage of 0-9 year olds who die from flash flooding may be children playing near floodwaters, although this makes up a smaller number that one would imagine, as shown in Figure 5.

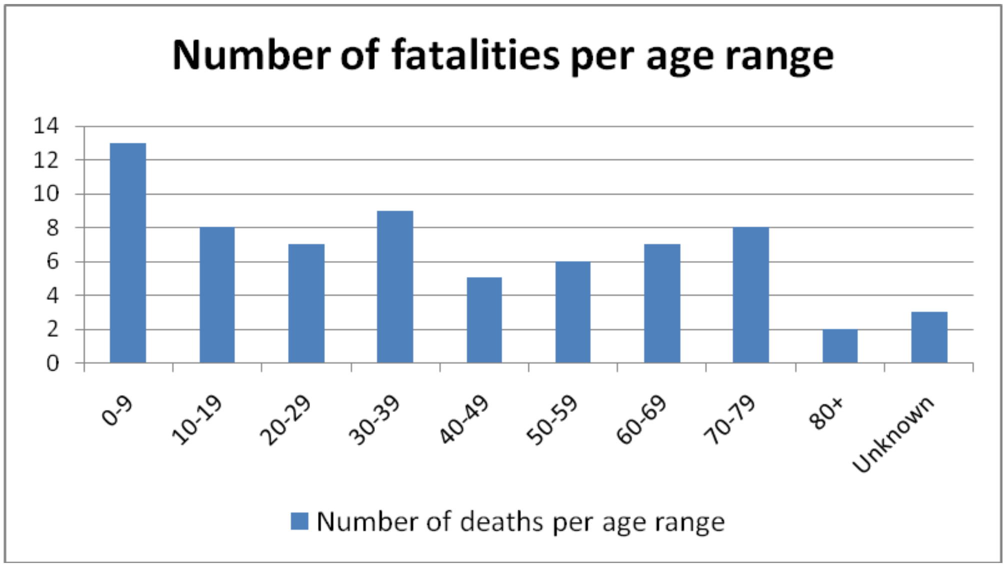


Figure 4. Flash flood fatality data by age range. The 0-9 yr old group, 30-39 yr old group, and 70-79 yr old group are at the highest risk.

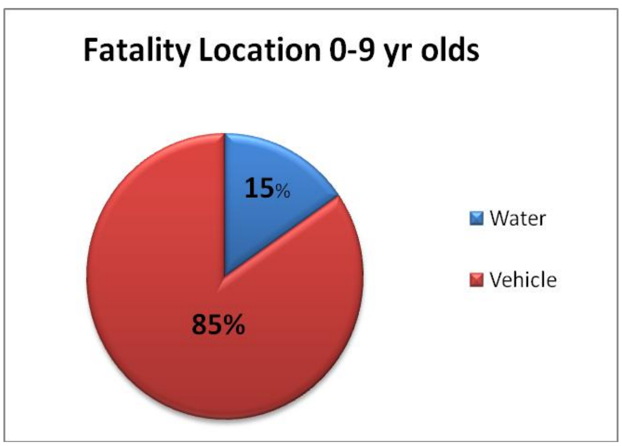


Figure 5. Flash flood fatality data of the 0-9 yr old group. Most of the deaths occurred in vehicles.

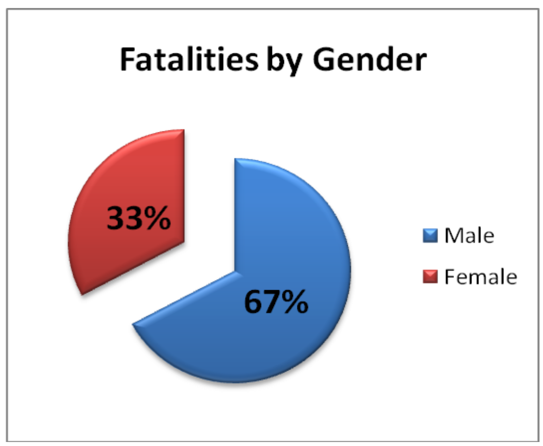


Figure 6. Flash flood fatality data by gender. Two-thirds of the deaths were males.

e. Fatality frequency by Gender

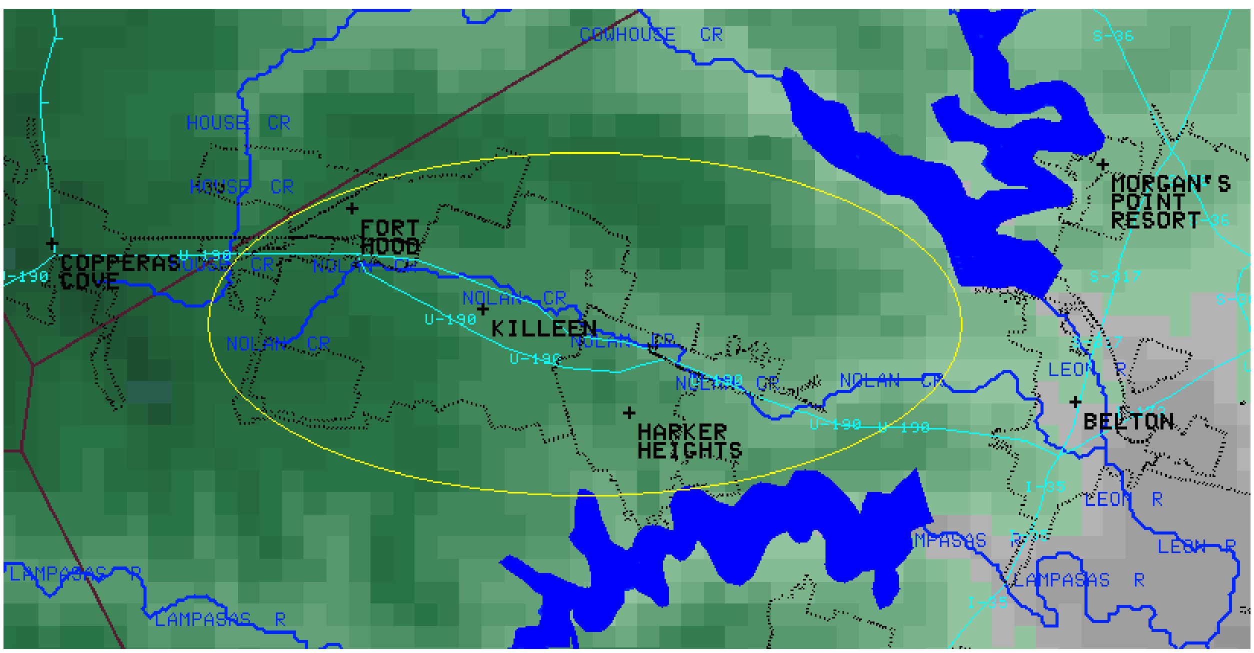
Taking a look at the fatality statistics by gender shows that two-thirds of the deceased were males. This possibly reflects the fact that men are more willing to take risks than women.

4. Top Ten Most Dangerous Locations in the CWA

After the database was compiled, it became clear that there were several areas where fatalities, high water rescues, and evacuations occurred frequently. A warning forecaster should have intimate knowledge of these locations to ensure that the threat is adequately assessed and conveyed to appropriate county officials while events are ongoing. A subjective ranking of the ten most dangerous flash flood locations and the creek basin responsible has been compiled. A brief summary of these locations, statistics, and notable events is discussed below.

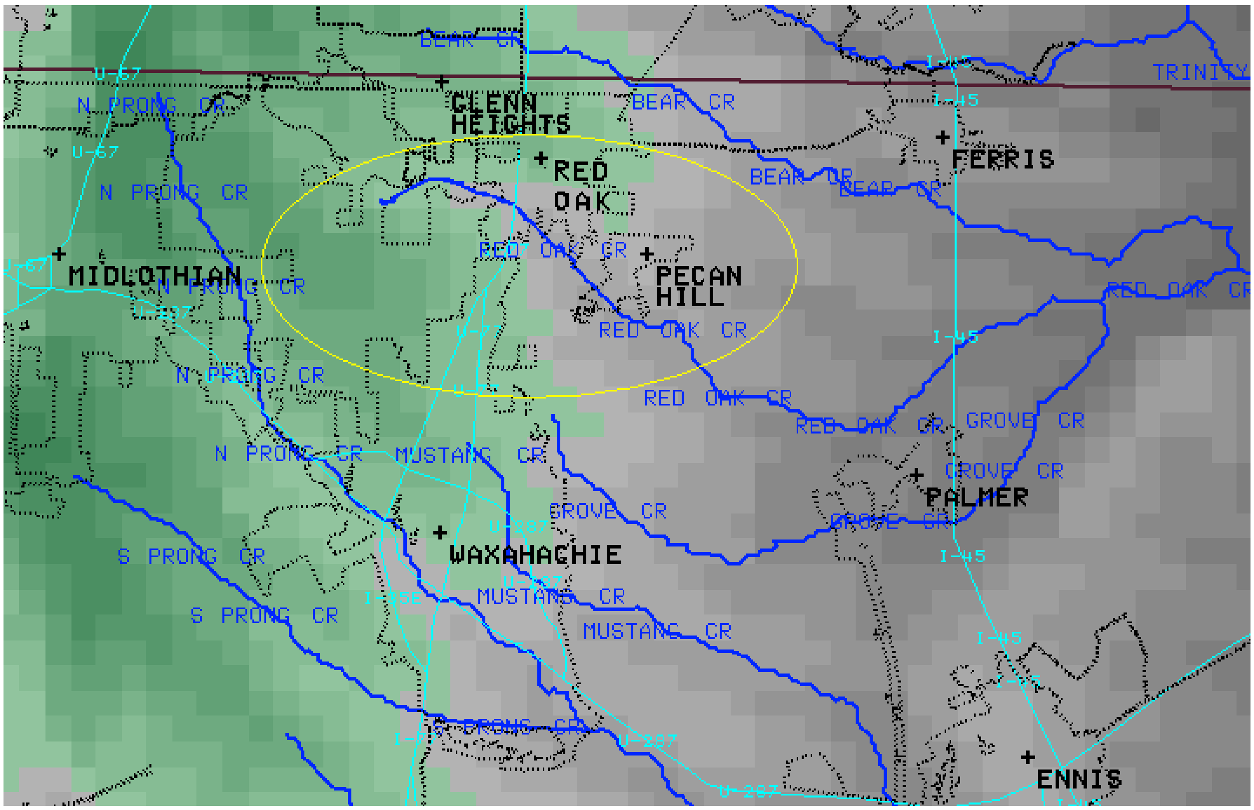
1. Nolan Creek (Bell County) – Nolan Creek in central Bell county runs roughly along Highway 190 from Fort Hood through Killeen, Harker Heights, and Nolanville. Much of the city of Killeen and Harker Heights has been built in and around the creek bed where there are numerous water crossings which traditionally flood during heavy rainfall.

Since 1995, six separate fatality events have occurred in the Nolan Creek Basin with several events citing numerous high water rescues. Most fatalities and high water events involved vehicles; however a few high water rescues resulted from children playing in flooded culverts. The high population density in and around Nolan Creek coupled with dozens of bridge crossings will continue to make Nolan Creek dangerous for commuters and children in the future.



2. Red Oak Creek (Ellis County)

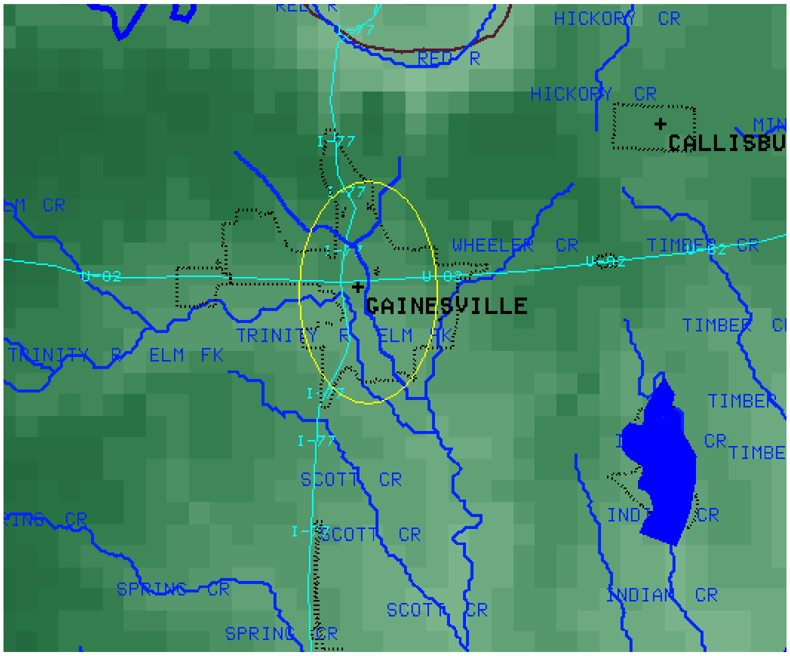
Red Oak Creek begins east of Midlothian and travels through several small predominantly rural communities in northern Ellis County. This creek has washed out several county bridges in past flood events. Numerous high water rescues in Red Oak Creek and two vehicle related fatality events have occurred. In addition, flooding of a mobile home park just south of the city of Red Oak has forced evacuations on three occasions. Apparently, the road infrastructure in several locations along Red Oak Creek is not adequately high when flash flooding is occurring. This coupled with a growing, yet predominantly rural population, suggests that vehicle related high water rescues and fatalities will continue.



3. Pecan Creek (Cooke County)

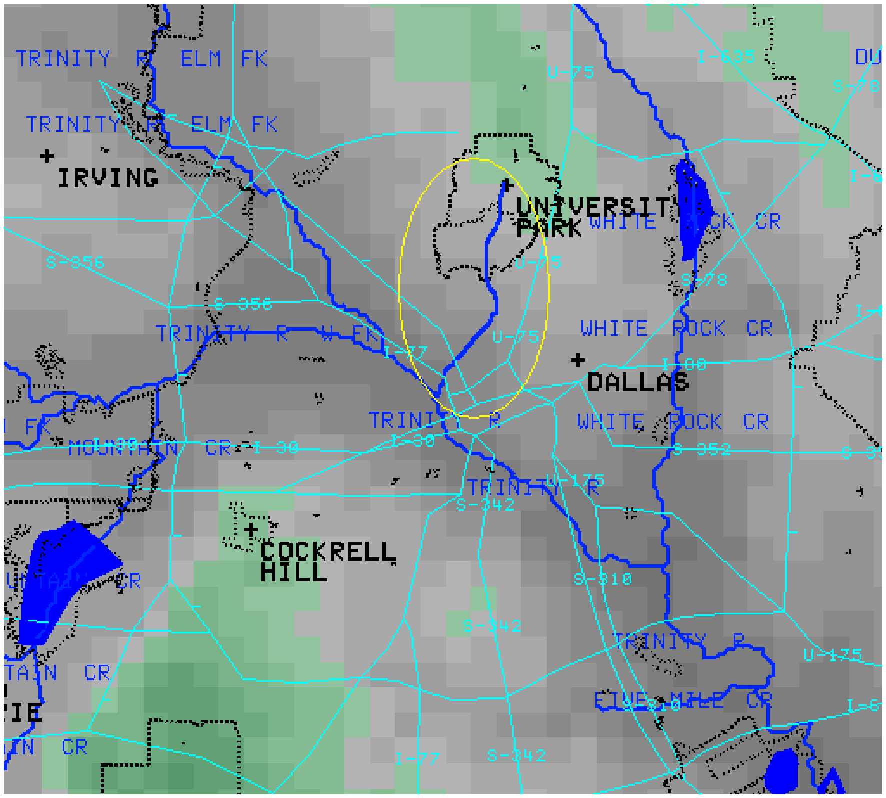
Pecan Creek originates north of the city of Gainesville and runs south, passing right through Downtown Gainesville, before emptying into the Elm Fork of the Trinity River Basin south of town. There is a history of flash flooding in the city of Gainesville associated with this creek overrunning its banks. The creek was channelized through the city of Gainesville in the 1930s and new flood reduction efforts are being analyzed. Several flash flood events have resulted in three fatalities, several high water rescues, and evacuations of residential structures along the creek. Until flood mitigation efforts are completed by the Corp of

Engineers by 2011, this area will remain a dangerous flash flood location. The Pecan Creek basin is a site specific forecast point, and river flood warnings are required for this location. The site specific model can be used to forecast and warn for catastrophic flooding events.



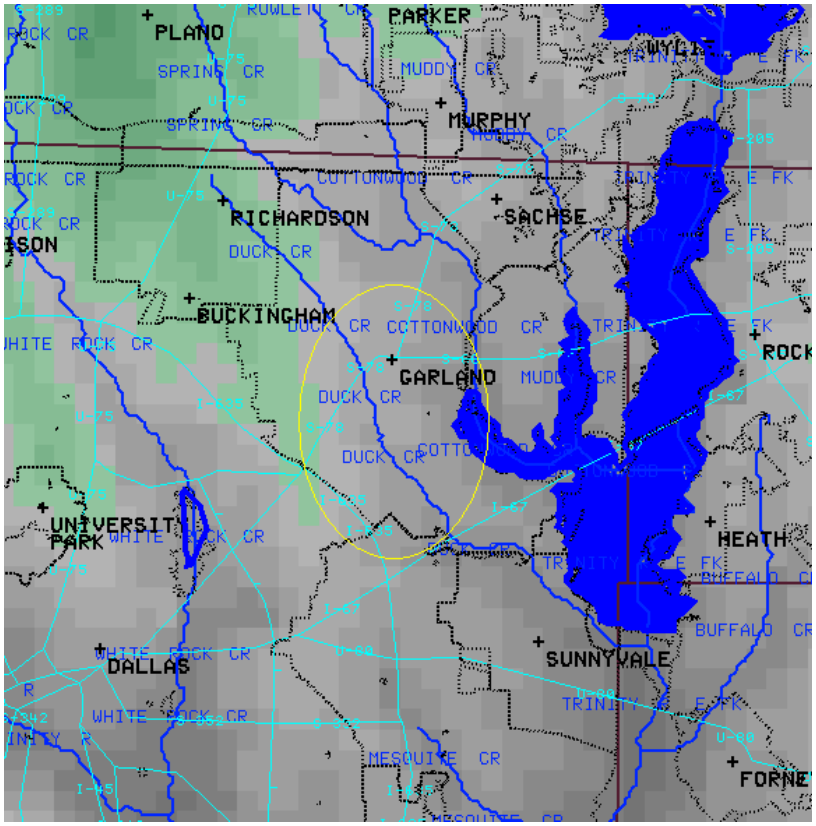
4. Turtle Creek (Dallas County)

Turtle Creek runs for just a few miles north of downtown Dallas, but is hardly a natural creek bed any more, and is not found on many river maps. High density urban development has transformed the creek bed into an urban drainage culvert. This drainage infrastructure appears adequate to handle most flood events, but during two of the major flash flood events for Dallas County (Mayfest 1995 and the March 2006 flood) fatalities did occur when vehicles were inundated. This area will continue to be dangerous during catastrophic flooding events. During the Mayfest flood reports spoke of rapidly rising waters inundating numerous cars while would be citizen rescuers were sucked down whirlpools that developed above manholes.



5. Duck Creek (Dallas County)

Duck Creek starts in southern Collin County and runs south into northeast Dallas County before emptying into the East Fork of the Trinity River in Kaufman County. The most dangerous stretch of Duck Creek begins just west of downtown Garland and continues into the southern part of the city of Garland. Along the creek bed in this area, the city has built several parks and a golf course, while numerous city streets cross the creek. Flooding of Duck Creek has been responsible for two separate fatality events, three high water rescue events, and several reports of flooded city streets in the Garland area. The recurring theme of flooded roadways coupled with high population density makes Duck Creek at Garland a dangerous flash flood location. Duck Creek is also a site specific forecast point, and forecasters are able to use the model to anticipate major flood events before they occur.

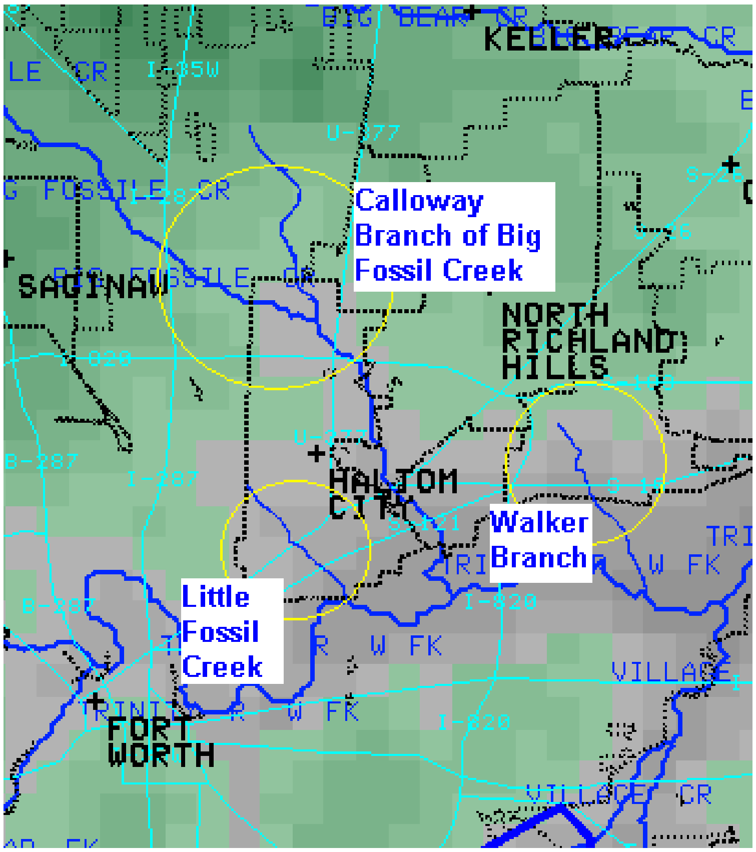


6. Big Fossil & Calloway Branch, Little Fossil, and Walker Branch (Tarrant County)

Several creeks in the Haltom City area have had flash flood issues in the past. A flood control project on the Little Fossil Creek basin in South Haltom City (southwest circle) has been completed and flash flooding issues appear to be resolved, but two other dangerous flash flood-prone areas remain. The Calloway Branch and the Big Fossil Creek (northern circle) remains the most dangerous. The secondary area of interest is in the southern section of Hurst on the Walker Branch.

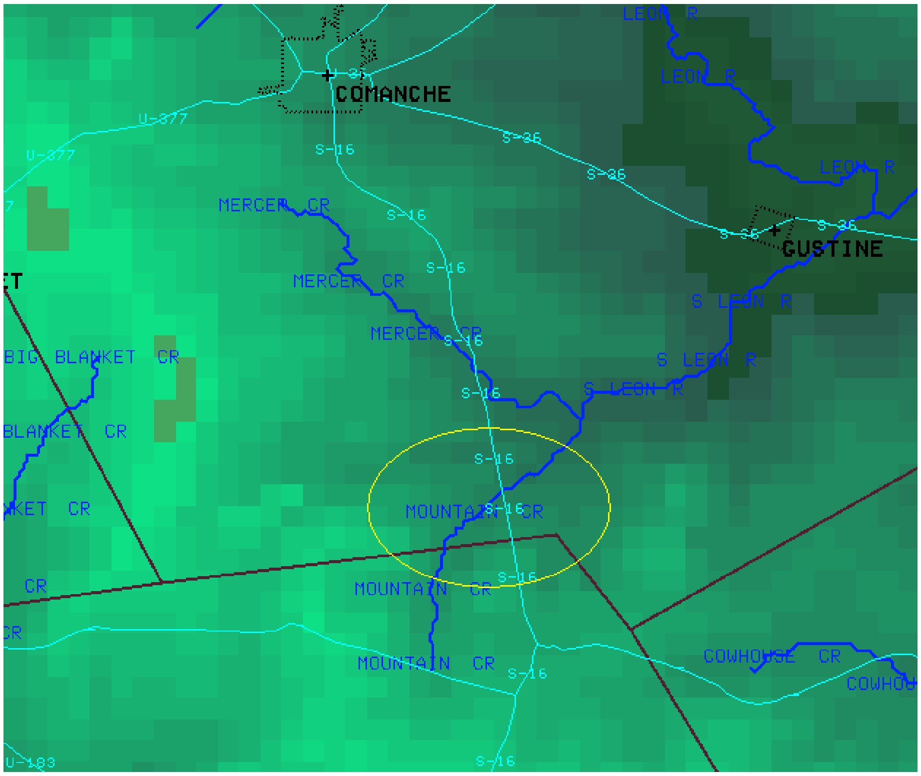
The Calloway Branch originates in south Keller and Watauga and travels south where it joins Big Fossil Creek near Northeast Loop 820 in Haltom City. Big Fossil Creek originates in parts of north and northwest Fort Worth. Both creek watersheds have undergone substantial suburban development in the last few years. A clustering of reports occurs at the intersection of US 377 and I-820 where the Calloway Branch merges with Big Fossil Creek. Several flood events have occurred, with evacuations of a mobile home park on the Calloway Branch in Haltom City a recurring incident. One fatality and a high water rescue event have occurred at this mobile home park. Swift water overtopping of I-820 has also occurred where Fossil Creek crosses the interstate.

The Walker Branch originates in North Richland Hills and travels south through the city of Hurst. A clustering of high water rescues and a fatality event have occurred in south Hurst along this creek where it crosses several roadways.



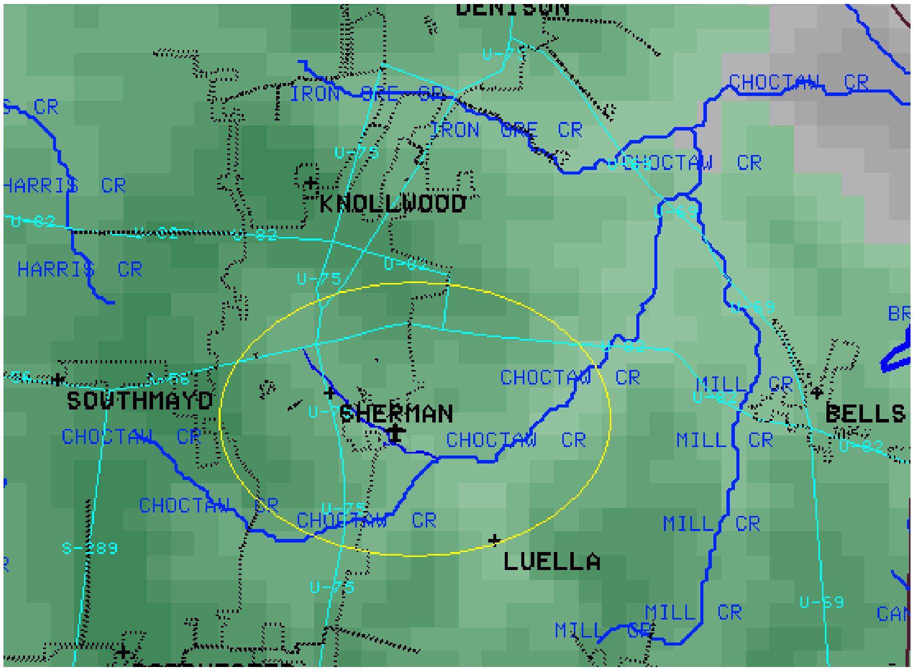
7. Mountain Creek (Comanche County)

Mountain Creek originates in northern Mills County and flows north and northeast into Comanche County. Two separate fatality events have occurred where SH-16 crosses Mountain Creek in extreme southern Comanche County. While population density is very low, the repeating high water rescues and fatalities at this location suggest the creek is especially dangerous when flash flooding is occurring.



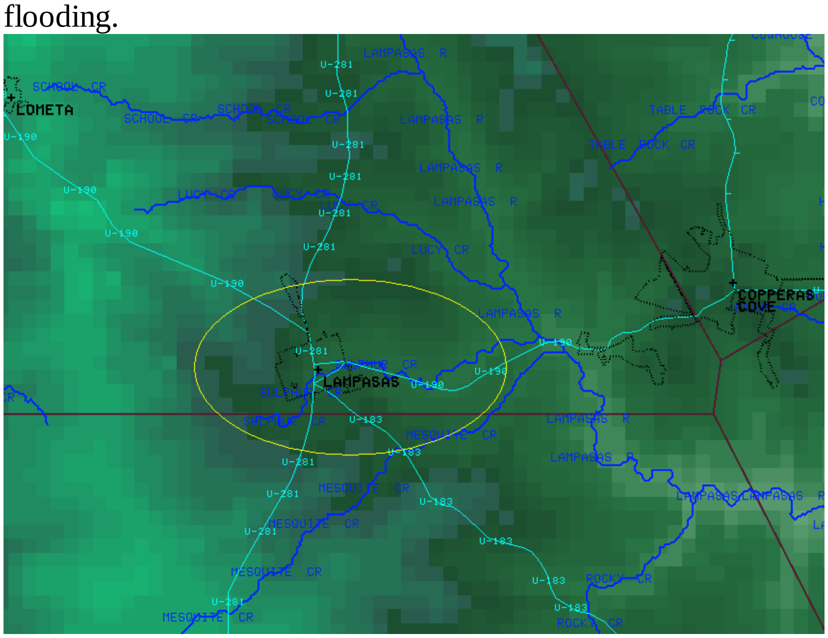
8. Choctaw Creek Basin (Grayson County)

The flash flood concern is specifically the northern branch of the Choctaw that originates in Sherman and runs southeast to join the other part of Choctaw Creek southeast of town. Two fatality events have occurred along this stretch of the creek, but in slightly different locations. Evacuations and flooding of residential structures have also occurred in Sherman near the intersection of the creek with US-75. Several high water rescue events have taken place on farm-to-market roads on the Southeast side of Sherman, just south of the Sherman municipal airport.



9. Sulphur Creek (Lampasas County)

Sulphur Creek begins west of the city of Lampasas and travels east through town and along US-190 in southeast Lampasas County. The creek has not caused fatalities since the start of the database, but several catastrophic floods took place in the city decades ago which resulted in present day flood control measures. Even so, the creek still floods the town, with the biggest events since 1995 resulting in evacuations, damage to residential structures and vehicles, and at least one high water rescue event. Downstream of Lampasas, the Sulphur Creek crisscrosses US-190 several times and has caused high water rescues and highway flooding.



10. Tenmile Creek (Dallas County)

Tenmile Creek originates in southwest Dallas County and travels east through the cities of Desoto and Lancaster. No fatality events have occurred in association with this creek yet. It is primarily a threat to hundreds of homes in Lancaster where evacuations have taken place in the past. Continued suburban development upstream will likely exacerbate flooding in the future for this area, and the Corp of Engineers is investigating flood control mitigation measures.