4.4 Lightning

4.4.1 Hazard Profile


Lightning can strike 10 miles ahead of an advancing rain column

Lightning is generated by the buildup of charged ions in a thundercloud. When the buildup interacts with prime conductive objects or surfaces on the ground, the result is a discharge of a lightning bolt. Thunder is the sound of the shock wave produced by the rapid heating and cooling of the air near the lightning bolt.The air in the channel of a lightning strike can reach temperatures higher than 50,000° Fahrenheit.

Location

Lightning can strike 10 miles out from the rain column, and lightning deaths often occur under a clear sky ahead of the storm. This is largely because people wait until the last minute to seek shelter – not fully comprehending the behavior and true danger of lightning.

As lightning is a by-product of thunderstorms, the entire jurisdiction of Canadian County is subject to the exposure and effects of lightning events.

Measurement

Lightning can be measured in a variety of ways: lightning flash frequency, flash intensity, and lightning impacts. One method is VAISALA's free lightning explorer map, described below (http://www.lightningstorm.com/explorer.html), which uses information from the National Lightning Detection Network.

The U.S. National Lightning Detection Network is comprised of about 105 antennae connected to a central processor that records the time, polarity, signal strength, and number of strokes of each cloud-to-ground lightning flash detected over the United States. A combination of time of arrival and direction finding technology is used to locate the flash. Depending on the location within the network, GAI claims a location accuracy of a few km, with a detection probability greater than 60%. The flash time is accurate to better than 2 milliseconds.

The 15-minute lightning product is made by binning the number of flashes that occur over a 15-minute period to a pixel. A pixel is 0.0718954 degrees (latitude) by 0.0765027 degrees (longitude) (approximately 8 km by 8 km). The grid consists of 459 pixels in the North-South direction and 915 pixels in the East-West direction. Lightning flash values can range from 0-254. A value of 255 denotes 255 or more flashes occurred in the pixel during the 15 minute period. (Note: the maximum pixel value observed is about 100).

A daily log is also produced containing the number of flashes that occurred in each pixel during a 24-hr period (00 UTC to 00 UTC). The binned values are scaled by 5, such that a value of 1 corresponds to 1-5 flashes, 2 from 6-10, etc. A value of 255 indicates more than 1,270 flashes occurred in the pixel over the 24-hour period.

Both the 15-minute and daily products are generated in realtime and the annotation (in the hdf file) identifies files run in realtime. Missing data occurs in the realtime data, so the raw data file is checked for completeness and data gaps are filled. The products (daily and 15-minute) are then reprocessed and the annotation changed to denote that the files have been quality assured.

Extent/Severity

Canadian County has reported nine lightning events between 1995 and 2009 that resulted in $181,000 in damage (the file actually only contains strikes between 1993 and 2005 leaving a four-year recent gap in data). It is likely that there were many unreported lightning events producing unreported damage. Given what data exists, Canadian County, its communities and public school systems can expect a damaging lightning strike about once every 1.6 years, which causes approximately $20,111 damage. Although the entire jurisdiction of Canadian County is at risk from lightning, the probable extent of a damaging strike depends upon the type of structure that is hit, the age, condition and density of structures in the strike area, the community's fire response capability and the presence or absence of lightning warning and protection systems.

According to information provided by staff at the National Weather Service in Tulsa, Cloud-to-ground (CG) lightning is classified as either negative or positive. Positive CG flashes make up approximately 5-10% of the total CG lightning. Positive CG flashes typically originate in the upper portion of thunderstorms. This increases the distance between the charge region within the cloud and the earth. Stronger charge is needed to overcome the electric potential of this distance compared to negative CG flashes, which originate lower in the cloud. The result is positive CG flashes with higher peak current compared to negative CG flashes (positive CG flashes may have a peak current 10x that of a negative CG flash).

The National Weather Service explained that positive CG flashes are often observed away (as far as 10 miles or more) from the main precipitation area of a thunderstorm due to the location of the upper charge region. This poses an extra fire danger and can catch people who are outdoors off guard. For example, if a positive CG flash ignites a wildfire, there may not be any rain to help extinguish the fire. Once in contact with an object on the ground, a CG flash can have multiple return strokes (this looks like the flash is flickering), a continuous current (this looks like the flash remains illuminated for a length of time and does not flicker), or a combination of these two.

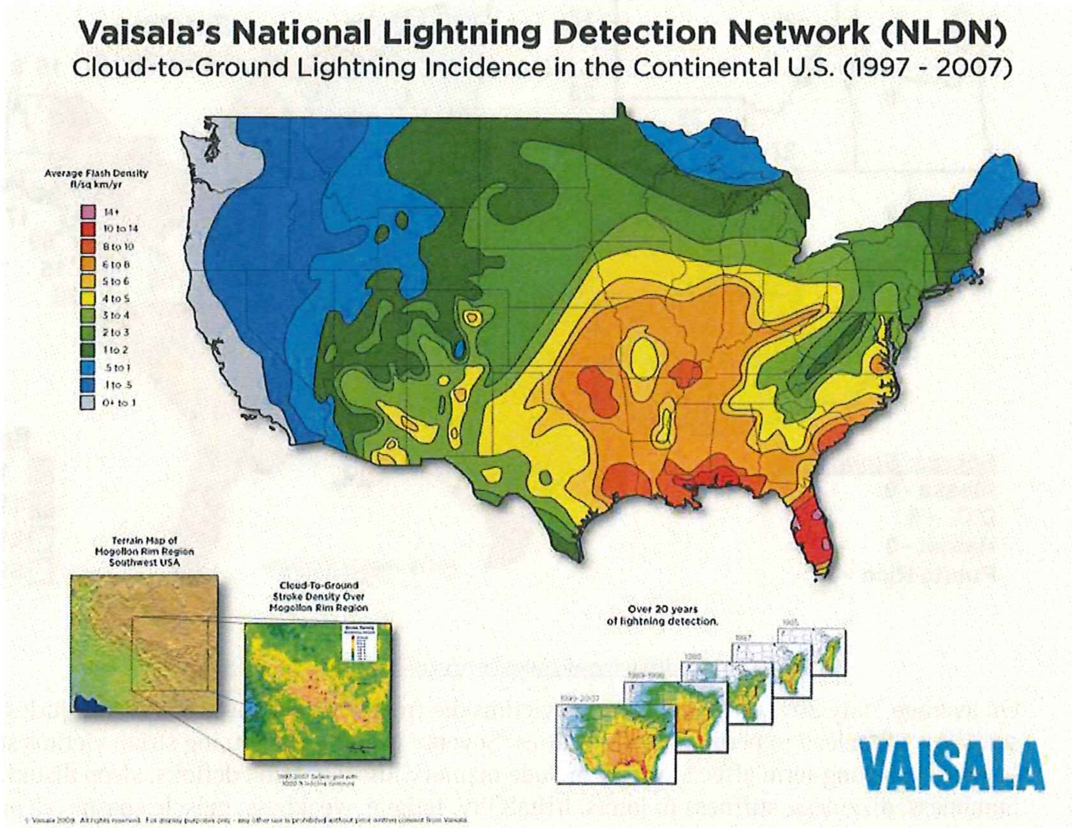
Continuous current is more destructive and leads to a greater chance of fire. This is because the electricity remains in contact with an object for a longer period of time, allowing for greater heat to build up (lightning can be as hot as 50,000 degrees Fahrenheit). Positive CG flashes predominantly have continuous currents. Positive CG flashes are more likely to cause damage than negative CG flashes due to the likelihood of continuous current and high peak current. It is important to remember that all lightning can cause damage.

Based on the information provided by the National Weather Service, Canadian County, its communities and public school systems consider a negative cloud-to-ground flash with multiple return strokes, that causes no loss of life or injury and less than $1,000 in property damage, to be a minor severity lightning event; and a positive cloud-to-ground flash with a continuous or high peak current, that causes loss of life and/or injury and more than $1,000 property damage, to be a major severity lightning event.

Frequency

According to the Vaisala Flash Density Map, Figure 4-10, Canadian County, its communities and schools, may experience between 6 and 8 lightning flashes per sq km per year.

Figure 4–10: Vaisala Cloud-to-Ground Lightning Incidence (Flash Density) Map



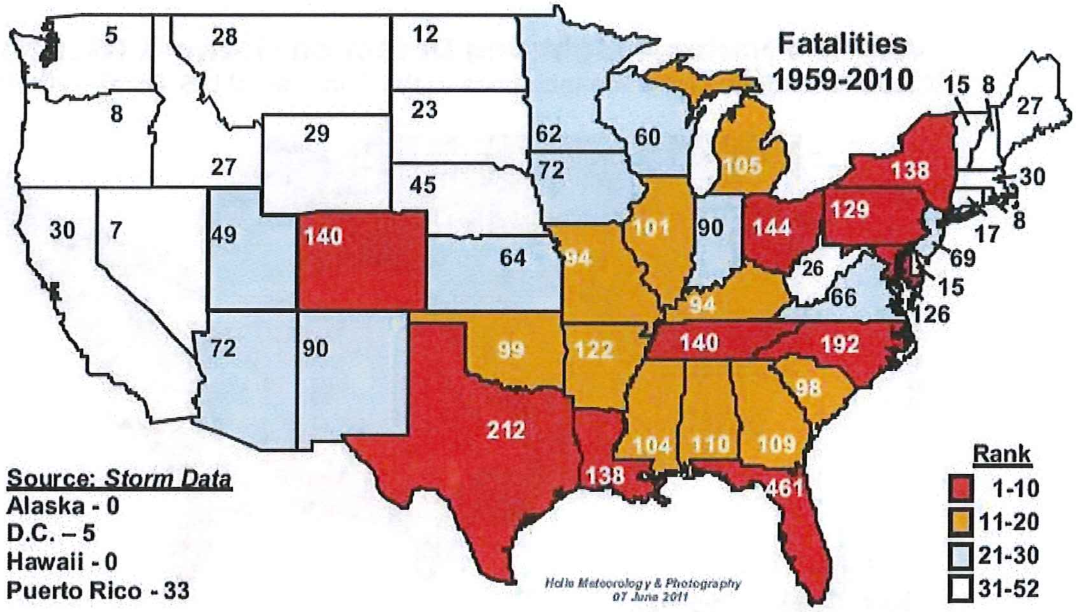
National Geographic reports that lightning strikes the surface of the earth approximately 100 times every second. According to the National Lightning Detection Network, researchers define a flash as all cloud-to-ground discharges which occur within 3 miles of each other within a one-second interval. In a 2006 report released by the NLDN, for the time period between 1996 and 2005, Oklahoma ranked 9th in the U.S. for average lightning flashes per year (966,295 flashes/year), which represents an average of 5.3 lightning flashes per square kilometer—about the number estimated by the Vaisala Scale.

Impact

The impact of this hazard could include people displaced from their homes, businesses being closed, and financial loss due to urban fire, wildfire, power outages, and damaged electronic equipment.

Lightning casualties and damages increase gradually through the spring when the thunderstorm season begins for most of the country, and peak during the summer months. In the reporting period 1959-2010, lightning claimed 99 casualties (see Figure 4-11). The months most notorious for lightning incidents are June (21%), July (30%) and August (22%). The most injurious lightning strikes have been shown to occur on Sundays, Wednesdays and Saturdays between the hours of 12:00 noon and 6:00 pm.

Figure 4-11: Lightning Deaths by State 1959-2010



Source: http://www.lightningsafety.noaa.gov/stats/59-10_fatalities_rates.pdf

On average, only 20% of lightning strike victims die from their injuries. However, injuries to survivors often lead to permanent disabilities. Seventy percent of lightning strike victims suffer from serious long-term effects, which include memory loss, attention deficits, sleep disturbance, numbness, dizziness, stiffness in joints, irritability, fatigue, weakness, muscle spasms, depression, and an inability to sit for long periods.

4.4.2 History/Previous Occurrences

In 2009, there were 31 deaths from lightning strikes in the United States. Florida was hardest hit with 5 deaths, followed by Texas and North Carolina with 3, and California, New York and Minnesota with 2.

Between 2000 and 2006 it was reported that an average of 12,000 wildland fires were started by lightning each year. This amounts to an average of 5.2 million acres burned annually. In 2005, a lightning-caused methane gas explosion in West Virginia killed twelve miners.

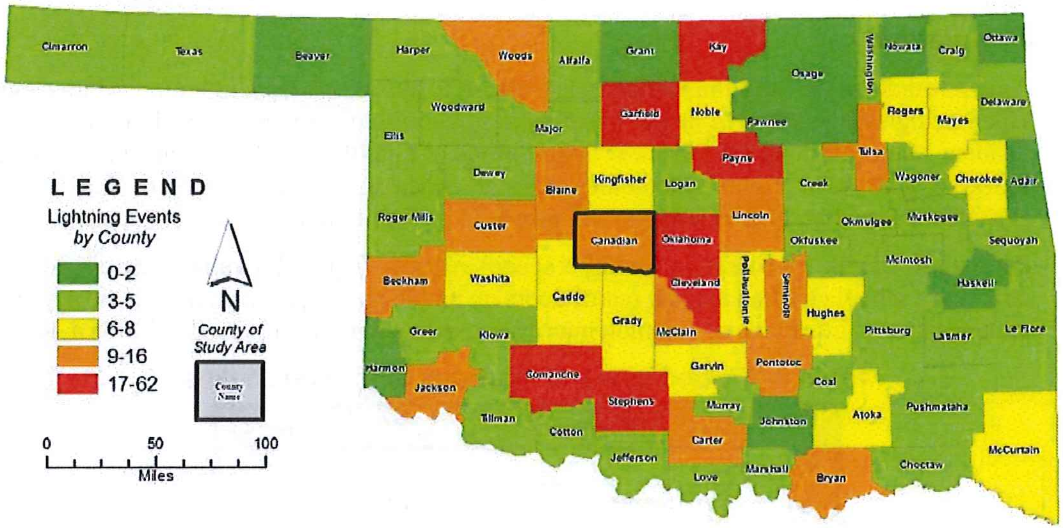
According to the National Climatic Data Center, from 1995 - 2009, there were 374 lightning events reported in the state of Oklahoma, resulting in 11 deaths, 76 injuries and $26 million in damage. The following table compares the recorded casualties and damages from lighting events in Canadian County and the total recorded casualties and damages from lighting events in Oklahoma from 1995-2009. Figure 4-12 is a map of historical lighting events in Oklahoma by county.

Table 4–16: Casualties and Damages Caused by Lightning from 1995-2009

Location	Events	Deaths	Injuries	Damage Events	Property Damages
Canadian County	9	0	0	9	$181,000
Oklahoma	374	11	76	301	$26,077,000

Source: From NOAA National Climatic Data Center
http://www4.ncdc.noaa.gov/cgi-win/wwcgi.dll?wwevent~storms

Figure 4–12: Lightning Events in Oklahoma from 1989-2009



Source: National Climatic Data Center U.S. Storm Events Database

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Canadian County Lightning Events

Between 1995 and 2009, Canadian County reported nine lightning events, according to the NCDC, resulting in $181,000 in property damage. No injuries were reported. It is almost certain that there were a number of unreported events producing residential and commercial damages.

- **May 25, 1998** - Lightning struck a house in Piedmont causing a fire. Damage was $40,000.
- **April 13, 1999** – Lightning started a large house fire in Yukon, damaging the attic and parts of the roof. Damage was $20,000.
- **June 24, 2000** – A lightning strike caused $10,000 in equipment damage at the El Reno Police Department.
- **June 11, 2003** - Lightning caused $25,000 damage to El Reno's Masonic Temple.
- **January 4, 2005** – Lightning struck two oil tank batteries in Yukon. The resulting fire destroyed the batteries and resulted in $75,000 damage.

Probability/Future Events

Oklahoma, Canadian County, its cities and towns and public schools are all subject to frequent thunderstorms and convective weather patterns, and are vulnerable to lightning, a constant and widespread threat during the thunderstorm season. Future lightning strikes within the Canadian County jurisdictions are certain, but their locations and impacts are unpredictable.

Canadian County, its cities and towns and public schools have a High probability of a future lightning event.

4.4.3 Vulnerability

This section summarizes information about Canadian County's vulnerability to lightning, including the impact on people, structures and buildings, critical facilities, and infrastructure. This information, as well as information provided by the County, incorporated communities and public schools, was used to determine the Vulnerability Criteria identified in Tables 4-2 and 4-3.

Canadian County was determined to be at high risk to the Lightning hazard. Appendices F and G identify how the cities and towns and public schools differ from Canadian County.

Population

Anyone outdoors during a thunderstorm is exposed to and at risk from lightning. More people are killed by lightning strikes while participating in some form of recreational activity than any other incident, source, or location. The next largest group of fatalities involves people under trees, followed by those in proximity to bodies of water. Other common incidents are related to agricultural activity, telephone users, and people in proximity to radios and antennas.

Particularly at risk are Canadian County's school districts. Especially vulnerable to lightning strikes are school children playing out of doors on jungle-gym equipment during the approach of a thunderstorm. Locations of common injuries caused by lighting are listed in Table 4-17.

Table 4–17: Locations of Injurious Lightning Strikes

Location	Percent
Not reported	40
Open fields and recreation areas (not golf courses)	27
Under trees (not golf courses)	14
Water related (boating, fishing, swimming)	8
Golfing and on a golf course under trees	5
Heavy equipment and machinery related	3
Telephone related	2.4
Radio, transmitter and antenna related	0.6

Structures/Buildings

Because Canadian County's facilities, as well as those of its communities and public school systems, are subject to frequent thunderstorms and convective weather patterns, their vulnerability to lightning is a constant and widespread during the thunderstorm season. These jurisdictions are at risk of lightning-caused fires, damages and casualties.

A bolt of lightning can explode walls of brick and concrete and cause fires to ignite within a structure. Vegetation on school campuses is vulnerable to lightning damage. Trees are particularly vulnerable, acting as natural conductors. All structures in Canadian County, including schools, are vulnerable to "side flashes" if a lightning strike jumps from a tree to the nearby facility, damaging both.

Critical Facilities

All critical facilities within the County's jurisdiction should be considered vulnerable to the effects of a lightning event. Power disruption and potential destruction of electronic equipment (computers, vital medical equipment, communication equipment, data storage, etc.) should be considered a primary vulnerability of critical facilities. Critical facilities in Canadian County are listed in Table 1-6.

Infrastructure

Lightning-caused problems are one of the most common troubles faced by American businesses today. A recent Carnegie-Mellon study showed that 33% of U.S. businesses are affected by lightning, and that more businesses are impacted by lightning storms than by floods, fires, explosions, hurricanes, earthquakes and violence.

Electronic equipment from computers to enterprise-level communications systems can be seriously damaged by power surges from lightning. Surge protection should be included in any electronic system to minimize the risk of damage from lightning. In addition, lightning warning/detection systems (such as ThorGuard©) should be included in protection plans for critical components of Canadian County, its communities and public school systems.

Water Treatment – A significant effect of a lightning event would be the loss of electrical power and damage to electrical equipment. Water plants experience power outages related to lightning and thunderstorms on a regular basis. As a rule, outages are of short in duration and affect only a portion of the facility.

Wastewater Treatment – The most significant threat to the operation of the wastewater treatment plants of Canadian County from a lightning event would be a power outage.

Utilities- The service stations and substations for utility providers would be vulnerable to lightning events.

> **Electricity:** During a lightning event, providers of electric service could experience many challenges meeting the needs of the County's communities, including: damage to transformers or other transmission components, downed broken power lines, danger to workers derived from downed power lines and fallen debris, and insufficient field and/or office staff to effectively handle the workload.
>
> **Gas:** During a lightning event, providers of gas service to a community could experience electrical outages and insufficient field and/or office staff to effectively handle the increased workload.

Transportation Systems (Highways, Public Transportation, Railway, Airports) – Transportations systems would experience the same vulnerability to lightning events as other county facilities.

Emergency Services- Fire, Police and Medical Services are all at risk to the effects of a lightning event – with electrical outages and the interruption or destruction of communication capabilities being the main vulnerabilities.

4.4.4 Lightning Scenario

A graphic scenario demonstrating the effects of a major lightning event for Canadian County would be difficult to assemble, and even more difficult to analyze due to the sporadic and erratic behavior of lightning itself. However, it is possible to examine two recent events involving lightning strikes to illustrate the likely parameters of a worst-case event.

Lightning Strike on Public Building

On October 14, 2007, the city of Holdenville, located in nearby Hughes County, experienced a thunderstorm accompanied by lightning that struck the City Hall building, crippling the community's 911 system. While repairs were being made, those requiring emergency assistance were asked to call a local seven-digit phone number. In addition to the 911 system, the Holdenville Police Department reported major damage to its radio system. Damages reported were approximately $26,600. This was not the first time Holdenville had to contend with lightning damages. Over a period of 14 months (March 29, 2007 through May 27, 2008), the City experienced three different strikes resulting in damages in excess of $36,000.

Lightning Strikes at Sporting Events

The most frequently reported incidents involving injuries and/or deaths from lightning strikes occur during common outdoor activities such as hunting, swimming, soccer and football. According to the website www.struckbylightning.org, by mid-October 2009 there had been 36 fatalities and 245 injuries attributed to lightning strikes in the United States.

Two events illustrate this hazard: During a football game in Bonaire, Georgia, at approximately 3:30 pm, officials, who were using a hand-held lightning detector, decided to end the game when the detector went into alarm mode due to an approaching thunderstorm. They were in the process of moving players off the field when lightning struck. Thirteen individuals were injured, twelve sent to local hospitals, and one of the coaches remained in critical condition for several days.

A second event took place in Dorchester, Massachusetts on July 20, 2008, also at approximately 3:30 pm; this time, the sporting event was a local soccer game. There were 10 injuries reported, four of them critical. Seven or eight of the players were knocked unconscious, and the injuries reported ranged from burns to cardiac conditions. The victims ranged in age from 13 to 41yrs, and all were males.

These two events are particularly pertinent to the public schools of Canadian County, which sponsor frequent outdoor gatherings for football, soccer and other sports.

4.4.5 Future Trends

Population

As the "baby-boomer" population moves into retirement, it could be anticipated that the number of people pursuing outdoor sports and/or social activities may also increase. Priority should be given to continuing the process of educating the community of the dangers associated with lightning. Also adding to this increase in out-of-doors activity could be the rising cost of fuel. With more families looking for activities closer to home, parks and other outdoor recreation areas may become more attractive.

With any future development comes construction. An increase in new construction or even large renovation projects would also increase the number of outdoor workers in a wide variety of functions. These groups should also be included in the continuing education of the public on the lightning hazard.

Structures/Buildings

As uninhabited areas continue to be developed and existing structures are renovated, actions to lessen the potential effects of lightning strikes should be considered. Installation of surge protectors for electricity and phone lines should be actively encouraged as well as working with utility companies to facilitate the relocation of above-ground utility lines to underground.

Critical Facilities

As technology continues to advance, the need to protect power sources supporting that technology should advance as well. Working with local utility companies to coordinate the relocation of above-ground utilities (phone, electricity, etc.) to underground should be considered a top priority in the construction of new facilities, or the renovation of facilities to accommodate the updating of current systems.

Infrastructure

Ensuring local government facilities are well protected against the potential effects of lightning strikes is an on-going endeavor. Investigating and implementing new technology as it is made available will help ensure the continuity of operations at all levels, particularly for communications systems and electronic data files.

4.4.6 Conclusion

Lightning is one of the most deadly and consistent hazards in the United States. People outside can have a false sense of security, thinking that they are safe because a storm front has not yet reached their location. In fact, lightning can strike 10 miles out from the rain column, putting people that are still in clear weather at risk. The general rule of safety is that anyone outside during a thunderstorm should take cover.

Electronic equipment, from personal computers to enterprise-level communications systems, can be seriously damaged by power surges from lightning. Surge protection should be included in any electronic system to minimize the risk of damage from lightning.

In recent years, new technology has provided ample opportunities for communities and individuals to provide increased warning and alerts, increased surge protection, and increased building strike protection. The threat of injury, death, or property damage in Canadian County, its communities and public school systems is high.

Data Limitations

Accurate data on the effects of lightning events is difficult to obtain for several reasons:

Regarding injuries – many survivors do not seek immediate medical care and only come to the attention of medical personnel when they seek care for effects of the shock that have not resolved in the days following their injury. In addition, many lightning deaths and injuries are attributable to nervous system disruption with no visible signs of injury. In some cases, injuries or deaths may be misdiagnosed as heart attacks or other ailments.

Regarding property damages – home and business owners often choose not to submit insurance claims in connection with their damages. Typically, events that are documented are the more widespread occurrences affecting several business/residential locations.

Regarding data collection – much of the data utilized is taken from newspaper accounts. If a lightning event does not make the news, it will usually not show up in the data pool. Obviously, many, many more lightning events occur than are reported. In addition, the NCDC data file for Canadian County lightning events only covers the years 1993-2005.

Update Changes

Identified significant changes made from previous Multi-Hazard Mitigation Plans from Canadian County, Calumet, El Reno, Mustang, Piedmont, and Union City are outlined in Appendix E. Changes are based on criteria outlined for Plan Updates in the Local Multi-Hazard Mitigation Planning Guidance document of July 1, 2008.

4.4.7 Sources

Lightning Fatalities, Injuries, and Damage Reports in the United States from 1959-1994. NOAA Technical Memorandum NWS SR-19, 1997 and at Web Address: http://www.nssl.noaa.gov/papers/techmemos/NWS-SR-193/techmemo-sr193.html.

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National Lightning Safety Institute, at Web address: http://www.lightningsafety.com/.

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NCDC Storm Event Database, National Climatic Data Center.