

4.5 Hailstorm

4.5.1 Hazard Profile

A hailstorm is an outgrowth of a severe thunderstorm in which balls or irregularly shaped lumps of ice fall with rain. Extreme temperature changes from the ground upward into the jet stream produce strong updraft winds that cause hail formation. Hailstorms are usually considered “severe” when hail is larger than one inch in diameter.

Location

Oklahoma experiences an average of 602 hailstorms each year with hailstones measuring at least one inch in diameter. All buildings and agricultural areas in Canadian County are at risk.

Measurement

Hailstones are typically measured by their diameter. Common sizes and descriptions of hail are listed in Table 4-18. The damages expected from a hail event are a function of the diameter of the hailstones and wind speed, or velocity. Hailstorms are usually considered “destructive” when hail reaches 1.75 inches in diameter and is accompanied by high winds. When hailstones reach such dimensions, they can be extremely dangerous to property, agriculture and people caught outside, without shelter.

Early in 2010, the National Weather Service changed the criteria for a severe thunderstorm alert from predicted winds in excess of 58 mph and hail in excess of .75 inch to hail in excess of one inch in size.



Hailstones can cause widespread damage to crops and automobiles and serious bodily injury

Table 4-18: Common Sizes and Descriptions of Hail

Hail Size	Description	Hail Size	Description
0.25 inch	Pea Size	1.75 inch	Golf Ball Size
0.50 inch	Mothball Size	2.00 inch	Hen Egg Size
0.75 inch	Dime/Penny Size	2.50 inch	Tennis Ball Size
0.88 inch	Nickel Size	2.75 inch	Baseball Size
1.00 inch (Severe Criteria)	Quarter Size	3.00 inch	Teacup Size
1.25 inch	Half Dollar Size	4.00 inch	Grapefruit Size
1.50 inch	Walnut/Ping Pong Ball Size	4.50 inch	Softball Size

Source: National Weather Service

Extent/Severity

The damages expected from a hail event are a function of the diameter of the hailstones and the wind speed, or hailstone velocity. As shown in the Combined NOAA/TORRO Hailstorm Intensity Scale, Table 4-19, hail is considered “destructive” when it reaches 1.6 inches in diameter, or golf ball size.

Table 4–19: Combined NOAA/TORRO Hailstorm Intensity Scales

Size Code	Intensity Category	Typical Hail Diameter (inches)	Approximate Size	Typical Damage Impacts
H0	Hard Hail	up to 0.33	Pea	No damage
H1	Potentially Damaging	0.33-0.60	Marble or Mothball	Slight damage to plants, crops
H2	Potentially Damaging	0.60-0.80	Dime or grape	Significant damage to fruit, crops, vegetation
H3	Severe	0.80-1.20	Nickel to Quarter	Severe damage to fruit & crops, damage to glass & plastic structures, paint & wood scored
H4	Severe	1.2-1.6	Half Dollar to Ping Pong Ball	Widespread glass damage, vehicle bodywork damage
H5	Destructive	1.6-2.0	Silver dollar to Golf Ball	Wholesale destruction of glass, damage to tiled roofs, significant risk of injuries
H6	Destructive	2.0-2.4	Lime or Egg	Aircraft bodywork dented, brick walls pitted
H7	Very destructive	2.4-3.0	Tennis ball	Severe roof damage, risk of serious injuries
H8	Very destructive	3.0-3.5	Baseball to Orange	Severe damage to aircraft bodywork
H9	Super Hailstorms	3.5-4.0	Grapefruit	Extensive structural damage. Risk of severe or even fatal injuries to persons caught in the open
H10	Super Hailstorms	4+	Softball & up	Extensive structural damage. Risk of severe or even fatal injuries to persons caught in the open

The size of hailstones is a direct function of the severity and size of a storm. High velocity updraft winds keep hail in suspension in thunderclouds. The greater the intensity of heating at the Earth’s surface, the stronger the updraft will be. Higher temperatures relative to elevation result in increased suspension time, allowing hailstones to grow in size. As a general rule, hail damage increases sharply when stones reach 1.75 inches in diameter and larger.

Canadian County considers a minor severity to be an H2 or lower on the Combined NOAA/TORRO Hailstorm Intensity Scales, and a major severity to be an H3 or higher.

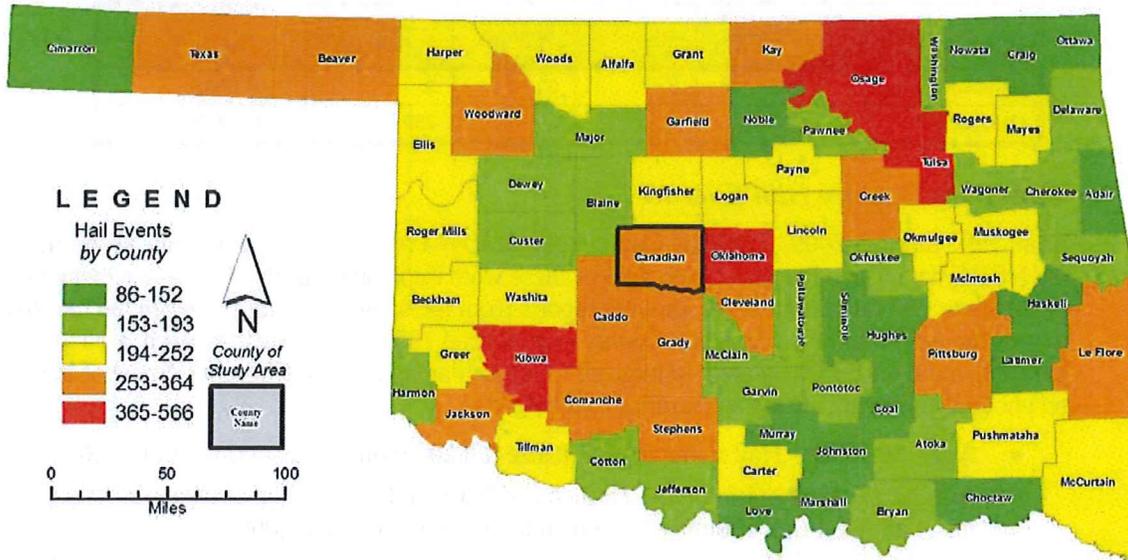
Hail has been reported in every month, with the highest frequency during the transitional months in the spring. The peak time of year falls right in the middle of that transition period, from mid-April to mid-May. Another small peak occurs in November, as the weather pattern transitions back into winter.

Frequency

The Great Plains, particularly the states of Oklahoma, Kansas, and Texas, are known for hailstorms. Figure 4-13 was developed through statistical analysis of hail reported by the National Severe Storm Laboratory from the early 1950’s to the late 1990’s using CHAP/e-Hail™ Hail Analysis Software developed by Haag Forensic Engineers of Dallas, Texas.

According to NCDC data, Canadian County reported 105 hail events (once multiple reports of the same storms are removed) between 1995 and 2009 with stones ranging in size from 0.75 inches to 3.0 inches in diameter causing \$501,000 in reported damage. Of these events, 30 separate hail storms had potentially damaging hail measuring 1.75 inches in diameter or larger. By far the most damaging hail (\$500,000) fell at Okarche on May 29, 2004. Communities that reported the most hail events were Piedmont (31 events), Yukon (28), Calumet (20), El Reno (20), Mustang (16), Union City (15), Okarche (14), Niles (12), Karns (nine) and Scott (six). Given this data, Canadian County can expect to experience 6.9 hail events annually, and two potentially damaging events per year (hailstones larger than 1.75 inches). A “very destructive” H8 hail event, with three-inch hail or larger, can be expected every five years.

Figure 4-13: Hail Events in Oklahoma 1989-2009



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

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Impact

When hail hits, it can damage cars, break windows, shred roof coverings, and lead to water damaged ceilings, walls, floors, appliances, and personal possessions. Large hailstones can also cause serious bodily injury.

Multiple impacts of concurrent severe thunderstorm effects (high winds, tornadoes and hail) are very likely within the Great Plains region. About 2% of United States' crop production is damaged by hail each year, and in the Great Plains states damages have sometimes reached 20%. In total, hail causes nearly \$1 billion in property and crop damage each year. In 2005, there were more than 13,000 hail storms in the United States. According to Swiss Re, four out of the top 20 most costly insurance losses of 2005 were hail-related.

However the impact of this hazard remains mainly financial due to repairs to cars, roofs, walls and windows. The loss of crops and livestock as a result of hail can be devastating to farmers and the economy in lost revenues.

4.5.2 History/Previous Occurrences

The Midwest hailstorm and tornado event in April 1994 lasted four days. According to Property Claims Services in Rahway, NJ, it produced 300,000 damage claims against insurers, more than Hurricane Andrew or the Northridge earthquake.

According to NOAA, the most expensive thunderstorm in United States history occurred on May 5, 1995 in the Fort Worth, Texas area. Hailstones up to four inches in diameter caused 109 hailstone-related injuries and contributed to over \$2 billion in damage. A map of all hail events occurring in Oklahoma by county from 1989-2009 is shown in Figure 4-13.

As stated above, Canadian County has reported 105 hail events from 1995 - 2009, with \$501,000 reported damage. Table 4-20 lists the number of events, deaths, injuries, damage events, and the value of property damage reported to the NCDC. The following table compares the casualties and damages caused by hail in Canadian County with the casualties and damages caused by hail in Oklahoma from 1995-2009.

Table 4–20: Casualties and Damages Caused by Hail from 1995 - 2009

Location	Events	Deaths	Injuries	Damage Events	Property Damage
Canadian County	105	0	0	2	\$501,000
Oklahoma	12,722	0	2	239	154,564,000

Canadian County Hail Events

From 1995 through 2009, Canadian County experienced a reported 223 hailstorms, according to the NCDC data base. However, over half of these were duplicate reports of the same event that passed over several communities, or were reports from the same community. When the multiple reports are accounted for, Canadian County experienced 105 separate hail storms in a 15-year period that did \$501,000 damage (almost all of which damage was at Okarche). Some of the more recent and significant events are summarized below:

- **April 30, 1961** – Hail seven inches in size fell about one mile southwest of El Reno.
- **August 17, 1994** – 4.5-inch, 2.75-inch and 2.5-inch hail reported at Okarche. The 4.5-inch hail fell 4 miles southeast of Okarche. Damage was \$100,000.
- **May 25, 1998** – A severe thunderstorm carrying 16 tornadoes moved through northern Kansas into central Oklahoma. Tennis ball-size hail (2.5 inches in diameter) damaged the wheat crop and numerous vehicles in Okarche. No damage figures were reported.
- **April 21, 2004** – Baseball size hail was reported at Yukon, resulting in accumulations of hail from 3 inches to 2 feet deep.
- **April 30, 2004** - 3.00-inch hail fell at Piedmont, breaking the windshields of two cars.
- **May 29, 2004** - 2.75-inch hail was reported in Okarche. Hail damaged homes and vehicles, Police Department cruisers, and heavily damaged the community’s school buildings, with 61 windows and 26 skylights broken. Losses were estimated at \$500,000.
- **April 24, 2006** - 2.75-inch hail fell 1 mile north of El Reno.
- **November 5, 2008** - 2.50-inch hail reported 1 mile south of Piedmont. Several areas reported hail covering ground to a depth of several inches. Two additional rounds of thunderstorms developed during the evening, with some areas receiving large hail three to five separate times.
- **May 23, 2011** – This severe thunderstorm, which did great damage in Calumet, El Reno and Piedmont, also dropped 2.5 and 2.75-inch hail on Okarche. No damage was reported on the NCDC site, but the *Kingfisher Times and Free Press* reported that Okarche was hard hit by hail, damaging both structures and crops.

Probability/Future Events

Hail is a direct by-product of the thunderstorms that sweep across the state from spring to autumn each year. The entire Canadian County jurisdiction is subject to thunderstorms of varying severity, with hail present in many of these storms.

Based on history and previous occurrences from the past 15 years, Canadian County can expect 6.9 hail events annually, with two of these being potentially damaging events (hailstones larger than 1.75 inches).

Canadian County, its Communities and Public School systems have a High probability of a future hailstorm event.

4.5.3 Vulnerability

This section summarizes information about Canadian County's vulnerability to hailstorms, 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 hailstorm hazard. Appendices F and G identify where the cities and towns and public schools differ from Canadian County.

Hailstorms occur in every state of the continental United States, but most frequently in the Great Plains during the late spring and early summer when the jet stream migrates northward. This period coincides with the Midwest's peak agricultural seasons for wheat, corn, barley, oats and rye, tobacco and fruit trees. Long-stemmed vegetation is especially vulnerable to damage from hail impacts and winds. Severe hailstorms also cause considerable damage to buildings and automobiles but rarely result in loss of life. Reported damage figures are deceptive, since most losses are not reported through weather service or other government agencies, but through insurance companies. The insurance industry considers hail to be one of its most costly consistent annual disasters. (Source: Insurance Information Institute, www.iii.org).

Population

Given the climatic environment in this jurisdiction, all demographic groups located within Canadian County are vulnerable to the effects and potential damages of hailstorm events. Particularly vulnerable are those pursuing farming and/or ranching activities, as crop damage is the highest percentage of reported hail damages. In addition, people engaged in outdoor recreational activities, such as school sports, golfing or camping, may find themselves without sufficient shelter.

Structures/Buildings

Severe hailstorms cause considerable damage to buildings, including schools, and (increasingly) to automobiles, but rarely result in injury or loss of life

Structures and schools without hail resistant roofs are especially vulnerable to hail damages. Hail can cause bruises, punctures and leaks on roofing systems. The amount of damage depends on the size of the hail, and the age, material, and surface temperature at the time of the event. Substantial hail damage may result in the need for a completely new roofing system. Large hail driven by high winds can break through school windows, doors and skylights that are not impact resistant, allowing rain water to enter the building. All school buildings are vulnerable to potential million dollar damages as a result of the impact of hail on their facilities.

Given its significant exposure to hailstorms, virtually all buildings and structures in the entirety of Canadian County, its communities and public school systems are vulnerable to the damaging effects of hail.

Critical Facilities

All critical facilities are vulnerable to hail damage (see Table 1-6 for a complete list of Canadian County critical facilities). Hail, however, is unlikely to render a critical facility non-operational.

Infrastructure

Water Treatment – It is not anticipated that a hail event would cause a major disruption in the normal operation of the water treatment systems in Canadian County.

Wastewater Treatment – It is not anticipated that a hail event would cause a major disruption in the normal operation of Canadian County's wastewater treatment systems.

Utilities – The primary utility providers for Canadian County are Oklahoma Gas and Electric Company (OG&E) and Oklahoma Natural Gas Company (ONG). Neither electric power nor gas service would suffer a major disruption from hail.

Transportation Systems – During a hail event, public vehicles may sustain damage. If severe enough—such as a “Very destructive” H8 event, there could be some loss of functionality, possibly disrupting normal County operations. During a major storm that is producing hail, it is reasonable to assume that flights leaving and arriving at local airports could be delayed. Aircraft on the runway during an H5 to H8 event could potentially experience some damage, especially if the event is prolonged. Hail events can render school busses not protected in a bus barn or other means of covered parking non-operational.

Emergency Services – Fire, Police and Medical Services would all be similarly at risk to the secondary effects of a hail event. Response vehicles in the open would likely be exposed to window and/or windshield damages. A secondary effect could be an increased call and work volume for County services.

If a major hail event were to occur between 7:30 and 8:30 a.m. or 5 and 6 p.m. on any weekday, the risk of commuters to and from work being caught in the event and involved in accidents is high, and could result in injuries.

4.5.4 Future Trends

Hailstorms occur in every state of the continental United States, but most frequently in the Great Plains during the late spring and early summer, which coincides with the peak agricultural season. Long-stemmed vegetation is especially vulnerable to damage by hail impacts and winds. Oklahoma has significant exposure to hailstorms, and virtually all buildings and crops are at risk.

Population

Because deaths or injuries from hail events are extremely rare, and all areas of the County are equally exposed to hailstorms, the vulnerability of populations in newly developed areas would be similar or equal to the vulnerability of established developments.

Structures/Buildings

In all areas being considered for future development, the construction of new structures/buildings should include plans to employ impact-resistant materials and components when feasible. As buildings are being considered for renovation or converted from one purpose to another, emphasis should be placed on installing impact-resistant roofing and windows.

Critical Facilities

Any future development and renovation of critical facilities should include consideration of the use of disaster resistant materials to improve the community’s sustainability. Hail-resistant materials should become standard on critical facilities, along with the use of protective screens for external equipment (i.e., air filtration/conditioning systems, backup generators, communication terminals, vehicles, etc.) to help protect them from damaging weather events.

Infrastructure

It is not anticipated that future Canadian County infrastructure (water treatment, wastewater treatment, utilities, emergency services, or transportation) will be disrupted by a severe hail storm. However, public vehicles may sustain damage in an H5 storm or higher and normal operations of area airports could be disrupted.

4.5.5 Conclusion

The states in the middle of the Great Plains, particularly Oklahoma, are the most likely to have severe thunderstorms and therefore have the greatest vulnerability to hail events. The peak season for hail is in the late spring and early summer. Canadian County experiences about 6.9 hail events annually, and two potentially damaging events per year (hailstones larger than 1.75 inches). A “very destructive” H8 hail event, with stones three inches in diameter, can be expected once every five years. All buildings and crops in the County are at risk.

Canadian County, its Communities and Public School system properties are at High risk to damaging hailstorms because of the frequency of convective thunderstorms in the region. A “Destructive” H5 hail event would likely affect more than 10% of the County’s and school districts’ property. A worst-case H8 or higher hailstorm could affect up to 25% of the critical facilities in a given area of the County, its communities and public school systems. There is a high probability a disaster level incident will occur within the next decade.

Measures that can reduce vulnerability to hail damage are the installation of hail-resistant roofing, siding and windows on public buildings and critical facilities, and the provision of shelters for public vehicles.

Data Limitations

The NCDC data base, from which the data used in the above analysis was taken, often lists two, three or as many as six reports for what is essentially the same hail storm, as it tracks across the county. Sometimes three reports are of hail in the same city or town within a 30-minute period. To derive a clear picture of how many hail events the county can expect to pass through its jurisdiction, these duplicate reports have been combined into one event for the purposes of this plan. For example, the hail storm of March 30, 2008 has four entries for Union City, all within a space of 12 minutes. In the adjusted data, this is counted as one event. Although this method is not without its shortcomings, it provides a more precise method of estimating the frequency of hail storms and other large-scale weather events.

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.

4.5.6 Sources

Insurance Institute for Business and Home Safety, at Web address: www.disaster.org.

Multi-Hazard Identification and Risk Assessment, p. 56–60. FEMA, 1997.

NCDC Storm Event Database, at Web address: <http://www.ncdc.noaa.gov/stormevents/>. National Climatic Data Center.

National Weather Service: Office of Climate, Water, and Weather Services, at Web address: www.nws.noaa.gov/om/hazstats.shtml.

