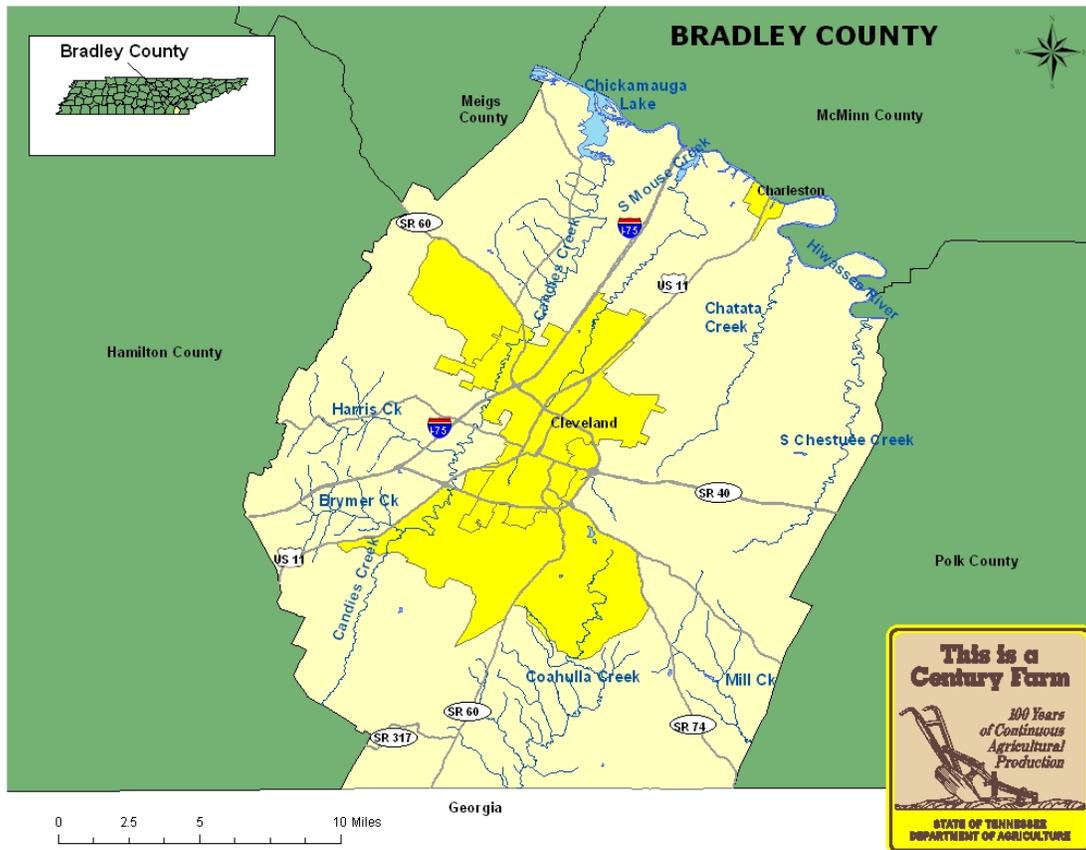


# Bradley County Natural Hazard Mitigation Plan



## 2017 Update

Prepared By:

**Bradley County Hazard Mitigation Committee  
Bradley County Emergency Management Agency**

## Executive Summary

Over the past two decades, hazard mitigation has gained increased national attention due to the large number of natural disasters that have occurred throughout the U.S. and the rapid rise in costs associated with those disaster recoveries. It has become apparent that money spent mitigating potential impacts of a disaster event can result in substantial savings of life and property. With these benefit cost ratios being extremely advantageous, the Disaster Mitigation Act of 2000 was developed as U.S. Federal legislation that reinforces the importance of pre-disaster mitigation planning by calling for local governments to develop mitigation plans (*44 CFR 201*).

The purpose of a local hazard mitigation plan is to identify the community's notable risks and specific vulnerabilities, and then to create/implement corresponding mitigation projects to address those areas of concern. This methodology helps reduce human, environmental, and economical costs from natural and man-made hazards through the creation of long-term mitigation initiatives.

The advantages of developing a local hazard mitigation plan are numerous including improved post-disaster decision making, education on mitigation approaches, an organizational method for prioritizing mitigation projects, etc. It has been noted that communities who successfully complete and maintain a mitigation plan receive larger amounts of Federal and State funding to be used on mitigation projects, and receive these funds faster, than communities who do not have a plan. Such funding sources that the plan caters to are Pre-Disaster Mitigation, Flood Mitigation Assistance, Severe Repetitive Loss, and Hazard Mitigation Grant Programs.

The 2017 update of the Bradley County Hazard Mitigation Plan was created to act as a well thought out guide to be used by, and for, the people of Bradley County. For this plan to be successful, each jurisdiction within the county participated in the drafting and preparation of the plan update. These participating jurisdictions include:

- Bradley County (unincorporated)
- City of Cleveland
- City of Charleston

Per federal code title *44 CFR 201*, an updated hazard mitigation plan is required to be submitted to both TEMA (State) and FEMA (Federal) for review every five years to be reapproved. When the plan is deemed “approval pending adoption” by FEMA (*44 CFR 201.6(c)5*), each of the participating jurisdictions will adopt the plan through a local resolution.

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## Section 1: Planning Process

### Planning Process Update

The previous Bradley County Hazard Mitigation Plan was approved by FEMA on July 10<sup>th</sup>, 2012. Per federal requirements stated in *44 CFR 201*, all local hazard mitigation plans are required to go through a FEMA update review every 5 years to remain eligible for hazard mitigation grants. This update methodology was developed to assure that local governments are continuing to re-evaluate their risks and to regularly implement mitigation projects that can reduce community vulnerabilities.

The beginning of the plan's five-year update process took place at a meeting on June 8<sup>th</sup>, 2017 with TEMA District Coordinator providing the guidance from TEMA planning to begin the update process. The first planning committee meeting took place on June 14<sup>th</sup> 2017 (See [Appendix 1](#) for the meeting's attendance sheet). At this meeting, Bradley County Emergency Management Agency stated that they would continue the role of leading staff and interested persons in updating their mitigation plan. The tasks to be undertaken by Bradley County Emergency Management Agency consisted of continuing to get agencies and the public involved in the county's mitigation efforts, performing the written plans required 5-year update, and soliciting for new mitigation actions/projects to be added to the plan.

Prior to this meeting, Bradley County began reorganizing the county-wide hazard mitigation committee. Realizing that a successful mitigation committee includes a number of representatives, specialists, and individuals who can give valuable/unique insights that local emergency management staff may not have considered; invites to be a part of this plan update included open invitation to elected officials, county and city staff, representatives of the jurisdictions, neighboring counties, local businesses, state agencies, private organizations, academia, non-profits, and other noticeable persons. In addition, adjacent counties were invited to participate via e-mail announcement to the Emergency Management directors. (see near neighbor's notification letter [Appendix 2](#))

The Bradley County Hazard Mitigation Committee for the plan update consists of the following members:

Member	Representation
Jerry Johnson (Chairman)	Operations Officer-Bradley County Emergency Management Agency
Troy Spence	Director, Bradley County Emergency Management Agency
D. Gary Davis	Bradley County Mayor
Joe Fivas	Cleveland City Manager
Tom Rowland	Cleveland Mayor
Walter Goode	Charleston Mayor
Ron Harrison	Chief Cleveland Fire Dept.
Tommy Myers	Cleveland Public Works
Gary Farlow	Chamber of Commerce
Lindsay Hathcock	Bradley County Mayor's Office
Greg Thomas	City of Cleveland Planning
Jonathan Jobe	City of Cleveland Planning
Eric Watson	Sheriff-Bradley County
Mark Gibson	Chief-Cleveland Police Dept.
Bentley Thomas	Bradley County Planning
Sandra Knight	Pike Road Dept.
Brian Beck	City of Cleveland Planning
Johnny Stokes	Chief-Charleston Police
Shawn Fairbanks	Director-Bradley County Fire/EMS
Johnny Mull	Bradley County Schools
Hal Taylor	Cleveland City Schools
Scotty Hernandez	Safe Schools Coordinator
Wayne Owenby	Bradley County GIS

The Bradley County Hazard Mitigation Committee continues to be the county's lead in all mitigation efforts and in the development of the county's mitigation plan. The committee member's efforts in the plan update were broken down into five stages: **1)** analysis of the original plan (*the plan as it stood prior to the updates*), **2)** updating of the plan, **3)** public participation, **4)** review of the final updated plan, and **5)** adoption of the plan.

**Stage 1:** During the analysis of the plan, Bradley County Emergency Management Agency reviewed the original county plan and made notes on what sections would require the main updates. Bradley County Emergency Management Agency suggested that the two core areas for needed updates were in the risk/vulnerability assessment and in the restructuring of the county's listed hazard mitigation projects.

**Stage 2:** From there the committee started making the updates to the plan. A large amount of this effort took place at the second Bradley County Hazard Mitigation Committee meeting that was held on July 19<sup>th</sup>, 2017. Tasks included re-evaluating the plan's hazards, re-assessing their risks, re-calculating each jurisdiction's vulnerable areas, re-establishing the county's mitigation goals, examine the status of mitigation projects listed in the original plan, finalize the county's mitigation project chart and to prioritize the projects listed, and to finalize any remaining business needs for the plan. TEMA personnel were present at this meeting to answer mitigation planning and grant questions. [Appendix 3](#) provides a copy of the meeting's attendance sheet.

This meeting was followed by a third public meeting which took place on August 18<sup>th</sup>, 2017. The purpose of this gathering was to allow the public input on the status of mitigation projects listed in the original plan, and projected projects in the new plan. [Appendix 4](#) provides a copy of the meeting's attendance sheet and minutes.

**Stage 3:** To encourage public involvement, the Bradley County Hazard Mitigation Committee public meeting was given public notice. [Appendix 5](#) presents a copy of the public notice.

The committee next met on \_\_\_\_\_, to conduct a final review of the hazard mitigation plan prior to submission to FEMA. [Appendix 6](#) provides a copy of the meeting's attendance sheet.

**Stage 4:** Next the committee evaluated the written updates of the plan against FEMA's crosswalk requirements via email correspondence. This also included having the jurisdictions review the drafts that specifically addressed aspects of their jurisdiction before the plan is sent to FEMA for review.

**Stage 5:** Upon receiving the "Approval Pending Adoption" designation from FEMA's review, the public will be given a chance to comment on the final draft of the update plan prior to its adoption by each local jurisdiction. This opportunity will take place at a local board meeting for each jurisdiction before the updated plan adoption decision takes place. The opportunity for final public comment will therefore be documented through the receipt of a signed adoption resolution.

## **Review of Existing Information**

A preliminary review of existing plans, reports, and information was conducted during the initial phase of creating the Bradley County Hazard Mitigation Plan. The primary purpose of reviewing this information was to identifying local hazards, recognizing local risks, and understanding different local vulnerabilities. The following list of sources identifies some of the existing studies that were reviewed:

- State of Tennessee Hazard Mitigation Plan
- Tennessee Emergency Management Plan (TEMP)
- U.S. Census Bureau
- FEMA Mitigation "How to" Guides
- NOAA National Climatic Data Center (NCDC) storm reports
- Bradley County BEOP
- Bradley County School District Emergency Plan
- Cleveland City School District Emergency Plan
- Bradley County Highway Department Plan
- Cleveland Public Works Emergency Plan
- Pipeline Emergency Plan
- City of Cleveland Storm Water Ordinance
- Bradley County Storm Water Ordinance
- Bradley County Regional Growth Plan
- Bradley County Land Use Plan
- Bradley County Zoning Resolution
- TVA Dam Safety Emergency Action Plan
- City of Cleveland Zoning Ordinance
- City of Cleveland Land Use & Transportation Ordinance
- City of Cleveland Flood Ordinance
- Bradley County Flood Damage Prevention Ordinance
- City of Charleston Flood Damage Prevention Ordinance
- BCC 2035 Strategic Plan Adopted for City of Cleveland
- City of Charleston Zoning Ordinance
- Bradley/Cleveland Subdivision Regulations

All the listed plans, studies, and data sources were incorporated into the Bradley County Hazard Mitigation Plan. These sources developed the plan's hazard, risk, and vulnerability assessment sections that in return led to the establishment of meaningful mitigation actions.

## **Updates within the Plan**

It is important to note that this countywide plan was entirely reorganized and updated head-to-toe from the original Bradley County Hazard Mitigation Plan. Bradley County reviewed and analyzed each section of the original plan and made updates in the following ways:

### Section 1: Planning Process

Bradley County updated the original plan's description of the planning process to include the new or no longer participating committee members, the most recent countywide mitigation meetings that took place for the plan's update, and the latest opportunity for the public to get involved. Bradley County also compiled a new list of existing documents that they reviewed in updating their sections in the plan.

### Section 2: County Profile

Bradley County created a new development trends section in this plan update.

### Section 3: Risk Assessment

Bradley County kept all their listed natural hazards from the original hazard mitigation plan. The committee also decided to remove Hazardous Materials. The hazard "Hazardous Materials" was removed because it was deemed a hazard that should be fully profiled in the County's Basic Emergency Operations Plan (BEOP) instead of the mitigation plan.

As part of the plan update, Bradley County updated their previous occurrence hazard listings to cover the most recent five years and re-evaluated each hazard's extent, probability, and potential impacts. The county then decided to use a different method for determining vulnerabilities/risks because this new method was considered superior to the older plan's method. Also, the plan now has a HAZUS-flood model study and simplified countywide floodplain maps for the first time, as seen in the plan's appendices.

### Section 4: Mitigation Strategy

Bradley County has updated their mitigation goals to address a more inclusive range of countywide aims and has utilized a new

method for prioritizing mitigation projects, (thought to be superior to the previous method). Bradley County also has brainstormed some new mitigation projects that were added to the list, used a new chart method to profile project details, and developed a system to describe where their previous plan's projects are in terms of being implemented.

Section 5: Plan Maintenance

Bradley County updated how they would work with the other jurisdictions in monitoring, evaluating, and updating the plan; provided an updated list of mechanisms they could incorporate mitigation within; stated that now the Bradley County BEOP has mitigation concepts incorporated into it; and updated how all the jurisdictions would keep the public involved in updating processes.

## Section 2: County Profile

### Development Trends

Bradley County and its jurisdictions can be found in the southeast portion of East Tennessee. It is bordered by the Hamilton County to the west, Meigs County to the northwest, McMinn County to the northeast, Polk County to the east, and Georgia Counties to the south. It has a population of **98,963 (2010 census)**. Bradley County was formed in 1836, and is named in honor of Col. Edward Bradley, a Revolutionary war veteran, and a Tennessee state legislator. The county has a total area of 331 square miles, of which 329 square miles is land and 2.7 square miles is water. Cleveland is the county seat.

The incorporated jurisdictions have populations as follows (2010 census):

Jurisdiction	Population
Cleveland	41,285
Charleston	651

Chattanooga, in Hamilton County to the west, is the focal point for medical services, dining, and entertainment. There is a major agricultural base and its support services in Bradley county. Bradley County is centrally located to all major U.S. markets with transportation access.

Due to current land use trends, the Bradley County Property Assessor predicts major future growth in residential, commercial, and industry. There is more growth expected with the expansion of Wacker Polysilicon, a large chemical producer and polysilicon manufacturer in Charleston. There is also a planned industrial expansion along I-75 in Cleveland with the development under way of a new industrial park.

### Legal & Regulatory Capability

The following chart indicates the legal and regulatory adherence of each of the jurisdictions within Bradley County:

Regulatory Tools/Plans	Regulatory Type: Ordinance Resolution Codes Plans, Etc.	Bradley County	Cleveland	Charleston
Building Codes	Municipal Code	Y	Y	Y
Zoning	Municipal Code	Y	Y	Y
Emergency Response Plan	Basic Emergency Operations Plan (BEOP)	Y	Y	Y
National Flood Insurance Program Participant		Y	Y	Y
Post-Disaster Recovery Plan	BEOP	Y	Y	Y

## Section 3: Risk Assessment

### Hazard Identification

To begin to assess Bradley County's risk to natural hazards and identify the community's areas of highest vulnerability, the mitigation committee had to identify which hazards have or could impact the county. This hazard identification process began with researching previous hazard events that have occurred in Bradley County by going through newspaper articles, Bradley County Emergency Management Agency records, and recalling personal experiences. From there Emergency Management staff also analyzed hazard events that could occur in the county by reviewing scientific studies and the State of Tennessee Hazard Mitigation Plan. The following hazards have been identified as hazards of concern by the Bradley County mitigation committee within the update process.

### Flooding

Flooding events occur when excess water from rivers and other bodies of water overflow onto riverbanks and adjacent floodplains. In addition, lower lying regions can collect water from rainfall and poorly drained land can accumulate rainfall through ponding on the surface. Floods in Bradley County are usually caused by rainfall, but may also be caused by snowmelt and man-made incidents. The below charts explain common ways flooding occurs and common factors that contribute toward the severity of floods.

Common Ways Flooding Occurs	
Methods	Description
<b>Overland Flow</b>	
<b>(a) Infiltration</b>	-Excess overland flow occurs when the rain is falling more rapidly than it infiltrates into the soil.
<b>(b) Saturation</b>	-Excess overland flow occurs when soil spaces are so full of water that no more rain can be absorbed.
<b>Throughflow</b>	-Rainwater which has infiltrated into unsaturated soil can move horizontally to the river channel. This process is slower than overland flow but faster than base flow.
<b>Baseflow</b>	-Rainwater which has percolated to the aquifer can seep into the river channel. This is the slowest process.

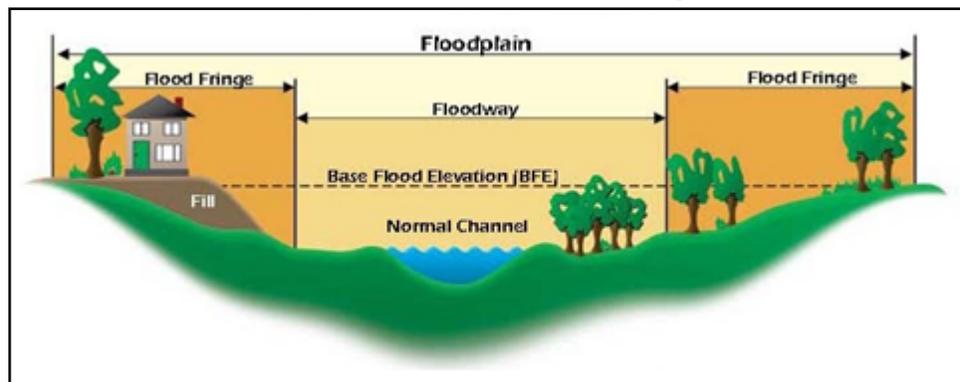
*Source: The Field Studies Council*

Common Causes of Flooding	
Factor	Effect on Flooding
<b>Geology</b>	Impermeable rocks are saturated more quickly than porous and pervious rocks. Saturation excess overland flow is more common. Sandy soils have larger pore spaces than clay soils. Infiltration is most rapid in sandy soils.
<b>Relief</b>	Water reaches the channel more rapidly in a steeper basin as water is travelling more quickly downhill.
<b>Vegetation</b>	Vegetation intercepts a large proportion of rainfall. Where trees are deciduous, discharge is higher in a forested basin in winter as there is less interception.
<b>Meteorological Factors</b>	Where rain is falling faster than the infiltration rate, there is infiltration-excess overland flow. This is common after a summer storm. Snow does not reach the channel but is stored on the ground surface. As snow melts, the meltwater will reach the channel quickly as infiltration is impeded if the ground is still frozen.
<b>Catchment Shape</b>	It takes less time for water to reach the channel in a circular basin as all extremities are roughly equidistant from the channel.
<b>Land Use</b>	Surface runoff is higher in urban areas because there are more urban surfaces (concrete & tarmac) and sewers take water rapidly to rivers. There is less interception and evapotranspiration and more surface runoff in a deforested catchment.
<b>Catchment Size</b>	Water reaches the channel more rapidly in a smaller basin as water has a shorter distance to travel.
<b>Antecedent Conditions</b>	The level of discharge before the storm is called the antecedent discharge. Even a small amount of rain can lead to flooding.

*Source: The Field Studies Council*

In Bradley County, some areas are more flood-prone than others. One of the ways of identifying these flood-prone areas is through determining the county’s 100- and 500-year floodplains. 100-year floods are calculated to be the level of flood water expected to be equaled or exceeded every 100 years on average, meaning a flood that has a 1% chance of being equaled or exceeded in magnitude in any single year. A 500-year floodplain has a 0.2% chance. A 100-year floodplain would include the areas adjoining a stream, river, or watercourse that would be covered by water in the event of a 100-year flood (see diagram below).

### Characteristics of a Floodplain



*Source: FEMA*

In Bradley County, all jurisdictions are susceptible to smaller localized flooding. Areas in the county known to flood more often include:

- Hiwassee River floodplains.
- South Mouse Creek floodplains.
- Candies Creek floodplains.
- Fillauer Branch floodplains.
- Cohulla Creek floodplains.

*Detailed Flood Insurance Rate Maps (FIRMs) are also included in [Appendix 7](#), which shows where FEMA has placed the 500-year floodplain for each jurisdiction.*

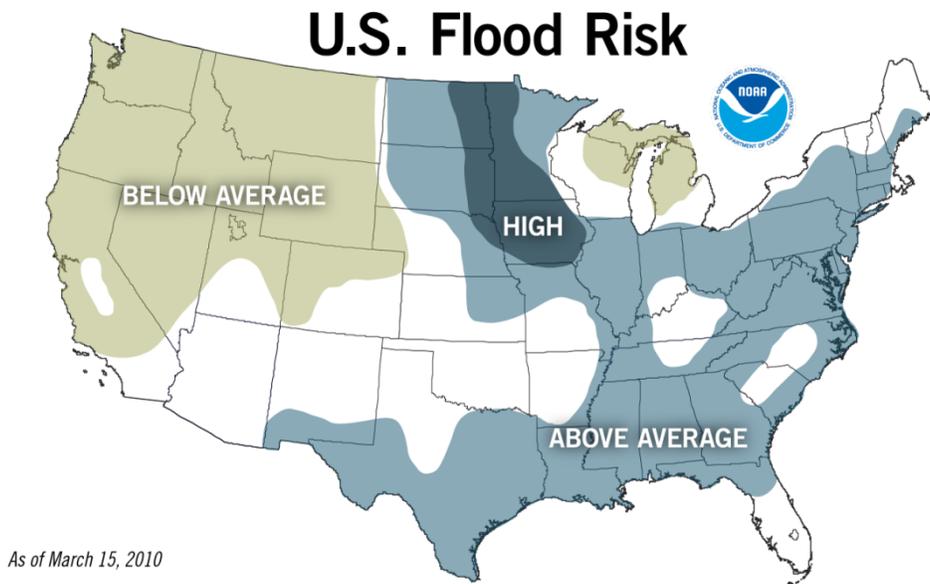
Bradley County historically has had many flood events in the past. Based on NOAA NCDC data, the following charts provide a list of flood events occurring in Bradley County from January 2006 to May 2016 and a list of floods with descriptions of their impacts imposed on the community.

**Flood Events in Bradley County: January 2003–May 2016**

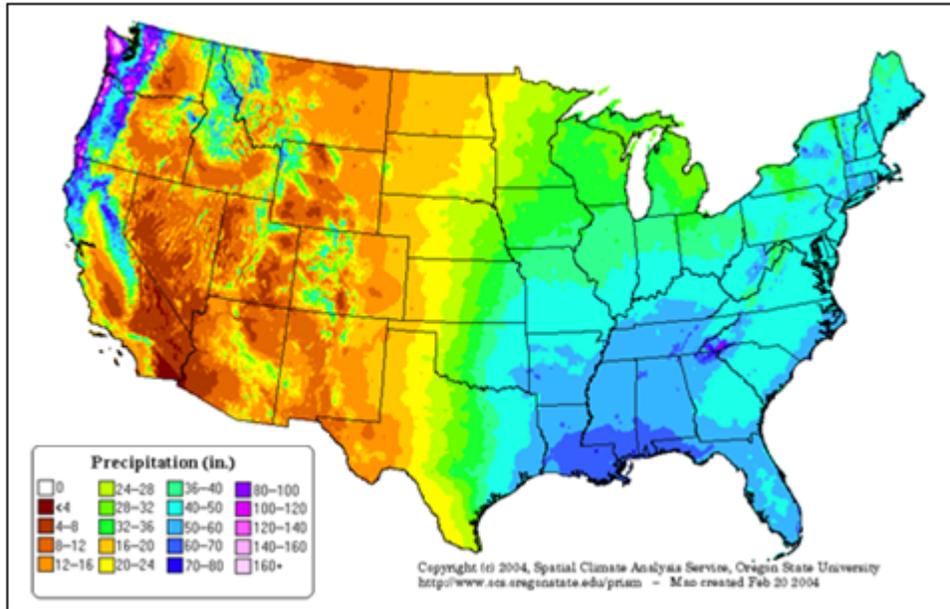
Location	Date	Type	Deaths	Injuries	Property Damage
Bradley County	05/06/2003	Flash Flood	0	0	18,950,000
Bradley County	04/07/2005	Flash Flood	0	0	50,000
Annadale	05/28/2009	Flash Flood	0	0	0
Cleveland	09/05/2011	Flash Flood	0	0	0
Tasso	09/05/2011	Flash Flood	0	0	0
Cleveland	08/01/2012	Flash Flood	0	0	1000
Cleveland	07/05/2015	Flash Flood	0	0	0
Bradley County	02/14/2003	Flood	0	0	0
Bradley County	02/21/2003	Flood	0	0	0
South Cleveland	09/21/2009	Flood	0	0	0
South Cleveland	09/26/2009	Flood	0	0	5000
Cleveland	03/12/2010	Flood	0	0	0
Cleveland	12/25/2015	Flood	0	0	2000
Cleveland	12/25/2015	Flood	0	0	1000
47, TENNESSEE	OBION	ALL	(C) Flash Flood	2006	01
	01	2012	12	30	

Small localized flood events are likely to occur approximately slightly less than twice every year in Bradley County. The severity of flooding that may occur in the county is measured by inches of rainfall. As seen with the May 2003 flood event, it is possible for Bradley County to receive up to 16" of rain in a 24-hour period. Many roads and bridges were flooded or wash out.

Per a NOAA Flood Risk Map (see map below), much of Tennessee was in an "above average" risk of flooding zone during spring 2010. This proposed vulnerability is coupled with the fact that on average Tennessee usually acquires over 50-60 inches of rainfall a year (see following map).



**Average Annual Precipitation per Year (1971-2000)**



Source: Spatial Climate Analysis Service, Oregon State University

Bradley County uses a ranking system to determine vulnerability to flooding events. This system is based off simple arithmetic which analyzes potential impacts to determine vulnerabilities and then analyzes the probability of a flood event occurring to calculate a flood risk ranking for each jurisdiction.

**Flooding**

Jurisdiction	Impacts			Vulnerability
	Human	Property	Business	$H+P+B=\#; \#/3=V$
Bradley County Unincorporated	2	2	1	1.67
City of Charleston	2	3	2	2.33
City of Cleveland	2	3	2	2.33

Jurisdiction	Vulnerability	Probability	Risk	
			$V+P=R$	
Bradley County Unincorporated	1.67	2	3.67	Moderate
City of Charlestown	2.33	2	4.33	Moderate
City of Cleveland	2.33	2	4.33	Moderate

Scale	
Low	2-3.6
Moderate	3.7-5.2
Medium	5.3-6.8
High	6.9-8.4
Severe	8.5-10

Human	
<i>Risk of Injuries and Death from the Hazard</i>	
<b>1</b>	Death very unlikely, injuries are unlikely
<b>2</b>	Death unlikely, injuries are minimal
<b>3</b>	Death unlikely, injuries may be substantial
<b>4</b>	Death possible, injuries may be substantial
<b>5</b>	Deaths probable, injuries will likely be substantial

Property	
<i>Amount of Residential Property Damage Associated from Hazard</i>	
<b>1</b>	Less than \$500 in damages
<b>2</b>	\$500-\$10,000 in damages
<b>3</b>	\$10,000-\$500,000 in damages
<b>4</b>	\$500,000-\$2,000,000 in damages
<b>5</b>	More than \$2,000,000 in damages

Business	
<i>Amount of Business Damage Associated from the Hazard</i>	
<b>1</b>	Less than 3 businesses closed for only a day
<b>2</b>	More than 3 businesses closed for a week
<b>3</b>	More than 3 businesses closed for a few months
<b>4</b>	More than 3 businesses closed indefinitely or relocated
<b>5</b>	A top-10 local employer closed indefinitely

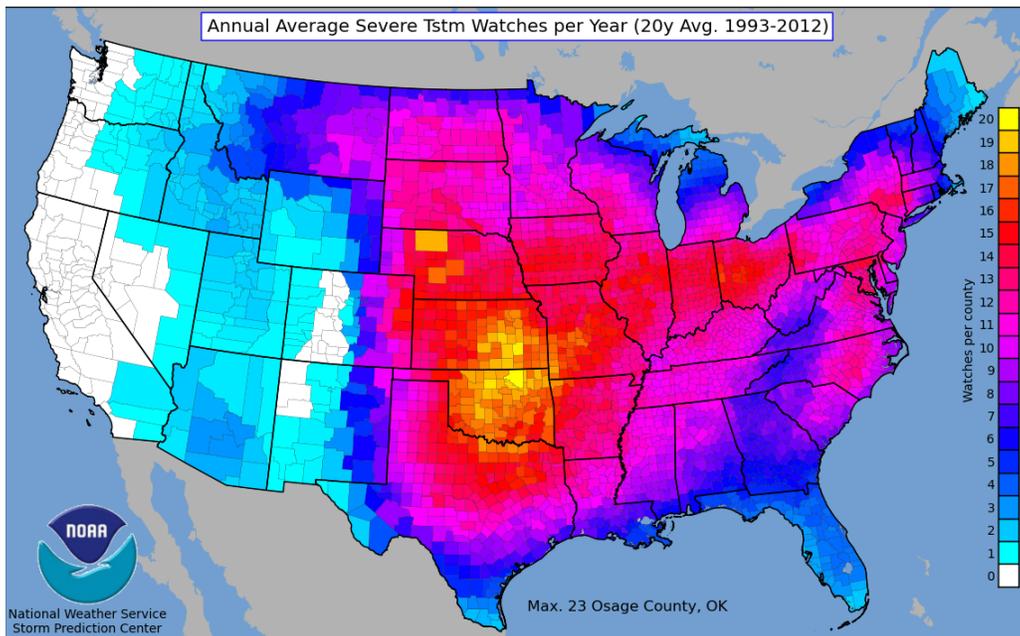
Probability	
<i>Amount of Residential Property Damage Associated from Hazard</i>	
<b>1</b>	Less than once every 10 years
<b>2</b>	About once every 5-10 years
<b>3</b>	About once every 2-5 years
<b>4</b>	About once a year
<b>5</b>	More than once a year

For further information about flooding hazards in Bradley County, see the HAZUS vulnerability study in [Appendix 8](#).

## **Tornadoes/Severe Storms**

Per the National Weather Service, to consider a storm severe it must encompass one of three traits: produce winds greater than 58 miles per hour (50.4 knots), produce hail  $\frac{3}{4}$  of an inch or greater in diameter, or produce tornadoes. On average, a typical county in Tennessee has about 10 severe storm watches per year (see map below).

### **Average Severe Storm Watches Per Year (1993-2012)**

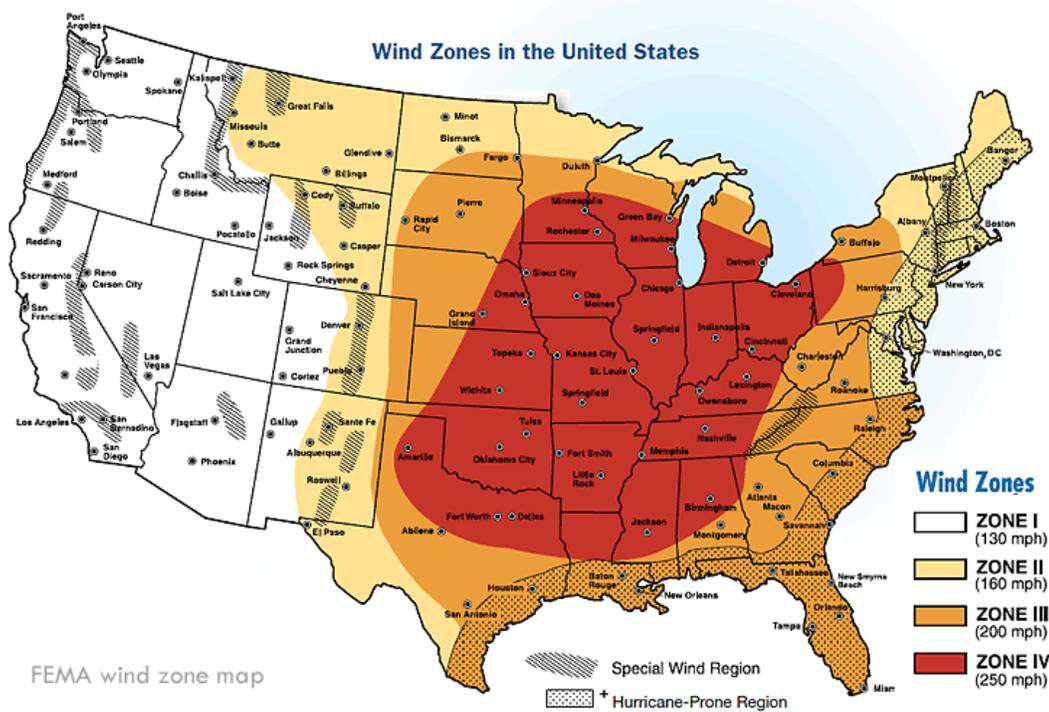


*Source: NOAA/NWS Storm Prediction Center*

## **Tornado**

A tornado is a violently rotating column of air that extends from a thunderstorm, etc. down to the ground, and can reach wind speeds of 40 mph to 250 mph and higher. Tornadoes paths, lengths, and widths can vary greatly. In Bradley County, all jurisdictions are vulnerable to tornado threats. The following map places much of Tennessee in the highest wind zone (see following map).

### Wind Zones in the United States



Source: FEMA

Bradley County historically has had several tornado events in the past. Based on NOAA NCDC data, the following chart provides a list of tornado events occurring in Bradley County from January 1950 to May 2016.

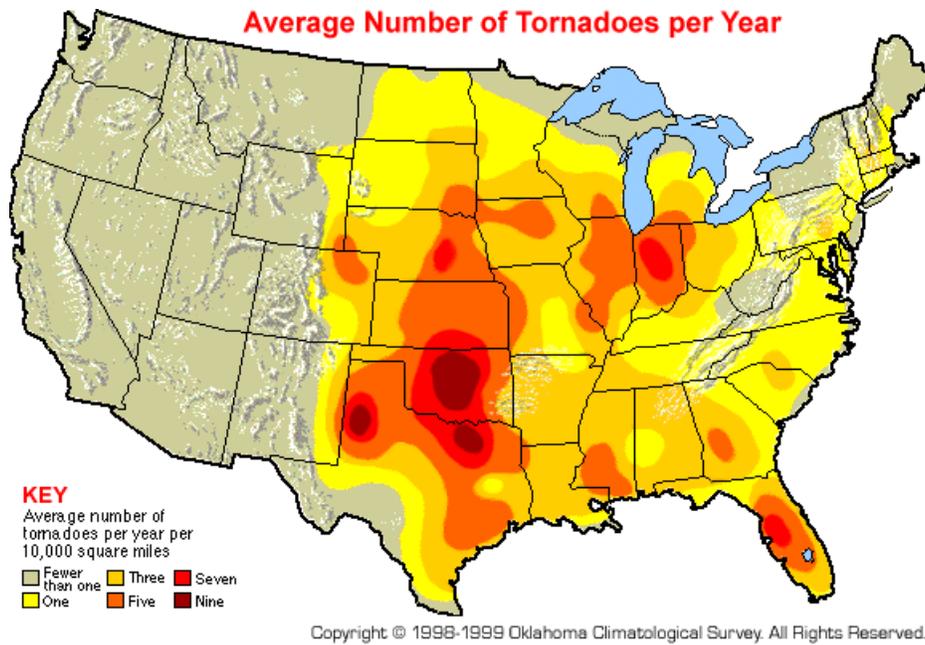
### Tornado Events in Bradley County: January 1950–May 2016

Location	Date	Extent	Deaths	Injuries	Property Damage
Bradley County	03/19/1963	F2	0	3	250000
Bradley County	04/15/1965	F3	0	50	2500000
Bradley County	04/03/1974	F3	1	100	250000
Bradley County	04/03/1974	F3	2	0	250000

Bradley County	04/08/1980	F1	0	0	25000
Bradley County	02/06/1986	F3	0	5	250000
Bradley County	11/15/1989	F1	0	0	25000
Cleveland	05/27/1996	F0	0	0	0
SW of Cleveland	03/29/1997	F3	0	50	3200000
Cleveland	04/16/1998	F1	1	0	750000
Cleveland	05/07/1998	F1	0	0	375000
Weatherly Switch	05/31/2004	F1	0	0	80000
Cleveland	08/02/2004	F0	0	0	20000
Charleston	10/26/2010	EF1	0	0	100000
Etola	04/27/2011	EF2	0	2	125000
McDonald	04/27/2011	EF1	1	0	75000
Hopewell	04/27/2011	EF0	0	0	15000
Cleveland	04/27/2011	EF0	0	0	500000
Cecilton	04/27/2011	EF2	4	0	500000
Cleveland	04/27/2011	EF0	0	0	20000
Pine Hill	04/27/2011	EF4	4	200	23000000
Baugh Springs	03/02/2012	EF2	0	7	3840000
Gap Spring	04/28/2014	EF1	0	0	90000

Based on previous occurrences in adjoining communities, tornado events are likely to occur about three times every year in Bradley County, (see the following map for other probability information).

### **Average Number of Tornadoes Per Year**



Source: Oklahoma Climatological Survey

The severity of tornadoes that may occur in the county is measured using the Enhanced Fujita Scale for tornadoes (see chart below). Based on historical events, in a worst-case scenario it is possible for the extent of a tornado to reach an F4 ranking, as demonstrated in the April 27<sup>th</sup>, 2011 tornado, which saw over 200 injuries, 9 deaths and over \$65 million in damages.

### Fujita Scale/Enhanced Fujita Scale for Tornadoes

Fujita / Enhanced Fujita Scale for Tornadoes				
F-Scale	Fastest Quarter Mile Wind Speed	Typical Impacts	Enhanced Scale: 3 Sec Wind Gust Speed	Enhanced F-Scale
<b>F0</b>	40-72 MPH	Some damage to chimney; breaks branches off trees; pushes over shallow-rooted trees; damages sign boards.	65-85 MPH	<b>EF0</b>
<b>F1</b>	73-112 MPH	Peels surface off roofs; mobile homes pushed off foundations or overturned; moving autos pushed off the roads; attached garages may be destroyed.	86-110 MPH	<b>EF1</b>
<b>F2</b>	113-157 MPH	Considerable damage. Roofs torn off frame houses; mobile homes demolished; boxcars pushed over; large trees snapped or uprooted; light object missiles generated.	111-135 MPH	<b>EF2</b>
<b>F3</b>	158-206 MPH	Roof and some walls torn off well-constructed homes; trains overturned; most trees in forest uprooted.	136-165 MPH	<b>EF3</b>

Section 4: Mitigation Strategy

<b>F4</b>	207-260 MPH	Well-constructed houses leveled; structures with weak foundations blown off some distance; cars thrown and large missiles generated.	166-200 MPH	<b>EF4</b>
<b>F5</b>	261-318 MPH	Strong frame houses lifted off foundations and carried considerable distances to disintegrate; automobile sized missiles fly through the air in excess of 100 meters; trees debarked; steel reinforced concrete structures badly damaged.	Over 200 MPH	<b>EF5</b>

Source: NOAA National Weather Service; The Tornado Project

## Tornado

Jurisdiction	Impacts			Vulnerability
	Human	Property	Business	$H+P+B=\#; \#/3=V$
Bradley County Unincorporated	4	5	4	4.33
City of Charleston	4	4	4	4.00
City of Cleveland	4	5	4	4.33

Jurisdiction	Vulnerability	Probability	Risk	
			$V+P=R$	
Bradley County Unincorporated	4.33		4.33	Moderate
City of Charlestown	4.00		4.00	Moderate
City of Cleveland	4.33		4.33	Moderate

Scale	
Low	2-3.6
Moderate	3.7-5.2
Medium	5.3-6.8
High	6.9-8.4
Severe	8.5-10

<b>Human</b>	
<i>Risk of injuries and deaths from the hazard</i>	
1	Death very unlikely, injuries are unlikely
2	Death unlikely, injuries are minimal
3	Death unlikely, injuries may be substantial
4	Death possible, injuries may be substantial
5	Deaths probable, injuries will likely be substantial

<b>Property</b>	
<i>Amount of residential property damage associated from the hazard</i>	
1	Less than \$500 in damages
2	\$500-\$10,000 in damages
3	\$10,000-\$500,000 in damages
4	\$500,000-\$2,000,000 in damages
5	More than \$2,000,000 in damages

<b>Business</b>	
<i>Amount of business damage associated from the hazard</i>	
1	Less than 3 businesses closed for only a day
2	More than 3 businesses closed for a week
3	More than 3 businesses closed for a few months
4	More than 3 businesses closed indefinitely or relocated
5	A top-10 local employer closed indefinitely

<b>Probability</b>	
<i>Likelihood of the hazard occurring within a given span of years</i>	
1	Less than once every 10 years
2	About once every 5-10 years
3	About once every 2-5 years
4	About once a year
5	More than once a year

## **Hail**

Hail is the frozen form of precipitation, falling as small spheres of solid ice. Even though the risk from hail is relatively low, all jurisdictions have the possibility of hail causing some window and roof damage. Historically, hail events occur just less than once per year in Bradley County. The severity of hail is measured by the diameter of the hail itself, commonly using the TORRO Hail Index (see following chart). Bradley County's largest hail extent is reported at 1.75 inches (H5). Most of the county's hail events were reported causing minor roof damage to several homes and vehicles.

### TORRO Hail Index

TORRO Hail Index			
Scale	Max Diameter	Comparisons	Typical Impacts
H0	5-9 MM	Pea	No damage.
H1	10-15 MM	Mothball	Slight general damage to plants, crops.
H2	16-20 MM	Marble	Significant damage to fruit, crops, vegetation.
H3	21-30 MM	Walnut	Severe damage to fruit and crops, damage to glass and plastic structures, paint and wood scored.
H4	31-40 MM	Pigeon's Egg	Widespread glass damage, vehicle bodywork damage.
H5	41-50 MM	Golf Ball	Wholesale destruction of glass, damage to tiled roofs, significant risk of injuries.
H6	51-60 MM	Hen's Egg	Bodywork of grounded aircraft dented, brick walls pitted.
H7	61-75 MM	Tennis Ball	Severe roof damage, risk of serious injuries.
H8	76-90 MM	Soft Ball	Severe damage to aircraft bodywork.
H9	91-100 MM	Grapefruit	Extensive structural damage. Risk of severe or even fatal injuries to persons caught in the open.

*Source: The Tornado & Storm Research Organization*

The following chart provides hail event information for Bradley County between January 2006 and May 2016.

#### Hail Events in Bradley County: January 2006–May 2016

Location	Date	Extent	Deaths	Injuries	Property Damage
Cleveland	05/13/2006	.75	0	0	None reported
Hopewell	05/20/2006	1.5	0	0	None reported
Hopewell	05/20/2006	2.75	0	0	None reported
Cleveland	06/21/2006	.75	0	0	None reported
Cleveland	06/30/2006	1.75	0	0	None reported
Cleveland	06/30/2006	.88	0	0	None reported
Cleveland	06/15/2007	.75	0	0	None reported
Cleveland	02/06/2008	.75	0	0	None reported
Cleveland	05/18/2008	1.0	0	0	None reported
Felker	05/18/2008	1.0	0	0	None reported
Felker	05/20/2008	1.0	0	0	None reported
Cleveland	05/15/2009	1.0	0	0	None reported
Cleveland	06/11/2009	.75	0	0	None reported
Cleveland	03/12/2010	.75	0	0	None reported
Eureka	05/15/2010	1.0	0	0	None reported
Cleveland	05/28/2010	1.0	0	0	None reported
Cleveland	02/28/2011	1.0	0	0	None reported
Charleston	04/04/2011	.88	0	0	None reported

Cleveland	04/27/2011	1.75	0	0	None reported
Cleveland	04/27/2011	1.75	0	0	None reported
Cleveland	04/27/2011	1.0	0	0	None reported
Cleveland	04/27/2011	1.75	0	0	None reported
Cleveland	04/27/2011	1.25	0	0	None reported
Cleveland	04/27/2011	1.75	0	0	None reported
Cleveland	04/27/2011	1.75	0	0	None reported
Hopewell	06/05/2011	.88	0	0	None reported
Cleveland	06/05/2011	1.0	0	0	None reported
Cleveland	06/15/2011	1.0	0	0	None reported
Charleston	06/18/2011	1.0	0	0	None reported
Cleveland	01/11/2012	.75	0	0	None reported
Cleveland	01/11/2012	.88	0	0	None reported
Cleveland	02/22/2012	1.0	0	0	None reported
Cleveland	02/22/2012	1.0	0	0	None reported
McDonald	03/02/2012	1.0	0	0	None reported
Waterville	03/02/2012	1.25	0	0	None reported
Cleveland	04/26/2012	1.75	0	0	None reported
Cleveland	04/20/2012	2.0	0	0	None reported
Cleveland	07/10/2012	1.0	0	0	None reported
Cleveland	08/01/2012	1.25	0	0	None reported
East Cleveland	04/22/2016	1.0	0	0	None reported

## **Wind events**

Severe storm winds most commonly occur as straight-line winds; a downburst of wind created by an area of significantly rain-cooled air that spreads out in all directions after hitting the ground. All jurisdictions are vulnerable to receiving damage from these severe storm winds.

Historically severe storm wind events occur slightly more than three times per year in Bradley County. The severity of severe storm winds is commonly measured by wind speed (knots or mph). The largest severe storm wind events within Bradley County in recent years were recorded on April 27<sup>th</sup>, 2011. The damage in these events was a result of wind

speeds over 80 mph. During this storm, numerous tornados and areas of wind damage were reported.

The following chart provides severe storm wind event information for Bradley County between January 2006 and May 2016.

### Wind Events in Bradley County: January 2006–May 2016

Location	Date	Type	Extent	Deaths	Injuries	Property Damage
Cleveland	04/08/2006	Thunderstorm Wind	60 kts. EG	0	0	5000
Cleveland	04/19/2006	Thunderstorm Wind	70 kts. EG	0	0	20000
Cleveland	05/13/2006	Thunderstorm Wind	60 kts. EG	0	0	5000
East Cleveland	05/20/2006	Thunderstorm Wind	60 kts. EG	0	0	20000
Cleveland	05/26/2006	Thunderstorm Wind	60 kts. EG	0	0	20000
Hopewell	05/27/2006	Thunderstorm Wind	60 kts. EG	0	0	3000
Cleveland	05/27/2006	Thunderstorm Wind	60 kts. EG	0	0	10000
Cleveland	06/21/2006	Thunderstorm Wind	60 kts. EG	0	0	10000
Cleveland	06/23/2006	Thunderstorm Wind	60 kts. EG	0	0	30000
South Cleveland	07/14/2006	Thunderstorm Wind	65 kts. EG	0	0	50000
Bradley County	07/21/2006	Thunderstorm Wind	60 kts. EG	0	0	30000
Bradley County	08/04/2006	Thunderstorm Wind	55 kts. EG	0	0	5000
Cleveland	08/20/2006	Thunderstorm Wind	60 kts. EG	0	0	15000
Cleveland	08/20/2006	Thunderstorm Wind	60 kts. EG	0	0	12000
Cleveland	09/04/2006	Thunderstorm Wind	65 kts. EG	0	0	30000
Cleveland	10/11/2006	Thunderstorm Wind	60 kts. EG	0	0	15000
Cleveland	06/08/2007	Thunderstorm Wind	60 kts. EG	0	0	18000
Cleveland	06/24/2007	Thunderstorm Wind	55 kts. EG	0	0	15000
Cleveland	06/25/2007	Thunderstorm Wind	55 kts. EG	0	0	5000
Cleveland	08/01/2007	Thunderstorm Wind	55 kts. EG	0	0	10000
Cleveland	11/14/2007	Thunderstorm Wind	55 kts. EG	0	0	0
Cleveland	02/06/2008	Thunderstorm Wind	55 kts. EG	0	0	10000
Cleveland	03/19/2008	Thunderstorm Wind	55 kts. EG	0	0	0
Chestuee	04/11/2008	Thunderstorm Wind	60 kts. EG	0	0	15000
Cleveland	04/11/2008	Thunderstorm Wind	60 kts. EG	0	0	3000
Hopewell	05/18/2008	Thunderstorm Wind	55 kts. EG	0	0	0
Flint Springs	05/20/2008	Thunderstorm Wind	55 kts. EG	0	0	0
Cleveland	06/01/2008	Thunderstorm Wind	60 kts. EG	0	0	15000

## Section 4: Mitigation Strategy

Charleston	06/10/2008	Thunderstorm Wind	52 kts. EG	0	0	3000
Cleveland	07/21/2008	Thunderstorm Wind	55 kts. EG	0	0	0
Charleston	07/30/2008	Thunderstorm Wind	55 kts. EG	0	0	0
Climer	07/30/2008	Thunderstorm Wind	55 kts. EG	0	0	0
Cleveland	12/10/2008	Thunderstorm Wind	52 kts. EG	0	0	3000
Cleveland	04/10/2009	Thunderstorm Wind	60 kts. EG	0	0	20000
Mineral Park	04/10/2009	Thunderstorm Wind	55 kts. EG	0	0	12000
Cleveland	05/14/2009	Thunderstorm Wind	50 kts. EG	0	0	0
Cleveland	05/14/2009	Thunderstorm Wind	50 kts. EG	0	0	0
Cleveland	05/15/2009	Thunderstorm Wind	50 kts. EG	0	0	0
Cleveland	06/11/2009	Thunderstorm Wind	58 kts. EG	0	0	15000
Climer	07/05/2009	Thunderstorm Wind	50 kts. EG	0	0	0
Flint Springs	07/09/2012	Thunderstorm Wind	50 kts. EG	0	0	0
Cleveland	08/12/2009	Thunderstorm Wind	60 kts. EG	0	0	25000
Cleveland	10/09/2009	Thunderstorm Wind	52 kts. EG	0	0	3000
Cleveland	10/09/2009	Thunderstorm Wind	58 kts. EG	0	0	20000
Waterville	05/16/2010	Thunderstorm Wind	55 kts. EG	0	0	0
South Cleveland	06/10/2010	Thunderstorm Wind	50 kts. EG	0	0	2000
Cleveland	06/10/2010	Thunderstorm Wind	50 kts. EG	0	0	5000
Cleveland	06/14/2010	Thunderstorm Wind	60 kts. EG	0	0	20000
Chestuee	06/15/2010	Thunderstorm Wind	50 kts. EG	0	0	2000
Cleveland	06/15/2010	Thunderstorm Wind	60 kts. EG	0	0	20000
Cleveland	07/05/2010	Thunderstorm Wind	50 kts. EG	0	0	10000
Cleveland	07/26/2010	Thunderstorm Wind	55 kts. EG	0	0	0
Cleveland	07/26/2010	Thunderstorm Wind	55 kts. EG	0	0	0
Cleveland	08/05/2010	Thunderstorm Wind	60 kts. EG	0	0	20000
Cecilton	09/16/2010	Thunderstorm Wind	50 kts. EG	0	0	0
Cleveland	10/25/2010	Thunderstorm Wind	65 kts. EG	0	0	15000
Cleveland	10/25/2010	Thunderstorm Wind	60 kts. EG	0	0	15000
Cleveland	10/25/2010	Thunderstorm Wind	60 kts. EG	0	0	20000
Cleveland	10/25/2010	Thunderstorm Wind	60 kts. EG	0	0	15000
Cleveland	10/26/2010	Thunderstorm Wind	60 kts. EG	0	0	12000
Charleston	10/26/2010	Thunderstorm Wind	60 kts. EG	0	0	15000
Cleveland	02/25/2011	Thunderstorm Wind	55 kts. EG	0	0	8000
Cleveland	02/28/2011	Thunderstorm Wind	52 kts. EG	0	0	10000
Eureka	03/26/2011	Thunderstorm Wind	50 kts. EG	0	0	0

## Section 4: Mitigation Strategy

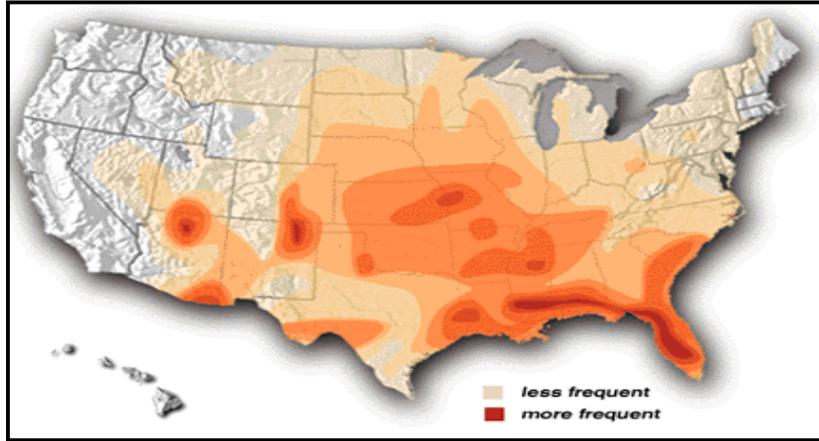
Cleveland	04/27/2011	Thunderstorm Wind	60 kts. EG	0	0	25000
Cleveland	04/27/2011	Thunderstorm Wind	60 kts. EG	0	0	30000
Cleveland	04/27/2011	Thunderstorm Wind	55 kts. EG	0	0	10000
Cleveland	04/27/2011	Thunderstorm Wind	55 kts. EG	0	0	5000
Cleveland	05/26/2011	Thunderstorm Wind	50 kts. EG	0	0	0
Waterville	05/26/2011	Thunderstorm Wind	50 kts. EG	0	0	0
Charleston	05/26/2011	Thunderstorm Wind	50 kts. EG	0	0	15000
Prospect	07/13/2011	Thunderstorm Wind	50 kts. EG	0	0	0
Cleveland	07/13/2011	Thunderstorm Wind	50 kts. EG	0	0	0
Bellfounte	09/22/2011	Thunderstorm Wind	50 kts. EG	0	0	0
Charleston	09/22/2011	Thunderstorm Wind	50 kts. EG	0	0	0
Cleveland	07/01/2012	Thunderstorm Wind	50 kts. EG	0	0	0
Bellfounte	07/01/2012	Thunderstorm Wind	50 kts. EG	0	0	0
Cleveland	08/01/2012	Thunderstorm Wind	50 kts. EG	0	0	2000
Cleveland	08/01/2012	Thunderstorm Wind	50 kts. EG	0	0	15000
Cleveland	08/10/2012	Thunderstorm Wind	50 kts. EG	0	0	1000
Union Grove	03/18/2013	Thunderstorm Wind	50 kts. EG	0	0	0
Cleveland	07/17/2013	Thunderstorm Wind	50 kts. EG	0	0	0
Cleveland	02/21/2014	Thunderstorm Wind	50 kts. EG	0	0	10000
Cleveland	04/28/2014	Thunderstorm Wind	55 kts. EG	0	0	10000
Cleveland	04/28/2014	Thunderstorm Wind	60 kts. EG	0	0	15000
Cleveland	06/10/2014	Thunderstorm Wind	50 kts. EG	0	0	2000
Cleveland	06/10/2014	Thunderstorm Wind	55 kts. EG	0	0	20000
Cleveland	07/08/2014	Thunderstorm Wind	50 kts. EG	0	0	0
Cleveland	04/03/2015	Thunderstorm Wind	50 kts. EG	0	0	2000
Cleveland	04/03/2015	Thunderstorm Wind	52 kts. EG	0	0	8000
Cleveland	06/08/2015	Thunderstorm Wind	55 kts. EG	0	0	0
Charleston	06/19/2015	Thunderstorm Wind	60 kts. EG	0	0	0
Climer	06/24/2015	Thunderstorm Wind	50 kts. EG	0	0	0
Red Hill	06/26/2015	Thunderstorm Wind	50 kts. EG	0	0	0
Annadale	06/26/2015	Thunderstorm Wind	50 kts. EG	0	0	0
Waterville	06/26/2015	Thunderstorm Wind	50 kts. EG	0	0	0
Hopewell	06/26/2015	Thunderstorm Wind	50 kts. EG	0	0	0
Cleveland	07/14/2017	Thunderstorm Wind	50 kts. EG	0	0	0
Cleveland	08/10/2015	Thunderstorm Wind	50 kts. EG	0	0	0
Charleston	06/03/2016	Thunderstorm Wind	50 kts. EG	0	0	0

South Cleveland	07/08/2016	Thunderstorm Wind	50 kts. EG	0	0	0
Waterville	07/08/2016	Thunderstorm Wind	50 kts. EG	0	0	0
Chestuee	08/28/2016	Thunderstorm Wind	50 kts. EG	0	0	0
Hopewell	08/28/2016	Thunderstorm Wind	50 kts. EG	0	0	0
Eureka	11/30/2016	Thunderstorm Wind	50 kts. EG	0	0	0
Cleveland	11/30/2016	Thunderstorm Wind	52 kts. EG	0	0	0
Eureka	11/30/2016	Thunderstorm Wind	50 kts. EG	0	0	0
47, TENNESSEE	OBION	ALL	(C) Lightning	2006	01	
	01	2012	12	30		

## **Lightning**

Lightning is an enormous electrical discharge is caused by an imbalance between positive and negative charges. During a storm, colliding particles of rain, ice, or snow increase this imbalance and often negatively charge the lower reaches of storm clouds. Objects on the ground, like steeples, trees, and the Earth itself, become positively charged—creating an imbalance that nature seeks to remedy by passing current between the two charges. Lightning events may affect the entire area of Bradley County any time of the year, though they are more numerous in spring and summer. There are two recorded lightning strikes on record in Bradley County with one confirmed death in 1999. The severity of damages depends on what the lightning strikes.

### **Lightning Probability Incidence Map: Annual Frequency of Cloud-to-Ground Lightning**



The following chart provides lightning event information for Bradley County between January 2006 and May 2016.

**Recorded Lightning Impacts in Bradley County:  
June 1999 – May 2016**

Location	Date	Deaths	Injuries	Property Damage
Cleveland	06/26/1999	1	0	0
Cleveland	08/19/2009	0	0	0

Throughout the county all buildings and infrastructure are vulnerable to tornadoes and severe storm impacts. Bradley County’s building stock can be broken down into the following percentage categories: 65% residential, 20% commercial, 6% industrial, 2% agricultural, 1% governmental, 3% religious, and 3% educational. Impacts could range from slight roof damages caused by hail to total structure flattening caused by strong tornadoes. In the county, manufactured homes, electrical lines, and older barns are some of the most vulnerable features.

Bradley County uses a ranking system to determine each jurisdiction’s vulnerability to severe storm events (with a focus on tornadoes). This system is based off simple arithmetic which analyzes potential impacts to determine vulnerabilities and then analyzes the probability of a severe storm event occurring to calculate a risk ranking for each jurisdiction.

**Severe Storms**

Jurisdiction	Impacts			Vulnerability
	Human	Property	Business	$H+P+B=\#; \#/3=V$
Bradley County Unincorporated	2	2	2	2.00
City of Charleston	2	2	2	2.00
City of Cleveland	2	2	2	2.00

Jurisdiction	Vulnerability	Probability	Risk	
			$V+P=R$	
Bradley County Unincorporated	2.00	2	4.00	Moderate
City of Charlestown	2.00	2	4.00	Moderate
City of Cleveland	2.00	2	4.00	Moderate

Scale	
Low	2-3.6
Moderate	3.7-5.2
Medium	5.3-6.8
High	6.9-8.4
Severe	8.5-10

<b>Human</b>	
<i>Risk of injuries and deaths from the hazard</i>	
1	Death very unlikely, injuries are unlikely
2	Death unlikely, injuries are minimal
3	Death unlikely, injuries may be substantial
4	Death possible, injuries may be substantial
5	Deaths probable, injuries will likely be substantial

<b>Property</b>	
<i>Amount of residential property damage associated from the hazard</i>	
1	Less than \$500 in damages
2	\$500-\$10,000 in damages
3	\$10,000-\$500,000 in damages
4	\$500,000-\$2,000,000 in damages
5	More than \$2,000,000 in damages

<b>Business</b>	
<i>Amount of business damage associated from the hazard</i>	
1	Less than 3 businesses closed for only a day
2	More than 3 businesses closed for a week
3	More than 3 businesses closed for a few months
4	More than 3 businesses closed indefinitely or relocated
5	A top-10 local employer closed indefinitely

<b>Probability</b>	
<i>Likelihood of the hazard occurring within a given span of years</i>	
1	Less than once every 10 years
2	About once every 5-10 years
3	About once every 2-5 years
4	About once a year
5	More than once a year

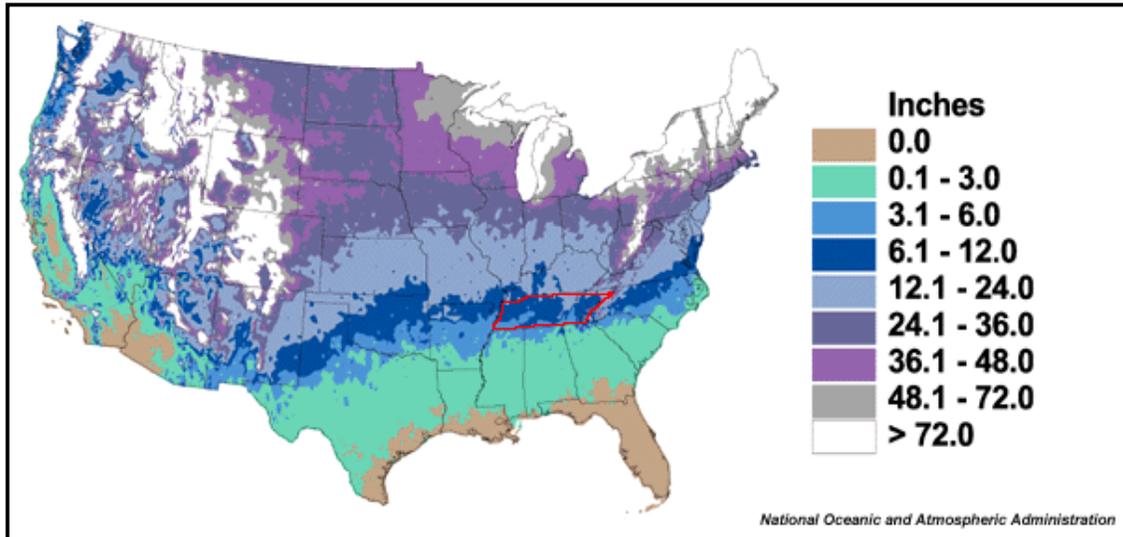
### **Freezes/Winter Storms**

A freeze occurs when temperatures are below 32 degrees Fahrenheit for an extended period. These temperatures can damage agricultural crops, burst water pipes, and create layers of “black ice.” Winter storms are events that can range from a few hours of moderate snow to blizzard-like circumstances that can affect driving conditions and impact communications, electricity, and other services. In Bradley County, all jurisdictions are vulnerable to freezes and moderate winter storms, but not to the severity level seen in much of the northern U.S.

Based on previous occurrences, Bradley County usually experiences one to two instances of winter weather every year. The severity of winter

storms is commonly measured by inches of ice or snowfall. It is possible for over 11" of a combination of ice, sleet, and snow to accumulate, as it did on March 4<sup>th</sup>-5<sup>th</sup>, 2015, causing road closures, power interruptions, and stranding people in their homes.

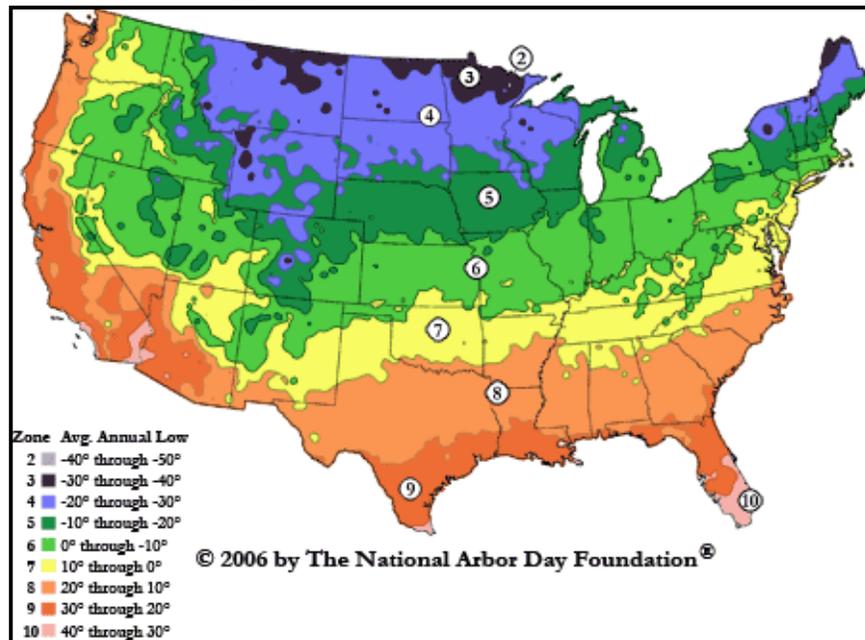
### Average Mean Snowfall Per Year



Source: NOAA

Bradley County can experience temperatures between 15 to 5 degrees Fahrenheit, thus causing multiple freeze conditions during the winter months (see the following map for other average lows).

### Average Annual Low Temperatures



Source: NOAA

The following chart provides winter storm event information for Bradley County between January 2005 and May 2016.

#### Winter Events in Bradley County: January 2006–May 2016

Jurisdiction	Date	Type	Deaths	Injuries	Property Damage
Bradley County	01/29/2010	Heavy Snow	0	0	Unknown
Bradley County	12/25/2010	Heavy Snow	0	0	Unknown
Bradley County	01/10/2011	Heavy Snow	0	0	Unknown
Bradley County	02/12/2014	Heavy Snow	0	0	Unknown
Bradley County	02/13/2014	Heavy Snow	0	0	Unknown
Bradley County	02/21/2015	Winter Storm	0	0	Unknown
Bradley County	02/25/2015	Heavy Snow	0	0	Unknown
Bradley County	02/26/2015	Heavy Snow	0	0	Unknown

47, TENNESSEE	OBION	OBION	(Z) Winter Weath	2006	01
	01	2012	12	30	

Throughout the county many buildings and much of the infrastructure networks can be vulnerable to winter storm impacts. Throughout the county all buildings and infrastructure are vulnerable to tornadoes and severe storm impacts. Bradley County’s building stock can be broken down into the following percentage categories: 65% residential, 20%

commercial, 6% industrial, 2% agricultural, 1% governmental, 3% religious, and 3% educational. Many of these structures wouldn't receive direct impacts from winter storms unless the snowfall exceeded the weight limit for roof structures, but they could receive indirect impacts such as downed electrical lines that cut off electricity to the structures, frozen pipelines that crack, destroyed agriculture crops, and customers not being able to access travels to the structures due to ice covered roads. In the county, road traveling conditions, electrical lines, and agricultural functions are some of the most vulnerable features.

Bradley County uses a ranking system to determine each jurisdiction's vulnerability to freezes/winter storm events. This system is based off simple arithmetic which analyzes potential impacts to determine vulnerabilities and then analyzes the probability of a freeze/winter storm event occurring to calculate a risk ranking for each jurisdiction.

**Winter Storms**

Jurisdiction	Impacts			Vulnerability
	Human	Property	Business	$H+P+B=\#; \#/3=V$
Bradley County Unincorporated	2	2	2	2.00
City of Charleston	2	2	2	2.00
City of Cleveland	2	2	2	2.00

Jurisdiction	Vulnerability	Probability	Risk	
			$V+P=R$	
Bradley County Unincorporated	2.00	1	3.00	Moderate
City of Charlestown	2.00	1	3.00	Moderate
City of Cleveland	2.00	1	3.00	Moderate

Scale	
Low	2-3.6
Moderate	3.7-5.2
Medium	5.3-6.8
High	6.9-8.4
Severe	8.5-10

<b>Human</b>	
<i>Risk of injuries and deaths from the hazard</i>	
1	Death very unlikely, injuries are unlikely
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4	Death possible, injuries may be substantial
5	Deaths probable, injuries will likely be substantial

<b>Property</b>	
<i>Amount of residential property damage associated from the hazard</i>	
1	Less than \$500 in damages
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3	\$10,000-\$500,000 in damages
4	\$500,000-\$2,000,000 in damages
5	More than \$2,000,000 in damages

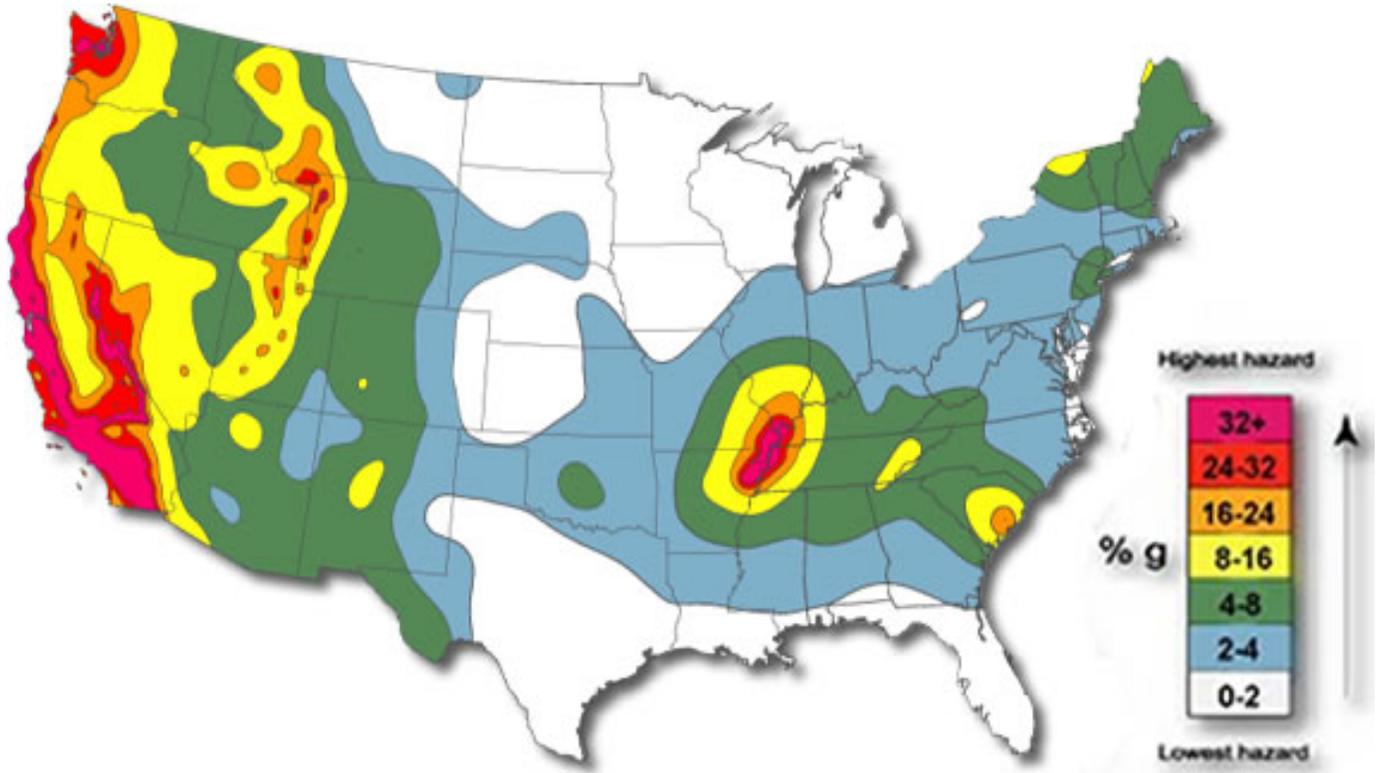
<b>Business</b>	
<i>Amount of business damage associated from the hazard</i>	
1	Less than 3 businesses closed for only a day
2	More than 3 businesses closed for a week
3	More than 3 businesses closed for a few months
4	More than 3 businesses closed indefinitely or relocated
5	A top-10 local employer closed indefinitely

<b>Probability</b>	
<i>Likelihood of the hazard occurring within a given span of years</i>	
1	Less than once every 10 years
2	About once every 5-10 years
3	About once every 2-5 years
4	About once a year
5	More than once a year

## **Earthquakes**

Bradley County is in the East Tennessee Seismic Zone (ETSZ), the second most active seismic zone east of the Rocky Mountains. The greatest danger from earthquakes comes from structural failures, disruption of utilities, and falling objects. Secondary effects include fires and dam failures. In 1993, a fault zone was identified in East Tennessee running roughly parallel to Interstate 75 between Chattanooga and Bristol. The probability of a major earthquake is assumed to be small. However, because the underlying fault lines and geology of the ETSZ, are not fully understood, the potential for a major earthquake should be taken seriously.

The entire county would be affected by a major earthquake. Critical infrastructure, including multiple Tennessee Valley Authority (TVA) Dams and Nuclear Power facilities are of great concern. TVA maintains rigorous design and inspection requirements for its facilities. TVA also regularly conducts emergency drills to prepare for such events.

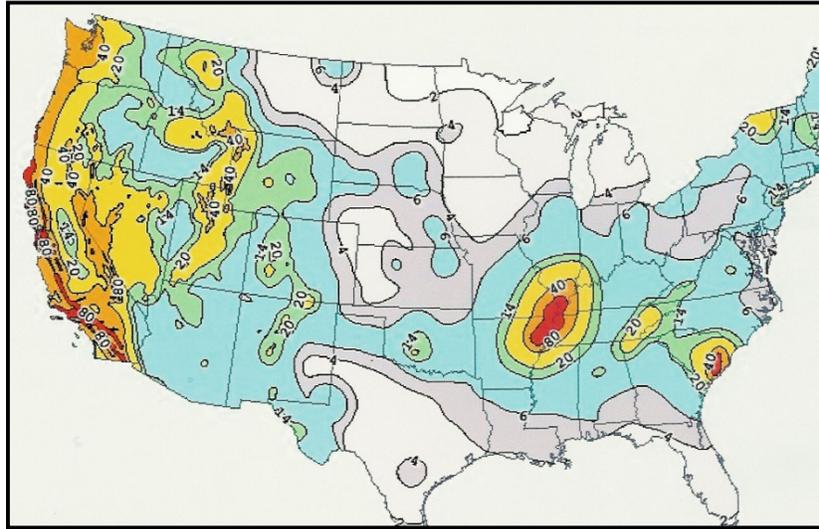


Richter Scale for Earthquakes		
Magnitudes	Description	Typical Impacts
< 2.0	Micro	Not felt.
2.0-2.9	Slight	Generally, not felt, but recorded.
3.0-3.9	Minor	Often felt, but rarely causes damage.
4.0-4.9	Light	Noticeable shaking of indoor items, rattling noises. Significant damage likely.
5.0-5.9	Moderate	Can cause major damage to poorly constructed building over small regions. At most slight damage to well-designed buildings.
6.0-6.9	Strong	Can be destructive in areas up to about 100 miles across populated areas.
7.0-7.9	Major	Can cause serious damage over larger areas.
8.0-8.9	Great	Can cause serious damage in areas several hundred miles across.
9.0-9.9	Epic	Devastating in areas several thousand miles across.

Source: USGS



**National Seismic Hazard Map  
Ground Motions with a 2% Chance of Occurring in 50 Years**



Source: USGS

Bradley County uses a ranking system to determine each jurisdiction’s vulnerability a large NMSZ earthquake. This system is based off simple arithmetic which analyzes potential impacts to determine vulnerabilities and then analyzes the probability of a severe storm event occurring to calculate a risk ranking for each jurisdiction.

**Earthquake**

Jurisdiction	Impacts			Vulnerability <i>H+P+B=#; #/3= V</i>
	Human	Property	Business	
Bradley County Unincorporated	2	2	2	2.00
City of Charleston	3	3	3	3.00
City of Cleveland	4	5	5	4.67

Jurisdiction	Vulnerability	Probability	Risk	
			<i>V+P=R</i>	
Bradley County Unincorporated	2.00	2	4.00	Moderate
City of Charlestown	3.00	2	5.00	Moderate
City of Cleveland	4.67	2	6.67	High

Scale	
Low	2-3.6
Moderate	3.7-5.2
Medium	5.3-6.8
High	6.9-8.4
Severe	8.5-10

<b>Human</b>	
<i>Risk of injuries and deaths from the hazard</i>	
1	Death very unlikely, injuries are unlikely
2	Death unlikely, injuries are minimal
3	Death unlikely, injuries may be substantial
4	Death possible, injuries may be substantial
5	Deaths probable, injuries will likely be substantial

<b>Property</b>	
<i>Amount of residential property damage associated from the hazard</i>	
1	Less than \$500 in damages
2	\$500-\$10,000 in damages
3	\$10,000-\$500,000 in damages
4	\$500,000-\$2,000,000 in damages
5	More than \$2,000,000 in damages

<b>Business</b>	
<i>Amount of business damage associated from the hazard</i>	
1	Less than 3 businesses closed for only a day
2	More than 3 businesses closed for a week
3	More than 3 businesses closed for a few months
4	More than 3 businesses closed indefinitely or relocated
5	A top-10 local employer closed indefinitely

<b>Probability</b>	
<i>Likelihood of the hazard occurring within a given span of years</i>	
1	Less than once every 10 years
2	About once every 5-10 years
3	About once every 2-5 years
4	About once a year
5	More than once a year

**Bradley County Declared Disasters 1993 – 2017**

<b>JURISDICTION</b>	<b>1993</b>	<b>1994</b>	<b>1997</b>	<b>1998</b>	<b>2003</b>	<b>2011</b>	<b>2012</b>
<b>BRADLEY COUNTY</b>	<b>EM-3095</b> SEVERE SNOW/WINTER STORM	<b>DR-1010</b> ICE STORM, <b>DR1022</b> RAIN/FLOODING	<b>DR1171</b> STORMS TORNADOES	<b>DR1197</b> STORMS/FLOODING, <b>DR1215</b> STORMS. TORNADOES, FLOODING	<b>DR1464</b> STORMS. TORNADOES, FLOODING	<b>DR1974</b> STORMS. TORNADOES, FLOODING	<b>DR4060</b> STORMS. TORNADOES, FLOODING

## **Section 4: Mitigation Strategy**

### **Mitigation Goals**

The purpose for developing a set of goals is to clearly state the community's overall vision for hazard mitigation and to provide a path towards building a safer, more resilient community. The Bradley County Hazard Mitigation Committee identified the following goals to be the forefront in the overall development of this plan update. All actions/projects recommended as mitigation efforts for the Hazard Mitigation Plan must first meet or further at least one of these goals. The goals are provided in a ranked order where the first goal is paramount.

Goals: For the residents of Bradley County

Goal 1: To provide the residents of Bradley County a safe environment through minimum exposure to risks of natural hazards.

Goal 2: To promote a public awareness of natural hazards and individual activities which can lessen exposure to those hazards.

Goal 3: To improve coordination and communication among disaster response organizations, local, and county governments.

Goal 4: To reduce the current and future risks from hazards in Bradley County.

### **Identification and Prioritization of Mitigation Projects**

Bradley County has developed a comprehensive range of mitigation projects. These projects were solicited and identified by the different entities that make up the Bradley County Hazard Mitigation Committee. Once the proposed projects attained a sponsoring agency and the details of the projects were discussed by the committee, the committee then proceeded to prioritize the mitigation projects.

The prioritization process was important since most mitigation projects represent a large investment of financial and personal resources. By evaluating each project's degree of feasibility and the level of costs versus benefits, Bradley County could determine when and which projects should be implemented based on available funding and time.

For the plan update, the Bradley County Hazard Mitigation Committee used the SAFE-T method to prioritize these projects. This approach was

adopted from the successful methodology used by other counties in FEMA Region 4. This rating system uses five variables to evaluate the overall feasibility and appropriateness: Societal, Admistrative, Financial, Environmental, and Technical. A focus on this methodology emphasizes the use of a cost-benefit review to maximize benefits.

Project Prioritization Method: SAFE-T			
Variable		Value	Description
<b>S</b>	<b>Societal:</b> The public must support the overall implementation strategy and specified mitigation actions. The projects will be evaluated in terms of community acceptance and societal	1	Low community priority, few societal benefits
		2	Moderate community acceptance / priority
		3	High community acceptance / priority
<b>A</b>	<b>Administrative:</b> The projects will be evaluated for anticipated staffing and maintenance requirements to determine if the jurisdiction has the personnel and administrative capabilities necessary to implement the project or whether outside help will be needed.	1	High staffing, outside needed
		2	Some staffing, help may be needed
		3	Low staffing, no outside help needed
<b>F</b>	<b>Financial:</b> The projects will be evaluated on their general cost-effectiveness and whether additional outside funding will be required	1	Somewhat cost-effective
		2	Moderately cost-effective
		3	Very cost-effective
<b>E</b>	<b>Environmental:</b> The projects will be evaluated for any immediate or long-term environmental impacts caused by their construction or operation	1	Many environmental impacts, possibly long term
		2	Some environmental impacts, some possibly long term
		3	Few, if any, environmental impacts
<b>T</b>	<b>Technical:</b> the projects will be evaluated on their ability to reduce losses in the long-term, whether there are secondary impacts, and whether the proposed project solves the associated problem or if additional components are necessary.	1	Other actions are needed or short-term fix
		2	Other actions may be needed for long-term fix
		3	Other actions not needed, long-term fix

Committee members ranked the projects as a group by determining the value for each variable and then by adding the variables rates up for a project sum value. All the project rankings can be seen on the Bradley County Hazard Mitigation Project List.

### Bradley County Project List

The following Project List provides an overview of all projects decided on by the Bradley County Hazard Mitigation Committee. This includes potential funding sources, implementation timeframes, the project’s responsible agency, and other information. This list is to remain active and updated.

### Bradley County Project List

Mitigation Project List																	
Project Number	Numerical Priority	Priority Rank (High, Moderate, Low)	Action/Project	Hazard Mitigated				Jurisdictions Benefitted & Represented	Addresses New or Existing Buildings/ Infrastructure	Estimated Cost	Responsible Agency	Funding Sources				Population Affected	Timeframe
				Flood	Severe Storm	Winter Storm	Tornado					HMGP	PDM	FMA	Local		
1	13	L	Compile list of shelters available for public use and distribute through FD, local schools, etc.		x		X	Bradley	Both	\$500.00	EMA				x	98,963	Annually
2	1	H	US Army Corp of Engineers Flood Mitigation plan	x				Cleveland	Both	\$6,290,000.00	City	x	x	X	X	41,285	2-3 Years or more
3	2	H	Flood Mitigation Whirlpool redevelopment site	x				Cleveland	Both	\$4,000,000.00	City	X	X	X	x	41,285	2-3 years or more
4	3	H	Flood mitigation Old Woolen Mill Site	x				Cleveland	Both	\$4,000,000.00	City	x	x	x	X	41,285	2-3 years or more

Mitigation Project List																	
Project Number	Numerical Priority	Priority Rank (High, Moderate, Low)	Action/Project	Hazard Mitigated				Jurisdictions Benefitted & Represented	Addresses New or Existing Buildings/ Infrastructure	Estimated Cost	Responsible Agency	Funding Sources				Population Affected	Timeframe
				Flood	Severe Storm	Winter Storm	Tornado					HMGP	PDM	FMA	Local		
5	4	H	Flood mitigation Dye Creek	X				Cleveland	Both	\$1,500,000.00	City	X	X	X	X	41,285	2-3 years or more
6	5	H	Flood mitigation Inman St railroad bridge area	x				Cleveland	Existing	\$1,000,000.00	City	X	X	X	x	41,285	2-3 years or more
7	10	M	Cleveland Fire Dept. new training grounds	x	X	X	X	Cleveland	New	\$575,000.00	City	x	x	x	X	41,285	2-3 Years
8	11	M	Air Shores & stabilization equipment CFD	X	X	X	X	Cleveland	Both	\$40,000.00	City	X	X	X	X	41,285	2-3 years or more
9	12	M	Swift water rescue equipment CFD	X	X	X	X	Cleveland	Both	\$15,000.00	City	X	X	X	X	41,285	2-3 years or more
10	6	M	Mobile/back-up EOC trailer	X	X	X	X	Bradley County	Both	\$100,000.00	EMA	X	X	X	X	98,963	1-2 years

Mitigation Project List																	
Project Number	Numerical Priority	Priority Rank (High, Moderate, Low)	Action/Project	Hazard Mitigated				Jurisdictions Benefitted & Represented	Addresses New or Existing Buildings/ Infrastructure	Estimated Cost	Responsible Agency	Funding Sources				Population Affected	Timeframe
				Flood	Severe Storm	Winter Storm	Tornado					HMGP	PDM	FMA	Local		
11	7	M	EOC Technical enhancement project	X	X	X	X	Bradley	Both	\$75,000.00	EMA	X	X	X	X	98,963	1-2 years
12	8	M	City/County emergency notification expansion project	X	X	X	X	Bradley	Both	\$10,000.00	EMA	X	X	X	X	98,963	1-2 years
13	9	M	City/County wide smartphone App for emergency services	X	X	X	X	Bradley	Both	\$150,000.00	EMA	X	X	X	X	98,963	1-2 years
14	14	M	All jurisdictions adopt most recent building codes	X	X	X	X	Bradley	Both		Government					98,963	When updated
15	15	M	Clear ditches to prevent overflow and trim low hanging limbs in the right-of-way	X	X	X	X	Bradley	Both	\$5000.00	Road dept.				X	98,963	Annually
16	16	M	EMA/conduct public outreach at local events	X	X	X	X	Bradley	Both	\$1000.00	EMA				X	98,963	Annually

Mitigation Project List																	
Project Number	Numerical Priority	Priority Rank (High, Moderate, Low)	Action/Project	Hazard Mitigated				Jurisdictions Benefitted & Represented	Addresses New or Existing Buildings/ Infrastructure	Estimated Cost	Responsible Agency	Funding Sources				Population Affected	Timeframe
				Flood	Severe Storm	Winter Storm	Tornado					HMGP	PDM	FMA	Local		
17	17	M	Encourage weather radio use County wide	X	X	X	X	Bradley	Both	\$1,000.00	EMA				X	98,963	annually

**The US Army Corp of Engineers flood study mentioned in project 2 priority 1 is of great importance to the City of Cleveland as it addresses numerous flood plain problem areas. Final report approval is expected by 8/15/2017 pending appropriations, with design and implementation of the recommended plan scheduled for completion by the year 2020.**

## Project List Update

After reviewing the original list of mitigation projects seen in the 2012 plan, many of the projects were more geared towards preparedness and response rather than mitigation. The following chart shows the status of each project from the 2012 plan:

Project	Status
All jurisdictions adopt most recent building codes	Carried forward – projects 1 and 22
Relocate critical facilities within flood prone areas	Ongoing
Buy out repetitive loss flood structures	Ongoing
Investigate an early warning system for residents	Complete
Clear ditches to prevent overflow and trim low hanging limbs in the right-of-way	Carried forward – projects 5, 18, and 52
Investigate feasibility of underground utilities for known hazard areas and new developments	Ongoing
Investigate the feasibility of stream flow gauges	Ongoing
Establish requirements for stream buffers	Completed
Investigate seismic retrofit options for critical infrastructure	Ongoing
EMA to conduct public outreach at local festivals and during state/annual drills and outreach	Carried forward – projects 2, 3, 7, 10, 17, 23, and 24
EMA will encourage non-structural mitigation to governmental offices	Ongoing
Encourage weather radio use	Carried forward – Projects 3, 4, and 7
Identify additional building for use as tornado safe rooms	Ongoing
Build 3 safe tornado rooms inside the construction of 3 new firehalls	Complete
Encourage school systems to review need for safe spaces	Complete

The following definitions apply to the status as listed in the above chart:

- Completed-All work on the project complete
- Ongoing-Project funding is approved and work has begun
- Carried Forward-Project was not funded from the previous plan, and has been added to the new project list
- Deleted-Project has been deemed unqualified, unnecessary, or infeasible

In addition to the completed project(s), Bradley County has also added several new projects to the list as part of the 2017 hazard mitigation plan update.

### National Flood Insurance Program Compliance

The National Flood Insurance Program (NFIP) is a pre-disaster flood hazard mitigation and insurance protection program which has reduced the increasing cost of disasters. The intent of the program is to: require new and substantially improved structures be designed and constructed to minimize or eliminate future flood damage; provide floodplain residents and business owners with financial insurance assistance in the form of insurance after floods; and it transfers most of the cost of private property flood losses from the taxpayers to floodplain property owners through flood insurance premiums. Participation in the NFIP is based on an agreement between communities and FEMA.

Currently, Cleveland, Charleston, and the unincorporated Bradley County areas are NFIP participants. FEMA has listed these jurisdictions to have a current effective map date as of 8/3/2009. Below are two charts that give an overview of NFIP policy and loss data for Bradley County.

NFIP Policy Data for Bradley County			
Jurisdiction	Policies In-Force	Insurance In-Force Whole \$	Written Premium In-Force
Bradley County	66	\$15,778,600	\$63,999
Cleveland	212	\$39,908,700	\$232,361
Charleston	9	\$1,690,100	\$9,875

Policies In-force: number of NFIP flood insurance policies

Insurance In-force whole \$: value of building and contents insured by the NFIP

Written Premium In-force: total premiums paid for NFIP insurance policies

NFIP Loss Data for Bradley County					
Jurisdiction	Total Losses	Closed Losses	Open Losses	CWOP Losses	Total Payments
Bradley County	31	27	0	4	\$329,281.13
Cleveland	148	122	0	26	\$1,573,716.76
Charleston	5	5	0	0	\$27,468.31

Total Losses: number of flood insurance claims filled by policyholders

Closed Losses: number of flood insurance claims paid to policyholders

Open Losses: claims that are still being processed

CWOP Losses: claims that were "closed without payment"

Total Payments: total dollars paid to policyholders

Per the National Flood Insurance Program, repetitive flood loss is defined as a facility or structure that has experienced two or more insurance claims of at least \$1,000 in any given 10-year period since 1978. Within the NFIP, repetitive flood loss properties are usually considered the most

vital structures to mitigate. The chart below provides a summary of repetitive losses for Bradley County.

Repetitive Loss Properties for Bradley County						
Jurisdiction	Type of Structure	Flood Zone	Number of Losses	Total Paid	Total Building Paid	Total Contents Paid
Bradley County	None	-	-	-	-	-
Charleston	None	-	-	-	-	-
Cleveland	Single fmly	X	3	10,000	8000.00	2000.00
Cleveland	Single fmly	B	6	59,659.75	48,167.30	11,492.45
Cleveland	Single fmly	AE	4	130,928.50	130,928.50	0
Cleveland	Single fmly	AE	3	120,481.81	84,481.81	36,000.00
Cleveland	Single fmly	AE	9	145,658.02	145,658.02	0

The definition of severe repetitive loss as applied to this program was established in section 1361A of the National Flood Insurance Act, as amended (NFIA), 42 U.S.C. 4102a. A SRL property is defined as a residential property that is covered under an NFIP flood insurance policy and:

- (a) That has at least four NFIP claim payments (including building and contents) over \$5,000 each, and the cumulative amount of such claims payments exceeds \$20,000;
- (b) For which at least two separate claims payments (building payments only) have been made with the cumulative amount of the building portion of such claims exceeding the market value of the building.

For both (a) and (b) above, at least two of the referenced claims must have occurred within any ten-year period, and must be greater than 10 days apart.

Severe Repetitive Loss Properties for Bradley County						
Jurisdiction	Type of Structure	Flood Zone	Number of Losses	Total Paid	Total Building Paid	Total Contents Paid

Bradley County	Single fmly	A	4	41,085.92	22,647.68	18,448.24
Charleston	None					
Cleveland	Single fmly	AE	9	145,658.02	145,658.02	0
Cleveland	Single fmly	AE	3	27,745.08	24,555.49	1189.59
Cleveland	Single fmly	AE	3	24,935.41	18,441.85	6493.56

To continue compliance with the NFIP, the jurisdictions have identified, analyzed, and prioritized three mitigation strategies to stay active with the program.

1. Continue to evaluate improved standards that are proven to reduce flood damage.
2. Maintaining supplies of FEMA/NFIP materials to help homeowners evaluate measures to reduce damage.
3. Maintaining a map of areas that flood frequently and prioritizing those areas for inspection immediately following heavy rains or flooding event.

## Section 5: Plan Maintenance

### Monitoring, Evaluating, and Updating

The Bradley County Hazard Mitigation Committee is designated to monitor and evaluate the mitigation plan. This committee is chaired by Bradley County Emergency Management Agency who leads the monitoring, evaluating, and updating process.

Monitoring of the previous mitigation plan, progress and projects occurred informally over the life-cycle of the previous plan.

Monitoring activities will involve Bradley County Emergency Management Agency setting up a committee meeting to be held on an annual basis. Bradley County Emergency Management Agency will prepare a brief annual report of the meeting's findings by addressing mitigation progress and shortfalls within the county.

The plan is to be evaluated annually and after any significant disaster causing human, infrastructure, and property losses. Following each annual informal evaluation of the plan by emergency management staff, any proposed revisions or recommendations will be brought before the Mitigation Committee to be incorporated into the plan. Potential updates to the plan will address changes to the hazard assessment, the repetitive loss list, the committee membership list, and the project priority list.

The plan will be formally updated every five years in accordance to 44 CFR 201.6(d)3, which states that the plan shall be reviewed, revised, and resubmitted for approval within five years to continue eligibility for hazard mitigation grant funding. For the five-year update, Bradley County Emergency Management Agency will notify the jurisdictional governments and the Bradley County Hazard Mitigation Committee approximately one year prior to the plan's expiration date. The review of the plan will include updating the planning process, the County profile, the hazard profiles, the risk assessment, the vulnerability assessment, the mitigation strategies, and the plan maintenance descriptions.

The five-year plan update will also include soliciting other interested persons/agencies to join the Mitigation Committee and a review of what has been accomplished in the past 5 years. The Bradley County Hazard Mitigation Committee's goal is to have at least 4 meetings within this time span; dates, public notices, and objectives for these meetings will be determined by Bradley County Emergency Management Agency.

Five months prior to the plan's expiration date, Bradley County Emergency Management Agency will submit the revised plan to the Tennessee Emergency Management Agency for preliminary review. Upon approval by the state, TEMA will submit the updated plan to FEMA for review.

Once Bradley County has attained the designation of the plan's approval pending adoption, each jurisdiction will adopt the plan through a resolution within a year.

### **Incorporation into Planning Mechanisms**

By incorporating the Bradley County Hazard Mitigation Plan into other planning documents and mechanisms, information contained in the mitigation plan can help fill-in missing gaps in existing documents, can contribute to already existing mitigation-based projects, and can create a strengthened stance of mitigation implementation and awareness within the county and its jurisdictions.

Some of the mechanisms that the Bradley County Hazard Mitigation Plan could be incorporated into include:

- Bradley County BEOP
- Bradley County Highway Department Plan
- Bradley County School Emergency Plan
- Cleveland City School District Emergency Plan
- Cleveland City Road Department Plan

The process of incorporating the hazard mitigation plan into other plans will begin during the other plan's update cycles. Bradley County Emergency Management Agency will first review the plans side-by-side, and where deemed necessary, Emergency Management will make notes on how mitigation concepts and actions can be incorporated into the other plans. These recommendations will be submitted to the lead agencies of the other planning mechanisms for them to place relevant information within the documents.

Additionally, in the past few review cycles information from the original Bradley County Hazard Mitigation Plan has been incorporated into the County's BEOP. This method of incorporation roughly followed the described process stated above.

### **Continued Public Participation**

The Bradley County Mitigation Committee will strive to involve the public in future mitigation activities. This will be accomplished by continuing to host Mitigation Committee Meeting and by attempting to have a public mitigation meeting once a year, by providing public access to copies of the Bradley County Hazard Mitigation Plan in the local emergency management office, and by soliciting other interested persons to participate in the mitigation planning process. By implementing these methods, the public will have an opportunity to comment on the plan during the update drafting stage and prior to plan approval.