TORNADO

Hazard Description

Tornadoes are among the most violent storms on the planet. A tornado is a violently rotating column of air extending between, and in contact with, a cloud and the surface of the earth. The most violent tornadoes are capable of tremendous destruction with wind speeds of 250 miles per hour or more. In extreme cases, winds may approach 300 miles per hour. Damage paths can be in excess of one mile wide and 50 miles long.

Seasonal patterns are relevant to tornadoes. Thunderstorms form when warm, moist air collides with cooler, drier air. Since these masses tend to come together during the transition from summer to winter, most thunderstorms and resulting tornadoes occur during the spring (April through June) and fall (October through December). Warning time for tornadoes is minimal and ranges from no warning time to 30 minutes.

The most powerful tornadoes are produced by "super-cell thunderstorms." These storms are affected by horizontal wind shears (winds moving in different directions at different altitudes) that begin to rotate the storm. This horizontal rotation can be tilted vertically by violent updrafts, and the rotation radius can shrink, forming a vertical column of very quickly swirling air. This rotating air can eventually reach the ground, forming a tornado.

Severe thunderstorms can produce tornadoes, high winds, and hail—any of which can cause extensive property damage and loss of life. Tornadoes occasionally accompany tropical storms and hurricanes that move over land. They are the most common to the right and front of the storm center path as it

comes ashore. Tornadoes vary in terms of duration, wind speed and the toll that they take, as shown in Table 8-1.

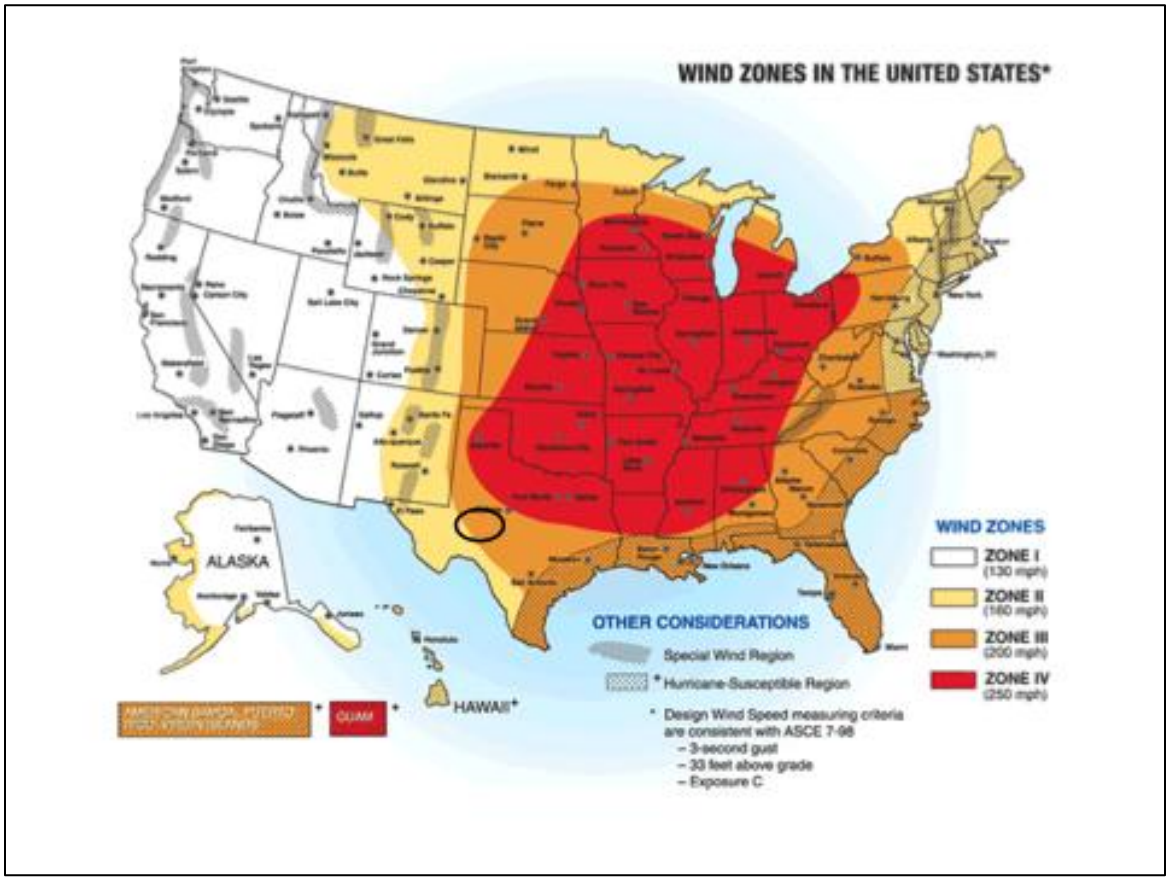
Table 8-1. Variations Among Tornadoes

WEAK TORNADOES	STRONG TORNADOES	VIOLENT TORNADOES
• 69% of all tornadoes • Less than 5% of tornado deaths • Lifetime 1-10+ minutes • Winds less than 110 mph	• 29% of all tornadoes • Nearly 30% of all tornado deaths • May last 20 minutes or longer • Winds 110 – 205 mph	• 2% of all tornadoes • 70% of all tornado deaths • Lifetime can exceed one hour • Winds greater than 205 mph

Location

While historical tornado events in the planning area total 141 during the 60 year reporting period (1950 to 2010), locations of these incidents are completely random and unpredictable. The planning region is located in FEMA Wind Zones II and III; most of the region is located is Zone III, one of the most severe (Figure 8-1). The jurisdictions in the planning area experience a uniform range of intensity for a tornado as evidenced by the location and historical occurrences.

Figure 8-1. FEMA Wind Zones in the United States



Extent

A tornado is given a Fujita rating of 0-5, based on the most intense damage along its path. Wind velocities necessary to produce center damage are often associated with the Fujita category, but that practice is often misleading. The Fujita wind estimates are intended to be based upon the expected damage to a well-built residential structure. Poorly built structures can suffer significant structural damage under lesser winds than the Fujita Scale might suggest. Commercial properties may or may not experience the same failures under high wind speeds as residential property. Thus, the Fujita scale is largely a residential scale, with much more care required in assessment after wind damage to a commercial structure. A wider range of construction techniques and materials can be found in a building section classified as commercial. For example, a concrete/steel reinforced building is much more durable than a typical community convenience store, yet both may be considered commercial in city land use/appraisal data sets.

Table 8-2. The Fujita Tornado Scale[1]

F-SCALE NUMBER	INTENSITY	WIND SPEED (MPH)	TYPE OF DAMAGE DONE	PERCENT OF APPRAISED STRUCTURE VALUE LOST DUE TO DAMAGE
F0	Gale Tornado	40 – 72	Some damage to chimneys; breaks branches off trees; pushes over shallow-rooted trees; damages sign boards.	None Estimated
F1	Moderate Tornado	73 – 112	The lower limit is the beginning of hurricane wind speed; peels surface off roofs; mobile homes pushed off foundations or overturned; moving autos pushed off roads; attached garages may be destroyed.	0% – 20%
F2	Significant Tornado	113 – 157	Considerable damage. Roofs torn off frame houses; mobile homes demolished; boxcars pushed over; large trees snapped or uprooted; light object missiles generated.	50% – 100%
F3	Severe Tornado	158 – 206	Roofs and some walls torn off well-constructed houses; trains overturned; most trees in forest uprooted.	100%
F4	Devastating Tornado	207 – 260	Well-constructed homes leveled; structures with weak foundations blown off some distance; cars thrown and large missiles generated.	100%
F5	Incredible Tornado	261 – 318	Strong frame houses lifted off foundations and carried considerable distances to disintegrate; automobile sized missiles flying through the air in excess of 330 yards; trees debarked; steel reinforced concrete badly damaged.	100%

Since February 2007, the Fujita Scale (above) has been replaced by the Enhanced Fujita Scale (Table8-3 below), which retains the same basic design as its predecessor with six strength categories. The newer scale reflects more refined assessments of tornado damage surveys, standardization, and damage consideration to a wider range of structures.

[1] Source: http://www.tornadoproject.com/fscale/fscale.htm

Table 8-3. Enhanced Fujita Scale for Tornadoes

STORM CATEGORY	DAMAGE LEVEL	3 SECOND GUST (MPH)	DESCRIPTION OF DAMAGES	PHOTO EXAMPLE
EF0	Gale	65 – 85	Some damage to chimneys; breaks branches off trees; pushes over shallow-rooted trees; damages sign boards.	
EF1	Weak	86 – 110	The lower limit is the beginning of hurricane wind speed; peels surface off roofs; mobile homes pushed off foundations or overturned; moving autos pushed off roads; attached garages may be destroyed.	
EF2	Strong	111 – 135	Considerable damage; roofs torn off frame houses; mobile homes demolished; boxcars pushed over; large trees snapped or uprooted; light object missiles generated.	
EF3	Severe	136 – 165	Roof and some walls torn off well-constructed houses; trains overturned; most trees in forest uprooted.	
EF4	Devastating	166 – 200	Well-constructed homes leveled; structures with weak foundations blown off some distance; cars thrown and large missiles generated.	
EF5	Incredible	200+	Strong frame houses lifted off foundations and carried considerable distances to disintegrate; automobile sized missiles flying through the air in excess of 330 yards; trees debarked; steel reinforced concrete badly damaged.	

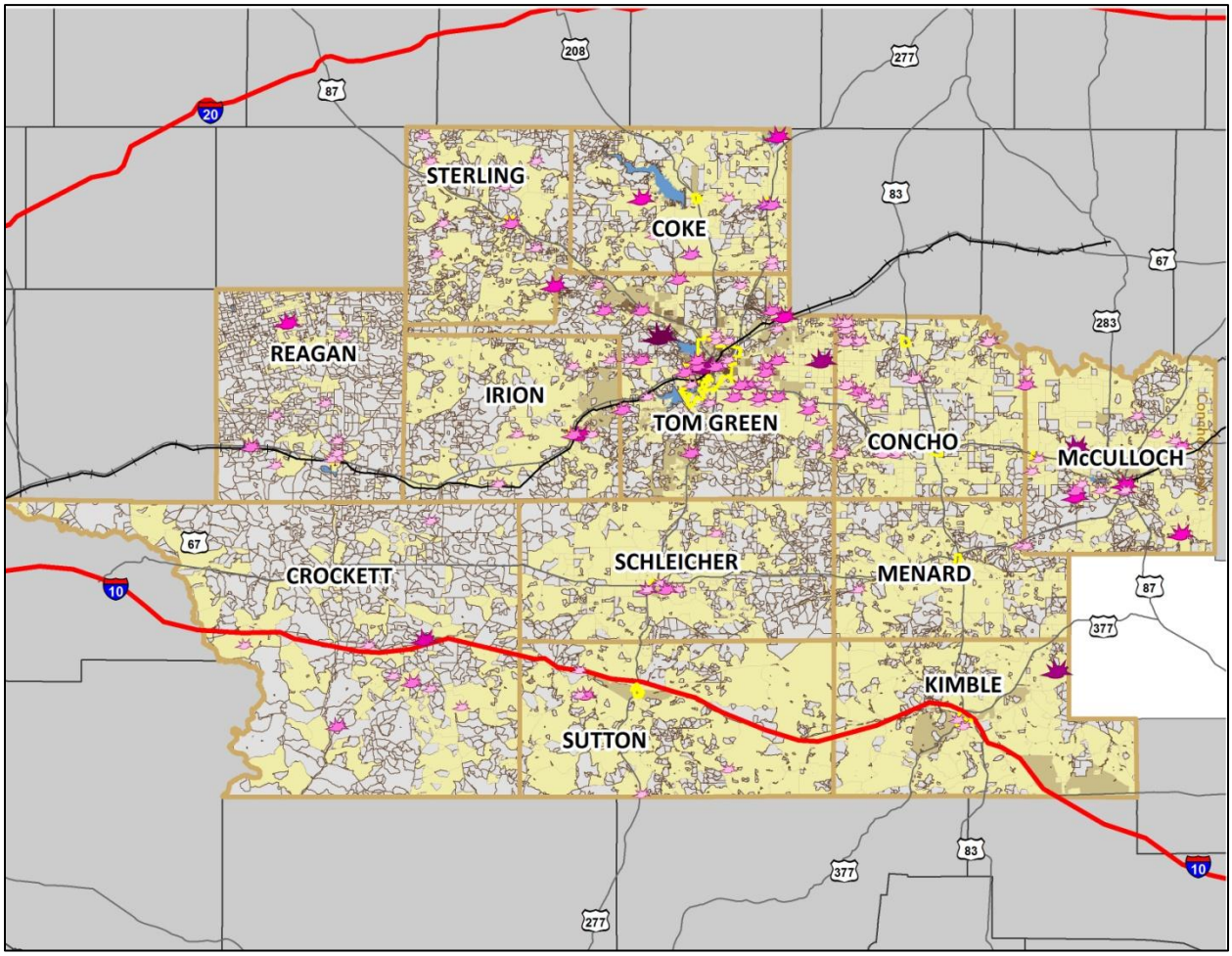
Both the Fujita Scale and Enhanced Fujita Scale should be referenced in reviewing previous occurrences as tornado events prior to 2007 will follow the original Fujita Scale.

Based on the geographic location of the Concho Valley planning area on the US Wind Speed Map, the range of intensity that the planning area can expect from a tornado can range from as low as an EF0, with gusts up to 85 miles per hour, to an EF5, which is an incredible storm with winds over 200 miles per hour. On average, a tornado to be mitigated for each jurisdiction could have winds up to 165 miles per hour, an EF3 from the Enhanced Fujita Scale.

Historical Occurrences

Historical evidence shows that most of the area is vulnerable to tornadic activity. This hazard can result from severe thunderstorm activity basin wide. Figure 8-2 presents a map of historical tornadoes that hit the study region based on information obtained from NOAA and Figures 8-3 to 8-14 provide an illustration of occurrences per county. Table 8-4 following the maps summarizes aggregated historical information by jurisdiction from the National Climatic Data Center (NCDC).

Figure 8-2. Spatial Historical Tornado Events, 1950–2010[2]



[2] Source: NOAA Records

Figure 8-3. Historical Tornado Events in Coke County

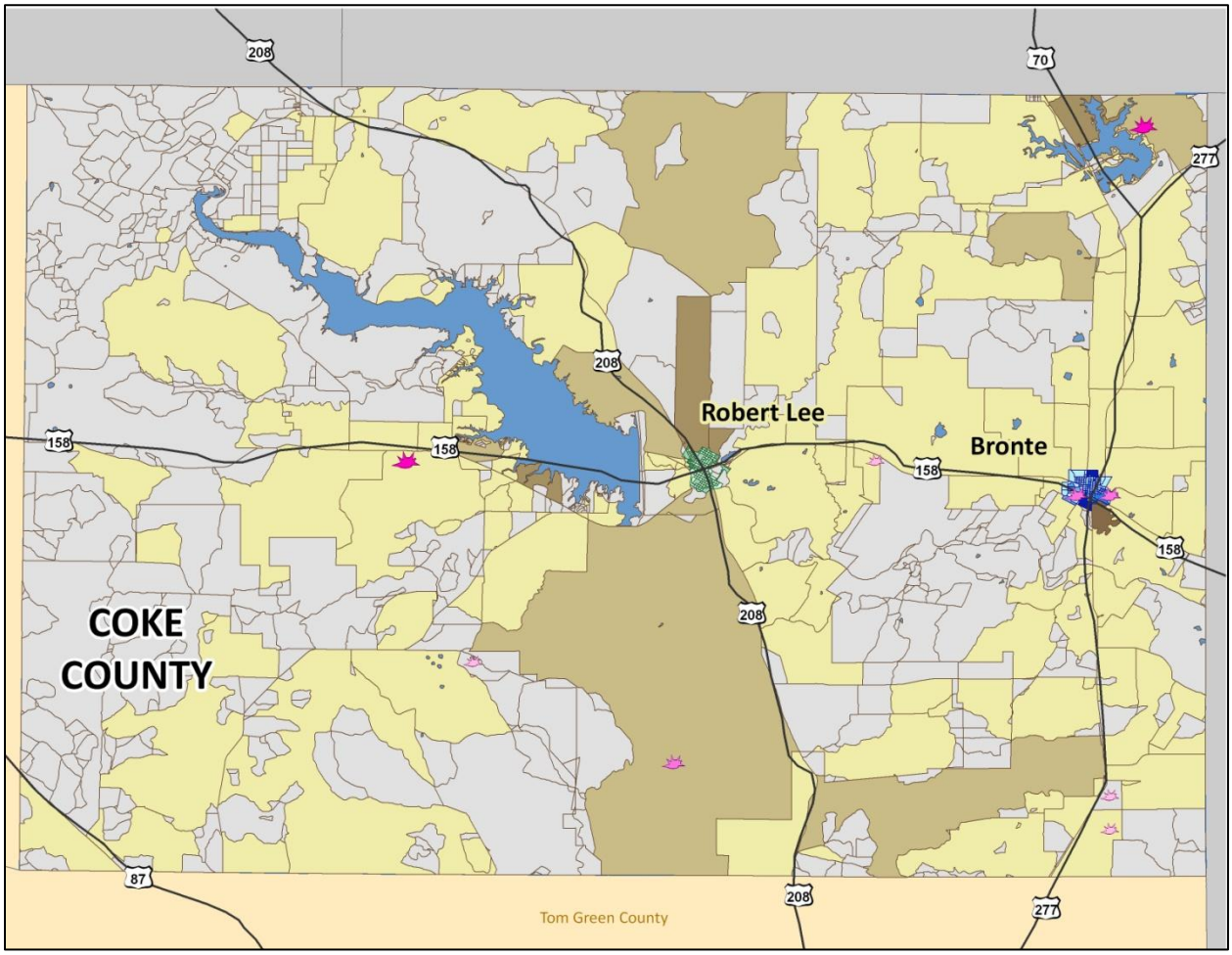


Figure 8-4. Historical Tornado Events in Concho County

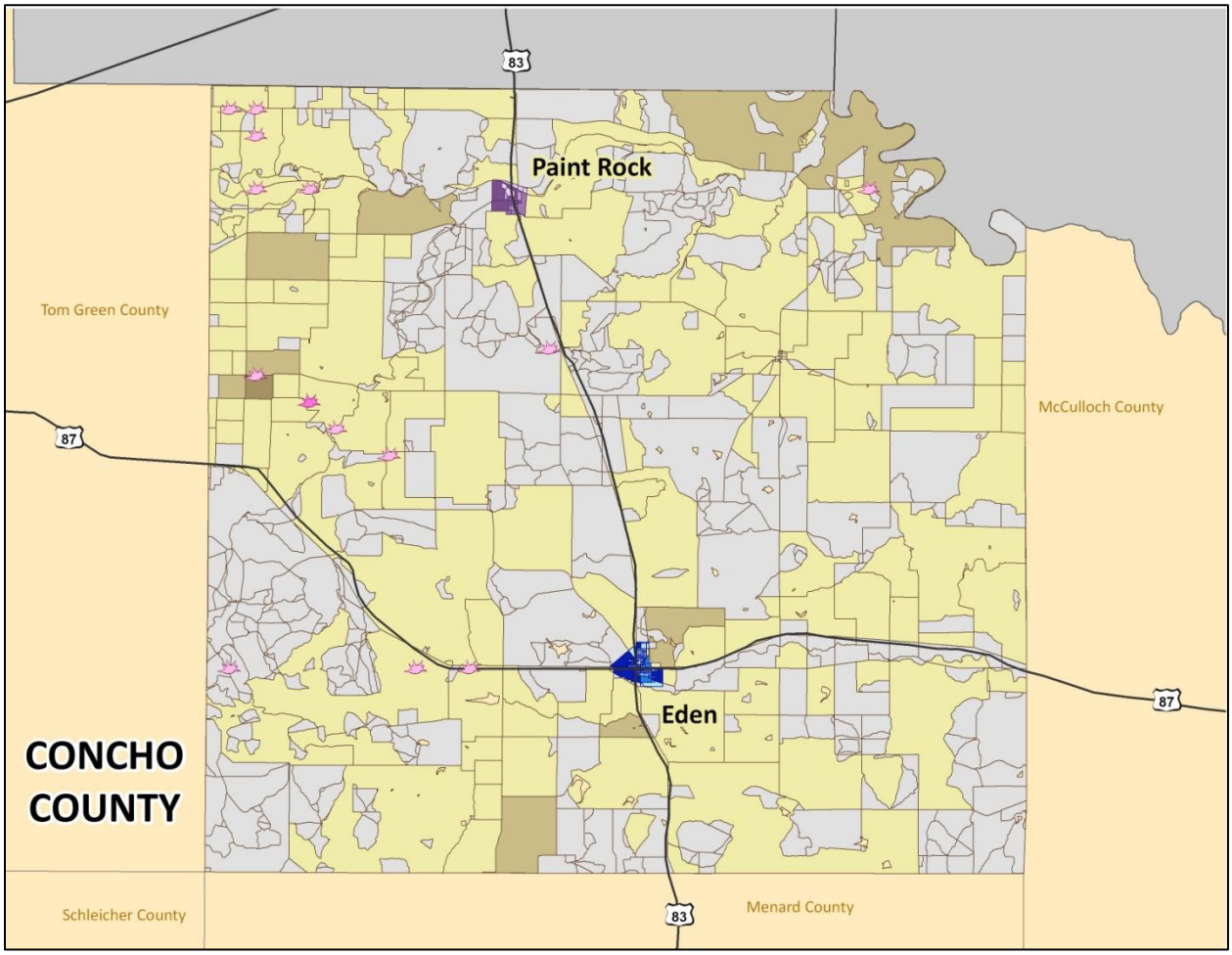


Figure 8-5. Historical Tornado Events in Crockett County

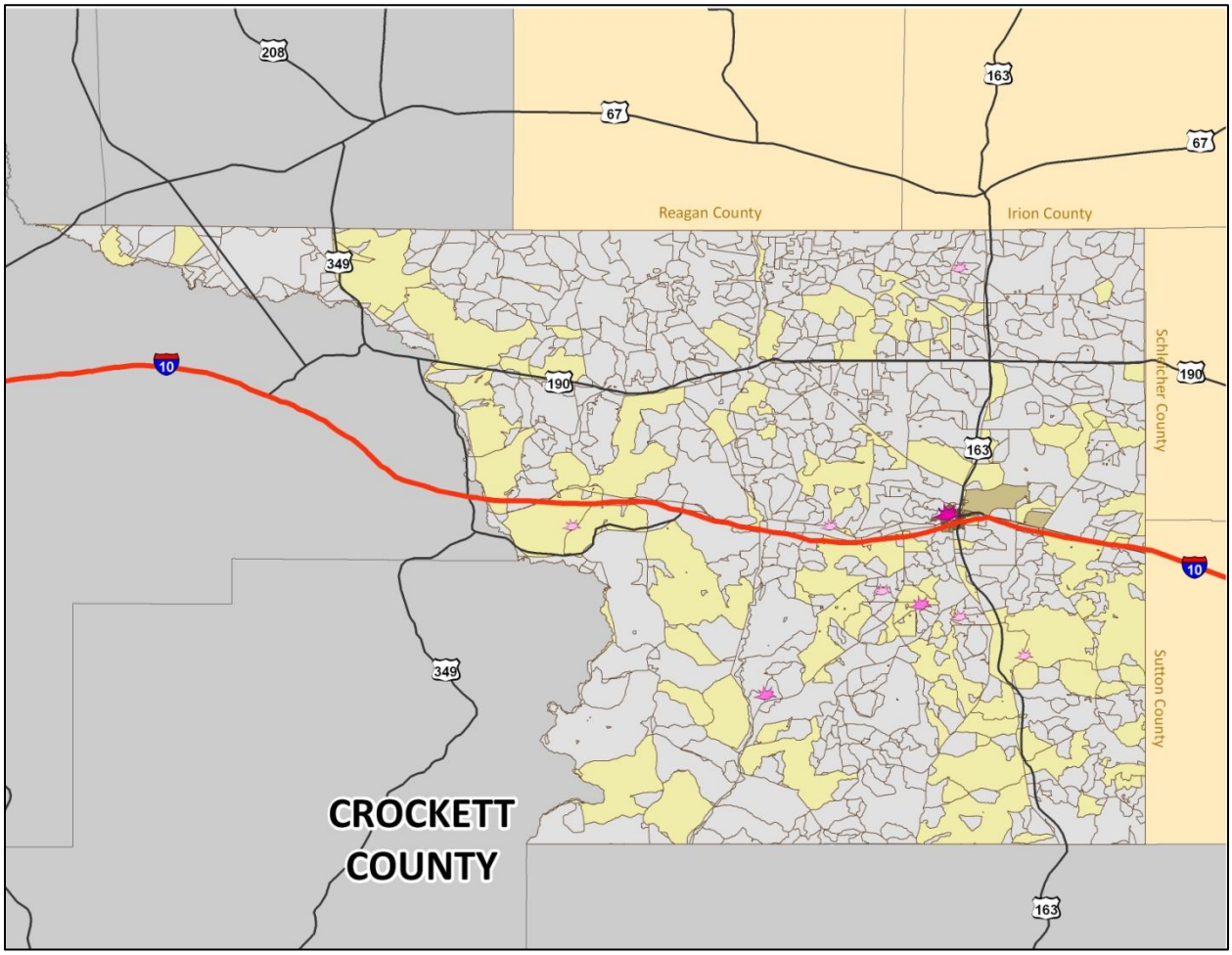


Figure 8-6. Historical Tornado Events in Irion County

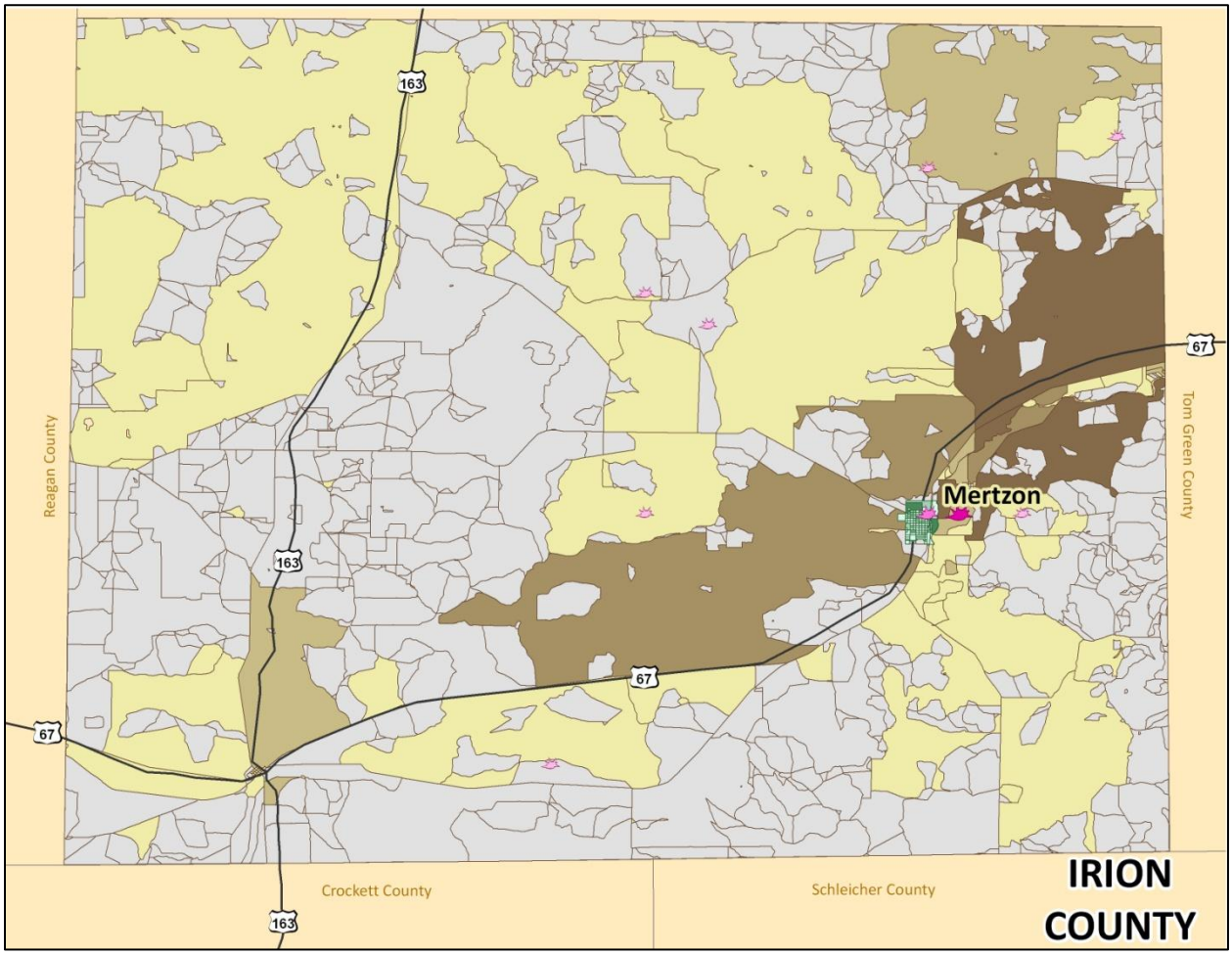


Figure 8-7. Historical Tornado Events in Kimble County

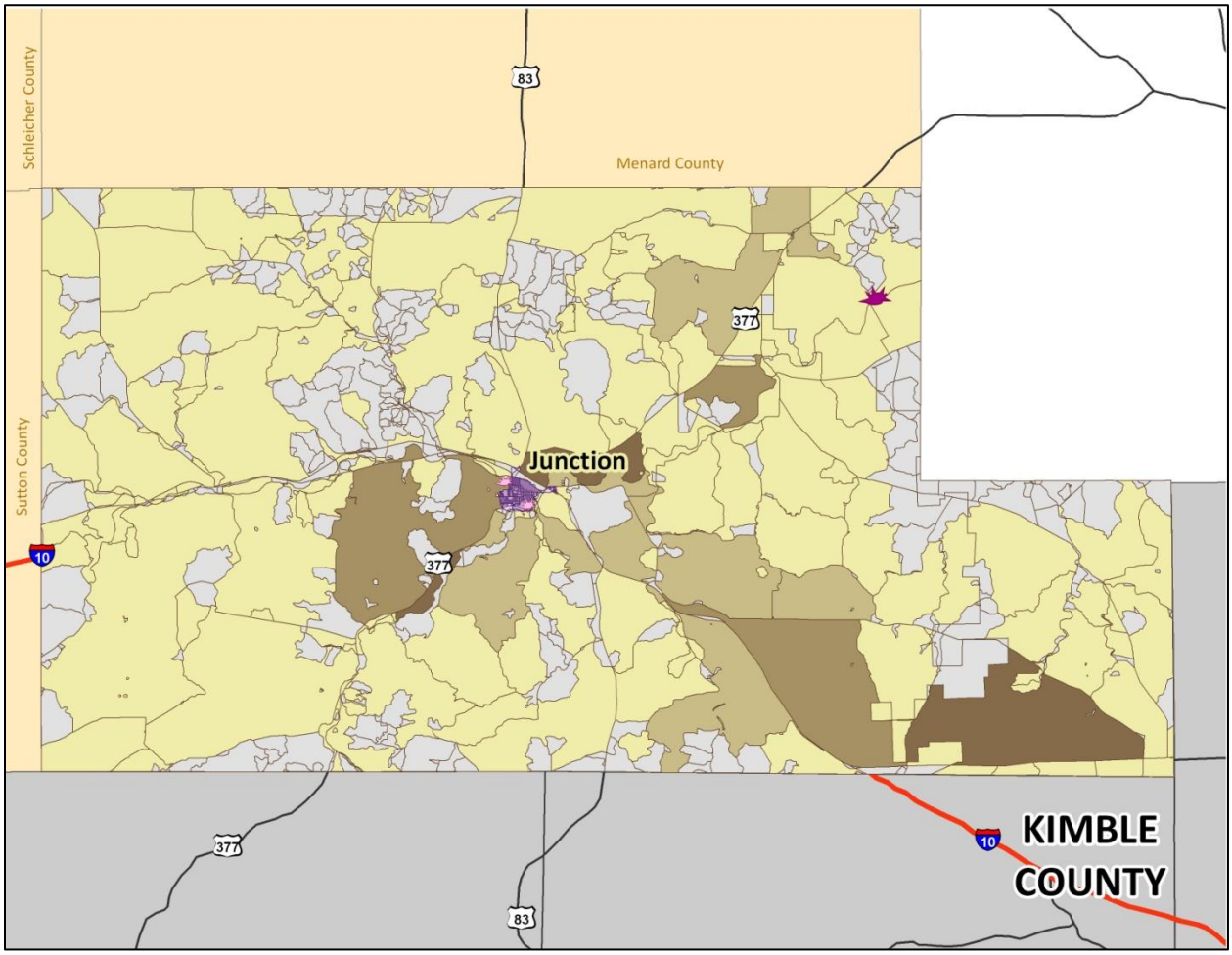


Figure 8-8. Historical Tornado Events in McCulloch County

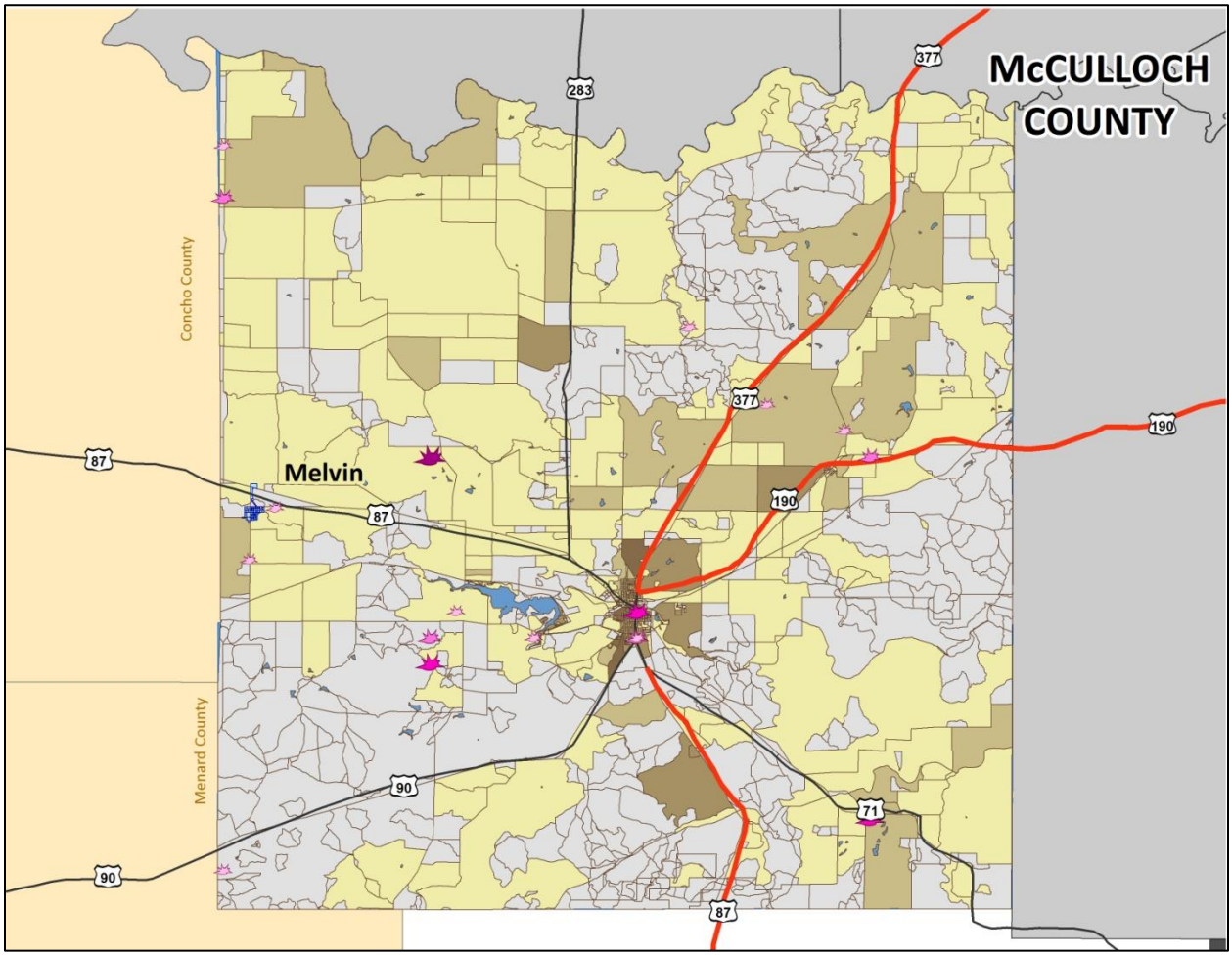


Figure 8-9. Historical Tornado Events in Menard County

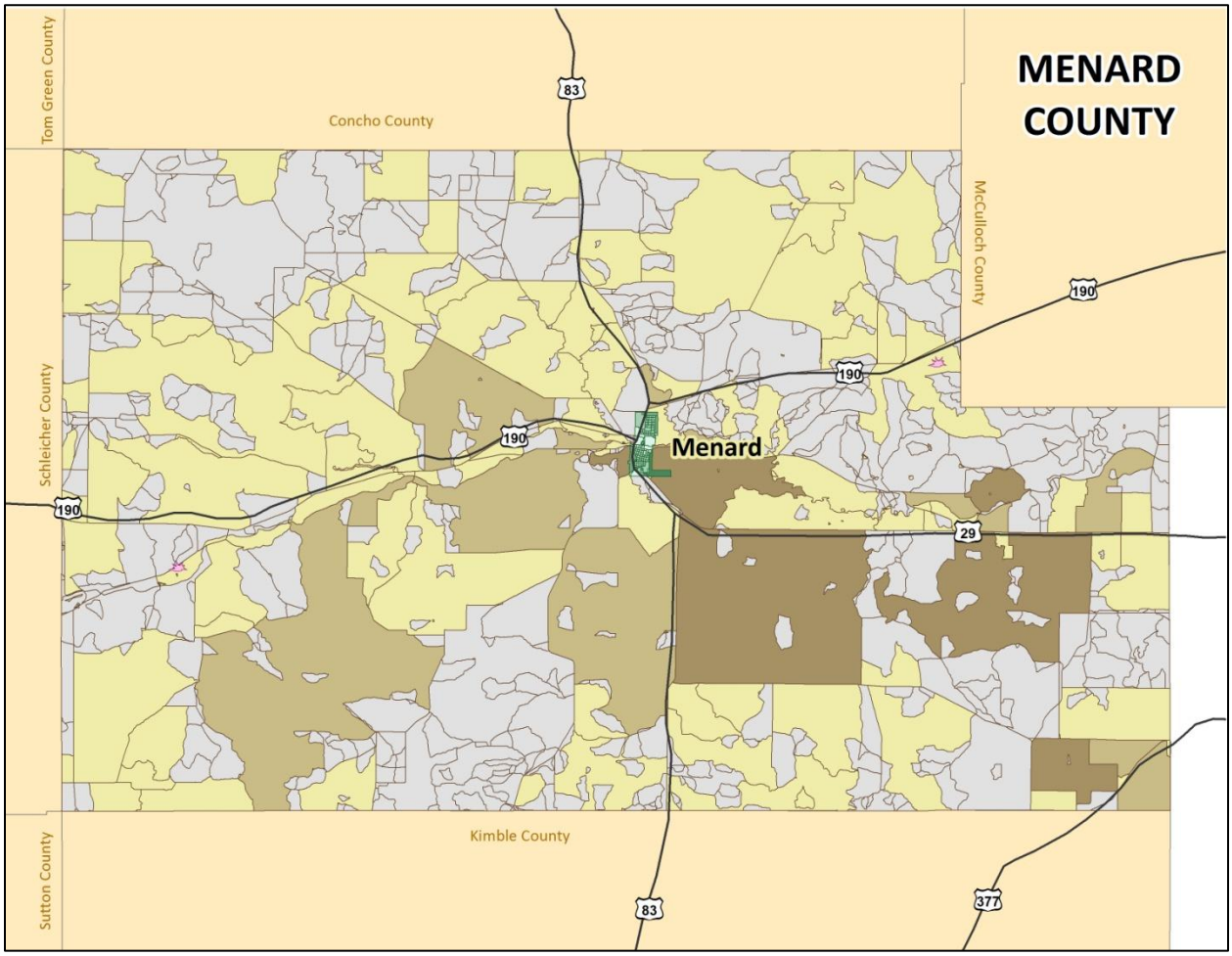


Figure 8-10. Historical Tornado Events in Reagan County

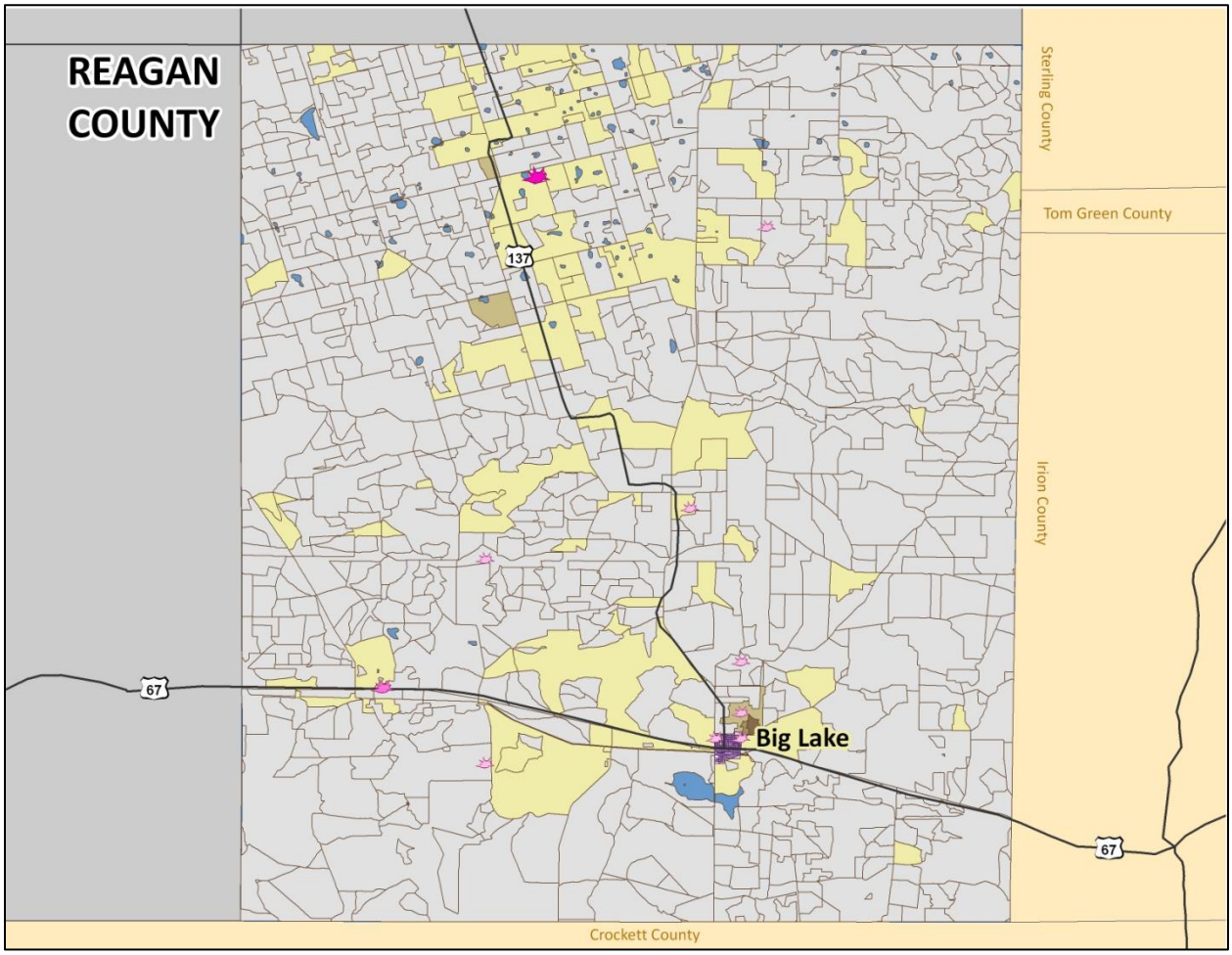


Figure 8-11. Historical Tornado Events in Schleicher County

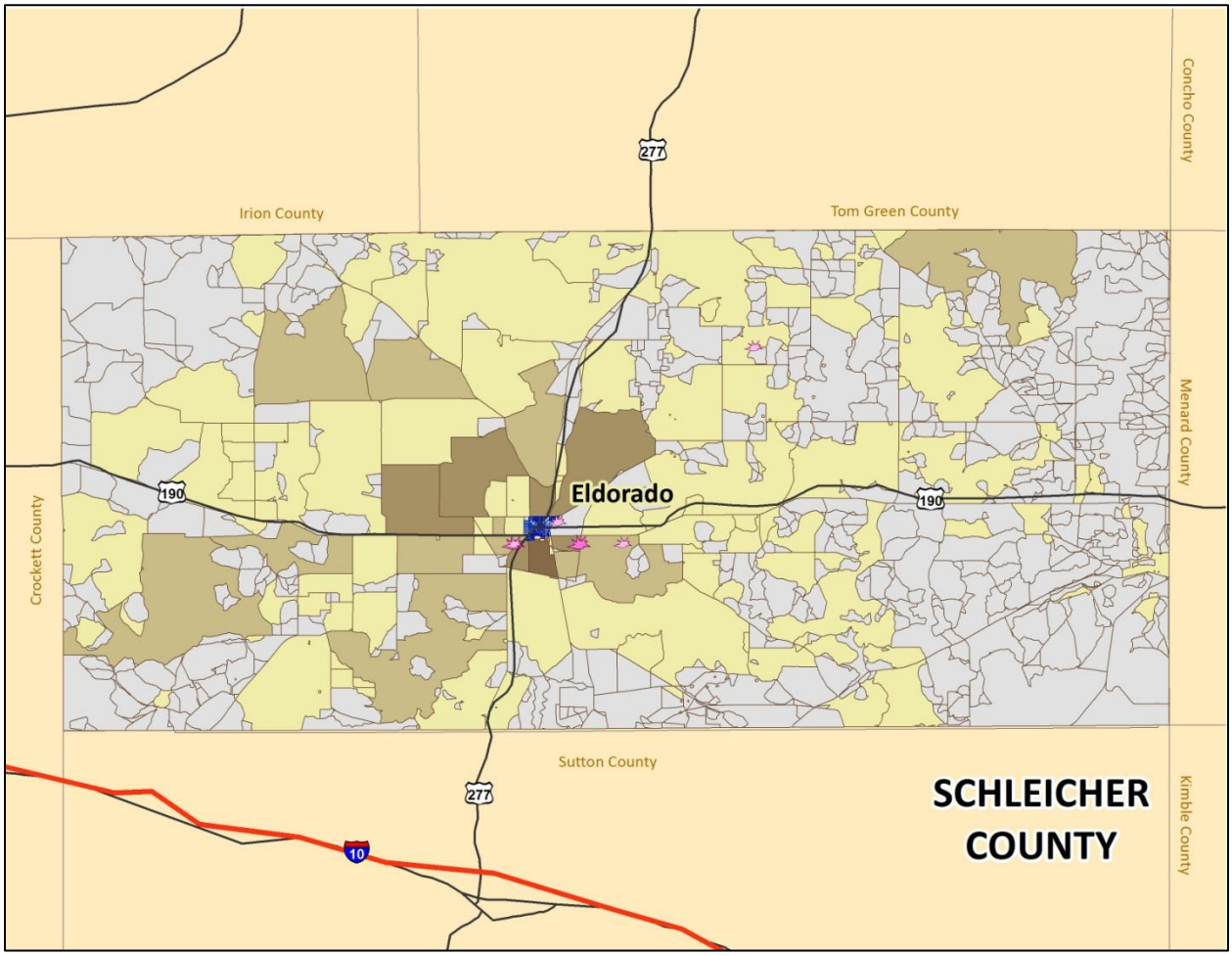


Figure 8-12. Historical Tornado Events in Sterling County

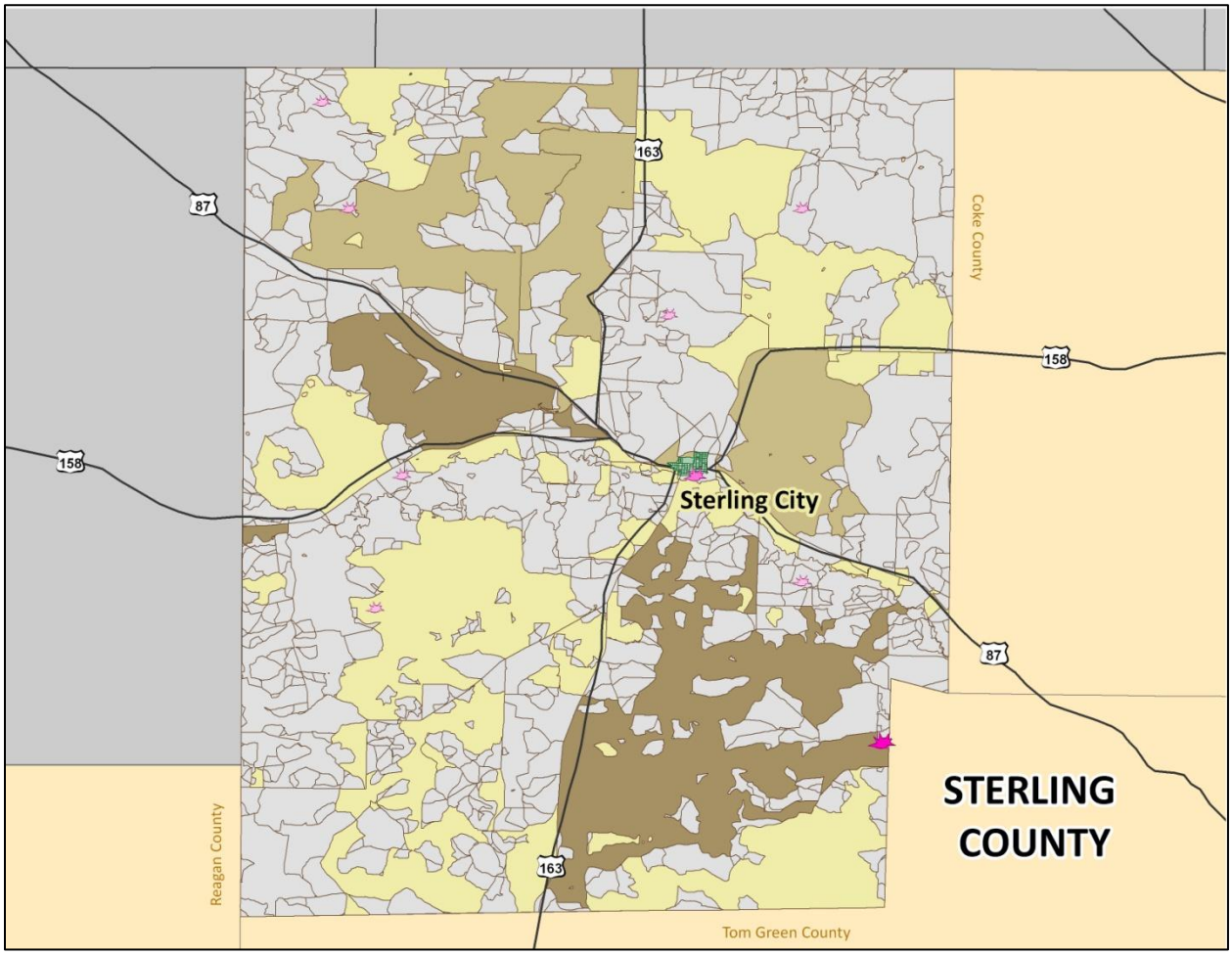


Figure 8-13. Historical Tornado Events in Sutton County

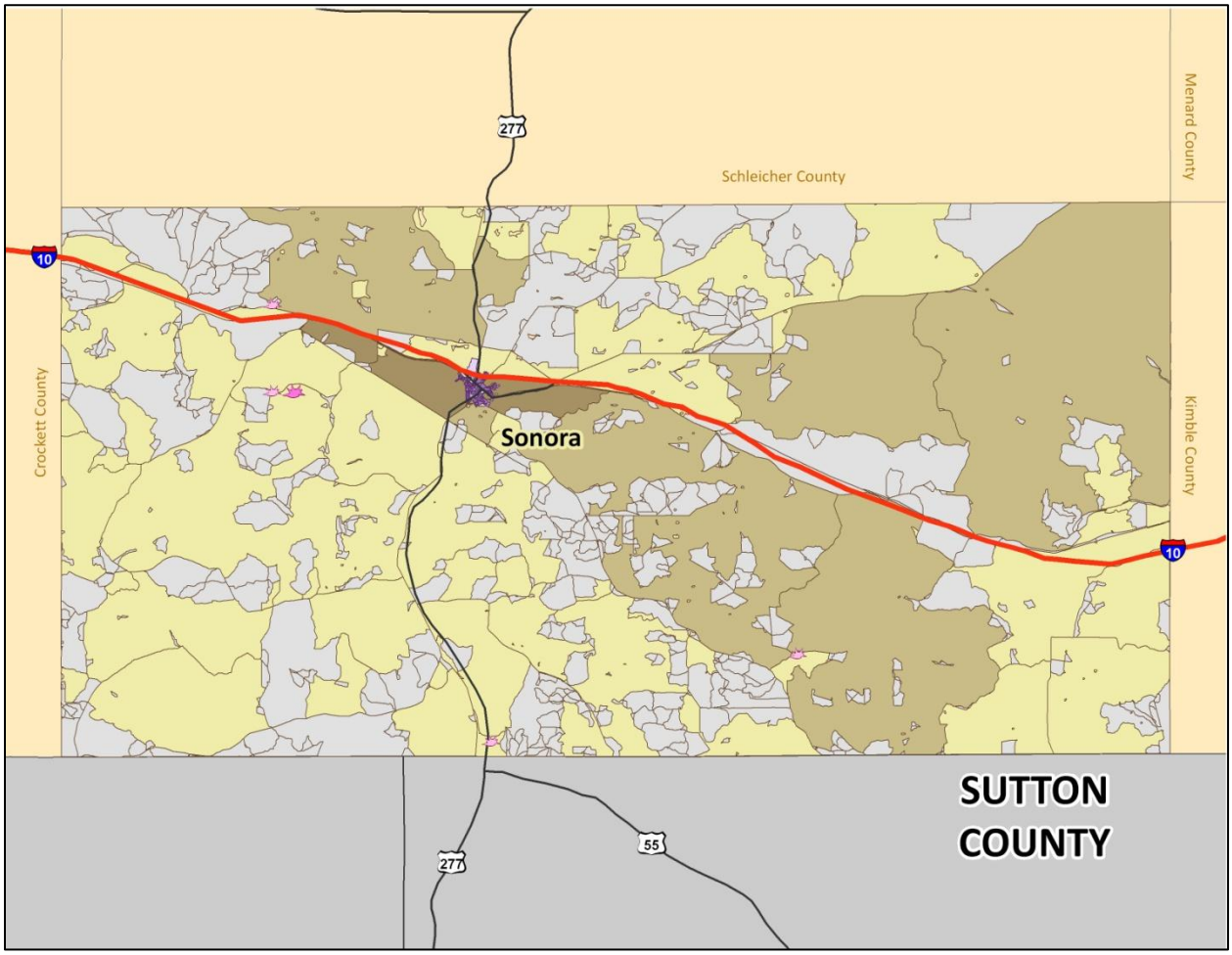
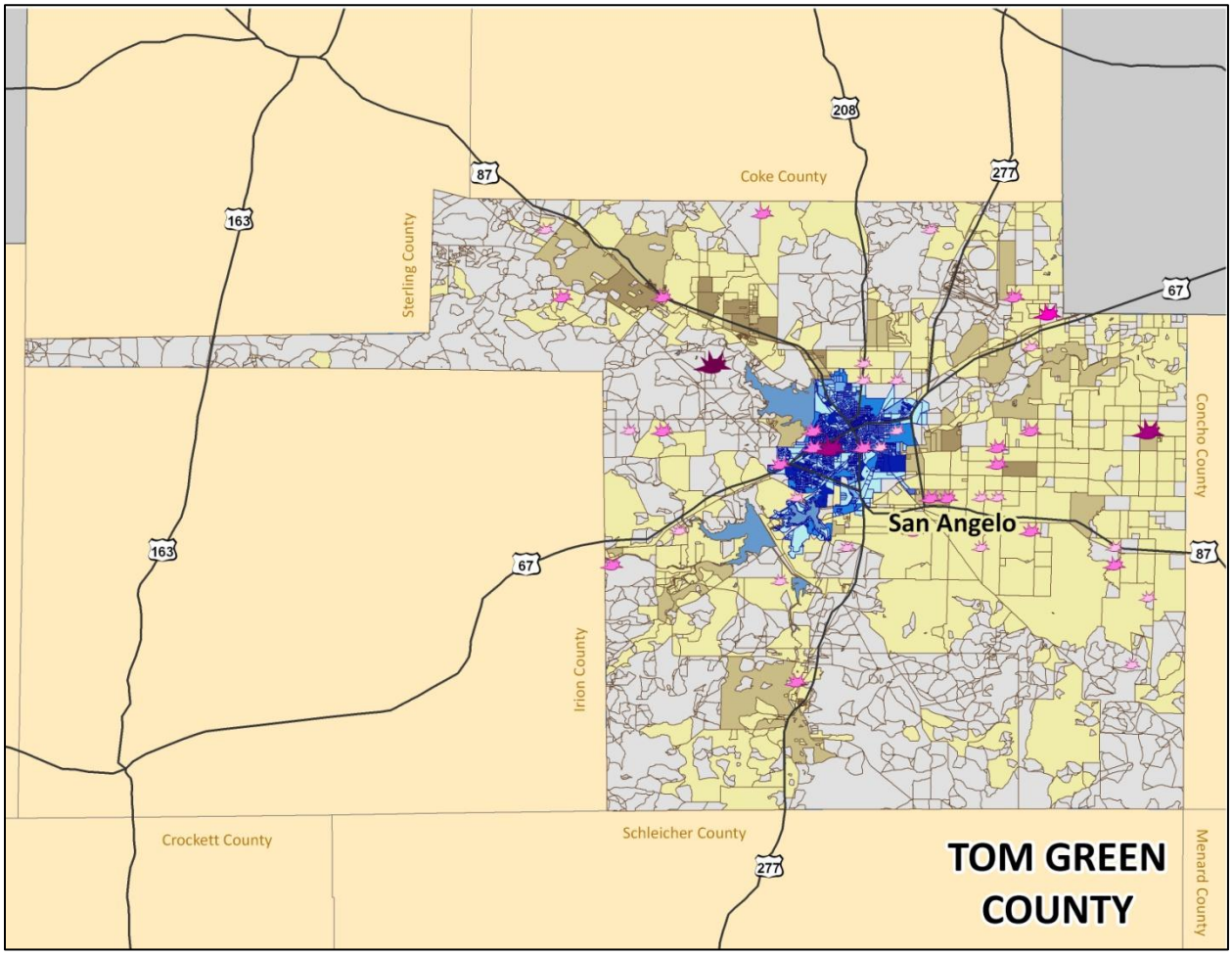


Figure 8-14. Historical Tornado Events in Tom Green County



Historical occurrences provide a basis from which a frequency of return can be determined. Based on reported historical occurrences, the planning area can expect a tornado event to occur anywhere in the region as frequently as 2 tornado events per year within the 12-county planning area.

Table 8-4. Overall Historical Tornado Impact by Jurisdiction

JURISDICTION	NUMBER OF EVENTS	MAGNITUDE (FUJITA SCALE)						MAXIMUM F SCALE
		F0	F1	F2	F3	F4	F5	
Coke County	**9**	**4**	**3**	**2**				**F2**
Bronte	1		1					F1
Robert Lee	2	2						F0
Uninc. Coke County	6	2	2	2				F2
Concho County	**18**	**16**	**2**					**F1**
Eden	4	4						F0
Paint Rock	1	1						F0
Uninc. Concho County	13	11	2					F1
Crockett County	**9**	**6**	**2**	**1**				**F2**
(No Incorporated Cities)	9	6	2	1				F2
Irion County	**9**	**7**	**1**	**1**				**F2**
Mertzon	6	5	1					F1
Uninc. Irion County	3	2		1				F2
Kimble County	**3**	**2**			**1**			**F3**
Junction	1	1						F0
Uninc. Kimble County	2	1			1			F3
McCulloch County	**20**	**12**	**4**	**3**	**1**			**F3**
Melvin	1	1						F0
Uninc. McCulloch County	19	11	4	3	1			F3
Menard County	**2**	**2**						**F0**
Menard	0							
Uninc. Menard County	2	2						F0
Reagan County	**10**	**8**	**1**	**1**				**F2**
Big Lake	0							
Uninc. Reagan County	10	8	1	1				F2
Schleicher County	**7**	**3**	**4**					**F2**
Eldorado	6	2	4					F1
Uninc. Schleicher County	1	1						F0
Sterling County	**11**	**7**	**3**	**1**				**F2**

JURISDICTION	NUMBER OF EVENTS	MAGNITUDE (FUJITA SCALE)						MAXIMUM F SCALE
		F0	F1	F2	F3	F4	F5	
Sterling City	6	6						F0
Uninc. Sterling County	5	1	3	1				F2
Sutton County	**5**	**4**	**1**					**F1**
Sonora	4	4						F0
Uninc. Sutton County	1		1					F1
Tom Green County	**38**	**14**	**20**	**1**	**2**	**1**		**F4**
San Angelo	8	5	3					F1
Uninc. Tom Green County	30	9	17	1	2	1		F4
TOTALS FOR STUDY AREA	**141**	**85**	**41**	**10**	**4**	**1**	**0**	**F4**

Significant Past Events

20 February 1997 – Schleicher County
A tornado that was embedded in very heavy rains destroyed four hangars and overturned an airplane at the Eldorado airport. The tornadic winds also toppled a grain silo on a farm ten miles north of Eldorado.

9 April 2008 – Tom Green County
The NSW storm survey team found a tornado track across the Houston Harte Expressway that caused severe damage to a large distribution warehouse. Also, the tornado overturned two trailers, knocked down a communication tower, utility poles, and power lines, flipped cars, damaged roofs, and road signs along the expressway. A couple of truck drivers who rode out the storm reported their tractor trailers were lifted at times during the tornado. One motorist in a smaller truck took shelter at the nearby gas station and reported being lifted up while he was in his small truck and seeing a small tornado.

Probability of Future Events

With over 140 events in the region over the reporting period, it can be expected that a frequency of return may be as high as two to three tornadoes in the CVCOG Region in any given year. It is highly likely that the planning area can expect a tornado event at least once annually.

Vulnerability and Impact

The CVCOG participating jurisdictions are uniformly exposed to wind speeds up to 160 to 200 miles per hour (EF3 tornado). All assets and population in the region are equally

vulnerable to the tornado hazard; however more vulnerable areas may be in unincorporated areas of counties where construction codes are not enforceable.

The potential severity of damages is partially defined by historic loss and loss estimates total over $8.9 billion for the region over the 60-year incident reporting period as shown in Table 8-5.

Table 8-5. Potential Annualized Losses by Jurisdiction[3]

JURISDICTION	NUMBER OF EVENTS	TOTAL ESTIMATED EXPOSURE	ANNUALIZED LOSS (AL)
Coke County	**9**	**$291,393,000**	**$18,881**
Bronte	1	$54,912,000	$0
Robert Lee	2	$70,672,000	$0
Uninc. Coke County	6	$165,809,000	$18,881
Concho County	**18**	**$187,173,000**	**$2,374**
Eden	4	$92,364,000	$371
Paint Rock	1	$11,315,000	$0
Uninc. Concho County	13	$73,494,000	$2,003
Crockett County	**9**	**$264,006,000**	**$15,212**
(No Incorporated Cities)			
Irion County	**9**	**$112,315,000**	**$0**
Mertzon	6	$38,576,000	$0
Uninc. Irion County	3	$73,739,000	$0
Kimble County	**3**	**$345,134,000**	**$16,205**
Junction	1	$152,827,000	$0
Uninc. Kimble County	2	$195,307,000	$16,205
McCulloch County	**20**	**$459,543,000**	**$127,524**
Melvin	1	$8,875,000	$0
Uninc. McCulloch County	19	$450,668,000	$127,524
Menard County	**2**	**$148,418,000**	**$1,144**
Menard	0	$75,051,000	$0
Uninc. Menard County	2	$73,397,000	$1,144
Reagan County	**10**	**$178,789,000**	**$30,144**
Big Lake	0	$146,223,000	$0
Uninc. Reagan County	10	$27,827,743	$30,144
Schleicher County	**7**	**$163,684,000**	**$131,841**

[3] Source: HAZUS-MH MR4 (total exposure) and NCDC (annualized losses)

JURISDICTION	NUMBER OF EVENTS	TOTAL ESTIMATED EXPOSURE	ANNUALIZED LOSS (AL)
Eldorado	6	$95,802,000	$131,841
Uninc. Schleicher County	1	$66,277,606	$0
Sterling County	**11**	**$89,092,000**	**$0**
Sterling City	6	$66,795,000	$0
Uninc. Sterling County	5	$18,645,655	$0
Sutton County	**5**	**$259,042,000**	**$692**
Sonora	4	$158,154,000	$692
Uninc. Sutton County	1	$19,012,957	$0
Tom Green County	**38**	**$6,412,709,000**	**$3,204,683**
San Angelo	8	$5,615,423,000	$46,706
Uninc. Tom Green County	30	$701,041,341	$3,157,977
TOTALS FOR STUDY AREA	**141**	**$8,903,862,000**	**$3,548,700**

While 141 tornado events of magnitudes F0 through F4 have impacted the planning area from 1950 to 2010; less than one tenth of one percent of assets have been destroyed or suffered major damage. Therefore, potential severity of tornado impact is limited, meaning injuries and illnesses are treatable with first aid, critical facilities would only be shut down for 24 hours or less, and less than 10 percent of property would be destroyed or suffer major damage.