3 RISK ASSESSMENT

44 CFR Requirement §201.6(c)(2): [The plan shall include] A risk assessment that provides the factual basis for activities proposed in the strategy to reduce losses from identified hazards. Local risk assessments must provide sufficient information to enable the jurisdiction to identify and prioritize appropriate mitigation actions to reduce losses from identified hazards.

The goal of the risk assessment is to estimate the potential loss in the planning area, including loss of life, personal injury, property damage, and economic loss, from a hazard event. The risk assessment process allows communities and school/special districts in the planning area to better understand their potential risk to the identified hazards. It will provide a framework for developing and prioritizing mitigation actions to reduce risk from future hazard events.

Changes in this version:
The risk assessment in this plan consolidates, updates, and streamlines content from the 2015 approved plan. Content has been restructured to cover a broad range of emerging hazards, vulnerabilities, and risk issues. Significant changes have been made that include standardized terminology, new GIS-based ranking methodology which assess hazard risk by jurisdiction, new analysis for all major hazards, and development of annualized loss by jurisdiction and review of local risk assessments, land use planning and development.

This chapter is divided into four main parts:

- **Section 3.1 Hazard Identification** identifies the hazards that threaten the planning area and provides a factual basis for elimination of hazards from further consideration;
- **Section 3.2 Assets at Risk** provides the planning area's total exposure to natural hazards, considering critical facilities and other community assets at risk;
- **Section 3.3 Land Use and Development** discusses development that has occurred since the last plan update and any increased or decreased risk that resulted. This section also discusses areas of planned future development and any implications on risk/vulnerability;
- **Section 3.4 Hazard Profiles and Vulnerability Analysis** provides more detailed information about the hazards impacting the planning area. For each hazard, there are three sections: 1) Hazard Profile provides a general description and discusses the threat to the planning area, the geographic location at risk, potential Strength/Magnitude/Extent, previous occurrences of hazard events, probability of future occurrence, risk summary by jurisdiction, impact of future development on the risk; 2) Vulnerability Assessment further defines and quantifies populations, buildings, critical facilities, and other community/school or special district assets at risk to natural hazards; and 3) Problem Statement briefly summarizes the problem and develops possible solutions.

3.1 HAZARD IDENTIFICATION

Requirement §201.6(c)(2)(i): [The risk assessment shall include a] description of the type…of all natural hazards that can affect the jurisdiction.

Natural hazards can be complex, occurring with a wide range of intensities. Some events are instantaneous and offer no window of warning, such as earthquakes. Some offer a short warning in which to alert the public to take actions, such as tornadoes or severe thunderstorms. Others occur less frequently and are typically more expensive, with some warning time to allow the public time to prepare such as flooding.

Each year there are increases in human-causes incidents, which can be just as devastating as natural disasters. For the purpose of this plan "human-caused hazards" are technological hazards and terrorism. These are distinct from natural hazards primarily in that they originate from human activity. In contrast, while the risks presented by natural hazards may be increased or decreased as a result of human activity, they are not inherently human-induced. The term "technological hazards" refers to the origins of incidents that can arise from human activities such as the manufacture, transportation, storage, and use of hazardous materials. For the sake of simplicity, this guide assumes that technological emergencies are accidental and that their consequences are unintended.

3.1.1 Review of Existing Mitigation Plans

The MPC previously developed a multi-jurisdictional Hazard Mitigation Plan dated 2015 and Macon County, Atlanta, Bevier, Callao, Elmer, Ethel, La Plata, Macon, New Cambria, Macon County R-I School District, Macon County R-IV School District, Callao C-8 School District, Atlanta C-3 School District, Bevier C-4 School District, and La Plata R-II School District participated in the multi-jurisdictional county wide-plan. The 2015 Macon County Multi-Jurisdictional Hazard Mitigation Plan was consulted in development of the risk assessment and information was included and updated where appropriate.

The MPC decided to include only natural hazards, as only natural hazards are required by the federal regulation to be included. The human-caused and technological hazards were eliminated from further analysis due to these hazards are not necessary for plans to meet the requirements of the Disaster Mitigation Act of 2000.

Levee failure was excluded from the mitigation planning process as there are no mapped levees nor associated levee protected areas within or immediately upstream of Macon County.

3.1.2 Review Disaster Declaration History

Disasters may be granted when the severity and magnitude of an event surpasses the ability of the local government to respond and recover. Disaster assistance is supplemental and sequential. When the local government's capacity has been surpassed, a state disaster declaration may be issued, allowing for the provision of state assistance. If the disaster is so severe that both the local and state governments' capacities are exceeded; a federal emergency or disaster declaration may be issued allowing for the provision of federal assistance.

FEMA also issues emergency declarations, which are more limited in scope and do not include the long-term federal recovery programs of major disaster declarations. Determinations for

declaration type are based on scale and type of damages and institutions or industrial sectors affected.

Table 3.1. FEMA Disaster Declarations that included Macon County, Missouri, 1965-Present

Disaster Number	Description	Declaration Date Incident Period	Individual Assistance (IA) Public Assistance (PA)
4451	SEVERE STORMS, TORNADOES, STRAIGHT-LINE WINDS, AND FLOODING	7/9/2019	PA
4238	SEVERE STORMS, TORNADOES, STRAIGHT-LINE WINDS, AND FLOODING	5/15/2015	PA
4200	SEVERE STORMS, TORNADOES, STRAIGHT-LINE WINDS, AND FLOODING	9/9/2014	PA
1961	SEVERE WINTER STORM AND SNOWSTORM	1/31/2011	PA
3317	SEVERE WINTER STORM	1/31/2011	PA
3303	SEVERE WINTER STORM	1/26/2009	PA
1773	SEVERE STORMS AND FLOODING	6/1/2008	IA, PA
3281	SEVERE WINTER STORMS	12/8/2007	PA
3232	HURRICANE KATRINA EVACUATION	8/29/2005	PA
1524	SEVERE STORMS, TORNADOES, AND FLOODING	5/18/2004	IA
1412	SEVERE STORMS, TORNADOES, AND FLOODING	4/24/2002	IA, PA
1403	SEVERE WINTER ICE STORM	1/29/2002	IA, PA
1270	SEVERE STORMS AND FLOODING	4/3/1999	IA
1253	SEVERE STORMS, FLOODING AND TORNADOES	10/4/1998	IA, PA
1054	SEVERE STORMS, TORNADOES, HAIL, FLOODING	5/13/1995	IA, PA
995	SEVERE STORMS & FLOODING	6/10/1993	IA, PA
3017	DROUGHT	9/24/1976	PA
466	TORNADOES, HIGH WINDS & HAIL	5/3/1975	IA, PA
407	SEVERE STORMS & FLOODING	11/1/1973	IA, PA
372	HEAVY RAINS, TORNADOES & FLOODING	4/19/1973	IA, PA

Source: Federal Emergency Management Agency, https://www.fema.gov/data-visualization-summary-disaster-declarations-and-grants

3.1.3 Research Additional Sources

Additional sources of data on locations and past impacts of hazards in the planning area:

- Missouri Hazard Mitigation Plans (2018)
- Previously approved planning area Hazard Mitigation Plan (2015)
- Federal Emergency Management Agency (FEMA)
- Missouri Department of Natural Resources (MDNR)
- National Drought Mitigation Center Drought Reporter
- US Department of Agriculture's (USDA) Risk Management Agency Crop Insurance Statistics
- National Agricultural Statistics Service (Agriculture production/losses)
- Data Collection Questionnaires completed by each jurisdiction
- State of Missouri GIS data
- Environmental Protection Agency
- Flood Insurance Administration
- Hazards US (HAZUS)
- Missouri Department of Transportation
- Missouri Division of Fire Marshal Safety
- Missouri Public Service Commission
- National Fire Incident Reporting System (NFIRS)
- National Oceanic and Atmospheric Administration's (NOAA) National Climatic Data Center (NCDC);
- Pipeline and Hazardous Materials Safety Administration
- County and local Comprehensive Plans to the extent available
- County Emergency Management
- County Flood Insurance Rate Map, FEMA
- Flood Insurance Study, FEMA
- SILVIS Lab, Department of Forest Ecology and Management, University of Wisconsin
- U.S. Army Corps of Engineers
- U.S. Department of Transportation
- United States Geological Survey (USGS)
- Various articles and publications available on the internet (you should state that you will give citations to the sources in the body of the plan)

Note that the only centralized source of data for many of the weather-related hazards is the National Oceanic and Atmospheric Administration's (NOAA) National Centers for Environmental Information (NCEI). Although it is usually the best and most current source, there are limitations to the data which should be noted. The NCEI documents the occurrence of storms and other significant weather phenomena having sufficient intensity to cause loss of life, injuries, significant property damage, and/or disruption to commerce. In addition, it is a partial record of other significant meteorological events, such as record maximum or minimum temperatures or precipitation that occurs in connection with another event. Some information appearing in the NCEI may be provided by or gathered from sources outside the National Weather Service (NWS), such as the media, law enforcement and/or other government agencies, private companies, individuals, etc. An effort is made to use the best available information but because of time and

resource constraints, information from these sources may be unverified by the NWS. Those using information from NCEI should be cautious as the NWS does not guarantee the accuracy or validity of the information.

The NCEI damage amounts are estimates received from a variety of sources, including those listed above in the Data Sources section. For damage amounts, the NWS makes a best guess using all available data at the time of the publication. Property and crop damage figures should be considered as a broad estimate. Damages reported are in dollar values as they existed at the time of the storm event. They do not represent current dollar values.

The database currently contains data from January 1950 to March 2014, as entered by the NWS. Due to changes in the data collection and processing procedures over time, there are unique periods of record available depending on the event type. The following timelines show the different time spans for each period of unique data collection and processing procedures.

1. Tornado: From 1950 through 1954, only tornado events were recorded.
2. Tornado, Thunderstorm Wind and Hail: From 1955 through 1992, only tornado, thunderstorm wind and hail events were keyed from the paper publications into digital data. From 1993 to 1995, only tornado, thunderstorm wind and hail events have been extracted from the Unformatted Text Files.
3. All Event Types (48 from Directive 10-1605): From 1996 to present, 48 event types are recorded as defined in NWS Directive 10-1605.

Note that injuries and deaths caused by a storm event are reported on an area-wide basis. When reviewing a table resulting from an NCEI search by county, the death or injury listed in connection with that county search did not necessarily occur in that county.

3.1.4 Hazards Identified

The jurisdictions in Macon County differ in their susceptibilities to certain hazards. The hazards identified were based on the input from the planning team members, available historical data and the hazard modeling results described with the hazard mitigation plans. The jurisdictions and hazards chosen that significantly impact the planning area is listed in alphabetical order in Table 3.2. The chart includes an "x" to indicate the jurisdiction is impacted by the hazard and a "-"indicates the hazard is not applicable to that jurisdiction.

Table 3.2. Hazards Identified for Each Jurisdiction

Jurisdiction	Dam Failure	Drought	Earthquake	Extreme Temperatures	Flooding (River and Flash)	Land Subsidence/Sinkholes	Levee Failure	Severe Winter Weather	Thunderstorm/Lightning/Hail/ High Wind	Tornado	Wildfire	
Macon	-	x	x	x	x	X	-	x	x	x	x	-
Atlanta	-	X	X	X	-	-	-	X	X	X	-	-
Bevier	-	X	X	X	X	-	-	X	X	X	-	-
Callao	-	X	X	X	X	-	-	X	X	X	-	-
Elmer	-	X	X	X	X	-	-	X	X	X	-	-
La Plata	-	X	X	X	X	-	-	X	X	X	-	-
Macon	X	X	X	X	X	-	-	X	X	X	-	-
Schools and Special Districts												
Macon County R-I	-	-	-	-	-	-	-	X	X	X	-	-
Macon County R-IV	-	-	-	-	-	-	-	X	X	X	-	-
Atlanta C-3	-	-	-	-	-	-	-	X	X	X	-	-

3.1.5 Multi-Jurisdictional Risk Assessment

For this multi-jurisdictional plan, the risks are assessed for each jurisdiction where they deviate from the risks facing the entire planning area. The planning area is fairly uniform in terms of climate and topography as well as building construction characteristics. Accordingly, the geographic areas of occurrence for weather-related hazards do not vary greatly across the planning area for most hazards. Macon is the most urbanized within the planning area and have more assets that are vulnerable to the weather-related hazards and varied development trends impact the future vulnerability. Similarly, more rural areas have more assets (crops/livestock) that are vulnerable to animal/plant/crop/disease. These differences are discussed in greater detail in the vulnerability sections of each hazard.

The hazards that vary across the planning area in terms of risk include dam failure, flash flood, grass or wildland fire, and sinkholes/land subsidence. The difference in hazards is explained in each hazard profile under a separate heading.

3.2 ASSETS AT RISK

This section assesses the population, structures, critical facilities and infrastructure, and other important assets in the planning area that may be at risk to natural hazards. Table 3.3 shows the total population, building count, estimated value of buildings, estimated value of contents and estimated total exposure to parcels by jurisdiction.

3.2.1 Total Exposure of Population and Structures

Unincorporated County and Incorporated Cities

In the following three tables, population data is based on 2010 Census Bureau data. Building counts and building exposure values are based on parcel data provided by the State of Missouri Geographic Information Systems (GIS) database which can be obtained directly from the SEMA Mitigation Management Section. Contents exposure values were calculated by factoring a multiplier to the building exposure values based on usage type. The multipliers were derived from the Hazus and are defined below in **Table 3.3**. Land values have been purposely excluded from consideration because land remains following disasters, and subsequent market devaluations are frequently short term and difficult to quantify. Another reason for excluding land values is that state and federal disaster assistance programs generally do not address loss of land (other than crop insurance). It should be noted that the total valuation of buildings is based on county assessors' data which may not be current. In addition, government-owned properties are usually taxed differently or not at all, and so may not be an accurate representation of true value. Note that public school district assets and special districts assets are included in the total exposure tables assets by community and county.

Table 3.3 shows the total population, building count, estimated value of buildings, estimated value of contents and estimated total exposure to parcels for the unincorporated county and each incorporated city. For multi-county communities, the population and building data may include data on assets located outside the planning area. Table 3.3 that follows provides the building value exposures for the county and each city in the planning area broken down by usage type. Finally, Table 3.4 provides the building count total for the county and each city in the planning area broken out by building usage types (residential, commercial, industrial, and agricultural).

Table 3.3. Maximum Population and Building Exposure by Jurisdiction

Jurisdiction	2010 Annual Population Estimate	Building Count	Building Exposure ($)	Contents Exposure ($)	Total Exposure ($)
Atlanta	385	250	$33,948	$15,671	$49,620
Bevier	718	303	$40,330	$22,136	$62,466
Callao	292	163	$19,842	$10,446	$30,288
Elmer	80	109	$9,217	$5,646	$14,862
La Plata	1,366	837	$106,193	$63,248	$169,441
Macon	5,471	14,389	$789,232	$434,058	$1,223,290
Totals	8,312	16,051	$943,777	$551,205	$1,549,967

Source: U.S. Bureau of the Census, Annual population estimates/ 5-Year American Community Survey 2010; Building Count and Building Exposure, Missouri GIS Database from SEMA Mitigation Management; Contents Exposure derived by applying multiplier to Building Exposure based on Hazus MH 2.1 standard contents multipliers per usage type as follows: Residential (50%), Commercial (100%), Industrial (150%), Agricultural (100%). For purposes of these calculations, government, school, and utility were calculated at the commercial contents rate.

Table 3.4. Building Values/Exposure by Usage Type

Jurisdiction	Residential	Commercial	Industrial	Agricultural	Total
Atlanta	$23,439	$10,398	$0	$113	$33,948
Bevier	$33,120	$7,187	$0	$23	$40,330
Callao	$15,413	$4,350	$0	$77	$19,842
Elmer	$6,879	$2,206	$0	$132	$9,217
La Plata	$78,341	$24,970	$2,628	$254	$106,193
Macon	$649,654	$97,217	$14,455	$27,906	$789,232
Totals	$806,846	$146,328	$17,083	$28,505	$943,777

Source: Missouri GIS Database, SEMA Mitigation Management Section

Table 3.5. Building Counts by Usage Type

Jurisdiction	Residential Counts	Commercial Counts	Industrial Counts	Agricultural Counts	Total
Atlanta	184	31	0	35	250
Bevier	260	36	0	7	303
Callao	121	18	0	24	163
Elmer	109	14	0	41	164
La Plata	837	143	12	79	1,049
Macon	5,100	544	66	8,679	14,389
Totals	6,611	786	78	8,865	16,340

Source: Missouri GIS Database, SEMA Mitigation Management Section; Public School Districts and Special Districts

Even though schools and special districts' total assets are included in the tables above, additional discussion is needed, based on the data that is available from the districts' completion of the Data Collection Questionnaire and district-maintained websites. The number of enrolled students at the participating public school districts is provided in **Table 3.4** below. Additional information includes the number of buildings, building values (building exposure) and contents value (contents

exposure). These numbers will represent the total enrollment and building count for the public school districts regardless of the county in which they are located.

Table 3.6. Population and Building Exposure by Jurisdiction-Public School Districts

Public School District	Enrollment	Building Count	Building Exposure ($)	Contents Exposure ($)	Total Exposure ($)
Macon County R-I	1,301	3	$112,491,277	-	$112,491,277
Macon County R-IV	111	2	$12,828,622	-	$12,828,622
Atlanta C-3	207	2	$16,480,527	-	$16,480,527

Source: http://mcds.dese.mo.gov/quickfacts/Pages/District-and-School-Information.aspx

3.2.2 Critical and Essential Facilities and Infrastructure

This section will include information from the Data Collection Questionnaire and other sources concerning the vulnerability of participating jurisdictions' critical, essential, high potential loss, and transportation/lifeline facilities to identified hazards. Definitions of each of these types of facilities are provided below.

- Critical Facility: Those facilities essential in providing utility or direction either during the response to an emergency or during the recovery operation.
- Essential Facility: Those facilities that if damaged, would have devastating impacts on disaster response and/or recovery.
- High Potential Loss Facilities: Those facilities that would have a high loss or impact on the community.
- Transportation and lifeline facilities: Those facilities and infrastructure critical to transportation, communications, and necessary utilities.

Table 3.7 includes a summary of the inventory of critical and essential facilities and infrastructure in the planning area. The list was compiled from the Data Collection Questionnaire as well as the following sources:

- 2018 Missouri State Hazard Mitigation Plan and Hazard Mitigation Viewer http://bit.ly/MoHazardMitigationPlanViewer2018
- List other sources used to assemble critical facility inventory
- Chemical Facilities (Tier II Facilities) information (if included in the list of hazards identified by the participants) can be obtained by contacting the county LEPC. The LEPC will then request information (name, address, purpose for asking, etc.) and then provide the information. In order to find out who the LEPC contact is for your planning areas, see https://sema.dps.mo.gov/docs/programs/executive/MERC/LEPC_Manual/LEPC-addresses.pdf
- Hazus contains an inventory of critical facilities that can be exported for each jurisdiction.
- The Homeland Security Infrastructure Protection Program (HSIPP) is another source.

Table 3.7. Inventory of Critical/Essential Facilities and Infrastructure by Jurisdiction

Jurisdiction	Airport Facility	Bus Facility	Childcare Facility	Communications Tower	Electric Power Facility	Emergency Operations	Fire Service	Government	Housing	Shelters	Highway Bridge	Hospital/Health Care	Military	Natural Gas Facility	Nursing Homes	Police Station	Potable Water Facility	Rail	Sanitary Pump Stations	School Facilities	Stormwater Pump Stations	Tier II Chemical Facility	Wastewater Facility	TOTAL
Atlanta	-	-	-	X	-	X	X	X	X	X	-	-	-	-	-	-	-	-	-	X	-	-	-	7
Bevier	-	-	-	-	-	-	X	X	-	X	X	-	-	-	-	-	-	X	-	X	-	-	-	6
Callao	-	-	-	-	-	X	X	X	-	X	X	-	-	-	-	-	-	X	-	X	-	-	X	8
Elmer	-	-	-	-	-	-	X	X	-	X	-	-	-	-	-	-	-	X	-	-	-	-	-	4
La Plata	-	-	-	X	X	X	X	X	X	X	X	-	-	-	X	X	-	X	-	X	-	-	X	13
Macon	X	-	X	X	X	X	X	X	X	X	X	X	X	X	X	X	-	X	-	X	-	-	X	18
Macon County	-	-	-	X	X	X	X	X	X	X	X	-	-	X	-	X	-	X	-	X	-	-	-	12
Totals	1	-	1	4	3	5	7	7	4	7	5	1	1	2	2	3	-	6	0	6	-	-	3	68

Source: Missouri 2018 State Hazard Mitigation Plan and Hazard Mitigation Viewer; Data Collection Questionnaires; Hazus, etc

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Bridges: The term “scour critical” refers to one of the database elements in the National Bridge Inventory. This element is quantified using a “scour index”, which is a number indicating the vulnerability of a bridge to scour during a flood. Bridges with a scour index between 1 and 3 are considered “scour critical”, or a bridge with a foundation determined to be unstable for the observed or evaluated scour condition.

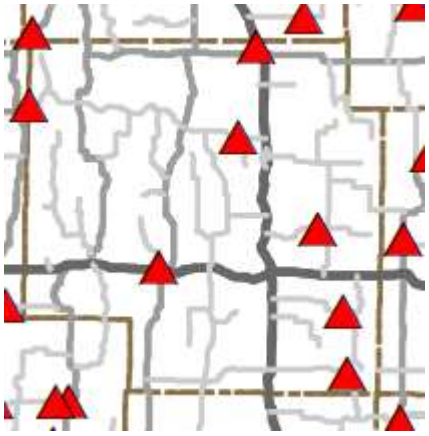
Figure 3.1. Macon County Bridges

Missouri

County	Bridge Counts				Bridge Area (Square Meters)			
	All	Good	Fair	Poor	All	Good	Fair	Poor
MACON (121)	290	173	103	14	65,508	39,632	22,560	3,316

Source: http://www.fhwa.dot.gov/bridge/nbi/no10/county.cfm

Figure 3.2. Macon County Structurally Deficient Bridges



Source: https://www.modot.org/sites/default/files/documents/Statewide_Poor_Bridges_2018_with_insets%5B1%5D.pdf

3.2.3 Other Assets

Assessing the vulnerability of the planning area to disaster also requires data on the natural, historic, cultural, and economic assets of the area. This information is important for many reasons.

- These types of resources warrant a greater degree of protection due to their unique and irreplaceable nature and contribution to the overall economy.
- Knowing about these resources in advance allows for consideration immediately following a hazard event, which is when the potential for damages is higher.
- The rules for reconstruction, restoration, rehabilitation, and/or replacement are often different for these types of designated resources.
- The presence of natural resources can reduce the impacts of future natural hazards, such as wetlands and riparian habitats which help absorb floodwaters.
- Losses to economic assets like these (e.g., major employers or primary economic sectors) could have severe impacts on a community and its ability to recover from disaster.

Threatened and Endangered Species: Table 3.8 shows Federally Threatened, Endangered, Proposed and Candidate Species in Macon County.

Table 3.8. Threatened and Endangered Species in Macon County

Common Name	Scientific Name	Status
Gray Bat	Myotis Grisescens	Endangered
Indiana Bat	Myotis Sodalis	Endangered
Northern Long-Eared Bat	Myotis Septentrionalis	Threatened

Source: U.S. Fish and Wildlife Service, http://www.fws.gov/midwest/Endangered/lists/missouri-cty.html

Natural Resources: Macon County has fourteen conservation and recreation areas. The Missouri Department of Conservation (MDC) provides a database of lands the MDC owns, leases or manages for public use. Table 3.9 provides the names and location of parks and conservation areas in the planning area owned by Missouri Department of Conservation and owed by the jurisdictions.

Table 3.9. Parks in Macon County

Park / Conservation Area	Address	City
Atlanta CA	From Macon, take Highway 63 north 5 miles, then Route AX west 2 miles, and Jupiter Avenue north 2.50 miles	Atlanta
Bee Hollow CA	From Macon, take Highway 63 south 8 miles, then Jackpot Road west 2 miles	Macon
Dodd Access	From Callao, take Highway 36 west, then Route UU north 5 miles, then Echo Avenue one mile to the area	Callao
Griffiths Mem CA	From New Cambria, take Highway 149 north 2 miles, then Derby Street west 0.60 mile, and Crystal Avenue north 0.40 mile	New Cambria
Hidden Hollow CA	From LaPlata, take Highway 156 west 7 miles, then Highway 3 south 1.50 mile, and Fox Road west 3 miles	La Plata
La Plata City Lake	From La Plata, take Highway 156 east 2.50 miles, then Leopard Ave. south 0.50 mile to the entrance road	La Plata
Long Branch Lake ML	From Macon, take Highway 63 north 5 miles, then Route AX west 2 miles	Macon
Macon (Blees Lake)	Located on the south edge of Macon, across from the fairgrounds on the west side of Highway 63	Macon
Macon City Lake	From Macon, take Highway 63 north 1 mile, then Lake Street west 1 mile, then Macon Lake Road south	Macon
Macon County (Fairgrounds Lake)	In Macon at the junction of Highways 63/36, take Highway 63 south 2.50 miles, then east to the Macon County Fairgrounds	Macon
Montgomery Woods CA	From Kirksville, take Highway 11 west 18 miles, then take Montgomery Woods Trail south 0.75 mile to the area	Macon
Mussel Fork CA	From Brookfield, take Highway 36 east 10 miles to the area	New Cambria
Redman CA	From Redman, take Route KK south 0.50 mile	Macon
Thomas Hill Reservoir CA	From Macon, take Highway 36 west 5.25 miles, then Route C south 10 miles to College Mound, then Route T west 2.40 miles to the main entrance	Macon

Source: http://mdc7.mdc.mo.gov/applications/moatlas/AreaList.aspx?txtUserID=guest&txtAreaNm=s

Historic Resources: The National Register of Historic Places is the official list of registered cultural resources worthy of preservation. It was authorized under the National Historic Preservation Act of 1966 as part of a national program. The purpose of the program is to coordinate and support public and private efforts to identify, evaluate, and protect our historic and archeological resources. The National Register is administered by the National Park Service under the Secretary of the Interior. Properties listed in the National Register include districts, sites, buildings, structures and objects that are significant in American history, architecture, archeology, engineering and culture.

Table 3.10. Macon County Properties on the National Register of Historic Places

Property	Address	City	Date Listed
Blees Military Academy	US 63 S	Macon	10/11/79
Dent, Lester and Norma, House	225 N Church St.	La Plata	5/18/90
Doneghy, John T. and Mary M., House	301 N Owensby St.	La Plata	3/22/90
Gardner and Tinsely Filling Station	Old US 36, near junction with MO 149		4/25/02
Gillbreath-McLorn House	225 N Owenby	La Plata	11/16/78
La Plata Square Historic District	Along portions of Gex, Sanders, and	La Plata	11/20/08
Macon County Courthouse and Annex	Courthouse Sq.	Macon	12/08/78
Morrow, Johnson, House	2nd St. W of junction with Pine St.	Callao	7/07/94
Wardell House	1 Wardell Rd.	Macon	3/12/86

Source: Missouri Department of Natural Resources – Missouri National Register Listings by County

Table 3.11. Major Non-Government Employers in Macon County

Employer Name	Main Locations	Product or Service	Employees
Chariton Valley	Macon	Telecommunication services	~100
ConAgraFoods	Macon	Foods factory	440
Macon Electric Co-Op	Macon	Rural electric cooperative	47
Macon-Atlanta State Bank	Macon	Financial institution	40+
Onshore Technologies	Macon	IT services, off-shore program management, business analysis/consulting, and architecture, integration planning	150
POET Biorefining	Macon		40+
Sydenstricker Farm & Lawn	Macon	Sells and services farm, residential, commercial, and construction	35
Loch Haven	Macon	Nursing Home	220
C&R Market	Macon	Grocery Store	41
Samaritan Hospital	Macon	Health Care	160
Walmart	Macon	Retail	115

Source: Data Collection Questionnaires; local Economic Development Commissions

Table 3.12. Agriculture-Related Jobs in Macon County

Item		Macon
Hired farm labor	farms	217
	workers	414
	$1,000 payroll	2,288
Farms with-		
1 worker	farms	128
	workers	128
2 workers	farms	46
	workers	92
3 or 4 workers	farms	28
	workers	90
5 to 9 workers	farms	11
	workers	61
10 workers or more	farms	4
	workers	43
Workers by days worked:		
150 days or more	farms	70
	workers	99
Farms with-		
1 worker	farms	54
	workers	54
2 workers	farms	9
	workers	18
3 or 4 workers	farms	6
	workers	(D)
5 to 9 workers	farms	1
	workers	(D)
10 workers or more	farms	-
	workers	-
Less than 150 days	farms	165
	workers	315
Farms with-		
1 worker	farms	90
	workers	90
2 workers	farms	45
	workers	90
3 or 4 workers	farms	21
	workers	67
5 to 9 workers	farms	5
	workers	27
10 workers or more	farms	4
	workers	41
Reported only workers working 150 days or more	farms	52
	workers	69
	$1,000 payroll	962
Reported only workers working less than 150 days	farms	147
	workers	270
	$1,000 payroll	617
Reported both - workers working 150 days or more and workers working less than 150 days	farms	18
	150 days or more, workers	30
	less than 150 days, workers	45
	$1,000 payroll	709
Total migrant workers (see text)	farms	-
	workers	-
Migrant farm labor on farms with hired labor	farms	-
	workers	-
Migrant farm labor on farms reporting only contract labor	farms	-
	workers	-
Unpaid workers (see text)	farms	437
	workers	1,005

Source: https://www.agcensus.usda.gov/Publications/2012/Full_Report/Volume_1,_Chapter_2_County_Level/Missouri/st29_2_007_007.pdf

3.3 LAND USE AND DEVELOPMENT

3.3.1 Development Since Previous Plan Update

According to the Building permit data that was obtained through the U.S. Census Bureau, there has been growth in Callao, La Plata, and Macon since the last plan update. Growth in an area increases risk for the planning area as there can be more structural damage to the planning area.

The U.S. Census Bureau shows Macon County is expected to have decreased by 2.65% since the last census was performed. Table 3.13 provides the population growth statistics for all the cities in Macon, as well as Macon County as a whole. Population statistics represent the 2010 U.S. Census and American Community Survey 5-year estimates.

Table 3.13. Macon County Population Growth, 2010-2018

Jurisdiction	Total Population 2010	Total Population 2018	2010-2018 # Change	2000-2018 % Change
Macon County	15,566	15,153	-413	-2.65%
Atlanta	385	372	-13	-3.38%
Bevier	718	696	-22	-3.06%
Callao	292	280	-12	-4.11%
Elmer	80	78	-2	-2.5%
Ethel	62	60	-2	-3.23%
La Plata	1,366	1,318	-48	-3.51%
Macon	5,471	5,355	-116	-2.12%
New Cambria	195	188	-7	-3.59%

Source: U.S. Bureau of the Census, Decennial Census, Annual Population Estimates, American Community Survey 5-year Estimates; Population Statistics are for entire incorporated areas as reported by the Census bureau

Population growth or decline is generally accompanied by increases or decreases in the number of housing units. Macon County, Atlanta, Bevier, Callao, Ethel, and La Plata have shown an increase in housing, with Elmer, Macon, and New Cambria reflecting a decline.

Table 3.14. Change in Housing Units, 2010-2017

Jurisdiction	Housing Units 2010	Housing Units 2017	2010-2017 # Change	2000-2017 % Change
Macon County	7,665	7,671	6	0.08%
Atlanta	189	201	12	6.35%
Bevier	341	358	17	4.99%
Callao	144	180	36	25%
Elmer	47	32	-15	-31.91%
Ethel	54	56	2	3.7%
La Plata	683	765	82	12.01%
Macon	2,727	2,498	-229	-8.4%
New Cambria	108	106	-2	-1.85%

Source: U.S. Bureau of the Census, Decennial Census, American Community Survey 5-year Estimates; Population Statistics are for entire incorporated areas as reported by the U.S. Census Bureau

U.S. Census information is compiled every 10 years, with the last Census completed in 2010 estimates were used for the above data. According to the American Fact Finder, estimates show that in 2017 the number of housing units are expected to increase in all jurisdictions within Macon County, with the exception of Elmer, Macon, and New Cambria. Vulnerability to hazards will be affected based on population, and where new housing units have been built. Due to city ordinances, vulnerability is not expected to increase as ordinances for new builds have been set to protect citizens.

3.3.2 Future Land Use and Development

According to the Data Questionnaire's no participating jurisdictions anticipated future development within the planning area.

School District's Future Development

According to the Data Collection Questionnaire, Macon R-IV is currently expanding the school and Macon R-I may construct a new building in the next five years.

Special District's Future Development

According to the Data Collection Questionnaire, there is no anticipated future development.

3.4 HAZARD PROFILES, VULNERABILITY, AND PROBLEM STATEMENTS

Each hazard will be analyzed individually in a hazard profile. The profile will consist of a general hazard description, location, strength/magnitude/extent, previous events, future probability, a discussion of risk variations between jurisdictions, and how anticipated development could impact risk. At the end of each hazard profile will be a vulnerability assessment, followed by a summary problem statement.

Hazard Profiles

Requirement §201.6(c)(2)(i): [The risk assessment shall include a] description of the…location and extent of all natural hazards that can affect the jurisdiction. The plan shall include information on previous occurrences of hazard events and on the probability of future hazard events.

Each hazard identified in Section **3.1.4** will be profiled individually in this section in alphabetical order. The level of information presented in the profiles will vary by hazard based on the information available. With each update of this plan, new information will be incorporated to provide better evaluation and prioritization of the hazards that affect the planning area. Detailed profiles for each of the identified hazards include information categorized as follows:

- **Hazard Description:** This section consists of a general description of the hazard and the types of impacts it may have on a community or school/special district.
- **Geographic Location:** This section describes the geographic areas in the planning area that are affected by the hazard. Where available, use maps to indicate the specific locations of the planning area that are vulnerable to the subject hazard. For some hazards, the entire planning area is at risk.
- **Strength/Magnitude/Extent:** This includes information about the strength, magnitude, and extent of a hazard. For some hazards, this is accomplished with description of a value on an established scientific scale or measurement system, such as an EF2 tornado on the

Enhanced Fujita Scale. This section should also include information on the typical or expected strength/magnitude/extent of the hazard in the planning area. Strength, magnitude, and extent can also include the speed of onset and the duration of hazard events. Describing the strength/magnitude/extent of a hazard is not the same as describing its potential impacts on a community. Strength/magnitude/extent defines the characteristics of the hazard regardless of the people and property it affects.

- **Previous Occurrences:** This section includes available information on historic incidents and their impacts. Historic event records form a solid basis for probability calculations.
- **Probability of Future Occurrence:** The frequency of recorded past events is used to estimate the likelihood of future occurrences. Probability can be determined by dividing the number of recorded events by the number of years of available data and multiplying by 100. This gives the percent chance of the event happening in any given year. For events occurring more than once annually, the probability should be reported as 100% in any given year, with a statement of the average number of events annually. For hazards such as drought that may have gradual onset and extended duration, probability can be based on the number of months in drought in a given time-period and expressed as the probability for any given month to be in drought.
- **Changing Future Conditions Considerations**

Vulnerability Assessments

Requirement §201.6(c)(2)(ii) :[The risk assessment shall include a] description of the jurisdiction's vulnerability to the hazards described in paragraph (c)(2)(i) of this section. This description shall include an overall summary of each hazard and its impact on the community.

Requirement §201.6(c)(2)(ii)(A) :The plan should describe vulnerability in terms of the types and numbers of existing and future buildings, infrastructure, and critical facilities located in the identified hazard areas.

Requirement §201.6(c)(2)(ii)(B) :[The plan should describe vulnerability in terms of an] estimate of the potential dollar losses to vulnerable structures identified in paragraph (c)(2)(i)(A) of this section and a description of the methodology used to prepare the estimate.

Requirement §201.6(c)(2)(ii)(C): [The plan should describe vulnerability in terms of] providing a general description of land uses and development trends within the community so that mitigation options can be considered in future land use decisions.

Requirement §201.6(c)(2)(ii): (As of October 1, 2008) [The risk assessment] must also address National Flood Insurance Program (NFIP) insured structures that have been repetitively damaged in floods.

Following the hazard profile for each hazard will be the vulnerability assessment. The vulnerability assessment further defines and quantifies populations, buildings, critical facilities, and other community assets at risk to damages from natural hazards. The vulnerability assessments should be based on the best available data. The vulnerability assessments can also be based on data that was collected for the 2018 State Hazard Mitigation Plan Update. With the 2018 Hazard Mitigation Plan Update, SEMA is pleased to provide online access to the risk assessment data and associated mapping for the 114 counties in the State, including the independent City of St. Louis.

Through the web-based Missouri Hazard Mitigation Viewer, local planners or other interested parties can obtain all State Plan datasets. This effort removes from local mitigation planners a barrier to performing all the needed local risk assessments by providing the data developed during the 2018 State Plan Update.

The Missouri Hazard Mitigation Viewer includes a Map Viewer with a legend of clearly labeled features, a north arrow, a base map that is either aerial imagery or a street map, risk assessment data symbolized the same as in the 2018 State Plan for easy reference, search and query capabilities, ability to zoom to county level data and capability to download PDF format maps. The Missouri Hazard Mitigation Viewer can be found at this link: http://bit.ly/MoHazardMitigationPlanViewer2018.

The vulnerability assessments in the Macon County plan will also be based on:

- Written descriptions of assets and risks provided by participating jurisdictions;
- Existing plans and reports;
- Personal interviews with planning committee members and other stakeholders; and
- Other sources as cited.

Within the Vulnerability Assessment, the following sub-headings will be addressed:

- **Vulnerability Overview:** This section consists of a general overview narrative of the planning area's vulnerability to the hazard. Within this section, the magnitude/severity of the hazard is discussed. The magnitude of the impact of a hazard event (past and perceived) is related directly to the vulnerability of the people, property, and the environment it affects. This is a function of when the event occurs, the location affected, the resilience of the community and the effectiveness of the emergency response and disaster recovery efforts.

- **Potential Losses to Existing Development:** This section provides the potential losses to existing development. Where data is available, this section provides estimated financial losses as well as the methodology used. For hazards with an overall "Low" rating, potential losses may not be discussed.

- **Previous and Future Development:** This section provides information on how vulnerability to this hazard will be impacted by planned future development as well as information for jurisdictions to consider in planning future development.

- **Hazard Summary by Jurisdiction:** For hazard risks that vary by jurisdiction, this section will provide an overview how the hazard varies, followed by a table indicating the probability, magnitude, warning time, and duration rankings for each jurisdiction with the resulting hazard score and level.

Problem Statements

3.4.1 Flooding (Riverine and Flash)

Hazard Profile

Hazard Description

A flood is partial or complete inundation of normally dry land areas. Riverine flooding is defined as the overflow of rivers, streams, drains, and lakes due to excessive rainfall, rapid snowmelt, or ice. There are several types of riverine floods, including headwater, backwater, interior drainage, and flash flooding. Riverine flooding is defined as the overflow of rivers, streams, drains, and lakes due to excessive rainfall, rapid snowmelt or ice melt. The areas adjacent to rivers and stream banks that carry excess floodwater during rapid runoff are called floodplains. A floodplain is defined as the lowland and relatively flat area adjoining a river or stream. The terms "base flood" and "100- year flood" refer to the area in the floodplain that is subject to a one percent or greater chance of flooding in any given year. Floodplains are part of a larger entity called a basin, which is defined as all the land drained by a river and its branches.

Flooding caused by dam and levee failure is discussed in Section 3.4.3 and Section 3.4.2 respectively. It will not be addressed in this section.

A flash flood occurs when water levels rise at an extremely fast rate as a result of intense rainfall over a brief period, sometimes combined with rapid snowmelt, ice jam release, frozen ground, saturated soil, or impermeable surfaces. Flash flooding can happen in Special Flood Hazard Areas (SFHAs) as delineated by the National Flood Insurance Program (NFIP) and can also happen in areas not associated with floodplains.

Ice jam flooding is a form of flash flooding that occurs when ice breaks up in moving waterways, and then stacks on itself where channels narrow. This creates a natural dam, often causing flooding within minutes of the dam formation.

In some cases, flooding may not be directly attributable to a river, stream, or lake overflowing its banks. Rather, it may simply be the combination of excessive rainfall or snowmelt, saturated ground, and inadequate drainage. With no place to go, the water will find the lowest elevations – areas that are often not in a floodplain. This type of flooding, often referred to as sheet flooding, is becoming increasingly prevalent as development outstrips the ability of the drainage infrastructure to properly carry and disburse the water flow.

Most flash flooding is caused by slow-moving thunderstorms or thunderstorms repeatedly moving over the same area. Flash flooding is a dangerous form of flooding which can reach full peak in only a few minutes. Rapid onset allows little or no time for protective measures. Flash flood waters move at very fast speeds and can move boulders, tear out trees, scour channels, destroy buildings, and obliterate bridges. Flash flooding can result in higher loss of life, both human and animal, than slower developing river and stream flooding.

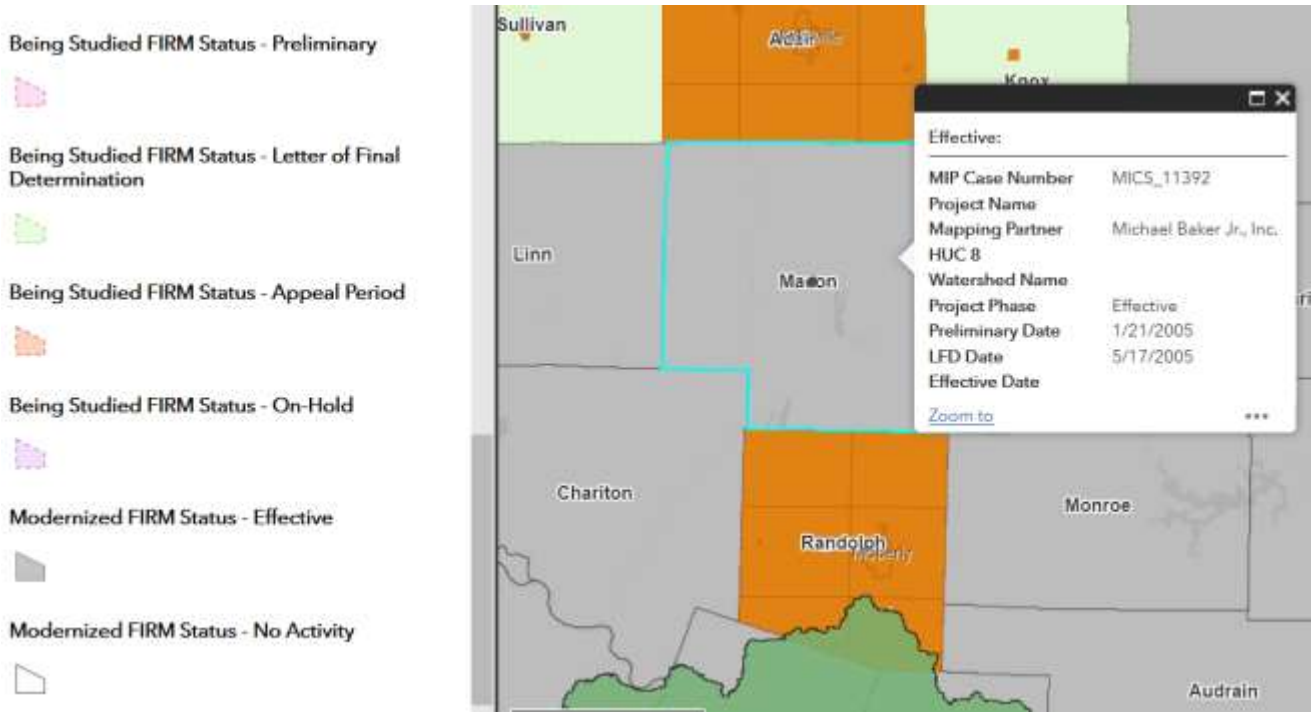
In certain areas, aging storm sewer systems are not designed to carry the capacity currently needed to handle the increased storm runoff. Typically, the result is water backing into basements, which damages mechanical systems and can create serious public health and safety concerns. This combined with rainfall trends and rainfall extremes all demonstrate the high probability, yet generally unpredictable nature of flash flooding in the planning area.

Although flash floods are somewhat unpredictable, there are factors that can point to the likelihood of flash floods occurring. Weather surveillance radar is being used to improve monitoring capabilities of intense rainfall. This, along with knowledge of the watershed characteristics, modeling techniques, monitoring, and advanced warning systems has increased the warning time for flash floods.

Geographic Location

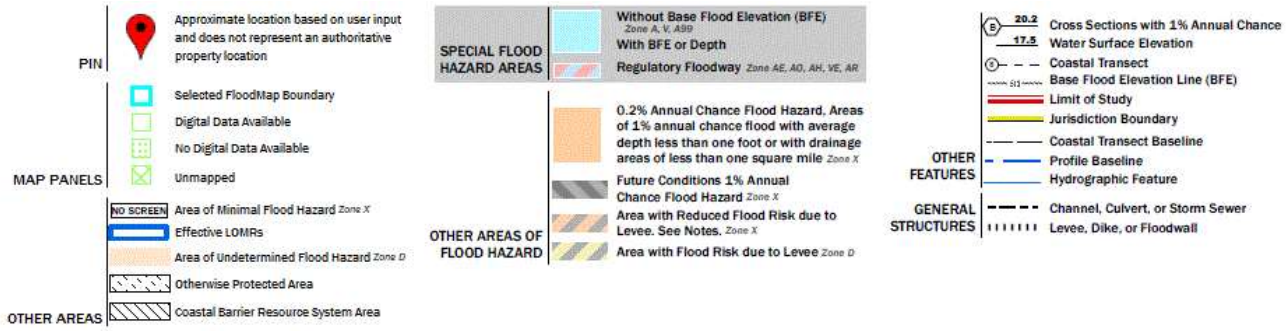
Riverine flooding is most likely to occur in (Special Flood Hazard Areas) SFHAs. Below is a Risk MAP Study Status Map. There are several areas in the unincorporated county at risk for river flooding.

Figure 3.3. Macon County Risk MAP Study Status Map



Source: http://fema.maps.arcgis.com/apps/webappviewer/index.html?id=48cfac9a9ffb4003b565aaccf464d0ac

Figure 3.4. Legend



Source: FEMA Map Service Center; https://msc.fema.gov/portal/home

The following are flood hazard maps for all jurisdictions to fully reflect the flooding hazards throughout Macon County.

Figure 3.5. Atlanta

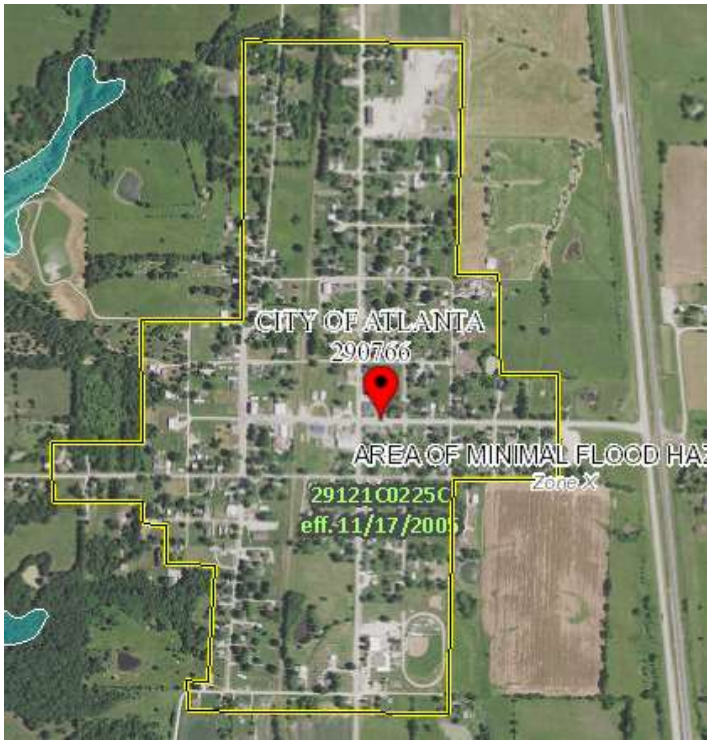


Figure 3.6. Bevier

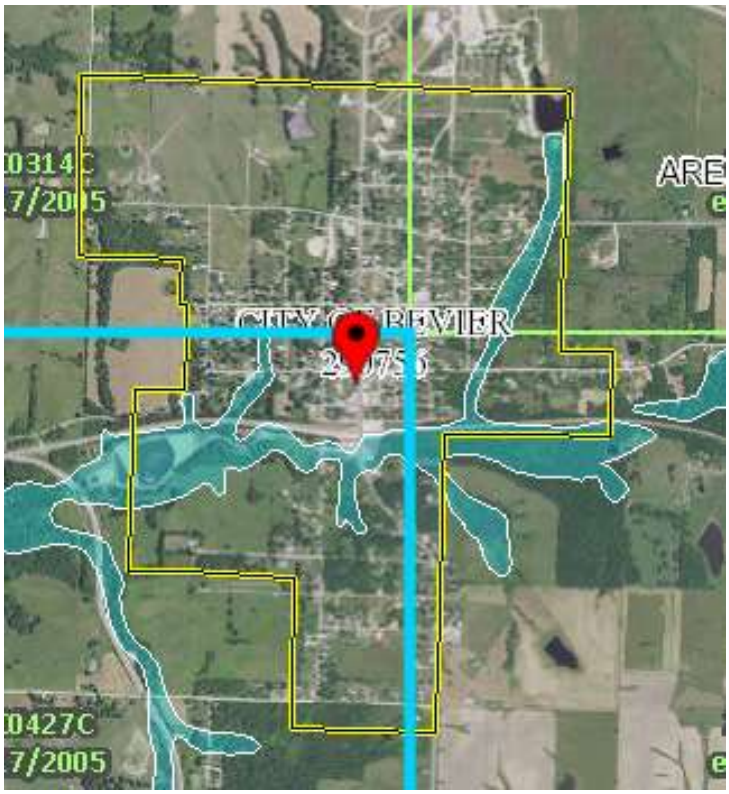


Figure 3.7. Callao

Figure 3.8. Elmer

Figure 3.9. La Plata

Figure 3.10. Macon

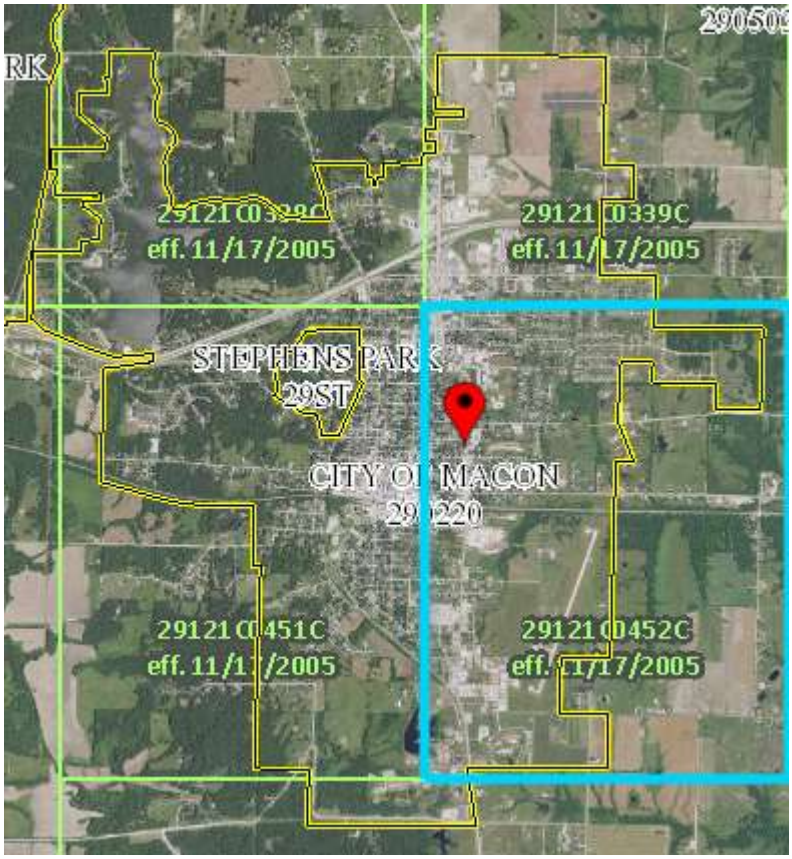


Figure 3.11. Macon County R-I

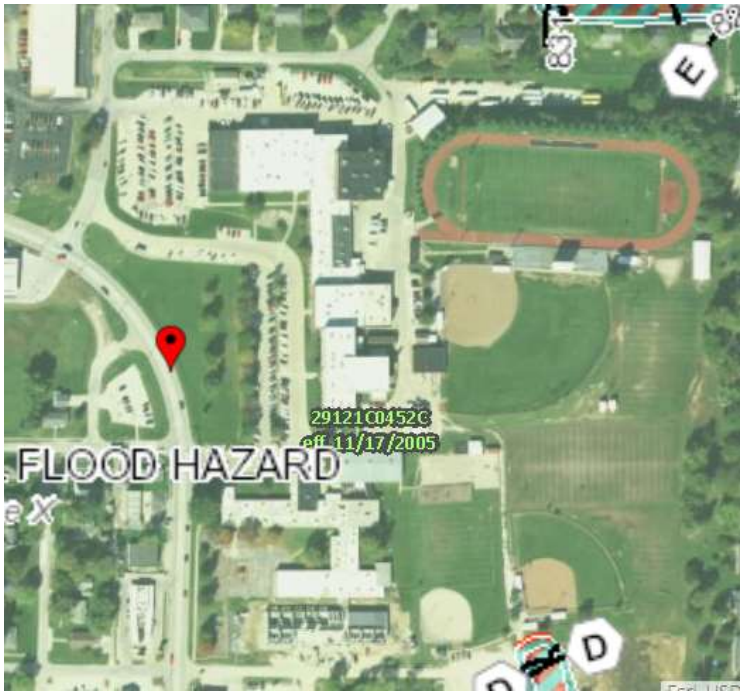


Figure 3.12. Macon County R-IV

Figure 3.13. Atlanta C-3

Source: FEMA Map Service Center; https://msc.fema.gov/portal/home

Table 3.15. Macon County NCEI Flood Events by Location, 1998-2018

Location	# of Events
Unincorporated Macon County	0
Atlanta	
-Highway J Closed	1
Macon	
-Highway C and T	2
-Route DD and PP	

Source: National Centers for Environmental Information, August 16, 2019 https://www.ncdc.noaa.gov/stormevents

Flash flooding occurs in SFHAs and low-lying locations in the planning area. They also occur in areas without adequate drainage to carry away the amount of water that falls during intense rainfall events. NCEI database was used to determine which jurisdictions are most prone to flash flooding during a 21-year time period. Table 3.16 shows the number of flash flood events by location recorded in NCEI for the 21-year period.

Table 3.16. Macon County NCEI Flash Flood Events by Location, 1998-2018

Location	# of Events
Unincorporated Macon County	10
-Axtell- Kellog Avenue- 1 flood events	
-Economy- Highway M- 2 flood events	
-Anabel- Route PP and DD- 1 flood events	
-Anabel- Highway 36- 1 flood events	
-Lingo- Highway 129- 1 flood events	
-Sue City- 1 flood events	
-La Crosse- Highway 3- 1 flood events	
-Mercyville- Highway 156- 1 flood events	
-Redman- Route DD, Highway 63, Road 149, Eagle Road, Dogwood Road- 1 flood events	
La Plata	5
-Harness Road- 1 flood events	
-Throughout the City- 2 flood events	

-Highway 156- 2 flood events	
Macon	9
-Throughout the City- 3 flood events	
-Jaguar Street- 1 flood events	
-Route PP and DD- 1 flood events	
-Highway PP- 2 flood events	
-Business 36- 1 flood events	
-Noll Drive- 1 flood events	
Atlanta	2
-Route J- 1 flood events	
-Main Street- 1 flood events	
Callao	2
-Highway 36- 1 flood events	
-Highway 3- 1 flood events	
Elmer	1
-Highway F- 1 flood events	
New Cambria	3
-Highway 36- 1 flood events	
-Road near Puzzle Creek- 1 flood events	
-Highway Z- 1 flood events	

Source: National Centers for Environmental Information, August 16, 2019 https://www.ncdc.noaa.gov/stormevents

Strength/Magnitude/Extent

Missouri has a long and active history of flooding over the past century, according to the 2018 State Hazard Mitigation Plan. Flooding along Missouri's major rivers generally results in slow-moving disasters. River crest levels are forecast several days in advance, allowing communities downstream sufficient time to take protective measures, such as sandbagging and evacuations. Nevertheless, floods exact a heavy toll in terms of human suffering and losses to public and private property. By contrast, flash flood events in recent years have caused a higher number of deaths and major property damage in many areas of Missouri.

According to the U.S. Geological Survey, two critical factors affect flooding due to rainfall: rainfall duration and rainfall intensity – the rate at which it rains. These factors contribute to a flood's height, water velocity and other properties that reveal its magnitude.

National Flood Insurance Program (NFIP) Participation

Table 3.17 provides details on NFIP participation for the communities in the planning area. Table 3.18 provides information on the number of policies in force, amount of insurance in force, number of closed losses, and total payments for each jurisdiction in Macon County.

Table 3.17. NFIP Participation in Macon County

Community ID #	Community Name	NFIP Participant (Y/N/Sanctioned)	Current Effective Map Date	Regular-Emergency Program Entry Date
	Atlanta	N		
290756	Bevier	N	11/17/2005	02/14/1976
290623	Callao	Y	11/17/2005	09/11/2008
290219	Elmer	N	11/17/2005	12/06/1975
290703	La Plata	N	11/17/2005	02/14/1976
290220	Macon	Y	11/17/2005	01/09/1978
290503	Macon County	N	11/17/2005	01/18/1985

Source: NFIP Community Status Book, August 16, 2019; BureauNet, http://www.fema.gov/national-flood-insurance-program/national- flood-insurance-program-community-status-book; M= No elevation determined – all Zone A, C, and X: NSFHA = No Special Flood Hazard Area; E=Emergency Program

Macon County, La Plata, Atlanta, Elmer, and Bevier do not participate in the National Flood Insurance Program due to having no properties in a floodplain.

Table 3.18. NFIP Policy and Claim Statistics as of Date

Community Name	Policies in Force	Insurance in Force	Closed Losses	Total Payments
Macon	1	$47,200	1	$8,284.73

Source: NFIP Community Status Book, August 16, 2019; BureauNet, http://bsa.nfipstat.fema.gov/reports/reports.html; *Closed Losses are those flood insurance claims that resulted in payment. Loss statistics are for the period as of July 2019.

According to Table 3.18 the City of Macon is the only jurisdiction with an insurance claim resulting in one payment.

Repetitive Loss/Severe Repetitive Loss Properties

Repetitive Loss Properties are those properties which two or more losses of at least $1,000 each have been paid under the National Flood Insurance Program (NFIP) within any 10-year period since 1978. According to the Flood Insurance Administration, jurisdictions included in the planning area have no repetitive loss properties.

Severe Repetitive Loss (SRL): A SRL property is defined it as a single family property (consisting of one-to-four residences) that is covered under flood insurance by the NFIP; and has (1) incurred flood-related damage for which four or more separate claims payments have been paid under flood insurance coverage with the amount of each claim payment exceeding $5,000 and with cumulative amounts of such claims payments exceeding $20,000; or (2) for which at least two separate claims payments have been made with the cumulative amount of such claims exceeding the reported value of the property.

According to the Flood Insurance Administration, jurisdictions included in the planning area have no severe repetitive loss properties.

Previous Occurrences

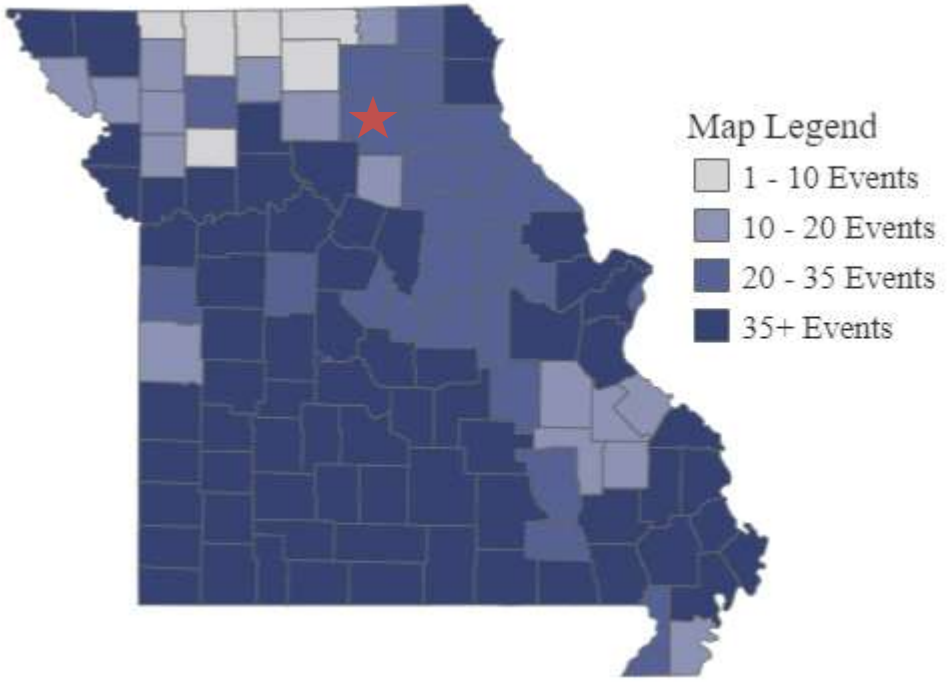
NCEI information for the last 21 years for both flash and river flooding events are shown in Table 3.19 and Table 3.20.

Table 3.19. NCEI Macon County Flash Flood Events Summary, 1998 to 2018

Year	# of Events	# of Deaths	# of Injuries	Property Damages	Crop Damages
1998	1	0	0	$0	$0
2002	1	0	0	$0	$0
2004	3	0	0	$0	$0
2006	1	0	0	$0	$0
2008	4	0	0	$0	$0
2009	2	0	0	$0	$0
2010	5	0	0	$0	$0
2013	1	0	0	$0	$0
2014	1	0	0	$0	$0

Source: NCEI, data accessed August 16, 2019

Figure 3.14. Historical Flood Impact by County



Source: https://www.fema.gov/data-visualization-floods-data-visualization *Red star indicates Macon County

The FEMA Data Visualization Tool as shown above, indicates Macon County had between 20 – 35 events of flood impact.

Table 3.20. NCEI Macon County Riverine Flood Events Summary, 1998 to 2018

Year	# of Events	# of Deaths	# of Injuries	Property Damages	Crop Damages
2008	2	0	0	0	0

Source: NCEI, August 16, 2019

Probability of Future Occurrence

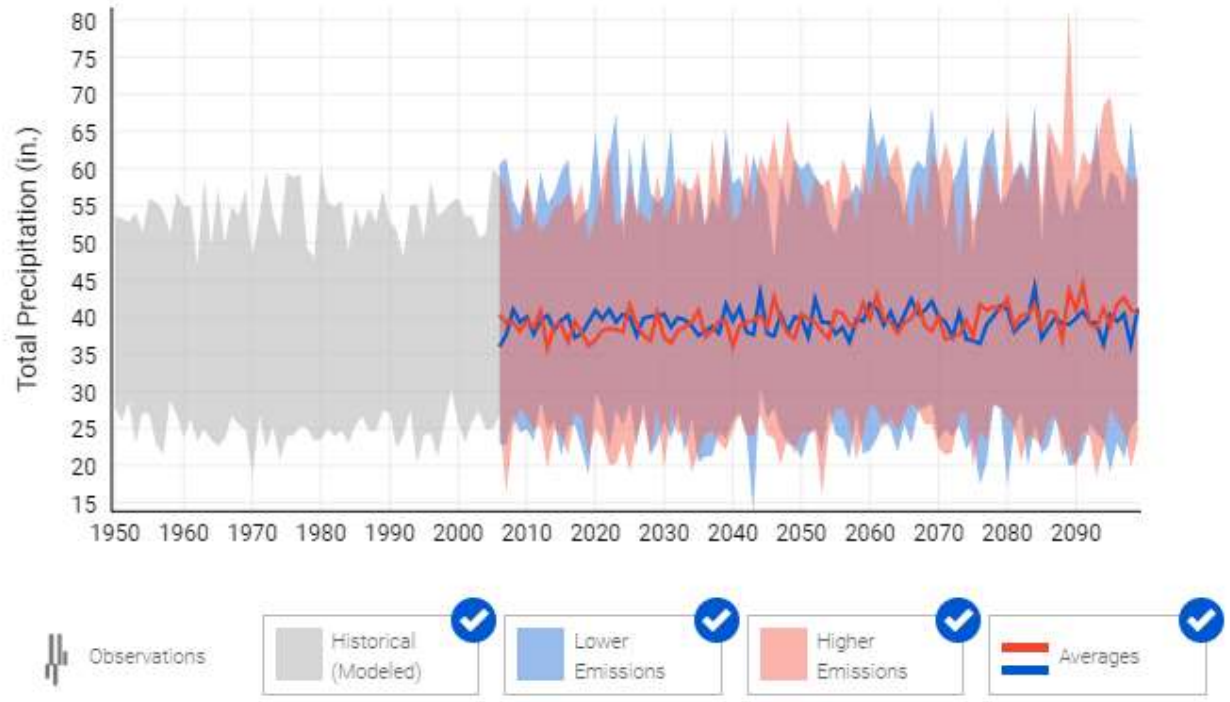
Flash flooding in the planning area has occurred 9 out of 21 years making flash flooding a 43% probability flash flooding will occur in any given year.

Riverine flooding in the planning area has occurred zero times in the last 20 years making riverine flooding a 0% probability flooding will occur in any given year.

Changing Future Conditions Considerations

According to the National Climate Assessment, extreme rainfall events and flooding have increased during the last century, and these trends are expected to continue.

Figure 3.15. Annual Total Precipitation for Macon County



Source: US Climate Resilience Toolkit, https://toolkit.climate.gov/tools/climate-explorer

Vulnerability

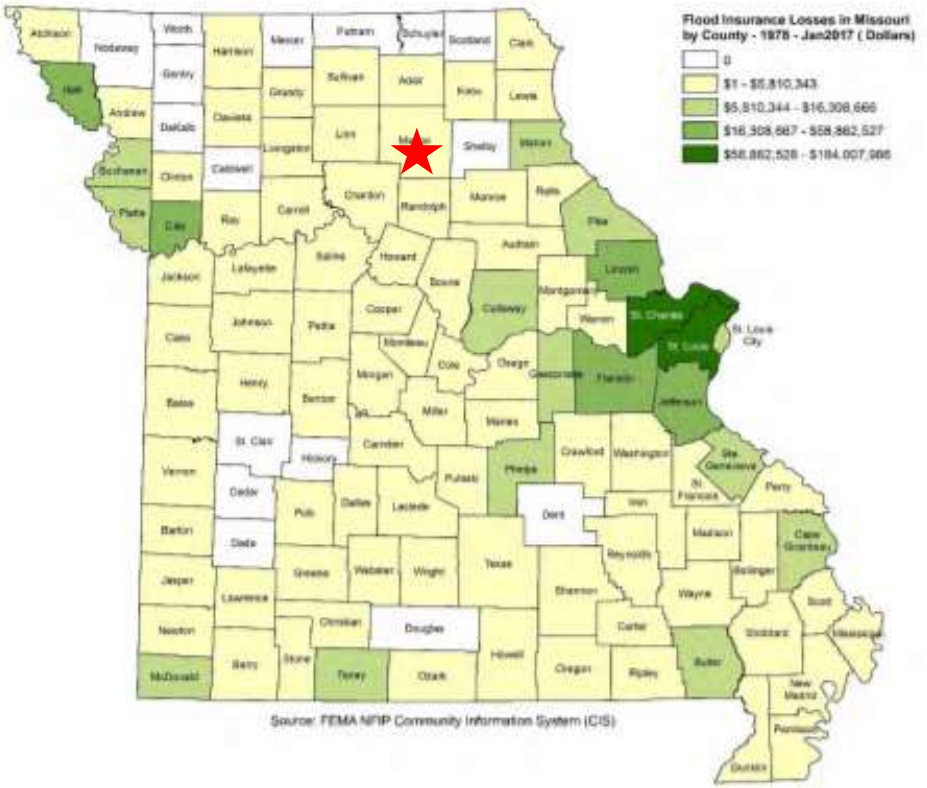
Vulnerability Overview

Flooding presents a danger to life and property, often resulting in injuries, and in some cases, fatalities. Floodwaters themselves can interact with hazardous materials. Hazardous materials stored in large containers could break loose or puncture as a result of flood activity. Examples are bulk propane tanks. When this happens, evacuation of citizens is necessary.

Public health concerns may result from flooding, requiring disease and injury surveillance. Community sanitation to evaluate flood-affected food supplies may also be necessary. Private water and sewage sanitation could be impacted, and vector control (for mosquitoes and other entomology concerns) may be necessary.

When roads and bridges are inundated by water, damage can occur as the water scours materials around bridge abutments and gravel roads. Floodwaters can also cause erosion undermining road beds. In some instances, steep slopes that are saturated with water may cause mud or rock slides onto roadways. These damages can cause costly repairs for state, county, and city road and bridge maintenance departments. When sewer back-up occurs, this can result in costly clean-up for home and business owners as well as present a health hazard.

Figure 3.16. Map of Dollars Paid Historically for Flood Insurance Losses by County 1978 – January 2017



Source: 2018 Missouri State Hazard Mitigation Plan, *Red star indicates Macon County

According to the 2018 Missouri State Hazard Mitigation Plan, Macon County ranged at the lower end of Flood Insurance Losses between $1-$5,810,343.

Potential Losses to Existing Development

Using the data obtained from Flood Insurance Administration, Macon County has no jurisdictions with a history of repetitive loss.

Impact of Previous and Future Development

Any future development in floodplains would increase risk in those areas. For the 2 communities participating in the National Flood Insurance Program, enforcement of the floodplain management regulations will ensure mitigation of future construction in those areas. However, even if structures are mitigated, evacuation may be necessary due to rising waters. In addition, floods that exceed mitigated levels may still cause damages.

EMAP Consequence Analysis

Table 3.21 summarizes the detrimental impacts from flooding.

Table 3.21. EMAP Impact Analysis: Flooding

Subject	Detrimental Impacts
Public	Localized impact expected to be severe for incident areas and moderate to light for other adversely affected areas.
Responders	Localized impact expected to limit damage to personnel in the flood areas at the time of the incident.
Continuity of Operations	Damage to facilities/personnel in the area of the incident may require temporary relocation of some operations. Localized disruption of roads, facilities, and/or utilities caused by incident may postpone delivery of some services.
Property, Facilities, and Infrastructure	Localized impact to facilities and infrastructure in the area of the incident. Some severe damage possible.
Environment	Localized impact expected to be severe for incident areas and moderate to light for other areas affected by the flood or HazMat spills.
Economic Condition of Jurisdiction	Local economy and finances adversely affected, possibly for an extended period of time.
Public Confidence in the Jurisdiction's Governance	Ability to respond and recover may be questioned and challenged if planning, response, and recovery not timely and effective.

Hazard Summary by Jurisdiction

Vulnerability to flooding varies by jurisdiction as each community has a different layout, as described above there are no jurisdictions in the planning area with a history of repetitive loss and would be more vulnerable to another loss in the future.

Table 3.16 reflects the NCEI Flash Flood Events in Unincorporated Macon County at 10 events, La Plata at 5 events, Macon at 9 events, Atlanta at 2 events, Callao at 2 events, and Elmer at 1 event. The floodplain maps in the Geographic Location section depict the flood area in each jurisdiction. The jurisdictions affected by flooding includes La Plata, Macon, Atlanta, Callao, and Elmer.

Problem Statement

Local governments should make a strong effort to improve emergency warning system to ensure future deaths and injuries do not occur. Local governments should consider make improvements to roads and low water crossings that consistently flood by placing them on a hazard mitigation projects list and actively seek funding to successfully complete the projects.

3.4.2 Dam Failure

Hazard Profile

Hazard Description

A dam is defined as a barrier constructed across a watercourse for the purpose of storage, control, or diversion of water. Dams are typically constructed of earth, rock, concrete, or mine tailings. Dam failure is the uncontrolled release of impounded water resulting in downstream flooding, affecting both life and property. Dam failure can be caused by any of the following:

1. Overtopping: Inadequate spillway design, debris blockage of spillways or settlement of the dam crest.
2. Piping: Internal erosion caused by embankment leakage, foundation leakage and deterioration of pertinent structures appended to the dam.
3. Erosion: Inadequate spillway capacity causing overtopping of the dam, flow erosion, and inadequate slope protection.
4. Structural Failure: Caused by an earthquake, slope instability or faulty construction.

Table 3.22. MoDNR Dam Hazard Classification Definitions

Hazard Class	Definition
Class I	Contains 10 or more permanent dwellings or any public building.
Class II	Contains 1 to 9 permanent dwellings or 1 or more campgrounds with permanent water, sewer, and electrical services or 1 or more industrial buildings.
Class III	Everything else.

Source: Missouri Department of Natural Resources, http://dnr.mo.gov/env/wrc/docs/rules_reg_94.pdf

Table 3.23. NID Dam Hazard Classification Definitions

Hazard Class	Definition
Low Hazard	A dam located in an area where failure could damage only farm or other uninhabited buildings, agricultural or undeveloped land including hiking trails or traffic on low volume roads that meet the requirements for low hazard dams.
Significant Hazard	A dam located in an area where failure could endanger a few lives, damage an isolated home, damage traffic on moderate volume roads that meet certain requirements, damage low-volume railroad tracks, interrupt the use or service of a utility serving a small number of customers, or inundate recreation facilities, including campground areas, intermittently used for sleeping and serving a relatively small number of persons.
High Hazard	A dam located in an area where failure could result in any of the following: extensive loss of life damage to more than one home, damage to industrial or commercial facilities, interruption of a public utility serving a large number of customers, damage to traffic on high-volume roads that meet the requirements for hazard class C dams or a high-volume railroad line, inundation of a frequently used recreation facility serving a relatively large number of persons, or two or more individual hazards described for significant hazard dams.

Source: National Inventory of Dams

Geographic Location

Dams Located Within the Planning Area

DAMS IN MISSOURI AS OF 7/20/2017 – MISSOURI DEPARTMENT OF NATURAL RESOURCES

Although this data set has been compiled by the Missouri Department of Natural Resources, no warranty, expressed or implied, is made by the Department as to the accuracy of the data. The act of distribution shall not constitute any such warranty, and no responsibility is assumed by the Department in the use of these data or related materials.

COUNTY	LOCATION	ID_NO	NAME	YEAR COMPLETE	LENGTH	DAMHT	RESAREA	DRAINAGE AREA (acres)	STATE REGULATED	HAZARD CLASS	PERMIT NUMBER
MACON	S36, T59 N, R17W	MO10055	ETHEL LAKE DAM	1950	1100	53	17	147	Y	2	R-261
MACON	S36, T59 N, R17W	MO40141	ED'S LAKE A DAM	2005	618	42.6	31	230	Y	2	S-122
MACON	S05, T60 N, R14W	MO10114	SANTA FE LAKE DAM	1900	0	30	40	235	N	3	
MACON	S17, T57 N, R14W	MO10153	MACON LAKE DAM	1927	1200	42	205	4048	Y	2	R-085
MACON	S32, T57 N, R16W	MO10327	TEMPLE STEPHENS CO DAM	1928	0	34	10	21	N	2	
MACON	S33, T57 N, R15W	MO10329	KEOTA LAKE DAM	1900	0	15	12	525	N	3	
MACON	S29, T59 N, R14W	MO10330	CITY OF ATLANTA RESERVOIR DAM	1967	0	31	22	225	N	3	
MACON	S14, T57 N, R15W	MO10332	CENTRAL COAL&COKE CORP LAKE DAM	1897	0	15	10	156	N	3	
MACON	S28, T57 N, R14W	MO10333	STILL HILDRETH SANITORIUM DAM	1900	0	30	10	48	N	3	
MACON	S18, T57 N, R13W	MO10335	MONONAME 22 DAM	1968	0	20	4	35	N	3	
MACON	S06, T58 N, R14W	MO10338	CLAUDE BLOOMBERG DAM (INUNDATED)	1930	0	0	0	380	N	3	
MACON	S09, T60 N, R14W	MO10339	LA PLATA LAKE DAM	1958	0	30	22	390	N	3	
MACON	S07, T59 N, R14W	MO10340	GEORGE BAAKE DAM	1972	0	20	7	270	N	3	
MACON	S16, T57 N, R14W	MO10341	B THIEMAN	1930	0	20	3	55	N	3	
MACON	S05, T59 N, R14W	MO10374	LOVE LAKE DAM	1905	0	25	20	223	N	3	
MACON	S05, T57 N, R17W	MO10375	WHITE LAKE DAM	1940	0	30	10	55	N	3	
MACON	S07, T57 N, R16W	MO10387	NEW CAMBRIA LAKE DAM	1936	0	21	7	115	N	1	
MACON	S18, T57 N, R14W	MO11176	LONG BRANCH DAM(FEDERAL)	1979	0	71	6100	0	N	1	
MACON	S34, T58 N, R15W	MO11482	MCVICKER LAKE DAM	1977	580	25	1	205	N	3	
MACON	S07, T57 N, R16W	MO11504	SCHELLE LAKE DAM	1974	0	25	7	39	N	3	
MACON	S23, T58 N, R14W	MO11666	MECHLIN LAKE DAM	1975	0	31	7	30	N	3	
MACON	S08, T58 N, R14W	MO11667	LARSON LAKE DAM	1977	0	30	8	100	N	3	
MACON	S14, T60 N, R14W	MO12126	LA PLATA NEW CITY DAM	1980	1000	43	81	800	Y	3	R-335
MACON	S06, T58 N, R14W	MO12411	BLOMBERG FARM DAM	1998	628	42.5	19	70	Y	1	S-082
MACON	S18,T59N,R16W	MO50625	REINHART DAM	1994	403	25.5	2	19	N	3	
MACON	S32,T58N,R17W	MO50626	GALL DAM	1994	225	28.1	8	390	N	3	
MACON	S06,T58N,R13W	MO50627	ROAMER DAM	1994	250	25.9	3	51	N	3	
MACON	S22, T56 N, R15W	MO12386	BEE VEER MINE DAM	1950	1700	60	111	111	Y	3	R-463
MACON	S23,T58N,R16W	MO50551	LOVELAND DAM	1992	177	33	1	26	N	3	
MACON	S18,T60N,R15W	MO50552	LAIRD DAM	1992	280	31	1	58	N	3	
MACON	S13,T57N,R15W	MO50169	BUSWELL DAM	1995	428	27	5	192	N	3	
MACON	S29,T60N,R17W	MO50170	LEISURE DAM	1995	369	28	6	193	N	3	
MACON	S33,T59N,R17W	MO50171	ATHA DAM	1995	206	30	5.5	269	N	3	
MACON	S20,T58N,R14W	MO50685	WEST DAM	1996	193	25.2	4	110	N	3	
MACON	S01,T56N,R15W	MO50686	CERVA DAM	1995	310	25.7	11	179	N	3	
MACON	S29,T58N,R17W	MO50709	WITT DAM	1997	2250	27.9	5	50	N	3	
MACON	S29,T57N,R16W	MO50711	HALL DAM	1997	370	25.5	13	253	N	3	
MACON	S25,T59N,R17W	MO50710	ALLARD DAM	1997	398	34.6	6.6	269	N	3	
MACON	S26,T57N,R14W	MO50712	CLEMA DAM	1997	355	26.2	7	243	N	3	
MACON	S34,T56N,R15W	MO50713	HENRY DAM	1997	450	29.7	2	32	N	3	
MACON	S01,T58N,R17W	MO50785	HUTCHISON DAM	1998	233	27.2	8	230	N	3	
MACON	S35,T58N,R17W	MO50784	MORRIS DAM	1998	340	24.3	7	160	N	3	
MACON	S15,T56N,R14W	MO50781	HACKMAN DAM	1998	650	23.2	4	187	N	3	
MACON	S13,T56N,R13W	MO50782	GREENWOOD DAM	1998	475	24.4	5	150	N	3	
MACON	S32,T57N,R15W	MO50783	TETER DAM	1998	440	28.8	5	160	N	3	
MACON	S06,T57N,R13W	MO50786	WHITE DAM	1998	477	25	9	150	N	3	
MACON	S30,T56N,R13W	MO50967	PHILLIP PAGLIAI DAM	2000	290	26	4	160	N	3	
MACON	S19,T57N,R15W	MO50968	PAUL ISAACSON DAM	2000	310	29	10	95	N	3	
MACON	S02,T58N,R17W	MO50981	HOFCO FARMS DAM	1999	320	29	4	77	N	3	
MACON	S01,T56N,R15W	MO51100	JEFF EMANUAL DAM	2001	300	25	2	32	N	3	
MACON	S11,T57N,R14W	MO51114	FOSTER DAM	2002	240	28	4	128	N	3	
MACON	S03,T59N,R15W	MO51172	HIATT DAM	2003	450	26	2	64	N	3	
MACON	S15,T58N,R15W	MO51173	WATSON DAM	2003	503	29	12	230	N	3	
MACON	S33,T58N,R15W	MO51192	RICK MCVICKER DAM	1989	620	27	3	115	N	3	
MACON	S31,T60N,R15W	MO51261	FOUNTAIN CREEK FARMS DAM	2004	389	28	6	262	N	3	
MACON	S1, T58 N, R17W	MO40169	ED'S LAKE B DAM	0000	450	47.5	6	53	Y	2	S-123
MACON	S17,T58N,R13W	MO51408	HOCHSTETLER DAM	2005	215	28	2	77	N	3	
MACON	S28,T60N,R13W	MO51409	WATTS DAM	2006	912	21	9	173	N	3	
MACON	S30,T59N,R14W	MO51503	JWEST DAM	2007	260	27	2	130	N	3	

Source: Missouri Department of Natural Resources, Dam and Reservoir Safety, https://dnr.mo.gov/geology/wrc/dam-safety/damsinmissouri.htm

There are 56 dams located inside the county boundaries, and 8 high hazard dams using both the NID and the Mo DNR data.

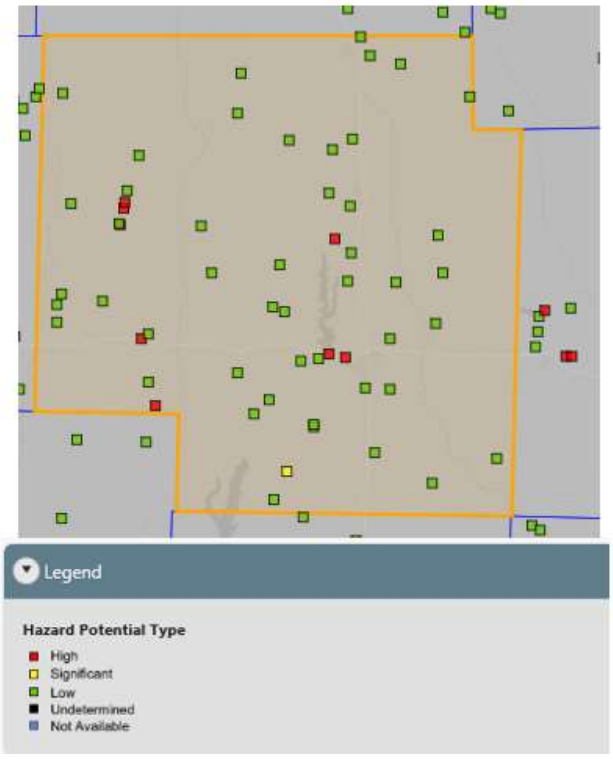
Table 3.24 lists the names, locations and other pertinent information for all high hazard dams in the planning area.

Table 3.24. High Hazard Dams in the Macon County Planning Area

Dam Name	Emergency Action Plan (EAP)AP	Dam Height (Ft)	Normal Storage (Acre-Ft)	Last Inspection Date	River	Nearest Downstream City	Distance To Nearest City (Miles)	Dam Owner
Ethel Lake Dam	Yes	53	258	9/12/17	Little Turkey Creek	Ethel	1.7	BNSF Railway Co.
Ed's Lake A Dam	Yes	44.4	543	9/15/15	Unnamed Tributary	Ethel	2	Private – Not Listed
Ed's Lake B Dam	Yes	49	98	9/15/15	Little Turkey Creek	Ethel	2.5	Private – Not Listed
New Cambria Lake Dam	Not Required	21	79	8/23/79	Chariton River	New Cambria	1.5	City of New Cambria
Temple Stephens Co. Dam	Not Required	34	182	-	-	New Cambria	6	Temple Stephens Co.
Macon Lake Dam	Yes	42	2,250	11/8/17	Duck Creek	Macon	2	City of Macon
Long Branch Dam	Yes	80	98,000	7/31/14	East Fork Little Chariton	Macon	2.8	Federal – CENWK
Blomberg Farm Dam	Yes	42.5	302	4/23/18	-	Atlanta	3	William S. Blomberg

Sources: Missouri Department of Natural Resources, https://dnr.mo.gov/geology/wrc/dam-safety/damsinmissouri.htm and National Inventory of Dams, http://nid.usace.army.mil/cm_apex/f?p=838:12.

Figure 3.17. High Hazard Dam Locations in Macon County



Source: National Inventory of Dams, http://nid.usace.army.mil/cm_apex/f?p=838:12

Upstream Dams Outside the Planning Area

The Missouri Department of Natural Resources was consulted to see if dams located outside of the county would impact Macon County in the event of a failure. It was determined that there are no upstream dams that would place Macon County in any danger.

Strength/Magnitude/Extent

The strength/magnitude of dam failure would be similar in some cases to flood events (see the flood hazard vulnerability analysis and discussion). The strength/magnitude/extent of dam failure is related to the volume of water behind the dam as well as the potential speed of onset, depth, and velocity. Note that for this reason, dam failures could flood areas outside of mapped flood hazards.

Inundation data, however, is not currently available for any of the county's dams or the surrounding areas. The future probable severity of a dam failure in Macon County is shown below according to DNR's hazard potential levels.

Hazard Level	Probable Risk
High	Catastrophic
Significant	Critical
Low	Negligible

Previous Occurrences

To determine previous occurrences of dam failure within the planning area, the Macon County Missouri Natural Hazard Mitigation Plan was consulted, as well as the 2018 Missouri State Hazard Mitigation Plan and the Stanford University's National Performance of Dams Program (http://npdp.stanford.edu/ http://npdp.stanford.edu). No record of dam failure within Macon County boundaries was found.

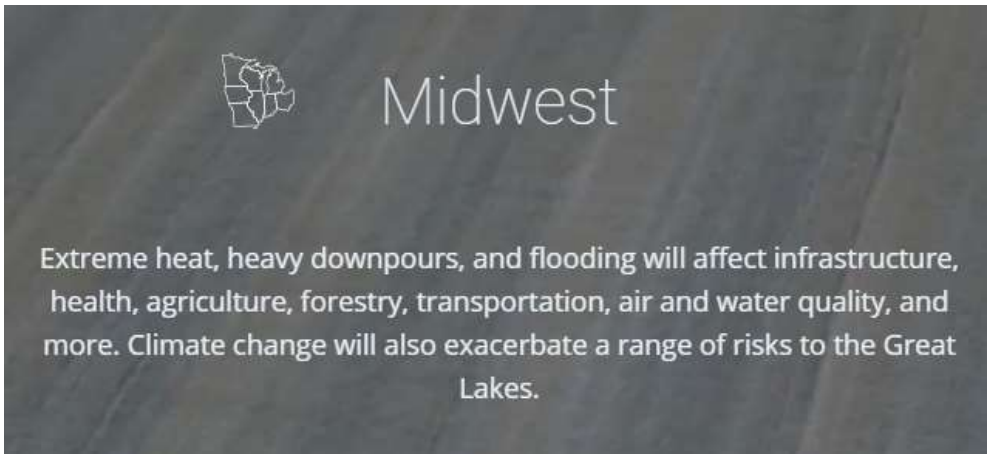
Probability of Future Occurrence

It is the responsibility of the individual landowners to inspect and maintain. All the dams are small in terms of dam height and storage area and are not a threat to significant population are as or critical facilities. Based on the number of high hazard dams in the planning area and no record of previous occurrences, the probability of a future occurrence cannot be calculated. The age and condition of local structures should be taken into consideration and monitored on a regular basis.

Figure 3.18. Macon County Changing Future Conditions Considerations

Source: US Climate Resilience Toolkit; https://toolkit.climate.gov/tools/climate-explorer

Figure 3.19. Climate Assessment for Macon County



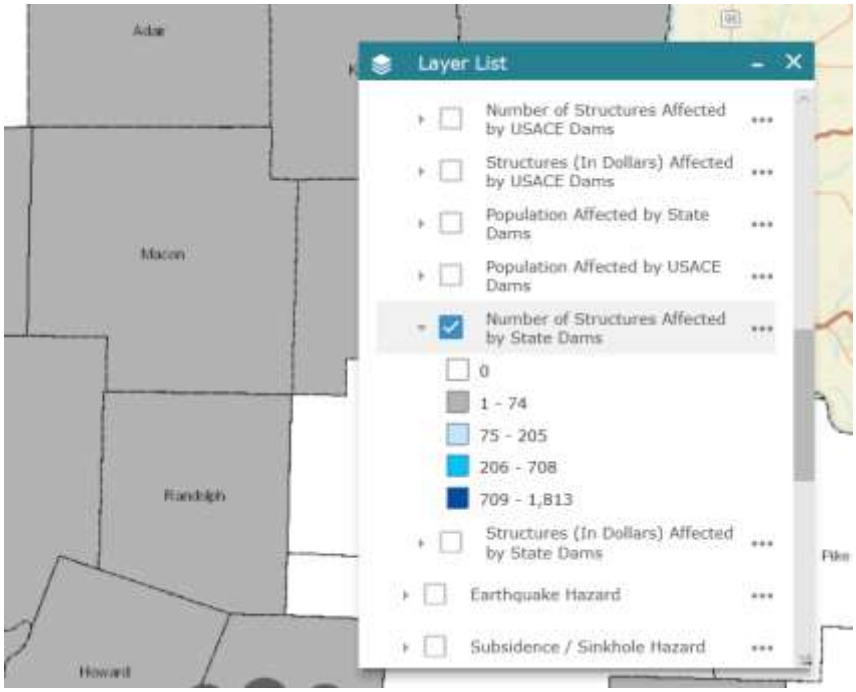
Source: National Climate Assessment; https://nca2014.globalchange.gov/

Vulnerability

Vulnerability Overview

Vulnerability to dam failure is a factor due to the multiple dams in the planning area, including several High Hazard Dams, indicating the loss of life is possible in the event of a failure. Neighboring communities are also at risk if they are downstream from a dam. Long Branch Dam is located on the west side of Macon and, if compromised, would affect a small portion of the community and would cause minimal damage. The planning committee chose only to address the high hazard dams within the planning area due to the pre-determined risk associated by these dams.

Figure 3.20. Estimated Number of Buildings Vulnerable to Dam Failure of State Regulated Dams



Potential Losses to Existing Development: (including types and numbers, of buildings, critical facilities, etc.)

There are 25 buildings within Macon County that could be affected by State Regulated dams.

Impact of Previous and Future Development

Future development in the inundation area of the Long Branch Dam could impact the amount of damages caused by a failure of the high hazard dam in Macon County. The Long Branch Dam is located within 3 miles of residents in Macon County.

EMAP Consequence Analysis

Table 3.25. EMAP Impact Analysis: Dam Failure

Subject	Detrimental Impacts
Public	Localized impact expected to be severe for inundation area and moderate to light for other adversely affected areas.
Responders	Localized impact expected to limit damage to personnel in the inundation area at the time of the incident.
Continuity of Operations	Damage to facilities/personnel in the area of the incident may require temporary relocation of some operations. Localized disruption of roads and/or utilities may postpone delivery of some services. Regulatory waivers may be needed locally. Fulfillment of some contracts may be difficult. Impact may reduce deliveries.
Property, Facilities, and Infrastructure	Localized impact to facilities and infrastructure in the inundation area of the incident. Some severe damage possible.
Environment	Localized impact expected to be severe for inundation area and moderate to light for other adversely affected areas.
Economic Condition of Jurisdiction	Local economy and finances adversely affected, possibly for an extended period of time, depending on damage and length of investigation.
Public Confidence in the Jurisdiction's Governance	Localized impact expected to primarily adversely affect dam owner and local entities.

Hazard Summary by Jurisdiction

Of the 56 dams in Macon County, 8 dams have been classified as high hazard dams. Macon and Atlanta are the participating jurisdictions with high hazard dams. All dams, with the exception of one, are small in terms of height and storage area, which does not pose a significant threat to the population. One dam in the planning area is 80 feet high and holds a significant amount of water (98,000 acre-feet), however, the location of the dam is in a rural area and is not relatively close to any significant population area or critical facilities. Jurisdictions and Schools in the planning area are unlikely to be affected by a compromised dame due to the rural location of the 80 feet high dam and the low water capacity of the remaining dams.

Problem Statement

A lack of regular inspection/maintenance of un-regulated high hazard dams was noted by the Mitigation Planning Committee. Possible solutions include the development of a regular maintenance schedule, identification of qualified staff and/or consultant to assist, and maintenance report submittal requirements.

Jurisdictions within Macon County that have control of dams do not properly inspect the dam to ensure the safety of the dam from failing. Jurisdictions and residents need to be informed of the proper way to inspect a dam and look for initial problems.

3.4.3 Earthquakes

Hazard Profile

Hazard Description

An earthquake is a sudden motion or trembling that is caused by a release of energy accumulated within or along the edge of the earth's tectonic plates. Earthquakes occur primarily along fault zones and tears in the earth's crust. Along these faults and tears in the crust, stresses can build until one side of the fault slips, generating compressive and shear energy that produces the shaking and damage to the built environment. Heaviest damage generally occurs nearest the earthquake epicenter, which is that point on the earth's surface directly above the point of fault movement. The composition of geologic materials between these points is a major factor in transmitting the energy to buildings and other structures on the earth's surface.

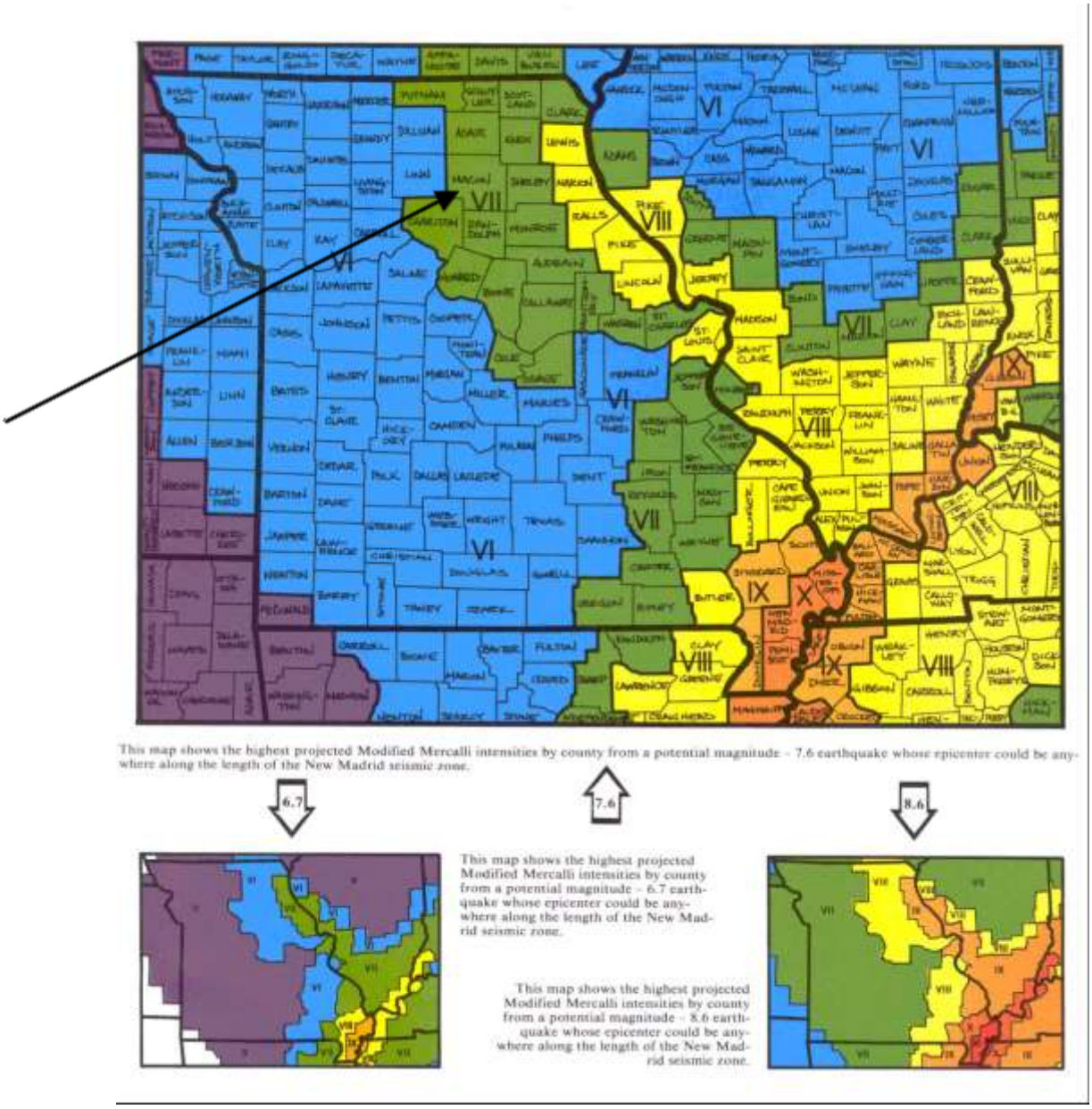
Some earthquakes occur in the middle of plates, as is the case for seismic zones in the Midwestern United States. The most seismically active area in the Midwest is the New Madrid Seismic Zone. The possibility of the occurrence of a catastrophic earthquake in the Central and Eastern United States is real as evidenced by history. The impacts of significant earthquakes affect large areas, terminating public services and systems needed to aid the suffering and displaced. As with hurricanes, mass relocation may be necessary, but the residents who are suffering from the earthquakes can neither leave the heavily impacted areas nor receive aid or even communication in the aftermath of a significant event.

Geographic Location

Seismic activity on the New Madrid Seismic Zone of Southeastern Missouri is very significant both historically and at present. On December 16, 1811 and January 23 and February 7 of 1812, three earthquakes struck the central U.S. with magnitudes estimated to be 7.5 – 8.0. These earthquakes caused violent ground cracking and volcano-like eruptions of sediment (sand blows) over an area of >10,500 km2, and uplift of a 50km by 23 km zone (the Lake County uplift). The shaking was felt over a total area of over 10 million km2 (the largest felt area of any historical earthquake). Of all the historical earthquakes that have the U.S., an 1811- style event would do the most damage if it recurred today. If an 1811 earthquake occurred in Macon County the earthquake intensity would not vary within the county. Damage would be to buildings of good design and construction, slight to moderate in well-built ordinary structures; considerable damage in poorly built or badly designed structures and some chimneys broken.

The following SEMA map (Figure 3.7) shows the highest projected Modified Mercalli intensities by county from a potential magnitude 7.6 earthquake whose epicenter could be anywhere along the length of the New Madrid Seismic Zone. The arrow indicates Macon County and the affects that could be felt from the earthquake.

Figure 3.21. Impact Zones for Earthquake Along the New Madrid Fault



Source: https://sema.dps.mo.gov/docs/EQ_Map.pdf

Figure 3.22. Projected Earthquake Intensities

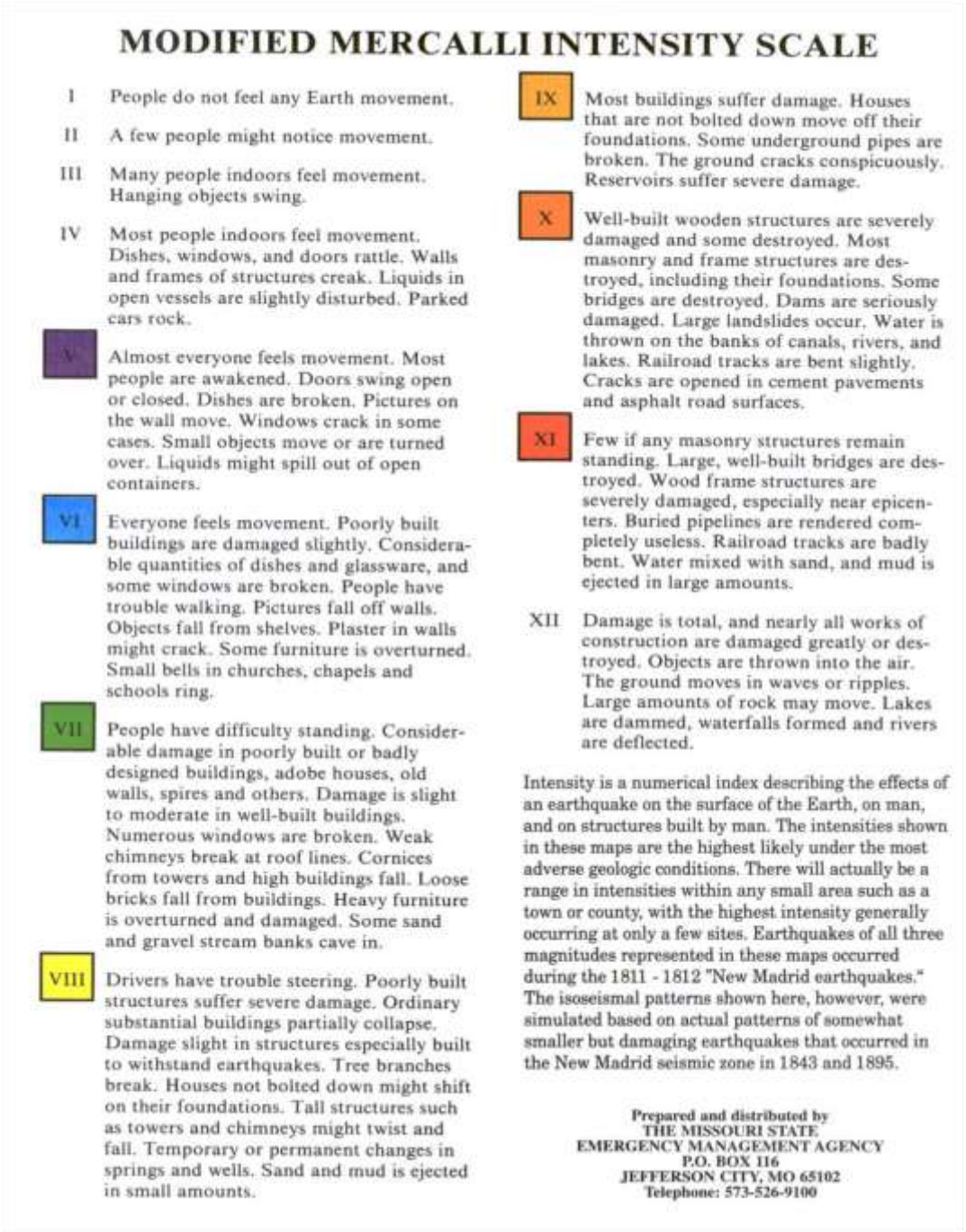
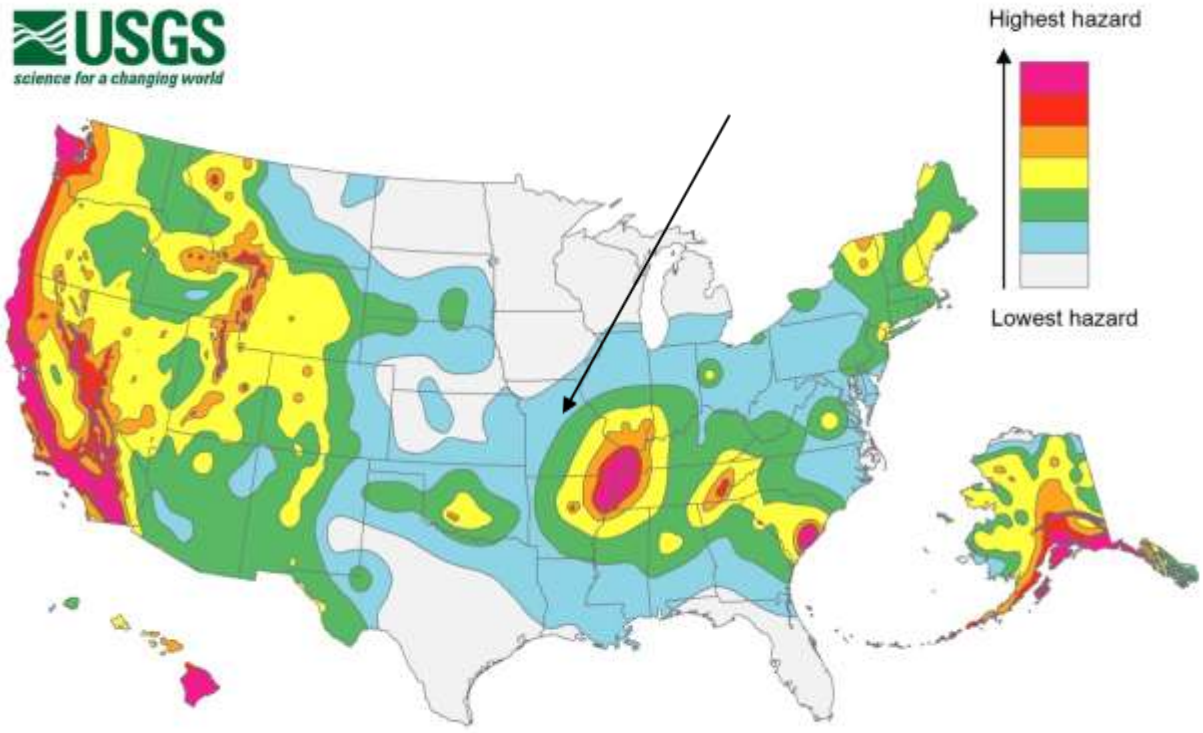


Figure 3.23. United States Seismic Hazard Map



Source: United States Geological Survey at
https://earthquake.usgs.gov/hazards/hazmaps/conterminous/2014/images/HazardMap2014_lg.jpg

Strength/Magnitude/Extent

The extent or severity of earthquakes is generally measured in two ways: 1) the Richter Magnitude Scale is a measure of earthquake magnitude; and 2) the Modified Mercalli Intensity Scale is a measure of earthquake severity. The two scales are defined as follows.

Richter Magnitude Scale

The Richter Magnitude Scale was developed in 1935 as a device to compare the size of earthquakes. The magnitude of an earthquake is measured using a logarithm of the maximum extent of waves recorded by seismographs. Adjustments are made to reflect the variation in the distance between the various seismographs and the epicenter of the earthquakes. On the Richter Scale, magnitude is expressed in whole numbers and decimal fractions. For example, comparing a 5.3 and a 6.3 earthquake shows that the 6.3 quake is ten times bigger in magnitude. Each whole number increase in magnitude represents a tenfold increase in measured amplitude because of the logarithm. Each whole number step in the magnitude scale represents a release of approximately 31 times more energy.

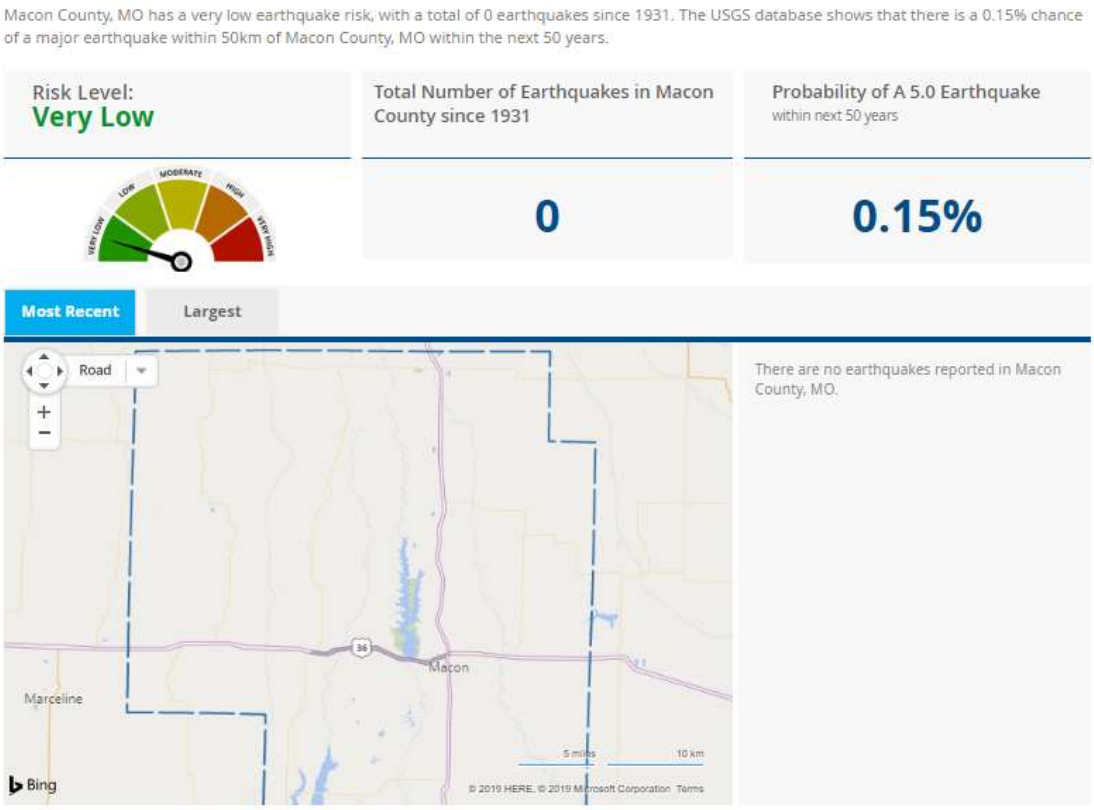
Modified Mercalli Intensity Scale

The intensity of an earthquake is measured by the effect of the earthquake on the earth's surface. The intensity scale is based on the responses to the quake, such as people awakening, movement of furniture, damage to chimneys, etc. The intensity scale currently used in the United States is the Modified Mercalli (MM) Intensity Scale. It was developed in 1931 and is composed of 12 increasing levels of intensity. They range from imperceptible shaking to catastrophic destruction, and each of the twelve levels is denoted by a Roman numeral. The scale does not have a mathematical basis, but is based on observed effects. Its use gives the laymen a more meaningful idea of the severity.

Previous Occurrences

There have been 0 earthquakes within 30 miles of Macon County since 1931.

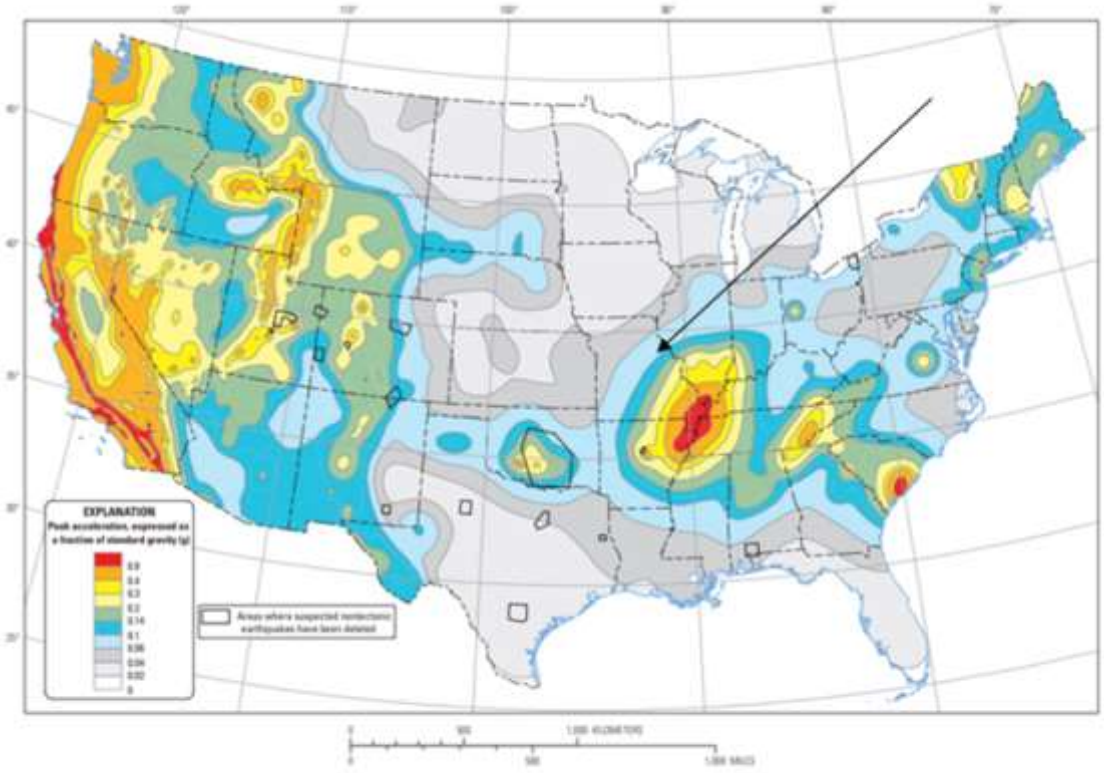
Probability of Future Occurrence



Source: https://www.homefacts.com/earthquakes/Missouri/Macon-County.html

Macon County has a very low earthquake risk, with 0 earthquakes since 1931 within 30 miles of the planning area. The USGS database shows that there is a 0.15% chance of a major earthquake within 50 km of Macon County within the next 50 years. There are no earthquakes reported in Macon County, MO.

Figure 3.24. United States Seismic Hazard Map Macon County Indicated



Two-percent probability of exceedance in 50 years map of peak ground acceleration

Source: https://earthquake.usgs.gov/hazards/hazmaps/conterminous/index.php#2014

Changing Future Conditions Considerations

Scientists are beginning to believe there may be a connection between changing climate conditions and earthquakes. Changing ice caps and sea-level redistribute weight over fault lines, which could potentially have an influence on earthquake occurrences. However, currently no studies quantify the relationship to a high level of detail, so recent earthquakes should not be linked with climate change. While not conclusive, early research suggests that more intense earthquakes and tsunamis may eventually be added to the adverse consequences which are caused by changing future conditions.

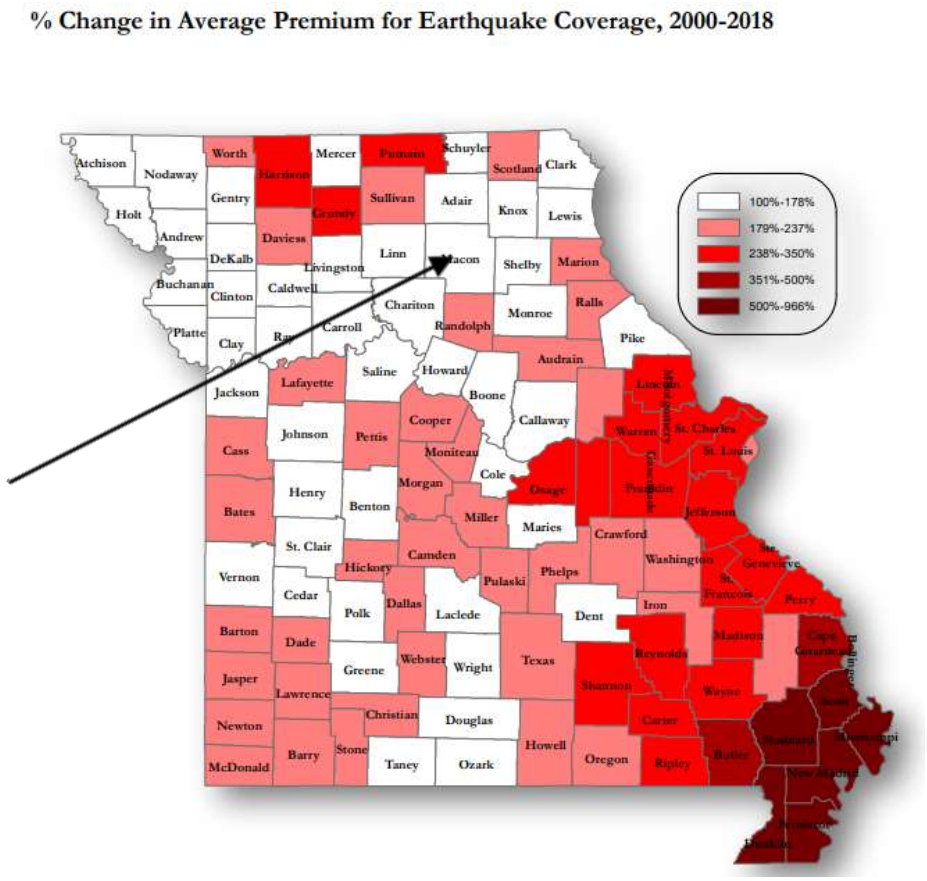
Vulnerability

Vulnerability Overview

According to the data obtained from the 2018 State Plan, Macon County was listed as N/A for Hazard Ranking.

The State of Earthquake Coverage Report states that the average premium for earthquake coverage in Macon County in 2018 was $73.

Figure 3.25. Macon County Change in Average Premium for Earthquake Coverage



Source: The State of Earthquake Coverage Report, https://insurance.mo.gov/earthquake/documents/EarthquakeInsuranceMarketsInMissouriReport20197-8-2019_000.pdf

Potential Losses to Existing Development

The Hazus building inventory counts are based on the 2010 census data adjusted to 2014 numbers using the Dun & Bradstreet Business Population Report. Inventory values reflect 2014 valuations, based on RSMeans (a supplier of construction cost information) replacement costs. Population counts are 2010 estimates from the U.S. Census Bureau.

Figure 3.26. HAZUS-MH Earthquake Loss Estimation: Annualized Loss Scenario-Direct Economic Losses to Buildings

Source: 2018 Missouri State Hazard Mitigation Plan

Figure 3.27. HAZUS-MH Earthquake Loss Estimation: Annualized Loss Scenario

County	Total Losses, in $ Thousands	Loss Per Capita, in $ Thousands	Loss Ratio, in $ per Million
Macon	$20	$0.0013	$12

Figure 3.28. Housing Density, Building Exposure, SOVI, and Mobile Home Data

County	Total Building Exposure (Hazus)	Building Exposure Rating	Housing Density	Housing Density Rating	SOVI Ranking	SOVI Ranking Rating	Percent Mobile Homes	Percent Mobile Homes Rating
Macon	$1,634,837,000	1	9.52	1	Medium High	4	12.1	3

Figure 3.29. Number of High Wind, Hail, and Lightning Events, Likelihood of Occurrence, and Associated Ratings

County	HIGH WIND			HAIL			LIGHTNING		
	Total Number of Events	Likelihood of Occurrence	Likelihood of Occurrence Rating	Total Number of Events	Likelihood of Occurrence	Likelihood of Occurrence Rating	Total Number of Events	Likelihood of Occurrence	Likelihood of Occurrence Rating
Macon	67	3.190	2	93	4.429	2	0	0.000	1

Figure 3.30. Annualized Property Loss and Associated Ratings

COUNTY	HIGH WIND		HAIL		LIGHTNING	
	Total Annualized Property Loss	Total Annualized Property Loss Rating	Total Annualized Property Loss	Total Annualized Property Loss Rating	Total Annualized Property Loss	Total Annualized Property Loss Rating
Macon	$8,012	1	$48	1	$0	1

Sources: Missouri State Hazard Mitigation Plan, 2018
https://sema.dps.mo.gov/docs/programs/LRMF/mitigation/MO_Hazard_Mitigation_Plan2018.pdf

Impact of Previous and Future Development

Future development is not expected to increase the risk other than contributing to the overall exposure of what could become damaged as a result of an event.

EMAP Consequence Analysis

Table 3.26. EMAP Impact Analysis: Earthquakes

Subject	Detrimental Impacts
Public	Adverse impact expected to be severe for unprotected personnel and moderate to light for protected personnel.
Responders	Adverse impact expected to be severe for unprotected personnel and moderate to light for protected personnel.
Continuity of Operations	Damage to facilities/personnel in the area of the incident may require relocation of operations and lines of succession execution. Disruption of lines of communication and destruction of facilities may extensively postpone delivery of services.
Property, Facilities, and Infrastructure	Damage to facilities and infrastructure in the area of the incident may be extensive for facilities, people, infrastructure, and HazMat.
Environment	May cause extensive damage, creating denial or delays in the use of some areas. Remediation needed.
Economic Condition of Jurisdiction	Local economy and finances adversely affected, possibly for an extended period of time.
Public Confidence in the Jurisdiction's Governance	Ability to respond and recover may be questioned and challenged if planning, response, and recovery not timely and effective.

Hazard Summary by Jurisdiction

Since the earthquake intensity is not likely to vary greatly throughout the planning area, the risk will be the same throughout. Chariton County is not near the New Madrid Shock Zone, but it will likely endure mild effects from the earthquake such as structure damage environmental impacts and economic disruption/losses. However, damages could vary due to structural variations in the planning area's built environment. For example, Elmer has 48% residential structures built prior to 1939 and is likely to experience higher damages than Macon with 7% or La Plata with 4% of the

residential structures built prior than 1939. Macon County would likely be impacted by the number of refugees traveling through the area seeking safety and assistance.

Problem Statement

Although Macon County is not located in an area that will likely see catastrophic damage from an earthquake, the County will be impacted by the loss of communications, transportation, the disruption of roads, rail and pipelines, water transportation, and the area will see a significant amount of refugees fleeing from Southern Missouri if a quake hits that area. Education is minimal for earthquakes due to the low likely hood of impact. There is one Emergency Management Director for the County that knows where all the generators and emergency buildings are. Not all citizens utilize social media and texting.

An emergency plan for earthquakes needs to be made available to all residents and stated what would happen in the event of an earthquake with details for communications and transportation. Downtown building owners need to know plan in case damage is done to their building. Residents need to be made aware of where the generators and emergency buildings are located. Utilization of social media and texting needs to be encouraged.

3.4.4 Land Subsidence/Sinkholes

Hazard Profile

Hazard Description

Sinkholes are common where the rock below the land surface is limestone, carbonate rock, salt beds, or rocks that naturally can be dissolved by ground water circulating through them. As the rock dissolves, spaces and caverns develop underground. The sudden collapse of the land surface above them can be dramatic and range in size from broad, regional lowering of the land surface to localized collapse. However, the primary causes of most subsidence are human activities: underground mining of coal, groundwater or petroleum withdrawal, and drainage of organic soils. In addition, sinkholes can develop as a result of subsurface void spaces created over time due to the erosion of subsurface limestone (karst).

Land subsidence occurs slowly and continuously over time, as a general rule. On occasion, it can occur abruptly, as in the sudden formation of sinkholes. Sinkhole formation can be aggravated by flooding.

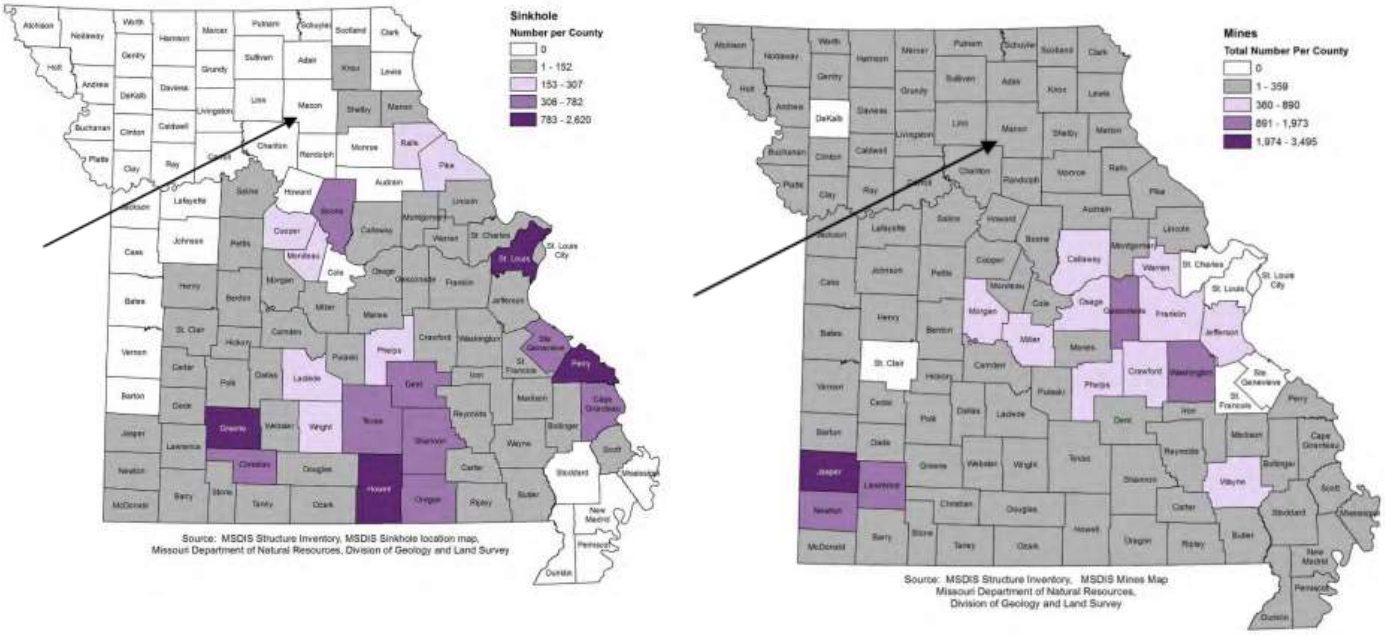
In the case of sinkholes, the rock below the surface is rock that has been dissolving by circulating groundwater. As the rock dissolves, spaces and caverns form, and ultimately the land above the spaces collapse. In Missouri, sinkhole problems are usually a result of surface materials above openings into bedrock caves eroding and collapsing into the cave opening. These collapses are called “cover collapses” and geologic information can be applied to predict the general regions where collapse will occur. Sinkholes range in size from several square yards to hundreds of acres and may be quite shallow or hundreds of feet deep.

According to the U.S. Geological Survey (USGS), the most damage from sinkholes tends to occur in Florida, Texas, Alabama, Missouri, Kentucky, Tennessee, and Pennsylvania. Fifty-nine percent of Missouri is underlain by thick, carbonate rock that makes Missouri vulnerable to sinkholes. Sinkholes occur in Missouri on a fairly frequent basis. Most of Missouri‘s sinkholes occur naturally in the State‘s karst regions (areas with soluble bedrock). They are a common geologic hazard in southern Missouri, but also occur in the central and northeastern parts of the State. Missouri sinkholes have varied from a few feet to hundreds of acres and from less than one to more than 100 feet deep. The largest known sinkhole in Missouri encompasses about 700 acres in western Boone County southeast of where Interstate 70 crosses the Missouri River. Sinkholes can also vary is shape like shallow bowls or saucers whereas other have vertical walls. Some hold water and form natural ponds.

According to the 2018 Missouri State Hazard Mitigation Plan, there are 202 mines in Macon County and 0 sinkholes.

Geographic Location

Figure 3.31. Sinkholes and Mines in Macon County



Source: Missouri State Hazard Mitigation Plan, 2018
https://sema.dps.mo.gov/docs/programs/LRMF/mitigation/MO_Hazard_Mitigation_Plan2018.pdf

Figure 3.32. Macon County Sinkhole and Mine Counts

County	Number of Sinkholes Per County	Number of Mines Per County
Macon	0	202

Source: Missouri State Hazard Mitigation Plan, 2018
https://sema.dps.mo.gov/docs/programs/LRMF/mitigation/MO_Hazard_Mitigation_Plan2018.pdf

Strength/Magnitude/Extent

Sinkholes vary in size and location, and these variances will determine the impact of the hazard. A sinkhole could result in the loss of a personal vehicle, a building collapse, or damage to infrastructure such as roads, water, or sewer lines. Groundwater contamination is also possible from a sinkhole. Because of the relationship of sinkholes to groundwater, pollutants captured or dumped in sinkholes could affect a community's groundwater system. Sinkhole collapse could be triggered by large earthquakes. Sinkholes located in floodplains can absorb floodwaters but make detailed flood hazard studies difficult to model.

Previous Occurrences

As noted in the 2018 State Plan, sinkholes are a regular occurrence in Missouri, but rarely are the events of any significance. There is no record of previous occurrences in Macon County.

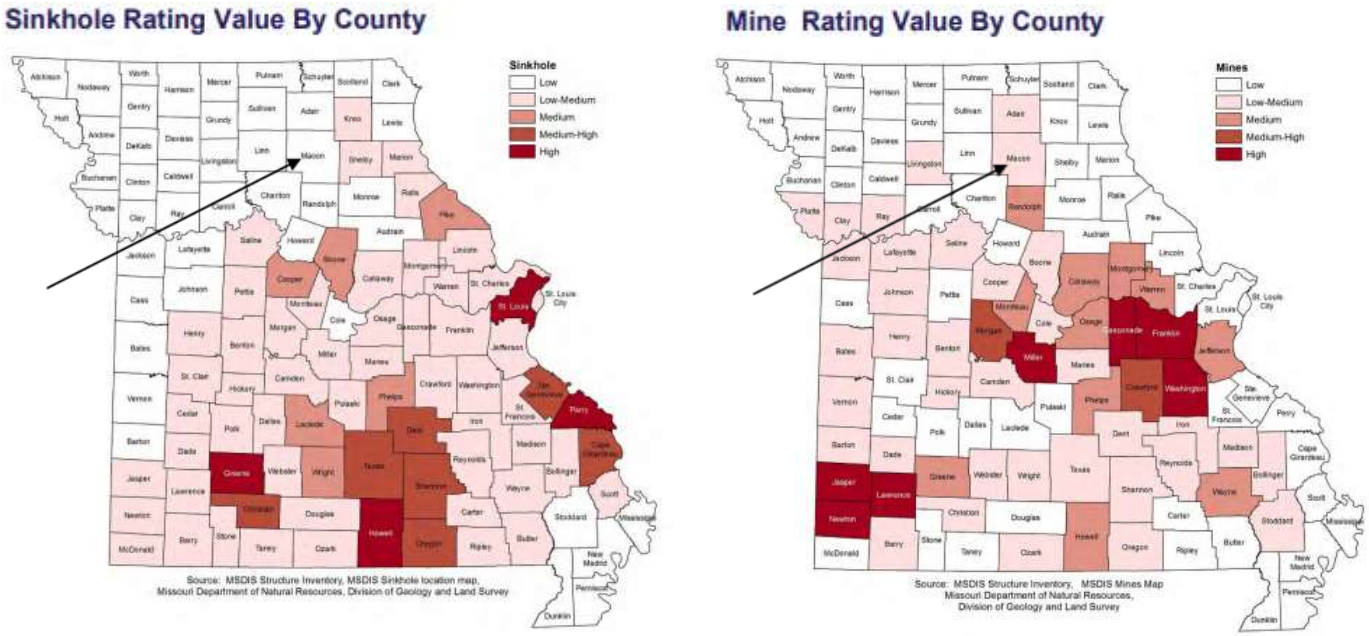
Probability of Future Occurrence

There are no records of previous event dates in the planning area and the probabilities cannot be calculated due to limited information. As represented in the figures below, the sinkholes and mines located in Macon County have been rated low risk.

Figure 3.33. Sinkhole Rating Values

Factor	1 (Low)	2 (Low-medium)	3 (Medium)	4 (Medium-high)	5 (High)
Sinkholes per county	0	1 – 200	201 – 400	401 – 800	801+
Mines per county	0 - 100	101 - 250	251 – 500	501 – 750	751 +

Figure 3.34. Sinkhole and Mine Rating by County



Sources: Missouri State Hazard Mitigation Plan, 2018 https://sema.dps.mo.gov/docs/programs/LRMF/mitigation/MO_Hazard_Mitigation_Plan2018.pdf

Changing Future Conditions Considerations

According to the 2018 Missouri State Hazard Mitigation Plan, direct effects from changing climate conditions such as an increase in droughts and could contribute to an increase in sinkholes. These changes raise the likelihood of extreme weather, meaning the torrential rain and flooding conditions which often lead to the exposure of sinkholes are likely to become increasingly common. Certain events such as a heavy precipitation following a period of drought can trigger a sinkhole due to low levels of groundwater combined with a heavy influx of rain.

Vulnerability

Vulnerability Overview

Sinkholes in the planning area are not common occurrence due to composition of the land. While some sinkholes may be considered a slow changing nuisance; other more sudden, catastrophic collapses can destroy property, delay construction projects and contaminate ground water resources.
The Missouri Department of Natural Resources shows no sinkholes for the planning area.

Potential Losses to Existing Development

The potential impact of sinkholes on existing structures is difficult to determine due to the lack of data on historic damages caused by sinkholes and the mapping of potential sinkholes is difficult if not impossible to predict where a sinkhole will collapse and how significant the collapse will be. Because sinkhole collapse is not predictable and previous events have not occurred in the rural area there is not significant data to estimate the future losses due to a sinkhole.

Impact of Previous and Future Development

As more development occurs on unmapped rural areas the vulnerability to the hazard will increase; however, sinkholes are unpredictable and the development in rural areas is difficult to limit due to the lack of occurrence. There are currently no sinkholes in the planning area, and the Macon County participating jurisdictions have no plans to limit construction due to sinkholes.

EMAP Consequence Analysis

Table 3.27. EMAP Impact Analysis: Land Subsidence/Sinkholes

Subject	Detrimental Impacts
Public	Localized impact expected to be moderate to light for incident areas and light for other adversely affected areas.
Responders	Localized impact expected to limit damage to personnel in the areas at the time of the incident.
Continuity of Operations	Damage to facilities/personnel in the area of the incident may require temporary relocation of some operations. Localized disruption of roads, facilities, and/or utilities caused by incident may postpone delivery of some services.
Property, Facilities, and Infrastructure	Localized impact to facilities and infrastructure in the area of the incident. Some severe damage possible.
Environment	Localized impact expected to be moderate to light for incident areas and moderate to light for other areas affected by the sinkhole.
Economic Condition of Jurisdiction	Local economy and finances adversely affected, possibly for an extended period of time.
Public Confidence in the Jurisdiction's Governance	Ability to respond and recover may be questioned and challenged if planning, response and recovery not timely and effective.

Hazard Summary by Jurisdiction

The risk for the development is uniform throughout Macon County and has not affected one jurisdiction specifically.

Problem Statement

Sinkholes can occur at any time and without warning and vary by size. There can be a disruption of transportation services and not residents in the dangerous areas are not educated on what to do if a sinkhole occurs. Education needs to occur on the danger areas of a sinkhole occurring and what to do if a sinkhole does occur.

3.4.5 Drought

Hazard Profile

Hazard Description

Drought is generally defined as a condition of moisture levels significantly below normal for an extended period of time over a large area that adversely affects plants, animal life, and humans. A drought period can last for months, years, or even decades. There are four types of drought conditions relevant to Missouri, according to the State Plan, which are as follows.

- Meteorological drought is defined in terms of the basis of the degree of dryness (in comparison to some "normal" or average amount) and the duration of the dry period. A meteorological drought must be considered as region-specific since the atmospheric conditions that result in deficiencies of precipitation are highly variable from region to region.

- Hydrological drought is associated with the effects of periods of precipitation (including snowfall) shortfalls on surface or subsurface water supply (e.g., streamflow, reservoir and lake levels, ground water). The frequency and severity of hydrological drought is often defined on a watershed or river basin scale. Although all droughts originate with a deficiency of precipitation, hydrologists are more concerned with how this deficiency plays out through the hydrologic system. Hydrological droughts are usually out of phase with or lag the occurrence of meteorological and agricultural droughts. It takes longer for precipitation deficiencies to show up in components of the hydrological system such as soil moisture, streamflow, and ground water and reservoir levels. As a result, these impacts also are out of phase with impacts in other economic sectors.

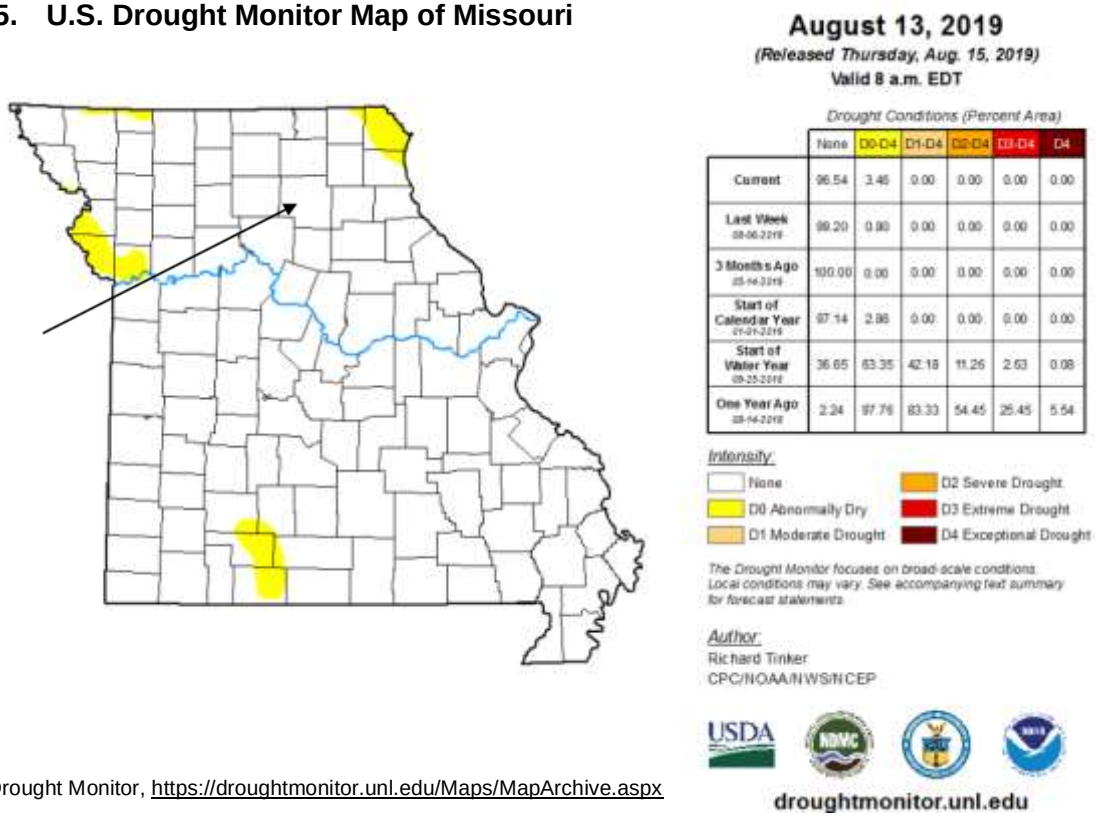
- Agricultural drought focus is on soil moisture deficiencies, differences between actual and potential evaporation, reduced ground water or reservoir levels, etc. Plant demand for water depends on prevailing weather conditions, biological characteristics of the specific plant, its stage of growth, and the physical and biological properties of the soil.

- Socioeconomic drought refers to when physical water shortage begins to affect people.

Geographic Location

Droughts are regional in nature. All areas of the United States are vulnerable to the risk of drought and extreme heat. Droughts can be widespread or localized events. The extent of the droughts varies both in terms of the extent of the heat and range of precipitation. The severity of a drought depends on locations, duration, and geographical extent. Additionally, drought severity depends on the water supply, usage demands made by human activities, vegetation and agricultural operations. Drought brings several different problems that must be addressed. The quality and quantity of crops, livestock and other agricultural assets will be affected during a drought. Drought can adversely impact forested areas leading to an increased potential for extremely destructive forest and woodland fires that could threaten residential, commercial, and recreational structures. According to the 2012 Census of Agriculture, Macon County consist of 386,005 acres land in farms, crop sales generate $35,836,000 and livestock sales generate $31,007,000. A drought would directly impact livestock production and the agriculture economy in Macon County.

Figure 3.35. U.S. Drought Monitor Map of Missouri



Source: U.S. Drought Monitor, https://droughtmonitor.unl.edu/Maps/MapArchive.aspx

Strength/Magnitude/Extent

The Palmer Drought Indices measure dryness based on recent precipitation and temperature. The indices are based on a "supply-and-demand model" of soil moisture. Calculation of supply is relatively straightforward, using temperature and the amount of moisture in the soil. However, demand is more complicated as it depends on a variety of factors, such as evapotranspiration and recharge rates. These rates are harder to calculate. Palmer tried to overcome these difficulties by developing an algorithm that approximated these rates and based the algorithm on the most readily available data — precipitation and temperature.

The Palmer Index has proven most effective in identifying long-term drought of more than several months. However, the Palmer Index has been less effective in determining conditions over a matter of weeks. It uses a "0" as normal, and drought is shown in terms of negative numbers; for example, negative 2 is moderate drought, negative 3 is severe drought, and negative 4 is extreme drought. Palmer's algorithm also is used to describe wet spells, using corresponding positive numbers.

Palmer also developed a formula for standardizing drought calculations for each individual location based on the variability of precipitation and temperature at that location. The Palmer index can therefore be applied to any site for which sufficient precipitation and temperature data is available.

Previous Occurrences

Drought occurs periodically in Missouri with the most severe and costly time occurring in 2018. Although droughts are not the spectacular weather events that floods, blizzards or tornadoes can be, historically they produce more economic damage to the State than all other weather events combined.

According to NCEI's storm database, 12 drought events have occurred in Macon County between

1999 to 2019.

Table 3.28. Missouri Insurance Payments Due to Drought from 2014 to 2018

Drought Year	Insurance Payment
2014	$4,826.80
2015	$401,419.90
2016	$9,058.00
2017	$94,969.00
2018	$2,742,063.22
Total	**$3,252,336.92**

Source: http://www.rma.usda.gov/data/cause.html

According to the National Drought Mitigation Center's Drought Impact Reporter, during the 20-year period from January 1999 to January 2019, Macon County had 15 drought impacts and 60 reports.

Figure 3.36. Drought Impacts in Macon County

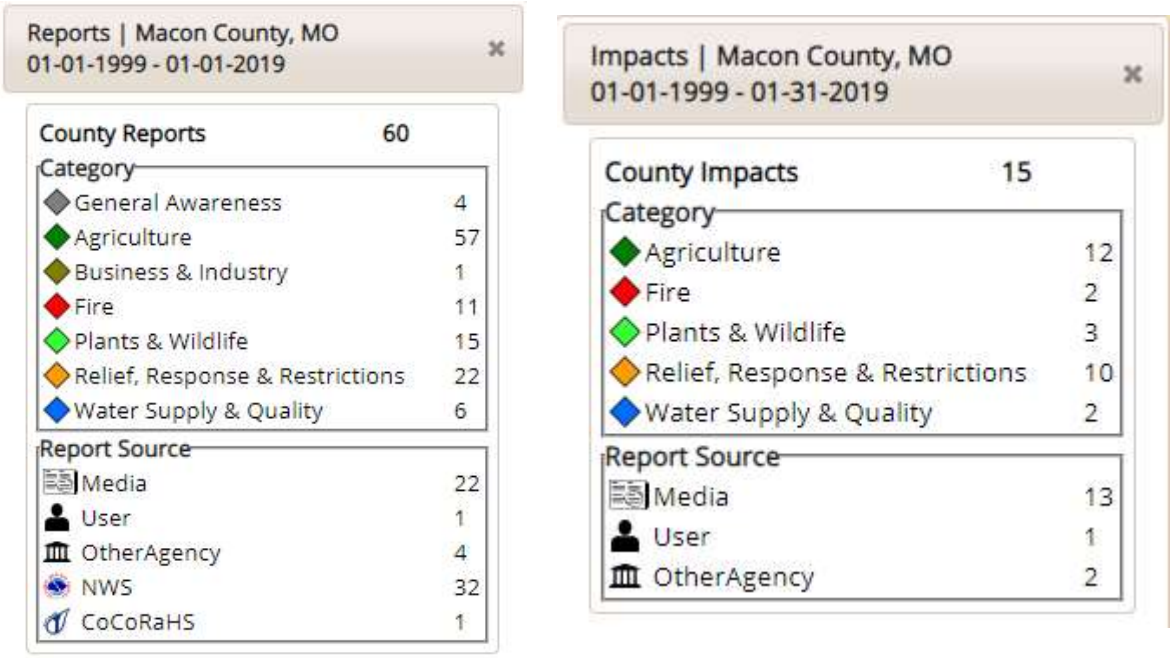
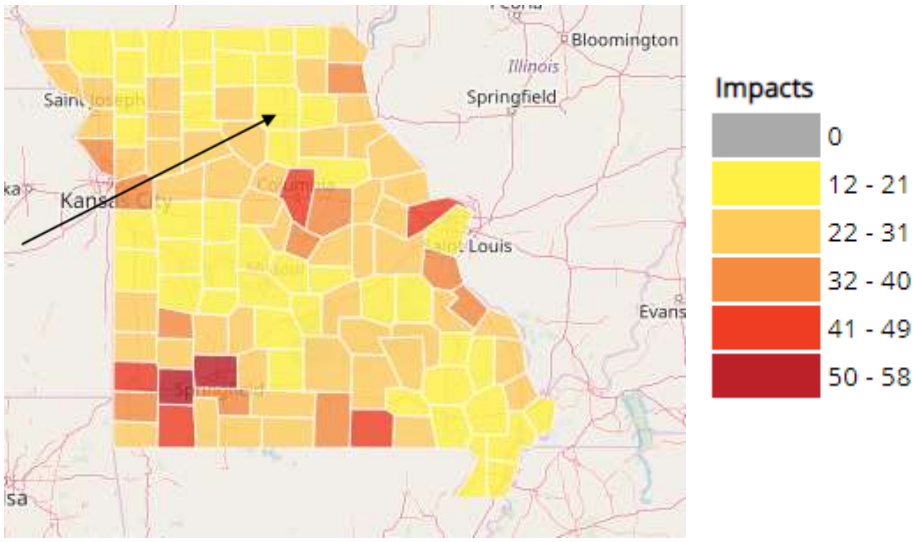


Figure 3.37. Macon County Drought Impact (January 1999 to December 2018)



Source: Drought Impact Reporter, https://droughtreporter.unl.edu

Probability of Future Occurrence

According to the 2018 State Plan, Macon County has a medium-high total rating for droughts and is very likely to experience droughts in the future, with a 10.72% chance likelihood of a severe drought.

Table 3.29. Vulnerability of Macon County to Drought

County	SOVI Index Rating	USDA RMA Total Drought Crop Claims	Average Annualized Crop Claims	USDA Claims Rating	2012 Crop Exposure	Crop Exposure Rating	Likeli-hood of Severe Drought (%)	Drought Occurrence Rating	Total Rating	Total Rating (Text) Drought
Macon	2	$34,324,215	$3,813,802	4	$35,836,000	3	10.72	5	14	Medium-High

Source: Missouri State Hazard Mitigation Plan, 2018

Table 3.30. Ranges for Drought Vulnerability Factor Ratings

Factors Considered	Low (1)	Low-medium (2)	Medium (3)	Medium-high-4	High (5)
Social Vulnerability Index	1	2	3	4	5
Crop Exposure Ratio Rating	$886,000 - $10,669,000	$10,669,001 - $33,252,000	$33,252,001 - $73,277,000	$73,277,001 - $155,369,000	$155,369,001 - $256,080,000
Annualized USDA Crop Claims Paid	< $340,000	$670,000-$669,999	$670,000-$999,999	$1M-$1,299,999	> $1,300,000
Likelihood of Occurrence of severe or extreme drought	1-1.9%	2-3.9%	4-5.9%	6-8.9%	9-10.72%
Total Drought Vulnerability Rating	7-8	9-10	11-12	13-14	15-17

Source: Missouri State Hazard Mitigation Plan, 2018
https://sema.dps.mo.gov/docs/programs/LRMF/mitigation/MO_Hazard_Mitigation_Plan2018.pdf

Although drought is not predictable, long-range outlooks and predicted impacts of climate change could indicate an increased chance of drought.

Changing Future Conditions Considerations

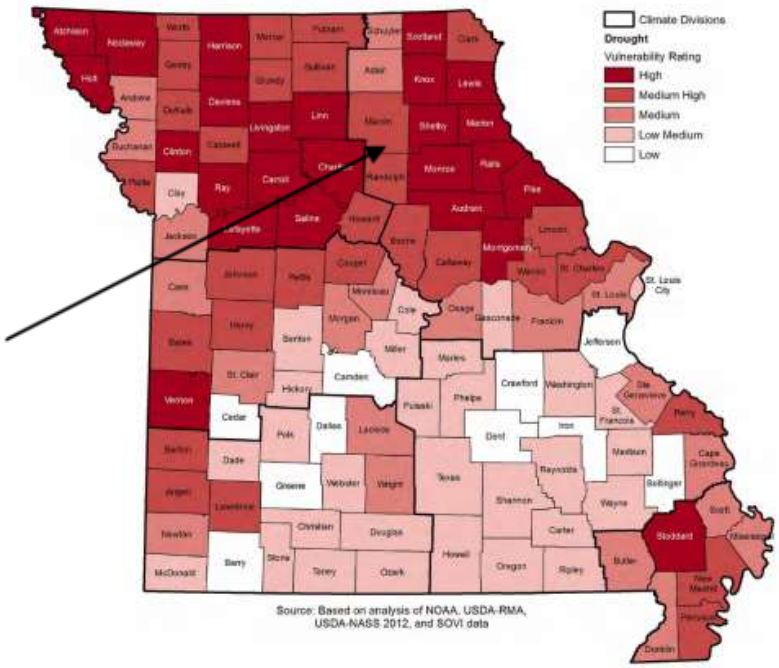
The 2018 State Plan, Severe drought, a natural part of Missouri's climate, is at risk to this agriculture-dependent state. Future increases in evaporation rates due to higher temperatures may increase the intensity of naturally-occurring droughts. The number of heavy rainfall events is predicted to increase, yet researchers currently expect little change in total rainfall amounts, indicating the periods between heavy rainfalls will be marked by an increasing number of dry days. Higher temperatures and increased evapotranspiration increase the likelihood of a drought. This could lead to agricultural drought and suppressed crop yields.

Vulnerability

Vulnerability Overview

According to the analysis from the 2018 State Plan, Macon County is a medium vulnerability County for droughts.

Figure 3.38. Missouri Drought Vulnerability by County



Source: Missouri State Hazard Mitigation Plan, 2018
https://sema.dps.mo.gov/docs/programs/LRMF/mitigation/MO_Hazard_Mitigation_Plan2018.pdf

Potential Losses to Existing Development

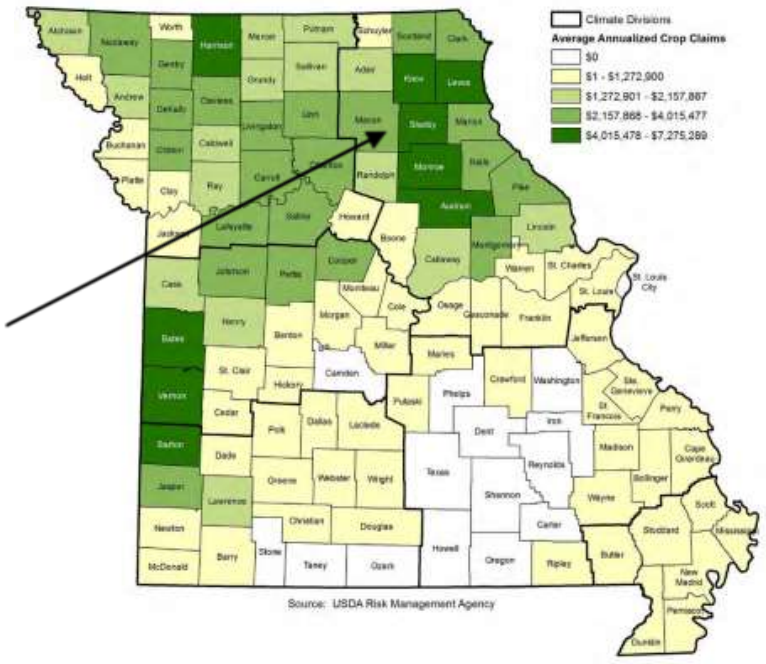
The National Drought Monitor Center at the University of Nebraska at Lincoln summarized the potential impacts of drought as follows: Drought can create economic impacts on agriculture and

related sectors, including forestry and fisheries, because of the reliance of these sectors on surface and subsurface water supplies. In addition to losses in yields in crop and livestock production, drought is associated with increases in insect infestations, plant disease, and wind erosion. Droughts also bring increased problems with insects and disease to forests and reduce growth. The incidence of forest and range fires increases substantially during extended droughts, which in turn place both human and wildlife populations at higher levels of risk. Income loss is another indicator used in assessing the impacts of drought because so many sectors are affected. Finally, while drought is rarely a direct cause of death, the associated heat, dust and stress can all contribute to increased mortality.

Impact of Previous and Future Development

Future development will remain vulnerable to drought. Typically, some urban and rural areas are more susceptible than others. For example, urban areas are subject to water shortages during periods of drought. Excessive demands of the populated area place a limit on water resources. In rural areas, crops and livestock may suffer from extended periods of heat and drought. As the size of farms increase more crops will be exposed to drought-related agricultural losses. Dry conditions can lead to the ignition of wildfires that could threaten residential, commercial and recreational areas.

Figure 3.39. Annualized Drought Crop Insurance Claims Paid from 2007 - 2016



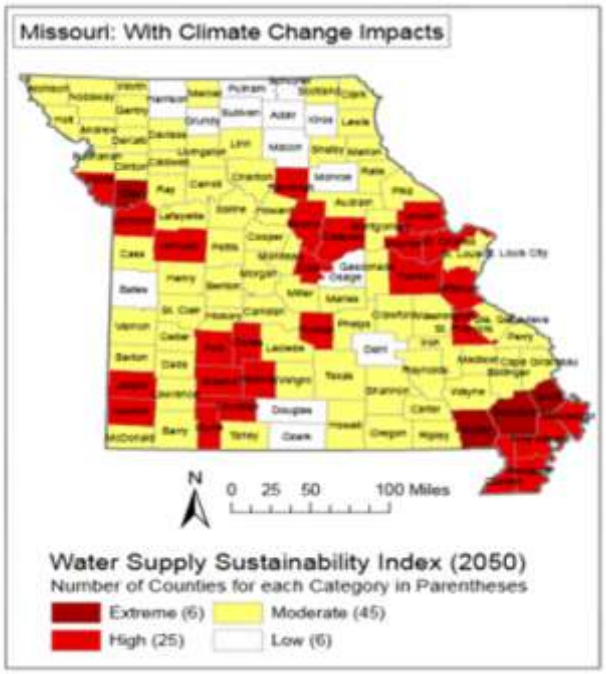
Source: Missouri State Hazard Mitigation Plan, 2018
https://sema.dps.mo.gov/docs/programs/LRMF/mitigation/MO_Hazard_Mitigation_Plan2018.pdf

Changing Future Conditions Considerations

A new analysis, performed for the Natural Resources Defense Council, examined the effects of climate change on water supply and demand in the contiguous United States. The study found that more than 1,100 counties will face higher risks of water shortages by mid-century as a result of

climate change. Two of the principal reasons for the projected water constraints are shifts in precipitation and potential evapotranspiration (PET). Climate models project decreases in precipitation in many regions of the U.S., including areas that may currently be described as experiencing water shortages of some degree.

Figure 3.40. Climate Change Impacts



Source: http://www.nrdc.org/globalWarming/watersustainability/

EMAP Consequence Analysis

Table 3.31. EMAP Impact Analysis: Drought

Subject	Detrimental Impacts
Public	Most damage expected to be agricultural in nature. However, water supply disruptions may adversely affect people.
Responders	Nature of hazard expected to minimize any serious damage to properly equipped and trained personnel.
Continuity of Operations	Unlikely to necessitate execution of the Continuity of Operations Plan. Nature of hazard expected to minimize serious damage to services, except for moderate impact on water utilities.
Property, Facilities, and Infrastructure	Nature of hazard expected to minimize any serious damage to facilities.
Environment	May cause disruptions in wildlife habitat, increasing interface with people, and reducing numbers of animals.
Economic Condition of Jurisdiction	Local economy and finances dependent on abundant water supply adversely affected for duration of drought.

Subject	Detrimental Impacts
Public Confidence in the Jurisdiction's Governance	Ability to respond and recover may be questioned and challenged if planning, response, and recovery not timely and effective.

Hazard Summary by Jurisdiction

The entire planning area will be affected by drought to some degree. The unincorporated agricultural areas of Macon County are the most vulnerable to drought while the drought condition will also affect the cities except the magnitude would be different with only lawns, local garden and possibly infrastructure impacted. In addition, damage to crops, produce, livestock, soils and building foundations could be weakened due to shrinking and expanding soil.

Problem Statement

Macon County is at a medium-high risk for a severe drought which is an extra strain placed on the water supply system. Possible solutions include the development of agreements with neighboring communities for a secondary water source and review of local ordinances/regulation for inclusion of water-use restrictions during periods of drought.

3.4.6 Extreme Temperatures

Hazard Profile

Hazard Description

Extreme temperature events, both hot and cold, can impact human health and mortality, natural ecosystems, agriculture and other economic sectors. According to information provided by FEMA, extreme heat is defined as temperatures that hover 10 degrees or more above the average high temperature for the region and last for several weeks. Ambient air temperature is one component of heat conditions, with relative humidity being the other. The relationship of these factors creates what is known as the apparent temperature. The Heat Index chart shown in **Figure 3.41** uses both of these factors to produce a guide for the apparent temperature or relative intensity of heat conditions.

Extreme cold often accompanies severe winter storms and can lead to hypothermia and frostbite in people without adequate clothing protection. Cold can cause fuel to congeal in storage tanks and supply lines, stopping electric generators. Cold temperatures can also overpower a building's heating system and cause water and sewer pipes to freeze and rupture. Extreme cold also increases the likelihood for ice jams on flat rivers or streams. When combined with high winds from winter storms, extreme cold becomes extreme wind chill, which is hazardous to health and safety.

The National Institute on Aging estimates that more than 2.5 million Americans are elderly and especially vulnerable to hypothermia, with the isolated elders being most at risk. About 10 percent of people over the age of 65 have some kind of bodily temperature-regulating defect, and 3-4 percent of all hospital patients over 65 are hypothermic.

Also at risk, are those without shelter, those who are stranded, or who live in a home that is poorly insulated or without heat. Other impacts of extreme cold include asphyxiation (unconsciousness or death from a lack of oxygen) from toxic fumes from emergency heaters; household fires, which can be caused by fireplaces and emergency heaters; and frozen/burst pipes.

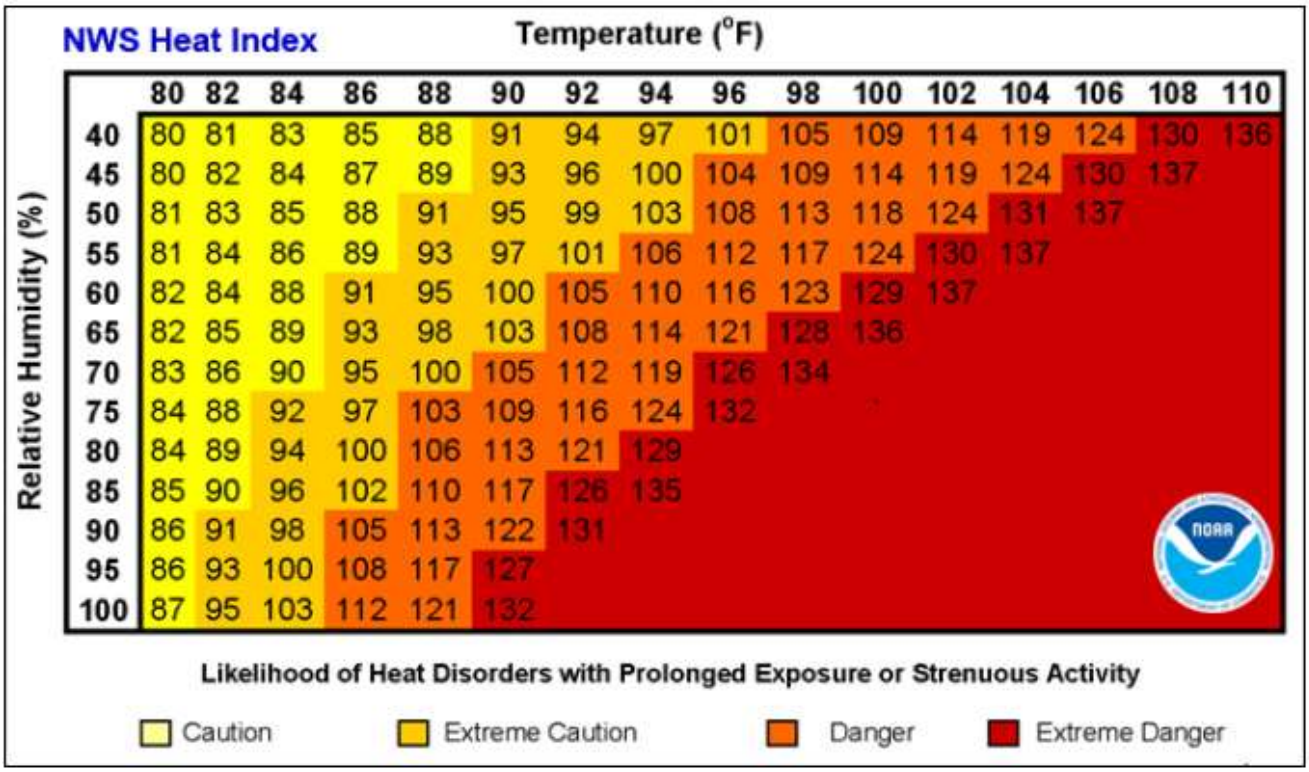
Geographic Location

The entire planning area is subject to extreme heat and all participating jurisdictions are affected.

Strength/Magnitude/Extent

The National Weather Service (NWS) has an alert system in place (advisories or warnings) when the Heat Index is expected to have a significant impact on public safety. The expected severity of the heat determines whether advisories or warnings are issued. A common guideline for issuing excessive heat alerts is when for two or more consecutive days: (1) when the maximum daytime Heat Index is expected to equal or exceed 105 degrees Fahrenheit (°F); and the night time minimum Heat Index is 80°F or above. A heat advisory is issued when temperatures reach 105 degrees and a warning is issued at 115 degrees.

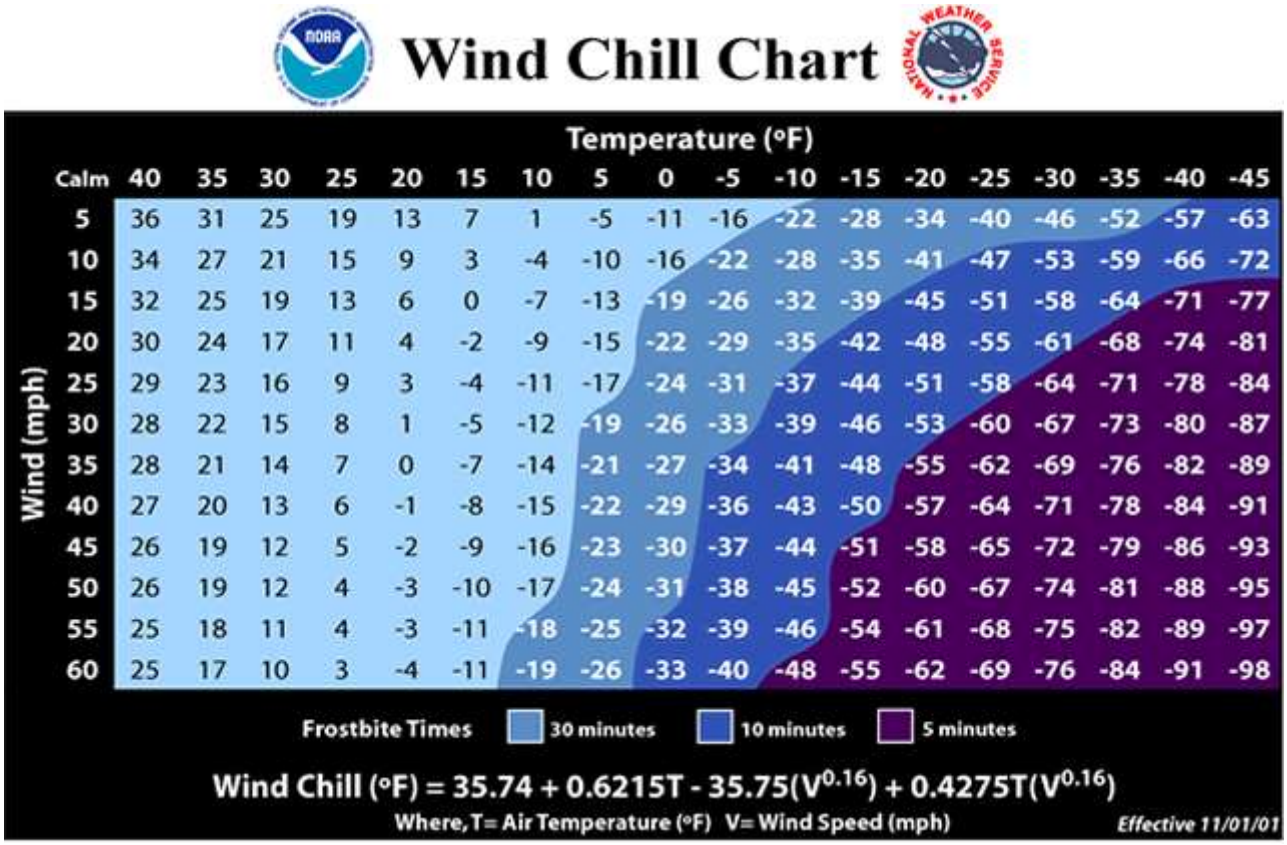
Figure 3.41. Heat Index (HI) Chart



Source: National Weather Service (NWS); https://www.weather.gov/safety/heat-index
Note: Exposure to direct sun can increase Heat Index values by as much as 15°F. The shaded zone above 105°F corresponds to a HI that may cause increasingly severe heat disorders with continued exposure and/or physical activity.

The NWS Wind Chill Temperature (WCT) index uses advances in science, technology, and computer modeling to provide an accurate, understandable, and useful formula for calculating the dangers from winter winds and freezing temperatures. The figure below presents wind chill temperatures which are based on the rate of heat loss from exposed skin caused by wind and cold. As the wind increases, it draws heat from the body, driving down skin temperature and eventually the internal body temperature.

Figure 3.42. Wind Chill Chart

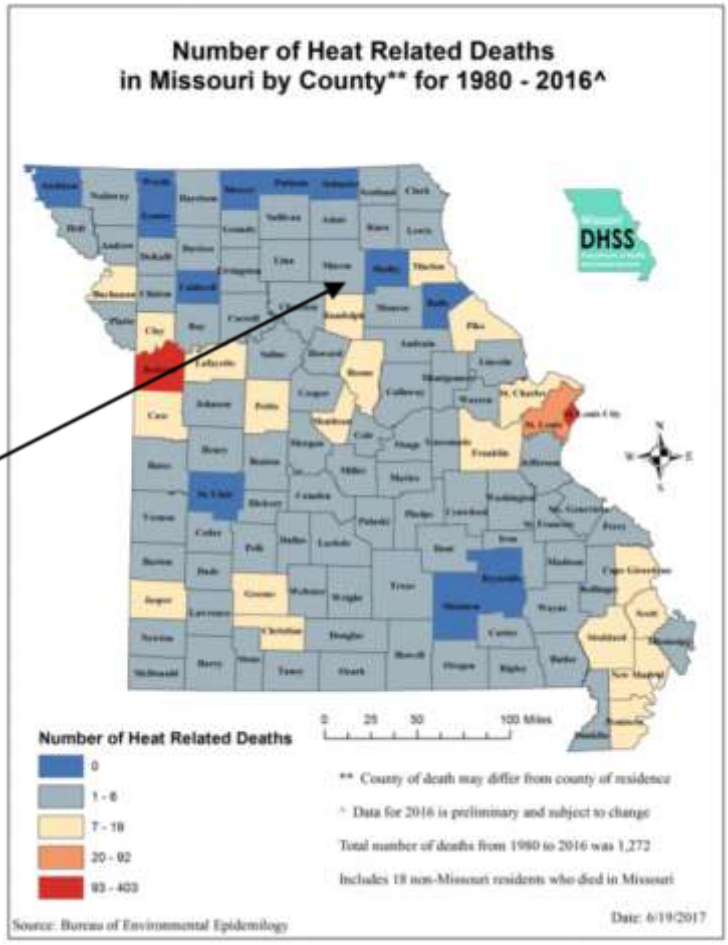


Source: https://www.weather.gov/safety/cold-wind-chill-chart

Previous Occurrences

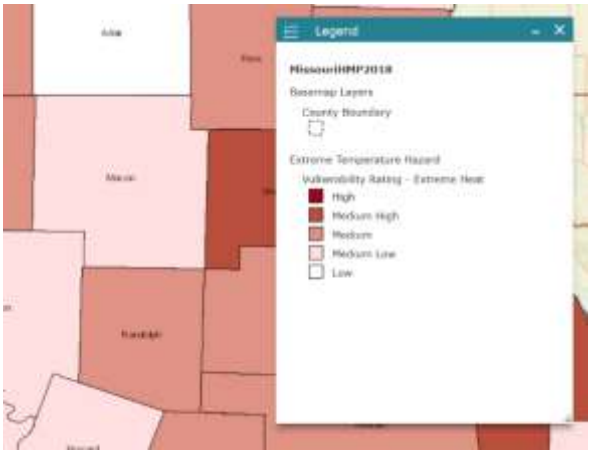
The recorded events in the National Centers for Environmental Information (NCEI) database state there have been 2 recorded events of excessive heat in the 21-year period of 1999-2019. There was 1 deaths or injuries associated with these events. The NCEI database shows 3 recorded events of extreme cold/wind chill, with 0 deaths or injuries associated with this event. Figure 3.43 illustrates between 1-6 heat related deaths in Macon County between the time of 1980-2016, no supporting documentation could be found to include in this plan.

Figure 3.43. Heat Related Deaths in Missouri 2000 - 2016



Source: *https://health.mo.gov/living/healthcondiseases/hyperthermia/pdf/stat-report.pdf* *Arrow indicates Macon County

Figure 3.44. Agricultural Insurance Claims Due to Extreme Temperatures



Source: USDA Risk Management Agency

Extreme heat can cause stress to crops and animals. According to USDA Risk Management Agency, Macon County has a medium low risk of damage to crops due to extreme temperatures. Extreme heat can also strain electricity delivery infrastructure overloaded during peak use of air conditioning during extreme heat events. Another type of infrastructure damage from extreme heat is road damage. When asphalt is exposed to prolonged extreme heat, it can cause buckling of asphalt-paved roads, driveways, and parking lots.

From 1988-2011, there were 3,496 fatalities in the U.S. attributed to summer heat. This translates to an annual national average of 146 deaths. During the same period, 0 deaths were recorded in the planning area, according to NCEI data. The National Weather Service stated that among natural hazards, no other natural disaster—not lightning, hurricanes, tornadoes, floods, or earthquakes—causes more deaths.

Probability of Future Occurrence

NCEI, dating back to 1998 indicates 2 years without extreme heat events (2013, 2018). In nine years, there were multiple extreme heat events. Based on this historical data, the calculated probability of an extreme heat event in any given year is 42.8%. The probability was determined by taking the number of years with an extreme heat events (9) divided by the number of year (21) data was obtained for. Based on this historical data, the calculated probability of an extreme cold event in any given year is 14.2%. The probability was figured using the same formula listed above.

Changing Future Conditions Considerations

According to the 2018 Missouri State Plan, average annual temperatures are projected to most likely exceed historical record levels by the middle of the 21st century. The impacts of extreme heat events are experienced most acutely by the elderly and other vulnerable populations. High temperatures are exacerbated in urban environments, a phenomenon known as the urban heat island effect, which in turn tend to have higher concentrations of vulnerable populations. Higher demand for electricity as people try to keep cool amplifies stress on power systems and may lead to an increase in the number of power outages. Atmospheric concentrations of ozone occur at higher air temperatures, resulting in poorer air quality, while harmful algal blooms flourish in warmer water temperatures, resulting in poorer water quality.

Vulnerability

Vulnerability Overview

Those at greatest risk for heat-related illness include infants and children up to five years of age, people 65 years of age and older, people who are overweight, and people who are ill or on certain medications. However, even young and healthy individuals are susceptible if they participate in strenuous physical activities during hot weather. In agricultural areas, the exposure of farm workers, as well as livestock, to extreme temperatures is a major concern.

Table 3.32 lists typical symptoms and health impacts due to exposure to extreme heat.

Table 3.32. Typical Health Impacts of Extreme Heat

Heat Index (HI)	Disorder
80-90° F (HI)	Fatigue possible with prolonged exposure and/or physical activity
90-105° F (HI)	Sunstroke, heat cramps, and heat exhaustion possible with prolonged exposure and/or physical activity
105-130° F (HI)	Heatstroke/sunstroke highly likely with continued exposure

Source: National Weather Service Heat Index Program, www.weather.gov/os/heat/index.shtml

Figure 3.45. Average Annual Occurrence for Extreme Heat

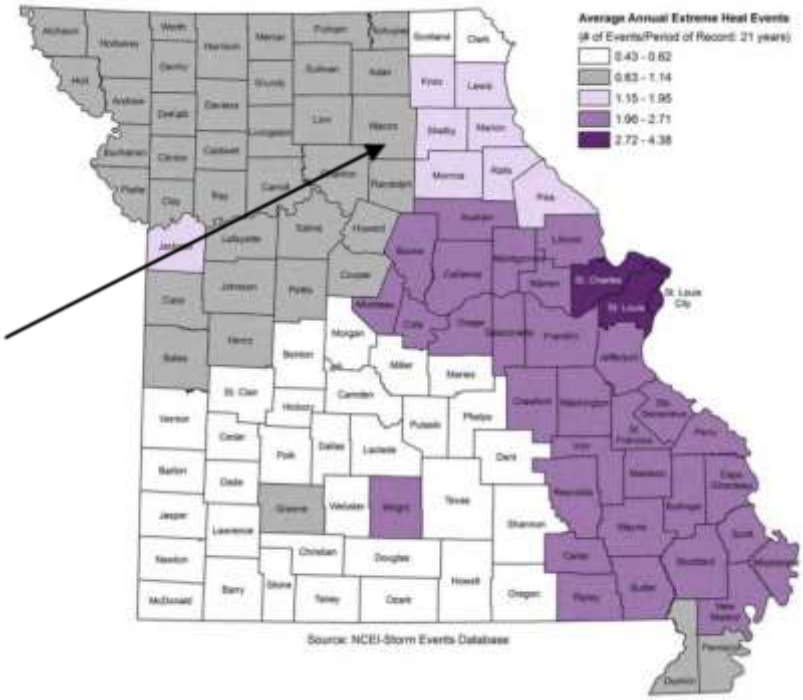


Figure 3.46. Vulnerability Rating for Extreme Heat

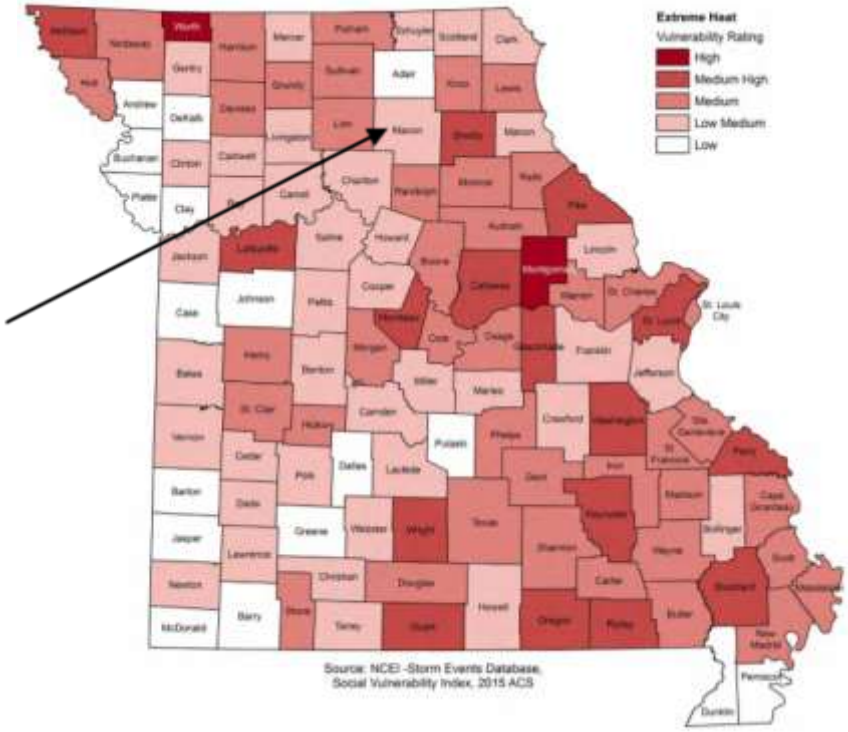


Figure 3.47. Vulnerability Rating for Extreme Cold Events

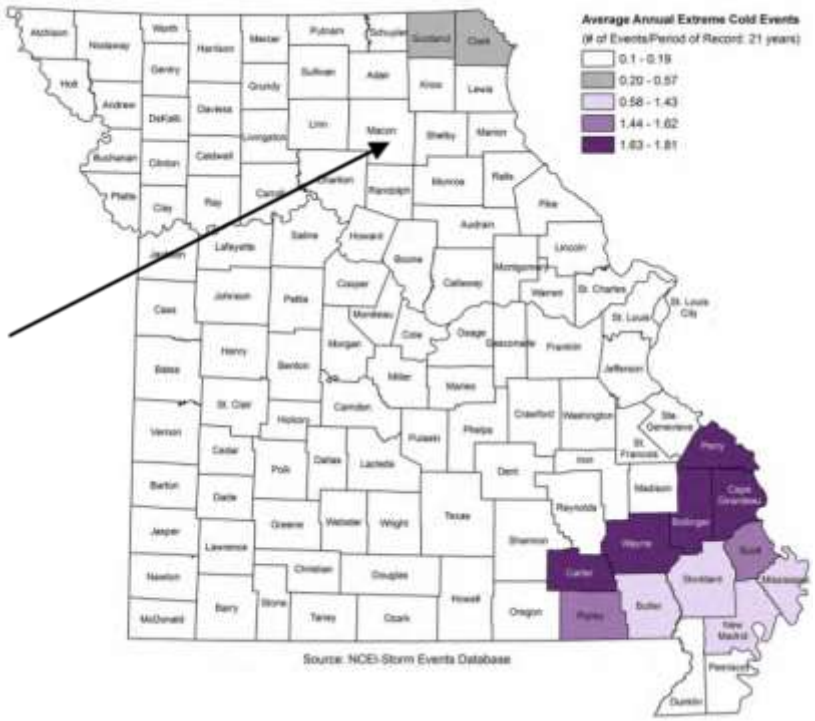
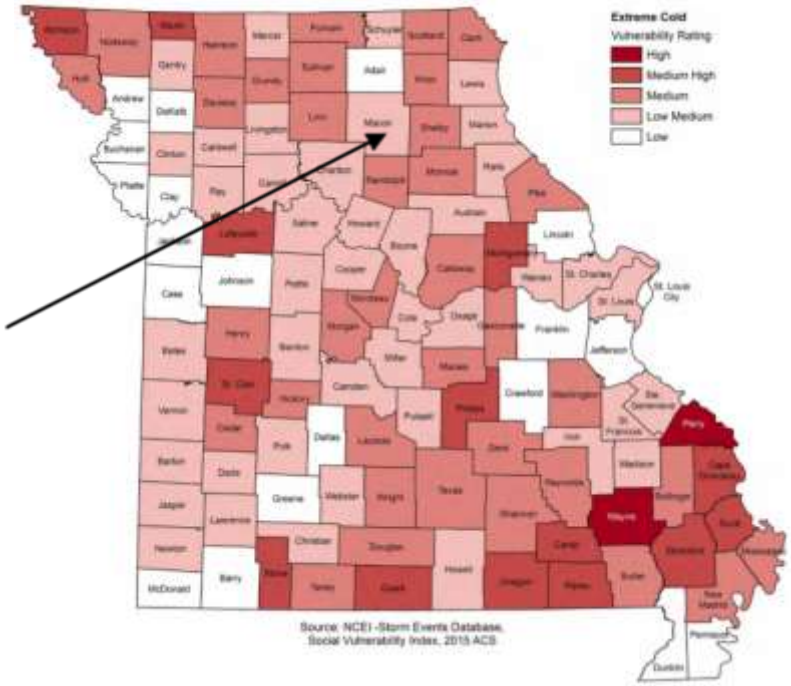


Figure 3.48. Vulnerability for Extreme Cold



Potential Losses to Existing Development

During extreme heat events structural, road, and electrical infrastructure are vulnerable to damages. Depending upon temperatures and duration of extreme heat, losses will vary.

Impact of Previous and Future Development

Population growth can result in increases in the age-groups that are most vulnerable to extreme heat. Population growth also increases the strain on electricity infrastructure, as more electricity is needed to accommodate the growing population.

According to the American Community Survey all jurisdictions in Macon County experienced a population decline and is not in a growth mode.

EMAP Consequence Analysis

Table 3.33. EMAP Impact Analysis: Extreme Temperatures

Subject	Detrimental Impacts
Public	Localized impact expected to be severe for incident areas and moderate to light for other adversely affected areas.
Responders	Localized impact expected to limit damage to personnel in the areas at the time of the incident.
Continuity of Operations	Unlikely to necessitate execution of the Continuity of Operations Plan. Extent of agricultural damage depends on duration. Water supplies and electricity may be disrupted.
Property, Facilities, and Infrastructure	Nature of hazard expected to minimize any serious damage to facilities. Asphalt parking lots and roads are routinely damaged during periods of extreme heat as the hot asphalt becomes less rigid and can be displaced by heavy equipment or automobiles.
Environment	Potential for crop damage; May cause disruptions in wildlife habitat, increase interface with people, and reduce numbers of animals.
Economic Condition of Jurisdiction	Local economy and finances dependent on stable electricity and water supply adversely affected for duration of heat wave.
Public Confidence in the Jurisdiction's Governance	Ability to respond and recover may be questioned and challenged if planning, response, and recovery not timely and effective.

Hazard Summary by Jurisdiction

Those at greatest risk for heat-related illness and deaths include children up to five years of age, people 65 years of age and older, people who are overweight, and people who are ill or on certain medications. To determine jurisdictions within the planning area with populations more vulnerable to extreme heat, demographic data was obtained from the 2010 census on population percentages in each jurisdiction comprised of those under age 5 and over age 65. Data was not available for overweight individuals and those on medications vulnerable to extreme heat. **Table 3.34** below summarizes vulnerable populations in the participating jurisdictions. Note that school and special

districts are not included in the table because students and those working for the special districts are not customarily in these age groups.

Table 3.34. Macon County Population Under Age 5 and Over Age 65, 2010 Census Data

Jurisdiction	Population Under 5 yrs	Population 65 yrs and over
Macon County	1,053	3,026
Atlanta	32	62
Bevier	34	109
Callao	21	34
Elmer	8	22
Ethel	0	24
La Plata	102	306
Macon	387	1,231
New Cambria	7	24

Source: U.S. Census Bureau, (*) includes entire population of each city or county

Problem Statement

Macon County has a growing population of residents over 65 years, who are at a greater risk for extreme-temperature related illnesses, injuries, and death. Possible solutions include organizing outreach to the vulnerable elderly populations, including establishing and promoting accessible heating or cooling centers in the community and creating a database in coordination with the Health Department to track those individuals at high risk.

3.4.7 Severe Thunderstorms Including High Winds, Hail, and Lightning

Hazard Profile

Hazard Description

Thunderstorms

A thunderstorm is defined as a storm that contains lightning and thunder which is caused by unstable atmospheric conditions. When cold upper air sinks and warm moist air rises, storm clouds or 'thunderheads' develop resulting in thunderstorms. This can occur singularly, as well as in clusters or lines. The National Weather Service defines a thunderstorm as "severe" if it includes hail that is one inch or more, or wind gusts that are at 58 miles per hour or higher. At any given moment across the world, there are about 1,800 thunderstorms occurring. Severe thunderstorms most often occur in Missouri in the spring and summer, during the afternoon and evenings, but can occur at any time. Other hazards associated with thunderstorms are heavy rains resulting in flooding (discussed separately in Section 3.4.1) and tornadoes (discussed separately in Section 3.4.9).

High Winds

A severe thunderstorm can produce winds causing as much damage as a weak tornado. The damaging winds of thunderstorms include downbursts, microbursts, and straight-line winds. Downbursts are localized currents of air blasting down from a thunderstorm, which induce an outward burst of damaging wind on or near the ground. Microbursts are minimized downbursts covering an area of less than 2.5 miles across. They include a strong wind shear (a rapid change in the direction of wind over a short distance) near the surface. Microbursts may or may not include precipitation and can produce winds at speeds of more than 150 miles per hour. Damaging straight-line winds are high winds across a wide area that can reach speeds of 140 miles per hour.

Lightning

All thunderstorms produce lightning which can strike outside of the area where it is raining and is has been known to fall more than 10 miles away from the rainfall area. Thunder is simply the sound that lightning makes. Lightning is a huge discharge of electricity that shoots through the air causing vibrations and creating the sound of thunder.

Hail

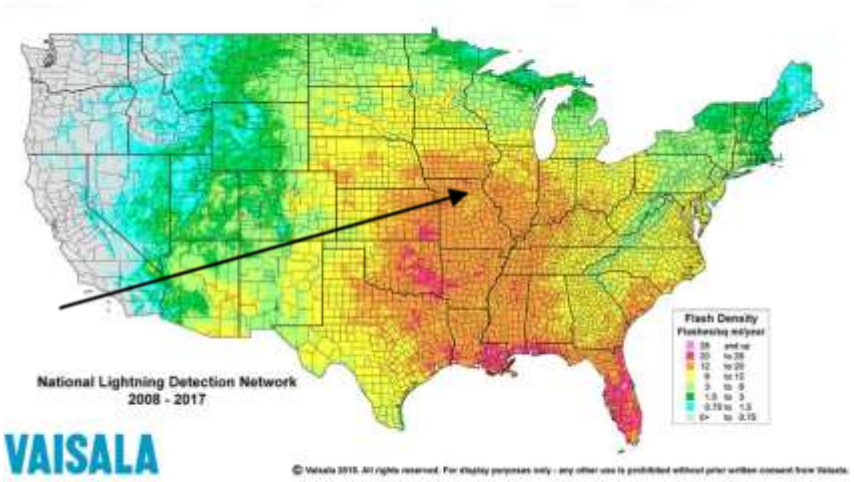
According to the National Oceanic and Atmospheric Administration (NOAA), hail is precipitation that is formed when thunderstorm updrafts carry raindrops upward into extremely cold atmosphere causing them to freeze. The raindrops form into small frozen droplets. They continue to grow as they come into contact with super-cooled water which will freeze on contact with the frozen rain droplet. This frozen droplet can continue to grow and form hail. As long as the updraft forces can support or suspend the weight of the hailstone, hail can continue to grow before it hits the earth.

At the time when the updraft can no longer support the hailstone, it will fall down to the earth. For example, a ¼" diameter or pea sized hail requires updrafts of 24 miles per hour, while a 2 ¾" diameter or baseball sized hail requires an updraft of 81 miles per hour. According to the NOAA, the largest hailstone in diameter recorded in the United States was found in Vivian, South Dakota on July 23, 2010. It was eight inches in diameter, almost the size of a soccer ball. Soccer-ball-sized hail is the exception, but even small pea-sized hail can do damage.

Geographic Location

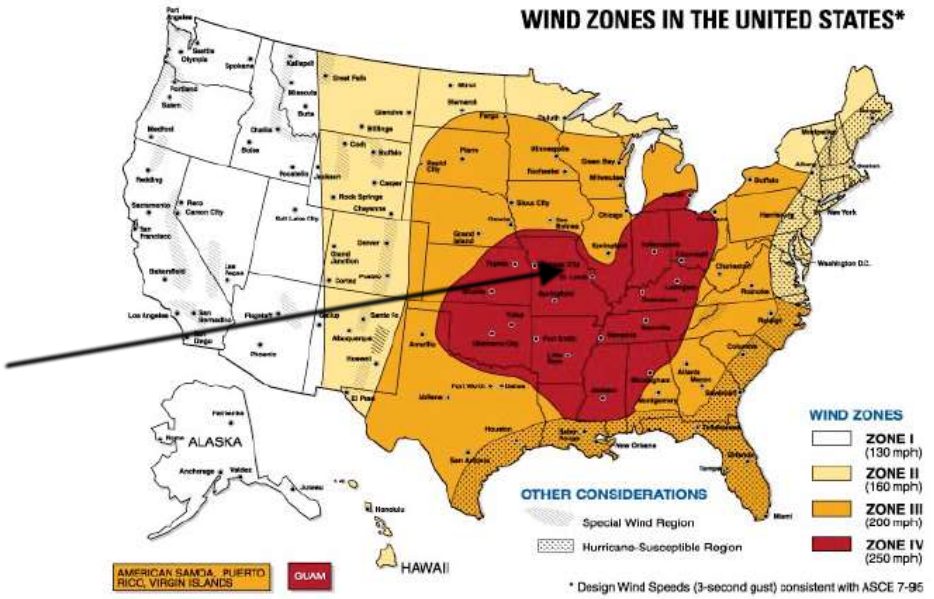
Thunderstorms/high winds/hail/lightning events are an area-wide hazard that can happen anywhere in the county. Although these events occur similarly throughout the planning area, they are more frequently reported in more urbanized areas. In addition, damages are more likely to occur in more densely developed urban areas.

Figure 3.49. Location and Frequency of Lightning in Missouri



Source: National Weather Service, http://www.vaisala.com/en/products/thunderstormandlightningdetectionsystems/Pages/NLDN.aspx .

Figure 3.50. Wind Zones in the United States



Source: FEMA 320, Taking Shelter from the Storm, 3rd edition, https://www.fema.gov/pdf/library/ism2_s1.pdf

Strength/Magnitude/Extent

Based on information provided by the Tornado and Storm Research Organization (TORRO), Table 3.35 below describes typical damage impacts of the various sizes of hail.

Table 3.35. Tornado and Storm Research Organization Hailstorm Intensity Scale

Intensity Category	Diameter (mm)	Diameter (inches)	Size Description	Typical Damage Impacts
Hard Hail	5-9	0.2-0.4	Pea	No damage
Potentially Damaging	10-15	0.4-0.6	Mothball	Slight general damage to plants, crops
Significant	16-20	0.6-0.8	Marble, grape	Significant damage to fruit, crops, vegetation
Severe	21-30	0.8-1.2	Walnut	Severe damage to fruit and crops, damage to glass and plastic structures, paint and wood scored
Severe	31-40	1.2-1.6	Pigeon's egg > squash ball	Widespread glass damage, vehicle bodywork damage
Destructive	41-50	1.6-2.0	Golf ball > Pullet's egg	Wholesale destruction of glass, damage to tiled roofs, significant risk of injuries
Destructive	51-60	2.0-2.4	Hen's egg	Bodywork of grounded aircraft dented, brick walls pitted
Destructive	61-75	2.4-3.0	Tennis ball > cricket ball	Severe roof damage, risk of serious injuries
Destructive	76-90	3.0-3.5	Large orange > Soft ball	Severe damage to aircraft bodywork
Super Hailstorms	91-100	3.6-3.9	Grapefruit	Extensive structural damage. Risk of severe or even fatal injuries to persons caught in the open
Super Hailstorms	>100	4.0+	Melon	Extensive structural damage. Risk of severe or even fatal injuries to persons caught in the open

Source: Tornado and Storm Research Organization (TORRO), Department of Geography, Oxford Brookes University
Notes: In addition to hail diameter, factors including number and density of hailstones, hail fall speed and surface wind speeds affect severity. http://www.torro.org.uk/site/hscale.php

Straight-line winds are defined as any thunderstorm wind that is not associated with rotation (i.e., is not a tornado). It is these winds, which can exceed 100 miles per hour, which represent the most common type of severe weather. They are responsible for most wind damage related to thunderstorms. Since thunderstorms do not have narrow tracks like tornadoes, the associated wind damage can be extensive and affect entire (and multiple) counties. Objects like trees, barns, outbuildings, high-profile vehicles, and power lines/poles can be toppled or destroyed, and roofs, windows, and homes can be damaged as wind speeds increase.

The onset of thunderstorms with lightning, high wind, and hail is generally rapid. Duration is less than six hours and warning time is generally six to twelve hours. Nationwide, lightning kills 75 to 100 people each year. Lightning strikes can also start structural and wildland fires, as well as damage electrical systems and equipment.

Previous Occurrences

The following four tables include NCEI reported events and damages for at least the past 11 years for all four included hazards when information is available.

Table 3.36. Reported Events and Damage in Macon County from Thunderstorms Summarized by Size 2009 – 2019

Wind Magnitude	Number of Events	Property Damages	Crop Damages
50-55	22	$3,250	$0
56-60	6	$0	$0
61-65	14	$12,000	$0
70-75	1	$5,000	$0
76+	0	$0	$0

Table 3.37. Reported Events and Damage in Macon County from High Winds Summarized by Size 2009 – 2019

Wind Magnitude	Number of Events	Property Damages	Crop Damages
	None		

Table 3.38. Reported Events and Damage in Macon County from Hail Summarized by Size 2009 – 2019

Hail Size (in.)	Number of Events	Property Damages	Crop Damages
0.75	14	$0	$0
0.88	4	$0	$0
1.00	19	$1,000	$0
1.25	4	$0	$0
1.50	1	$0	$0
1.75	4	$0	$0
2.25	1	$0	$0
2.50	2	$0	$0
2.75	1	$0	$0

Table 3.39. Reported Events and Damage in Macon County from Lightning Summarized by Size 2009 – 2019

Reported Lightning	Number of Events	Property Damages	Crop Damages
	None		

Source: https://www.ncdc.noaa.gov/

The tables below (Table 3.40 through Table 3.43) summarize past crop damages as indicated by crop insurance claims. The tables illustrate the magnitude of the impact on the planning area's agricultural economy.

Table 3.40. Crop Insurance Claims Paid in Macon County from Thunderstorms, 2008-2018.

Crop Year	Crop Name	Cause of Loss Description	Insurance Paid ($)
	No Reports		
Total			

Source: USDA Risk Management Agency, Insurance Claims, https://www.rma.usda.gov/data/cause

Table 3.41. Crop Insurance Claims Paid in Macon County from High Winds, 2008-2018.

Crop Year	Crop Name	Cause of Loss Description	Insurance Paid ($)
2012	Corn	Wind/Excess Wind	$1,424
2014	Wheat	Wind/Excess Wind	$2,481
Total			$3,905

Source: USDA Risk Management Agency, Insurance Claims, https://www.rma.usda.gov/data/cause

Table 3.42. Crop Insurance Claims Paid in Macon County from Lightning, 2008-2018.

Crop Year	Crop Name	Cause of Loss Description	Insurance Paid ($)
	No Reports		
Total			

USDA Risk Management Agency, Insurance Claims, https://www.rma.usda.gov/data/cause

Table 3.43. Crop Insurance Claims Paid in Macon County from Hail, 2008-2018.

Crop Year	Crop Name	Cause of Loss Description	Insurance Paid ($)
2008	Soybeans	Hail	$188,137
2009	Soybeans	Hail	$2,451
2010	Soybeans	Hail	$26,082.50
2010	Soybeans	Hail	$21,258
2010	Corn	Hail	$12,607.50
2010	Corn	Hail	$6,570
2011	Soybeans	Hail	$4,250
2011	Soybeans	Hail	$36,766
2011	Corn	Hail	$865
2012	Wheat	Hail	$5,158
2013	Corn	Hail	$12,506
2015	Corn	Hail	$7,009
2017	Soybeans	Hail	$6,277
Total			$329,937

USDA Risk Management Agency, Insurance Claims, https://www.rma.usda.gov/data/cause

Probability of Future Occurrence

Thunderstorms

NCEI, dating back to 2009, indicates 8 years with thunderstorms. Based on this historical data, the calculated probability of a thunderstorm in any given year is 100% with a probability of 4.3 events per year.

High Winds

Due to no reports, adequate calculations cannot be configured at this time.

Lightning

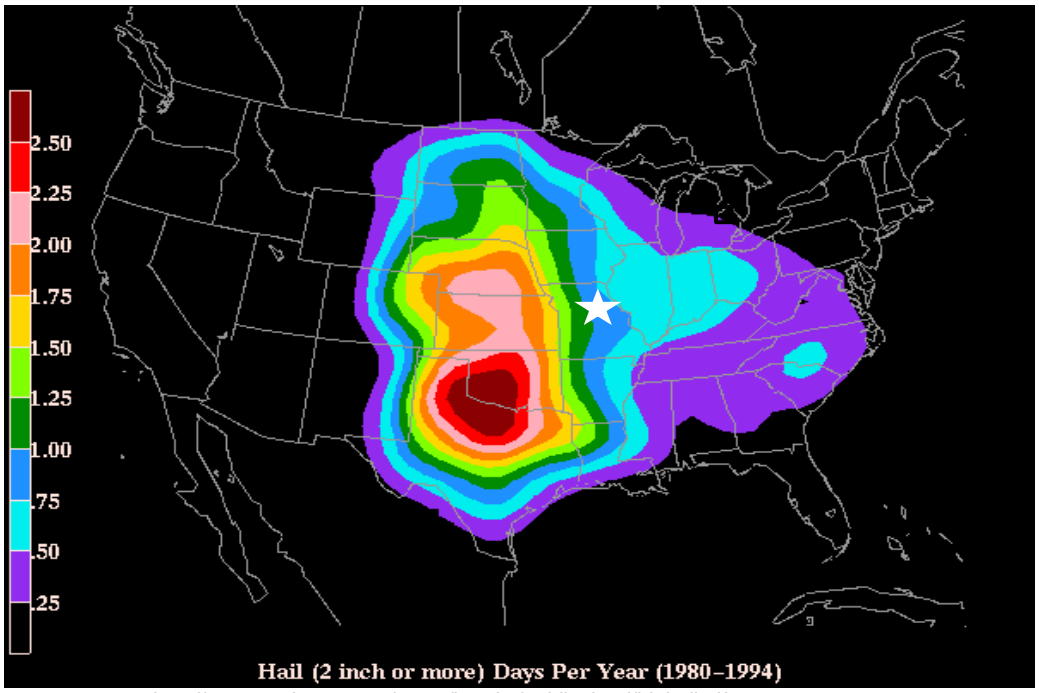
Due to no reports, adequate calculations cannot be configured at this time.

Hail

NCEI, dating back to 2009, indicates multiple hail events occurred every year. Based on this historical data, the calculated probability of a hail event in any given year is 100% with a probability of 4.5 events per year.

Figure 3.51 is based on hailstorm data from 1980-1994. It shows the probability of hailstorm occurrence (2" diameter or larger) based on number of days per year. Macon County is located in the region to receive between .75 and 1 hailstorm annually.

Figure 3.51. Annual Hailstorm Probability (2'' diameter or larger), U 1980- 1994



Source: NSSL, http://www.nssl.noaa.gov/users/brooks/public_html/bighail.gif Note: White star indicates approximate location of Macon County

Changing Future Conditions Considerations

According to the 2018 Missouri State Plan, predicted increases in temperature could help create atmospheric conditions that are fertile breeding grounds for severe thunderstorms and tornadoes in Missouri. Possible impacts include an increased risk to life and property in both the public and private sectors. Public utilities and manufactured housing developments will be especially prone to damages. Jurisdictions already affected should be prepared for more of these events, and should thus prioritize mitigation actions such as construction of safe rooms for vulnerable populations, retrofitting and/or hardening existing structures, improving warning systems and public education, and reinforcing utilities and additional critical infrastructure.

Vulnerability

Vulnerability Overview

Severe thunderstorm losses are usually attributed to the associated hazards of hail, downburst winds, lightning and heavy rains. Losses due to hail and high wind are typically insured losses that are localized and do not result in presidential disaster declarations. However, in some cases, impacts are severe and widespread and assistance outside state capabilities is necessary. Hail and wind also can have devastating impacts on crops. Severe thunderstorms/heavy rains that lead to flooding are discussed in the flooding hazard profile. Hailstorms cause damage to property, crops, and the environment, and can injure and even kill livestock. In the United States, hail causes more than $1 billion in damage to property and crops each year. Even relatively small hail can shred plants to ribbons in a matter of minutes. Vehicles, roofs of buildings and homes, and landscaping are also commonly damaged by hail. Hail has been known to cause injury to humans, occasionally fatal injury.

In general, assets in the County vulnerable to thunderstorms with lightning, high winds, and hail include people, crops, vehicles, and built structures. Although this hazard results in high annual losses, private property insurance and crop insurance usually cover the majority of losses. Considering insurance coverage as a recovery capability, the overall impact on jurisdictions is reduced.

Most lightning damages occur to electronic equipment located inside buildings. But structural damage can also occur when a lightning strike causes a building fire. In addition, lightning strikes can cause damages to crops, if fields or forested lands are set on fire. Communications equipment and warning transmitters and receivers can also be knocked out by lightning strikes. http://www.vaisala.com/en/products/thunderstormandlightningdetectionsystems/Pages/NLDN.aspx and http://www.lightningsafety.noaa.gov/

Potential Losses to Existing Development

Most damages occur to electronic equipment located inside buildings, but structural damage can also occur when a lightning strike causes a building fire. Communications equipment and warning transmitters and receivers can also be knocked out by lightning strikes. There has not been any fatalities or injuries due to lightning in Macon County during the 11-year period reviewed. When the review period was extended to 20 years, there was 0 reported lightning events with individuals injured. There have been several insurance claims due to wind, lightning and hail due to loss of property.

Hail

There were 13 reported crop insurance claims for a 11-year period resulting in $329,937 in insurance payments.

High Winds

There were 2 reported crop insurance claims for a 11-year period resulting in $3,905 in insurance payments.

Lightning

The total number of Lightning crop insurance claims for a 11-year period could not be determined as claims were listed under “Other (Snow, Lightning, etc.)”

Previous and Future Development

Macon County's trend in increased development will likely increase vulnerability to thunderstorms, high winds, hail and lightning. With more development of housing neighborhoods and businesses, the increased population will be vulnerable to all the hazards.

EMAP Consequence Analysis

Table 3.44. EMAP Impact Analysis: Severe Thunderstorms

Subject	Detrimental Impacts
Public	Localized impact expected to be severe for incident areas and moderate to light for other adversely affected areas.
Responders	Localized impact expected to limit damage to personnel in the areas at the time of the incident.
Continuity of Operations	Damage to facilities/personnel in the area of the incident may require temporary relocation of some operations. Localized disruption of roads, facilities, and/or utilities caused by incident may postpone delivery of some services.
Property, Facilities, and Infrastructure	Localized impact to facilities and infrastructure in the area of the incident. Some severe damage possible.
Environment	Localized impact expected to be severe for incident areas and moderate to light for other areas affected by the storm or HazMat spills.
Economic Condition of Jurisdiction	Losses to private structures covered, for the most part, by private insurance.
Public Confidence in the Jurisdiction's Governance	Ability to respond and recover may be questioned and challenged if planning, response, and recovery not timely and effective.

Hazard Summary by Jurisdiction

Thunderstorms/high winds/ lightning/hail events are area-wide, NCEI data did not seem to indicate that any particular community had higher losses as compared to another.

Problem Statement

Thunderstorms can damage power lines with the high winds or fallen debris such as tree limbs. Not everyone in the county utilizes social media, texting or have access to a weather radio, communities would benefit from updated sirens. Possible solutions include review of local ordinance and building codes to address high winds and/or construction techniques to include structural bracing, straps and clips, or anchor bolts.

3.4.8 Severe Winter Weather

Hazard Profile

Hazard Description

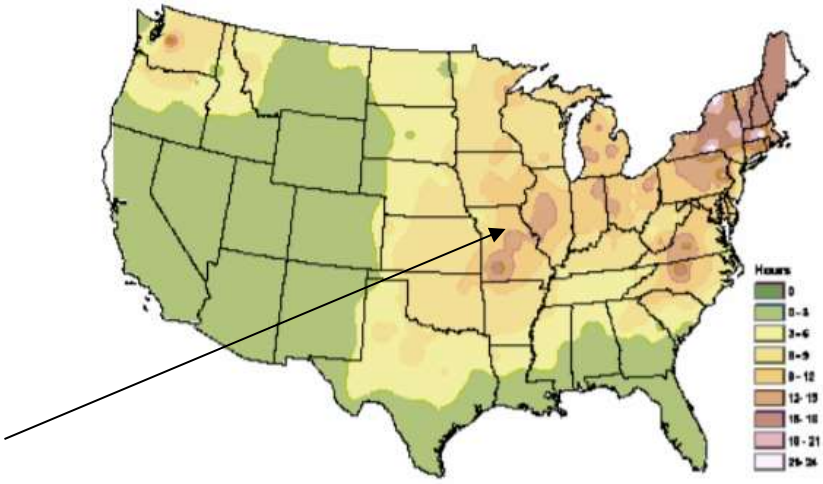
A major winter storm can last for several days and be accompanied by high winds, freezing rain or sleet, heavy snowfall, and cold temperatures. The National Weather Service describes different types of winter storm events as follows.

- **Blizzard**—Winds of 35 miles per hour or more with snow and blowing snow reducing visibility to less than ¼ mile for at least three hours.
- **Blowing Snow**—Wind-driven snow that reduces visibility. Blowing snow may be falling snow and/or snow on the ground picked up by the wind.
- **Snow Squalls**—Brief, intense snow showers accompanied by strong, gusty winds. Accumulation may be significant.
- **Snow Showers**—Snow falling at varying intensities for brief periods of time. Some accumulation is possible.
- **Freezing Rain**—Measurable rain that falls onto a surface with a temperature below freezing. This causes it to freeze to surfaces, such as trees, cars, and roads, forming a coating or glaze of ice. Most freezing-rain events are short lived and occur near sunrise between the months of December and March.
- **Sleet**—Rain drops that freeze into ice pellets before reaching the ground. Sleet usually bounces when hitting a surface and does not stick to objects.

Geographic Location

The entire Macon County is vulnerable to heavy snow, ice, extreme cold temperatures and freezing rain as shown in **Figure 3.52**.

Figure 3.52. NWS Statewide Average Number of Hours per Year with Freezing Rain



Source: American Meteorological Society. "Freezing Rain Events in the United States." http://ams.confex.com/ams/pdfpapers/71872.pdf

Strength/Magnitude/Extent

Severe winter storms include heavy snowfall, ice, and strong winds which can push the wind chill well below zero degrees in the planning area.

For severe weather conditions, the National Weather Service issues some or all of the following products as conditions warrant across the State of Missouri. NWS local offices in Missouri may collaborate with local partners to determine when an alert should be issued for a local area.

- Winter Weather Advisory — Winter weather conditions are expected to cause significant inconveniences and may be hazardous. If caution is exercised, these situations should not become life threatening. Often the greatest hazard is to motorists.
- Winter Storm Watch — Severe winter conditions, such as heavy snow and/or ice are possible within the next day or two.
- Winter Storm Warning — Severe winter conditions have begun or are about to begin.
- Blizzard Warning — Snow and strong winds will combine to produce a blinding snow (near zero visibility), deep drifts, and life-threatening wind chill.
- Ice Storm Warning -- Dangerous accumulations of ice are expected with generally over one quarter inch of ice on exposed surfaces. Travel is impacted, and widespread downed trees and power lines often result.
- Wind Chill Advisory -- Combination of low temperatures and strong winds will result in wind chill readings of -20 degrees F or lower.
- Wind Chill Warning -- Wind chill temperatures of -35 degrees F or lower are expected. This is a life-threatening situation.

Previous Occurrences

Table 3.45. NCEI Macon County Winter Weather Events Summary, 2008-2018

Type of Event	Inclusive Dates	Magnitude	# of Injuries	Property Damages	Crop Damages
Winter Weather	1/10/2011		0	0	0
Winter Weather	12/8/2011		0	0	0
Winter Weather	1/11/2012		0	0	0
Winter Weather	1/27/2012		0	0	0
Winter Weather	2/13/2012		0	0	0
Winter Storm	1/6/2010		0	0	0
Winter Storm	2/21/2010		0	0	0
Winter Storm	1/19/2011		0	0	0
Winter Storm	2/24/2011		0	0	0
Winter Storm	2/21/2013		0	0	0
Winter Storm	2/25/2013		0	0	0
Winter Storm	3/23/2013		0	0	0
Winter Storm	12/21/2013		0	0	0
Blizzard	2/1/2011		0	0	0
Blizzard	11/25/2018		0	0	0
Cold/Wind Chill	1/5/2014		0	0	0
Heavy Snow	2/4/2014		0	0	0
Heavy Snow	1/31/2015		0	0	0
Heavy Snow	2/1/2015		0	0	0
Ice Storm	12/18/2008		0	0	0
Sleet	No Reports		0	0	0

Source: NCEI, data accessed 8/27/2019

Table 3.46. Presidential Disaster Declarations for Winter Storms

Disaster Number	IH Program Declared	IA Program Declared	PA Program Declared	HM Program Declared	State	Declaration Date	Disaster Type	Incident Type	Title	Incident Begin Date	Incident End Date	Disaster Close Out Date	Place Code	Declared County/Area
1403	No	Yes	Yes	Yes	MO	2/6/2002	DR	Severe Ice Storm	SEVERE WINTER ICE STORM		1/29/2002	2/13/2002	2/11/2011	Macon (County)
1961	No	No	Yes	Yes	MO	3/23/2011	DR	Severe Storm(s)	SEVERE WINTER STORM AND SNOWSTORM		1/31/2011	2/5/2011	12/2/2015	Macon (County)
3303	No	No	Yes	No	MO	1/30/2009	EM	Severe Ice Storm	SEVERE WINTER STORM		1/26/2009	1/28/2009	11/8/2011	Macon (County)
3281	No	No	Yes	No	MO	12/12/2007	EM	Severe Ice Storm	SEVERE WINTER STORMS		12/8/2007	12/15/2007	3/15/2011	Macon (County)
3317	No	No	Yes	No	MO	2/3/2011	EM	Severe Storm(s)	SEVERE WINTER STORM		1/31/2011	2/5/2011	1/6/2012	Macon (County)

Source: https://www.fema.gov/data-visualization-summary-disaster-declarations-and-grants

Winter storms, cold, frost and freeze take a toll on crop production in the planning area. **Table 3.47 through Table 3.50** shows the USDA's Risk Management Agency payments for insured crop losses in the planning area as a result of cold conditions and snow for the past 11 years.

Table 3.47. Crop Insurance Claims Paid in Macon County as a Result of Cold Conditions and Snow 2008-2018

Crop Year	Crop Name	Cause of Loss Description	Insurance Paid ($)
2008	Corn	Cold Winter	4,666
2008	Wheat	Cold Winter	1,412
2008	Wheat	Cold Wet Weather	1,739.50
2008	Wheat	Cold Wet Weather	1,432
2009	Soybeans	Other (Snow, Lightning, etc)	4,329
2009	Corn	Other (Snow, Lightning, etc)	142
2009	Wheat	Other (Snow, Lightning, etc)	9,299
2009	Wheat	Other (Snow, Lightning, etc)	214
2009	Wheat	Cold Winter	8,687
2009	Wheat	Cold Wet Weather	10,258
2009	Wheat	Cold Wet Weather	50,242.49
2009	Wheat	Cold Wet Weather	1,332.19
2009	Soybeans	Freeze	2,772.40
2010	Wheat	Freeze	10,649
2010	Wheat	Cold Wet Weather	5,161.49
2010	Corn	Cold Wet Weather	638
2010	Corn	Cold Wet Weather	3,776
2011	Wheat	Cold Winter	1,534
2011	Wheat	Cold Winter	4,999
2011	Wheat	Cold Wet Weather	9,084
2011	Corn	Cold Wet Weather	9,416
2011	Corn	Cold Wet Weather	5,001
2011	Soybeans	Cold Wet Weather	9,240
2011	Soybeans	Cold Wet Weather	6,945
2012	Corn	Cold Wet Weather	13,191
2012	Corn	Cold Wet Weather	133,720
2013	Wheat	Cold Wet Weather	54,720.45
2013	Corn	Cold Wet Weather	950
2014	Wheat	Cold Winter	60,351
2014	Wheat	Cold Winter	97,274.50
2014	Wheat	Cold Wet Weather	43,119
2014	Wheat	Cold Wet Weather	8,171
2014	Soybeans	Cold Wet Weather	3,681
2014	Soybeans	Cold Wet Weather	511
2015	Soybeans	Cold Wet Weather	1,656
2016	Corn	Cold Wet Weather	9,886
2016	Soybeans	Cold Wet Weather	11,919
2017	Corn	Cold Wet Weather	4,469

2017	Soybeans	Cold Wet Weather	11,242
2018	Wheat	Cold Wet Weather	4,896
2018	Soybeans	Cold Wet Weather	16,348.40
Total			**639,074.42**

Source: USDA Risk Management Agency, https://www.rma.usda.gov/data/cause

Probability of Future Occurrence

The entire planning area is vulnerable to the effects of winter storm/blizzard, ice storms, winter weather, cold/wind chill and heavy snow. All effects of winters tend to make driving more treacherous and can impact the response of emergency vehicles. The probability of utility and infrastructure failure increases during winter weather due to the freezing rain accumulation on utility poles and power lines. Elderly populations are considered particularly vulnerable to the impact of winter weather.

Changing Future Conditions Considerations

According to the 2018 Missouri State Plan, a shorter overall winter season and fewer days of extreme cold may have both positive and negative indirect impacts. Warmer winter temperatures may result in changing distributions of native plant and animal species and/or an increase in pests and non-native species. Warmer winter temperatures will result in a reduction of lake ice cover. Reduced lake ice cover impacts aquatic ecosystems by raising water temperatures. Water temperature is linked to dissolved oxygen levels and many other environmental parameters that affect fish, plant, and other animal populations. A lack of ice cover also leaves lakes exposed to wind and evaporation during a time of year when they are normally protected. As both temperature and precipitation increase during the winter months, freezing rain will be more likely. Additional wintertime precipitation in any form will contribute to saturation and increase the risk and/or severity of spring flooding. A greater proportion of wintertime precipitation may fall as rain rather than snow.

Vulnerability

Vulnerability Overview

The method used to determine vulnerability to severe winter weather across Missouri was statistical analysis of data from several sources: National Centers for Environmental Information (NCEI) storm events data (1996 to December 31, 2016), HAZUS Building Exposure Value data, housing density data from the U.S. Census (2015 ACS), and the calculated Social Vulnerability Index for Missouri Counties from the Hazards and Vulnerability Research Institute in the Department of Geography at the University of South Carolina. From the statistical data collected, five factors were considered in determining overall vulnerability to severe winter weather as follows: housing density, building exposure, social vulnerability, likelihood of occurrence, and average annual property loss. Based on natural breaks in the statistical data, a rating value of 1 through 5 was assigned to each factor. These rating values correspond to the following descriptive terms: 1) Low 2) Low-medium 3) Medium 4) Medium-high 5) High.

Table 3.48. Ranges for Severe Winter Weather Vulnerability Factor Rating

Factors Considered	Low (1)	Low Medium (2)	Medium (3)	Medium High (4)	High (5)
Common Factors					
Housing Density (# per sq. mile)	4.11-44.23	44.24-134.91	134.92-259.98	259.99-862.69	862.70-2836.23
Building Exposure ($)	$269,532-$3,224,641	$3,224,642-$8,792,829	$8,792,830-$22,249,768	$22,249,769-$46,880,213	$46,880,214-$138,887,850
Social Vulnerability	1	2	3	4	5
Likelihood of Occurrence (# of events/ yrs. of data)	1.05-1.43	1.44-1.76	1.77-2.10	2.11-2.67	2.68-4.57
Average Annual Property Loss (annual property loss/ yrs. Of data)	$0-$143,095.24	$143,095.25-$406,666.67	$406,666.68-$1,191,000.95	$1,191,000.96-$3,184,761.90	$3,184,761.91-$5,861,666.67

Source: 2018 Missouri State Hazard Mitigation Plan

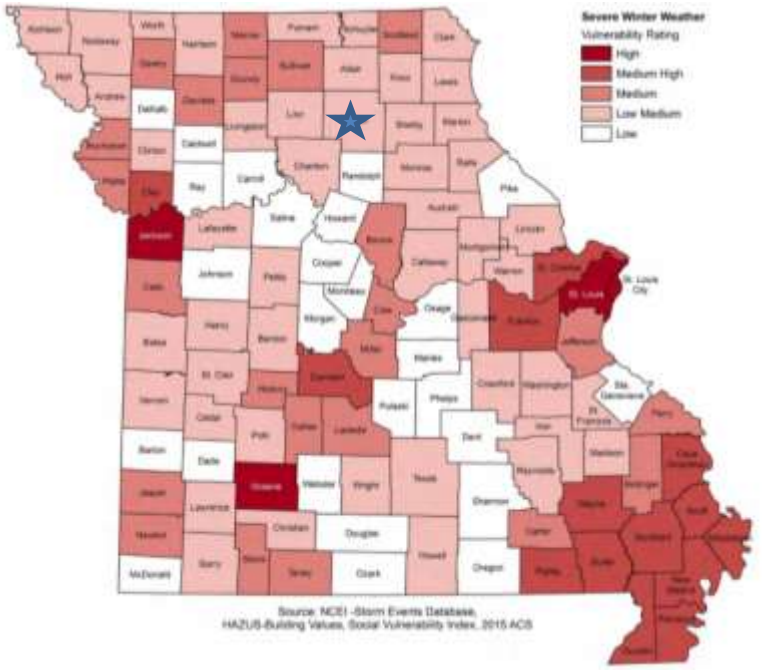
Table 3.49. Ranges for Severe Winter Weather Combined Vulnerability Rating

	Low (1)	Low-medium (2)	Medium (3)	Medium-high-4	High (5)
Severe Winter Weather Combined Vulnerability	7-8	8-10	10-12	12-15	15-22

Table 3.50. Housing Density, Building Exposure and SOVI Data by County

County	Total Building Exposure (Hazus)	Building Exposure Rating	Housing Density	Housing Density Rating	SOVI Ranking	SOVI Rating
Macon	$1,634,837,000	1	9.52	1	Medium High	4

Figure 3.53. Vulnerability Summary for Severe Winter Weather



Source: 2018 Missouri State Hazard Mitigation Plan *Blue star indicates Macon County

Heavy snow can bring a community to a standstill by inhibiting transportation (in whiteout conditions), weighing down utility lines, and by causing structural collapse in buildings not designed to withstand the weight of the snow. Repair and snow removal costs can be significant. Ice buildup can collapse utility lines and communication towers, as well as make transportation difficult and hazardous. Ice can also become a problem on roadways if the air temperature is high enough that precipitation falls as freezing rain rather than snow.

Buildings with overhanging tree limbs are more vulnerable to damage during winter storms when limbs fall. Businesses experience loss of income as a result of closure during power outages. In general heavy winter storms increase wear and tear on roadways though the cost of such damages is difficult to determine. Businesses can experience loss of income as a result of closure during winter storms.

Overhead power lines and infrastructure are also vulnerable to damages from winter storms. In particular ice accumulation during winter storm events damage to power lines due to the ice weight on the lines and equipment. Damages also occur to lines and equipment from falling trees and tree limbs weighted down by ice. Potential losses could include cost of repair or replacement of damaged facilities, and lost economic opportunities for businesses.

Secondary effects from loss of power could include burst water pipes in homes without electricity during winter storms. Public safety hazards include risk of electrocution from downed power lines. Specific amounts of estimated losses are not available due to the complexity and multiple variables associated with this hazard. Standard values for loss of service for utilities reported in FEMA's 2009 BCA Reference Guide, the economic impact as a result of loss of power is $126 per person per day of lost service.

Potential Losses to Existing Development

The next severe winter storm will most likely close schools and businesses for multiple days, and make roadways hazardous for travel. Heavy ice accumulation may damage electrical infrastructures causing prolonged power outages for large portions of the region. In addition, freezing temperatures

make water lines vulnerable to freeze/thaw. Fallen tree limbs also pose a threat to various structures/infrastructures across the county.

Previous and Future Development

Future development could potentially increase vulnerability to this hazard by increasing demand on the utilities and increasing the exposure of infrastructure networks.

EMAP Consequence Analysis

Table 3.51. EMAP Impact Analysis: Severe Winter Weather

Subject	Detrimental Impacts
Public	Localized impact expected to be severe for affected areas and moderate to light for other less affected areas.
Responders	Adverse impact expected to be severe for unprotected personnel and moderate to light for trained, equipped, and protected personnel.
Continuity of Operations	Unlikely to necessitate execution of the Continuity of Operations Plan. Localized disruption of roads and/or utilities caused by incident may postpone delivery of some services.
Property, Facilities, and Infrastructure	Localized impact to facilities and infrastructure in the areas of the incident. Power lines and roads most adversely affected.
Environment	Environmental damage to trees, bushes, etc.
Economic Condition of Jurisdiction	Local economy and finances may be adversely affected, depending on damage.
Public Confidence in the Jurisdiction's Governance	Ability to respond and recover may be questioned and challenged if planning, response, and recovery not timely and effective.

Hazard Summary by Jurisdiction

Although crop loss as a result of severe winter storm occurs more in the unincorporated portions of the planning area, the density of vulnerable populations is higher in the urban areas of the planning areas. It is considered that the magnitude of this hazard is relatively equal. The factors of probability, warning time, and duration are also equal across the planning area. Therefore, the conclusion is the hazard does not substantially vary by jurisdiction.

Problem Statement

Macon County is expected to experience at least one severe winter weather events annually; the county has a low-medium vulnerability rating. Jurisdictions should enhance their weather monitoring to be better prepared for sever weather hazards. If jurisdictions monitor winter weather, they can dispatch road crews to prepare for the hazard. County and city crews can also trim trees along power lines to minimize the potential for outages due to snow and ice. Citizens should also be educated about the benefits of being proactive to alleviate property damage as well as preparing for power outages. Education needs to occur to ensure all residents are aware of the shelters in the County, residents are educated on emergency supplies to have and the utilization of social media and texting increases.

3.4.9 Tornado

Hazard Profile

Hazard Description

Essentially, tornadoes are a vortex storm with two components of winds. The first is the rotational winds that can measure up to 500 miles per hour, and the second is an uplifting current of great strength. The dynamic strength of both these currents can cause vacuums that can overpressure structures from the inside.

Although tornadoes have been documented in all 50 states, most of them occur in the central United States. The unique geography of the central United States allows for the development of thunderstorms that spawn tornadoes. The jet stream, which is a high-velocity stream of air, determines which area of the central United States will be prone to tornado development. The jet stream normally separates the cold air of the north from the warm air of the south. During the winter, the jet stream flows west to east from Texas to the Carolina coast. As the sun "moves" north, so does the jet stream, which at summer solstice flows from Canada across Lake Superior to Maine. During its move northward in the spring and its recession south during the fall, the jet stream crosses Missouri, causing the large thunderstorms that breed tornadoes.

Tornadoes spawn from the largest thunderstorms. The associated cumulonimbus clouds can reach heights of up to 55,000 feet above ground level and are commonly formed when Gulf air is warmed by solar heating. The moist, warm air is overridden by the dry cool air provided by the jet stream. This cold air presses down on the warm air, preventing it from rising, but only temporarily. Soon, the warm air forces its way through the cool air and the cool air moves downward past the rising warm air. This air movement, along with the deflection of the earth's surface, can cause the air masses to start rotating. This rotational movement around the location of the breakthrough forms a vortex, or funnel. If the newly created funnel stays in the sky, it is referred to as a funnel cloud. However, if it touches the ground, the funnel officially becomes a tornado.

A typical tornado can be described as a funnel-shaped cloud that is "anchored" to a cloud, usually a cumulonimbus that is also in contact with the earth's surface. This contact on average lasts 30 minutes and covers an average distance of 15 miles. The width of the tornado (and its path of destruction) is usually about 300 yards. However, tornadoes can stay on the ground for upward of 300 miles and can be up to a mile wide. The National Weather Service, in reviewing tornadoes occurring in Missouri between 1950 and 1996, calculated the mean path length at 2.27 miles and the mean path area at 0.14 square mile.

The average forward speed of a tornado is 30 miles per hour but may vary from nearly stationary to 70 miles per hour. The average tornado moves from southwest to northeast, but tornadoes have been known to move in any direction. Tornadoes are most likely to occur in the afternoon and evening, but have been known to occur at all hours of the day and night.

Geographic Location

Tornados can occur in the entire planning area and no area is immune from tornado suffering.

Strength/Magnitude/Extent

Tornadoes are the most violent of all atmospheric storms and are capable of tremendous destruction. Wind speeds can exceed 250 miles per hour an damage paths can be more than one mile wide and 50 miles long. Tornadoes have been known to lift and move objects weighing more than 300 tons a distance of 30 feet, toss homes more than 300 feet from their foundations, and siphon millions of tons of water from water bodies. Tornadoes also can generate a tremendous amount of flying debris or "missiles," which often become airborne shrapnel that causes additional

damage. If wind speeds are high enough, missiles can be thrown at a building with enough force to penetrate windows, roofs, and walls. However, the less spectacular damage is much more common.

Tornado magnitude is classified according to the EF- Scale (or the Enhance Fujita Scale, based on the original Fujita Scale developed by Dr. Theodore Fujita, a renowned severe storm researcher). The EF-Scale (see Table 3.52) attempts to rank tornadoes according to wind speed based on the damage caused. This update to the original F Scale was implemented in the U.S. on February 1, 2007.

Table 3.52. Enhanced F Scale for Tornado Damage

FUJITA SCALE			DERIVED EF SCALE		OPERATIONAL EF SCALE	
F Number	Fastest ¼-mile (mph)	3 Second Gust (mph)	EF Nu	3 Second Gust (mph)	EF Number	3 Second Gust (mph)
0	40-72	45-78	0	65-85	0	65-85
1	73-112	79-117	1	86-109	1	86-110
2	113-157	118-161	2	110-137	2	111-135
3	158-207	162-209	3	138-167	3	136-165
4	208-260	210-261	4	168-199	4	166-200
5	261-318	262-317	5	200-234	5	Over 200

Source: The National Weather Service, www.spc.noaa.gov/faq/tornado/ef-scale.html

The wind speeds for the EF scale and damage descriptions are based on information on the NOAA Storm Prediction Center as listed in Table 3.53. The damage descriptions are summaries. For the actual EF scale it is necessary to look up the damage indicator (type of structure damaged) and refer to the degrees of damage associated with that indicator. Information on the Enhanced Fujita Scale's damage indicators and degrees or damage is located online at www.spc.noaa.gov/efscale/ef-scale.html.

Table 3.53. Enhanced Fujita Scale with Potential Damage

Enhanced Fujita Scale			
Scale	Wind Speed (mph)	Relative Frequency	Potential Damage
EF0	65-85	53.5%	Light. Peels surface off some roofs; some damage to gutters or siding; branches broken off trees; shallow-rooted trees pushed over. Confirmed tornadoes with no reported damage (i.e. those that remain in open fields) are always rated EF0).
EF1	86-110	31.6%	Moderate. Roofs severely stripped; mobile homes overturned or badly damaged; loss of exterior doors; windows and other glass broken.
EF2	111-135	10.7%	Considerable. Roofs torn off well-constructed houses; foundations of frame homes shifted; mobile homes complete destroyed; large trees snapped or uprooted; light object missiles generated; cars lifted off ground.
EF3	136-165	3.4%	Severe. Entire stores of well-constructed houses destroyed; severe damage to large buildings such as shopping malls; trains overturned; trees debarked; heavy cars lifted off the ground and thrown; structures with weak foundations blown away some
EF4	166-200	0.7%	Devastating. Well-constructed houses and whole frame houses completely levelled; cars thrown and small missiles generated.
EF5	>200	<0.1%	Explosive. Strong frame houses levelled off foundations and swept away; automobile-sized missiles fly through the air in excess of 300 ft.; steel reinforced concrete structure badly damaged; high rise buildings have significant structural deformation; incredible phenomena will occur.

Source: NOAA Storm Prediction Center, http://www.spc.noaa.gov/efscale/ef-scale.html

Enhanced weather forecasting has provided the ability to predict severe weather likely to produce tornadoes days in advance. Tornado watches can be delivered to those in the path of these storms several hours in advance. Lead time for actual tornado warnings is about 30 minutes. Tornadoes have been known to change paths very rapidly, thus limiting the time in which to take shelter. Tornadoes may not be visible on the ground if they occur after sundown or due to blowing dust or driving rain and hail.

Previous Occurrences

There are limitations to the use of NCEI tornado data that must be noted. For example, one tornado may contain multiple segments as it moves geographically. A tornado that crosses a county line or state line is considered a separate segment for the purposes of reporting to the NCEI. Also, a tornado that lifts off the ground for less than 5 minutes or 2.5 miles is considered a separate segment. If the tornado lifts off the ground for greater than 5 minutes or 2.5 miles, it is considered a separate tornado. Tornadoes reported in Storm Data and the Storm Events Database are in segments.

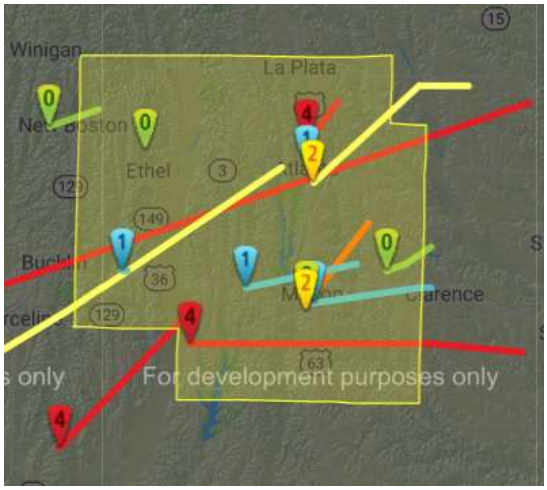
Table 3.54. Recorded Tornadoes in Macon County, 1993 – Present

Date	Beginning Location	Ending Location	Length (miles)	Width (yards)	F/EF Rating	Death	Injury	Property Damage	Crop Damages
6/14/1998	Atlanta	Atlanta	.3	25	F1	0	0	10K	0K
4/8/1999	7SWNewCambr	2W Atlanta	21	440	F2	0	2	1M	400K
4/8/1999	1SE Atlanta	10NE Atlanta	10	440	F2	0	0	500K	250K
5/10/2003	1N Anabel	3NE Anabel	2	25	F0	0	0	1K	0K
5/24/2004	1WNewCambri	New Cambria	1	100	F1	0	0	300K	0K
6/4/2010	1NNE Ethel	1NNE Ethel	.1	20	EF0	0	0	0K	0K
6/14/2011	4WSW Goldsbe	2W Goldsberry	1.82	100	EF0	0	0	0K	0K
	Total					0	2	1.811M	650K

Source: National Centers for Environmental Information, http://www.NCEI.noaa.gov/stormevents/

Figure 3.54 shows historic tornado paths in the planning area.

Figure 3.54. Macon County Map of Historic Tornado Events



Source: Missouri Tornado History Project, http://www.tornadohistoryproject.com/tornado/Missouri

Data from the USDA Risk Management Agency showed 0 insurance payments in Macon County for crop damages as a result of tornadoes within period of 2008-2018.

Probability of Future Occurrence

The National Centers for Environmental Information reported 7 tornadoes in Macon County in a 21-year time period, which calculates to a 33 percent chance of tornado in any given year. Therefore, it is a low probability that some portion of Macon County will experience tornado activity in any given year.

Changing Future Conditions Considerations

According to the 2018 Missouri State Hazard Mitigation Plan, Scientists do not know how the frequency and severity of tornadoes will change. Research published in 2015 suggests that changes in heat and moisture content in the atmosphere, brought on by a warming world, could be playing a role in making tornado outbreaks more common and severe in the U.S. The research concluded that the number of days with large outbreaks have been increasing since the 1950s and that densely concentrated tornado outbreaks are on the rise. It is notable that the research shows that the area of tornado activity is not expanding, but rather the areas already subject to tornado activity are seeing the more densely packed tornadoes. Because Missouri experiences on average around 39.6 tornadoes a year, such research is closely followed by meteorologists in the state.

Vulnerability

Vulnerability Overview

Macon County is located in a region of the U.S. with high frequency of dangerous and destructive tornadoes referred to as “Tornado Alley”. Figure 3.55 illustrates areas where dangerous tornadoes historically have occurred.

From the statistical data collected, six factors were considered in determining overall vulnerability to tornadoes as follows: building exposure, population density, social vulnerability, percentage of mobile homes, likelihood of occurrence, and annual property loss. Based on natural breaks in the statistical data, a rating value of 1 through 5 was assigned to each factor. These rating values correspond to the following descriptive terms: 1) Low 2) Low-medium 3) Medium 4) Medium-high 5) High.

Figure 3.55. Tornado Alley in the U.S.

Source: http://www.tornadochaser.net/tornalley.html

Table 3.55. Ranges for Tornado Vulnerability Factor Ratings

Factors Considered	Low (1)	Low-medium (2)	Medium (3)	Medium-High (4)	High (5)
Common Factors					
Building Exposure ($)	$269,532-$3,224,641	$3,224,642-$8,792,829	$8,792,830-$22,249,768	$22,249,769-$46,880,213	$46,880,214-$138,887,850
Population Density (#per sq. mile)	4.11-44.23	44.24-134.91	134.92-259.98	259.99-862.69	862.70-2,836.23
Social Vulnerability	1	2	3	4	5
Percent Mobile Homes	0.2-4.5%	4.51-8.8%	8.81-14%	14.01-21.2%	21.21-33.2%
Likelihood of Occurrence (# of events/ yrs. of data)	0.119 - 0.208	0.209 - 0.313	0.314 - 0.417	0.418 - 0.552	0.553 - 0.791
Total Annualized Property Loss ($ / yrs. of data)	$974 - $281,874	$281,875 - $991,825	$991,826 - $2,099,000	$2,099,001 - $5,047,474	$5,047,475 - $42,467,109

Table 3.56. Ranges for Tornado Combined Vulnerability Rating

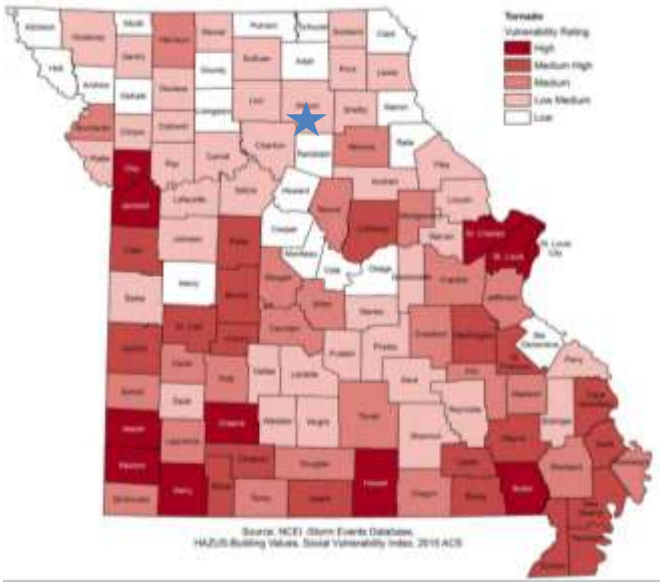
	Low (1)	Low-medium (2)	Medium (3)	Medium-High (4)	High (5)
Tornado Combined Vulnerability	7-10	11-12	13-14	15-16	17-21

Table 3.57. Building Exposure, Population Density, SOVI and Mobile Home Data for Macon County

County	Total Building Exposure (Hazus)	Exposure Rating	Population Density	Population Rating	SOVI Index Ranking	SOVI Rating	Percent Mobile Homes	Mobile Home Rating
Macon	$1,634,837,000	1	19.14	1	Medium High	4	12.1	3

Source: 2018 Missouri State Hazard Mitigation Plan

Figure 3.56. Vulnerability to Tornadoes



Source: 2018 Missouri State Hazard Mitigation Plan, *Star indicates Macon County

Potential Losses to Existing Development

In the past 67 years, Macon County has had minimal property ($974- $281,874) loss from tornadoes.

Figure 3.57. Annualized Property Loss for Tornadoes

Source: 2018 Missouri State Hazard Mitigation Plan, *Star indicates Macon County

Previous and Future Development

Vulnerability to tornadoes is anticipated to remain the same. Future development for public buildings such as schools, government offices, as well as buildings with high occupancy and campgrounds should consider including a tornado safe room to protect occupants in the event of a tornado.

EMAP Consequence Analysis

Table 3.58. EMAP Impact Analysis: Tornadoes

Subject	Detrimental Impacts
Public	Localized impact expected to be severe for incident areas and moderate to light for other adversely affected areas.
Responders	Localized impact expected to limit damage to personnel in the areas at the time of the incident.
Continuity of Operations	Damage to facilities/personnel in the area of the incident may require temporary relocation of some operations. Localized disruption of roads, facilities, and/or utilities caused by incident may postpone delivery of some services.
Property, Facilities, and Infrastructure	Localized impact to facilities and infrastructure in the area of the incident. Some severe damage possible.
Environment	Localized impact expected to be severe for incident areas and moderate to light for other areas affected by the storm or HazMat spills.
Economic Condition of Jurisdiction	Local economy and finances adversely affected, possibly for an extended period of time.

Subject	Detrimental Impacts
Public Confidence in the Jurisdiction's Governance	Ability to respond and recover may be questioned and challenged if planning, response, and recovery not timely and effective.

Hazard Summary by Jurisdiction

Tornado events could occur anywhere in the planning area, but some jurisdictions would suffer heavier damages because of the age of the housing or the high concentration of mobile homes. Communities that have adopted building codes may also be less vulnerable to damages.

Problem Statement

Macon County has inadequate tornado shelters throughout the county, not everyone utilizes social media and/or texting, the rural areas do not have warning sirens, lack of awareness for available shelters and more education needs to occur. Possible solutions include promoting the use of NOAA weather radios and conducting public education and outreach activities to increase awareness of tornado risk.

3.4.10 Wildfire

Hazard Profile

Hazard Description

The fire incident types for wildfires include: 1) natural vegetation fire, 2) outside rubbish fire, 3) special outside fire, and 4) cultivated vegetation, crop fire.

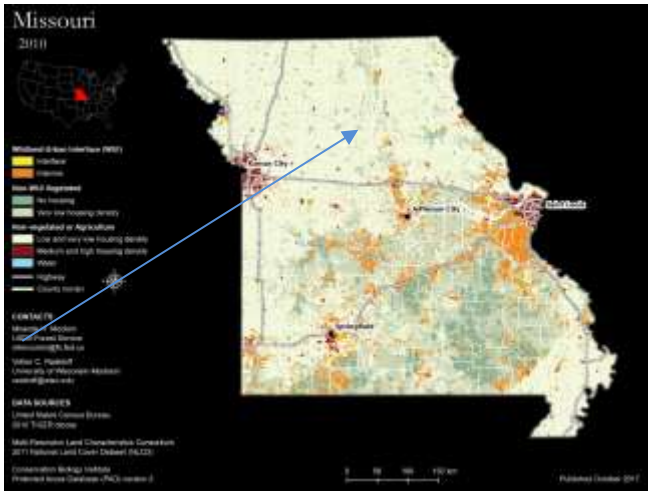
The Forestry Division of the Missouri Department of Conservation (MDC) is responsible for protecting privately owned and state-owned forests and grasslands from wildfires. To accomplish this task, eight forestry regions have been established in Missouri for fire suppression. The Forestry Division works closely with volunteer fire departments and federal partners to assist with fire suppression activities. Currently, more than 900 rural fire departments in Missouri have mutual aid agreements with the Forestry Division to obtain assistance in wildfire protection if needed.

Most of Missouri fires occur during the spring season between February and May. The length and severity of wildland fires depend largely on weather conditions. Spring in Missouri is usually characterized by low humidity and high winds. These conditions result in higher fire danger. In addition, due to the recent lack of moisture throughout many areas of the state, conditions are likely to increase the risk of wildfires. Drought conditions can also hamper firefighting efforts, as decreasing water supplies may not prove adequate for firefighting. It is common for rural residents burn their garden spots, brush piles, and other areas in the spring. Some landowners also believe it is necessary to burn their forests in the spring to promote grass growth, kill ticks, and reduce brush. Therefore, spring months are the most dangerous for wildfires. The second most critical period of the year is fall. Depending on the weather conditions, a sizeable number of fires may occur between mid-October and late November.

Geographic Location

The Wildland-Urban Interface term refers to the zone of transition between unoccupied land and human development and needs to be defined in the plan. Within the WUI, there are two specific areas identified: 1) Interface and 2) Intermix. The interface areas are those areas that abut wildland vegetation and the Intermix areas are those areas that intermingle with wildland areas.

At this time, Wildland-Urban Interface area has information not specifically identified for Macon County. If this information becomes available prior to the next update of this plan, it will be incorporated.



Source: http://silvis.forest.wisc.edu/data/wui-change/ *Arrow indicates approximate location of Macon County

Strength/Magnitude/Extent

Wildfires damage the environment, killing some plants and occasionally animals. Firefighters have been injured or killed, and structures can be damaged or destroyed. The loss of plants can heighten the risk of soil erosion and landslides. Although Missouri wildfires are not the size and intensity of those in the Western United States, they could impact recreation and tourism in and near the fires.

Wildland fires in Missouri have been mostly a result of human activity rather than lightning or some other natural event. Wildfires in Missouri are usually surface fires, burning the dead leaves on the ground or dried grasses. They do sometimes "torch" or "crown" out in certain dense evergreen stands like eastern red cedar and shortleaf pine. However, Missouri does not have the extensive stands of evergreens found in the western US that fuel the large fire storms seen on television news stories.

While very unusual, crown fires can and do occur in Missouri native hardwood forests during prolonged periods of drought combined with extreme heat, low relative humidity, and high wind. Tornadoes, high winds, wet snow and ice storms in recent years have placed a large amount of woody material on the forest floor that causes wildfires to burn hotter and longer. These conditions also make it more difficult for fire fighters suppress fires safely.

Often wildfires in Missouri go unnoticed by the general public because the sensational fire behavior that captures the attention of television viewers is rare in the state. Yet, from the standpoint of destroying homes and other property, Missouri wildfires can be quite destructive.

Previous Occurrences

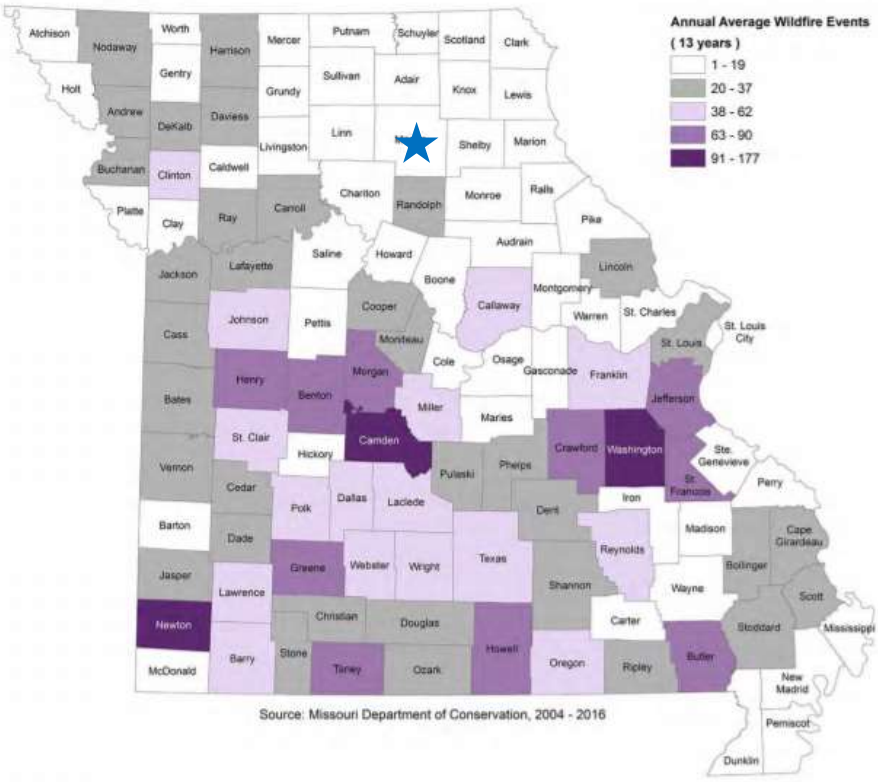
According to the Missouri Division of Fire Safety (MDFS) website, as well as the Missouri Department of Conversation Wildfire Data Search, there were 205 reported wildland or grass fires in Macon County from 2008-2018. In total, these 205 fires burned 3,497 acres and no injuries were reported. During the 11-year reporting period, 52 of the fires had an unknown cause for starting and burning 849.52 acres, 78 were started by debris and burnt 1,146.42 acres, 21 of the fires were started by equipment and burnt 208 acres. 3 of the fires were started by smoking and burnt 60 acres.

At this time, no information is available from school districts and special districts about previous fire events and the damages resulting from them.

Probability of Future Occurrence

Wildfires in the planning area are most likely to occur every year with very little resulting damage. The wildfires occur in the unincorporated areas and are limited to undeveloped land. The jurisdictions and school districts are largely surrounded by undeveloped land but have not been affected by wildfires. In years of significant drought or excessive heat the potential for a wildfire in planning area increases.

Figure 3.58. Likelihood of Wildfire Events with Macon County Indicated



Source: 2018 Missouri State Hazard Mitigation Plan, *Star indicates Macon County

When analyzing the wildland fires, there has been an average of 20.5 fires burning 349.7 acres per year. However, it was reported these fires did not result in major damages. The probability score to be likely in any given year that a wildfire could occur in the planning area.

Changing Future Conditions Considerations

According to the 2018 State Plan, higher temperatures and changes in rainfall are unlikely to substantially reduce forest cover in Missouri, although the composition of trees in the forests may change. More droughts would reduce forest productivity, and changing future conditions are also likely to increase the damage from insects and diseases. But longer growing seasons and increased carbon dioxide concentrations could more than offset the losses from those factors. Forests cover about one-third of the state, dominated by oak and hickory trees. As the climate changes, the abundance of pines in Missouri's forests is likely to increase, while the population of hickory trees is likely to decrease 0.

Additionally stated in the 2018 State Plan, higher temperatures will also reduce the number of days prescribed burning can be performed. Reduction of prescribed burning will allow for growth of understory vegetation – providing fuel for destructive wildfires. Drought is also anticipated to increase in frequency and intensity during summer months under projected future scenarios. Drought can lead to dead or dying vegetation and landscaping material close to structures which creates fodder for wildfires within both the urban and rural settings.

Vulnerability

Vulnerability Overview

With over 14 million acres, Missouri ranks seventh in the northeast region of the U.S. in forest land area. From the data obtained from the Department of Conservation, the likelihood of occurrence and the annualized acres burned were determined for Macon County and listed in the section below.

Potential Losses to Existing Development

Figure 3.59. Statistical Data for Wildfire Vulnerability for Macon County

County	Number of Wildfires 2004-2016	Likelihood of Occurrence (#/year)	Total Acres Burned	Average Annual Acreage Burned
Macon	196	15.08	4,162.25	320

Figure 3.60. Estimated Numbers and Values of Structures and Population Vulnerable to Wildfire for Macon County

County	Number of Structures	Value of Structures	Population
Macon	**645**	**$145,197,680**	**1,066**
Agriculture	144	$29,718,906	
Commercial	41	$24,242,548	
Education	8	$10,855,579	
Government	3	$2,400,094	

Figure 3.61. Wildfire Potential Loss Estimates for Macon County

County	Total WUI Acreage	Total Structure Value Within WUI	Average Value/Acre within WUI	Average Annual Acreage Burned	Potential Loss
Macon	4,131.03	$145,197,680	$35,148	320	$11,247,380

Source: 2018 Missouri State Hazard Mitigation Plan

According to the 2018 Missouri State Hazard Mitigation Plan, Macon County is estimated to have on average 320 acres burned with a potential loss of $11,247,380.

Impact of Previous and Future Development

Future and previous development in the wildland-urban interface would increase vulnerability to the hazard.

EMAP Consequence Analysis

Table 3.59. EMAP Impact Analysis: Wildfire

Subject	Detrimental Impacts
Public	Localized impact expected to be severe for incident areas and moderate to light for other adversely affected areas.
Responders	Localized impact expected to limit damage to personnel in the incident areas at the time of the incident.
Continuity of Operations	Damage to facilities/personnel in the area of the incident may require temporary relocation of some operations. Localized disruption of roads and/or utilities caused by incident may postpone delivery of some services.
Property, Facilities, and Infrastructure	Localized impact to facilities and infrastructure in the area of the incident. Some severe damage possible.
Environment	Localized impact expected to be severe for incident areas and moderate to light for other areas affected by smoke or HazMat remediation.
Economic Condition of Jurisdiction	Local economy and finances may be adversely affected, depending on damage and length of investigations.
Public Confidence in the Jurisdiction's Governance	Ability to respond and recover may be questioned and challenged if planning, response, and recovery not timely and effective.

Hazard Summary by Jurisdiction

The rural jurisdictions in the planning area are all surrounded by undeveloped agricultural land and face the possibility of a wildfire. The school districts are located in a rural area and do not face danger of wildfire due to barriers in place around the school. As long as drought conditions are not seriously inflamed, future wildfires in Macon County should have a negligible adverse impact on the community, as it would affect a small percentage of the population. Nonetheless, homes and businesses located in unincorporated areas are at higher risk from wildfires due to proximity to wood and distance from fire services. Variations in both structural/urban and wildfires are not able to be determined at this time due to lack of data. However, both fire types are expected to occur on an annual basis across the county.

Problem Statement

Residents do not comply with burn bans, education is not available for the levels of burn bans, many residents lack education in fire safety and not all residents utilize social media and texting. Education needs to occur on the dangers associated with not complying with the burn bans, more education for fire safety and encourage utilization of social media and texting. Due to Macon County's high drought rating, they may be more susceptible to fires.