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.

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.

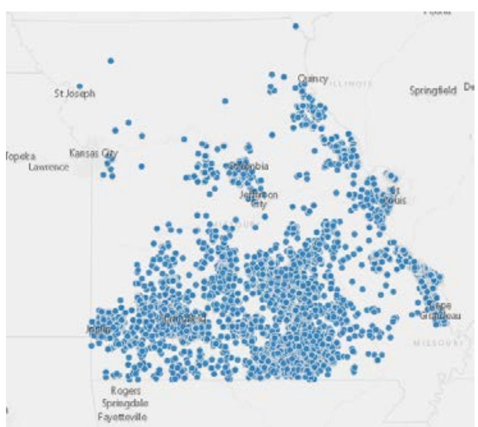
Natural hazards can be complex, occurring with a wide range of intensities. Some events are instantaneous and offer no window of warning, such as earthquakes. Some offer a short warning in which to alert the public to take actions, such as tornadoes or severe thunderstorms. Others occur less frequently 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-caused 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-jurisdiction Hazard Mitigation Plan dated 2018 and Lewis County, Canton, Ewing, LaBelle, LaGrange, Lewistown, Monticello, Canton R-V School District, Lewis County C-1 School District participated in the multi-jurisdictional county-wide plan. The 2018 Hazard Mitigation Plan was consulted in development of the risk assessment and information included and updated where appropriate.

Landslides and Land Subsidence/Sinkholes, according to the USGS website, are not likely to occur in Lewis County due to the type of soil and substructure in Northern Missouri. A map composed with data from MoDNR (below) highlights the point.



Sinkholes in Missouri 2018, https://data-msdis.opendata.arcgis.com/datasets/mo-2018-sinkholes/explore?location=38.500734%2C-89.264371%2C6.90

The MPC decided to include only natural hazards and public health risks. 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.

3.1.2 Review Disaster Declaration History

Declarations 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 Provides the FEMA Disaster Declarations that included Lewis County, Missouri from 1965 to present.

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

Disaster Number	Description	Declaration Date Incident Period	Individual Assistance (IA) Public Assistance (PA)
198	Floods	6/14/1965	NA
372	Heavy Rains, Tornadoes, Flooding	4/19/1973	IA,PA
407	Severe Storms, Flooding	11/1/1973	IA,PA
779	Severe Storms, Flooding	10/14/1986	PA
995	Severe Storms, Flooding	7/9/1993	IA,PA
1054	Severe Storm, Tornadoes, Hail, Flooding	6/2/1995	IA
1412	Severe Storm, Tornadoes & Flooding	5/6/2002	PA
1403	Severe Winter Ice Storm	2/6/2002	IA,PA
1463	Severe Storm, Tornadoes & Flooding	5/6/2003	IA,PA
3232	Hurricane	9/10/2005	NA
3281	Severe Winter Storm	12/12/2007	PA
1773	Severe Storms & Flooding	6/25/2008	IA,PA
1809	Severe Storms, Flooding & Tornado	11/13/2008	IA,PA
1847	Severe Storms, Flooding & Tornado	6/19/2009	PA
3303	Severe Winter Storm	1/30/2009	NA
1934	Severe Storms, Flooding & Tornado	8/17/2010	PA
3325	Flooding	6/30/2011	NA
3317	Severe Winter Storm	2/3/2011	NA

1961	Severe Winter Storm & Snowstorm	3/23/2011	PA
4130	Severe Storms, Straight-Line Winds, Tornado & Flooding	7/18/2013	PA
4200	Severe Storms, Straight-Line Winds, Tornado & Flooding	10/31/2014	PA
4238	Severe Storms, Straight-Line Winds, Tornado & Flooding	8/7/2015	PA
3374	Severe Storms, Straight-Line Winds, Tornado & Flooding	1/2/2016	NA
4451	Severe Storms, Tornadoes & Flooding	7/9/2019	IA,PA
3482	COVID	3/13/2020	NA
4490	COVID-19 Pandemic	3/26/2020	NA

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

3.1.3 Research Additional Sources

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

- Missouri Hazard Mitigation Plans (2010, 2013, and 2018)
- Previously approved planning area Hazard Mitigation Plan (2018)
- Federal Emergency Management Agency (FEMA)
- Missouri Department of Natural Resources
- 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 Centers for Environmental Information (NCEI);
- 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 Lewis 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	Fire / Wildfire	Flooding (River and Flash)	Levee Failure	Severe Winter Weather	Thunderstorm/Lightning/Hail/ High Wind	Tornado
Lewis County	X	X	X	X	X	X	X	X	X	X
City of Canton	-	X	X	X	-	X	X	X	X	X
City of Ewing	X	X	X	X	-	-	-	X	X	X
City of La Belle	-	X	X	X	-	-	-	X	X	X
City of La Grange	-	X	X	X	-	X	X	X	X	X
City of Lewistown	-	X	X	X	-	-	-	X	X	X
City of Monticello	-	X	X	X	-	-	-	X	X	X
Lewis County C-1 School	-	X	X	X	-	-	-	X	X	X
Canton School District	-	X	X	X	-	X	X	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. Canton is slightly more urbanized within the planning area and has 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, levee failure, river flood, and flash flood. 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 developed by the State of Missouri Geographic Information Systems (GIS) database. This data, organized by County, is available on Google Drive through the link provided on the previous page. 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 3.4** that follows provides the building value exposures for the county and each city in the planning area broken down by usage type. Finally, **Table 3.5** 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	2021 Annual Population Estimate	Building Count	Building Exposure ($)	Contents Exposure ($)	Total Exposure ($)
Canton	2,774	2,114	$164,013	$96,296	$260,309
Ewing	406	542	$35,708	$20,111	$55,819
La Belle	664	407	$27,902	$16,381	$44,283
La Grange	825	867	$58,680	$34,105	$92,785
Lewistown	521	332	$23,745	$14,262	$38,007
Monticello	104	200	$8,986	$5,016	$14,002
Lewis County	10,032	16,102	$309,091	$155,601	$464,692
Totals	**10,032**	**20,564**	**$628,153**	**$341,772**	**$969,896**

Source: U.S. Bureau of the Census, Annual population estimates/ 5-Year American Community Survey 2021; 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
Canton	$122,245	$22,144	$7,489	$89	$152,967
Ewing	$30,986	$4,212	$0	$105	$35,303
La Belle	$23,460	$3,645	$535	$59	$27,699
La Grange	$51,643	$3,807	$2,782	$144	$58,376
Lewistown	$19,550	$3,321	$642	$29	$23,542
Monticello	$7,156	$1,134	$0	$135	$8,425
Unincorporated Lewis Co.	$268,173	$13,203	$5,135	$19,409	$305,920
Totals	**$523,213**	**$51,466**	**$16,583**	**$19,970**	**$612,232**

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
Canton	1,657	273	70	56	2,056
Ewing	420	52	0	66	538
La Belle	318	45	5	37	405
La Grange	700	47	26	91	864
Lewistown	265	41	6	18	330
Monticello	97	14	0	85	196
Unincorporated Lewis Co.	3,635	163	48	12,240	16,086
Totals	**7,092**	**635**	**155**	**12,593**	**20,475**

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

The number of enrolled students at the participating public-school districts is provided in **Table 3.6** 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	Enrolment	Building Count	Total Exposure ($)
Lewis County C-1 School	918	2	$44,901,605
Canton School District	501	2	$86,862,950

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:

- NEMO RPC critical facility inventory

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
Lewis County	X		X	X				X	X		X			X				X						
Canton				X			X	X	X					X	X	X		X				X	X	
Ewing				X			X	X	X					X								X	X	
La Belle				X			X	X	X					X	X							X	X	
La Grange				X			X	X	X					X		X	X	X					X	
Lewistown				X			X	X	X					X	X								X	
Monticello				X				X	X					X									X	
Totals																								

Source: Data Collection Questionnaires, NEMO RPC Inventory List.

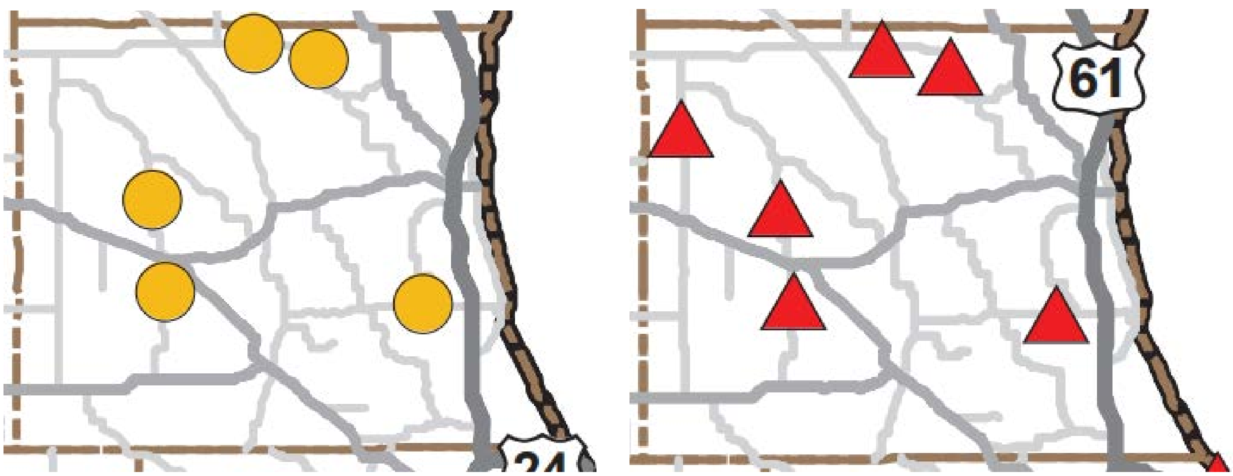
Bridges: The term “scour critical” refers to one of the database elements in the National Bridge Inventory. This element is quantified using a “scour index”, which is a number indicating the vulnerability of a bridge to scour during a flood. Bridges with a scour index between 1 and 3 are considered “scour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

Figure 3.1. Lewis County Bridges

Missouri								
County	Bridge Counts				Bridge Area (Square Meters)			
	All	Good	Fair	Poor	All	Good	Fair	Poor
Lewis (111)	169	48	107	14	40,911	17,519	20,268	3,124

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

Figure 3.2. Lewis County Structurally Deficient Bridges



Weight Restricted Bridges | Poor Condition Bridges

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.

Table 3.8. Threatened and Endangered Species in Lewis County

Common Name	Scientific Name	Status
Gray Bat	Myotis Grisescens	Endangered
Indiana Bat	Myotis Sodalis	Endangered
Northern Long-eared Bat	Myotis Septentrionalis	Threatened
Pallid Sturgeon	Scaphirhynchus albus	Endangered
Higgins Eye (pearlymussel)	Lampsilis higginsii	Endangered
Sheepnose Mussel	Plethobasus cyphyus	Endangered
Spectaclecase (Mussel)	Cumberlandia monodonta	Endangered
Eastern Prairie Fringed Orchid	Platanthera leucophaea	Endangered

Source: U.S. Fish and Wildlife Service, http://www.fws.gov/midwest/Endangered/lists/missouri-cty.html; see also https://ecos.fws.gov/ipac/ and select 'Get Started" > Step '1 Find Location', choose select by state or county and enter the county name, selecting the appropriate community > follow remaining on-screen instructions.

Natural Resources: Lewis County has six conservation and recreational areas. The Missouri Department of Conservation (MDC) provides a database of lands the MDC owns, leases, or manages for public use. Use **Table 3.9** to provide the names and locations of parks and conservation areas in the planning area.

Table 3.9. Parks in Lewis County

Park / Conservation Area	Address	City
Wakonda State Park	32836 State Park Road	La Grange
Martin Park	Hwy 136 and MO-81	Canton
Central Park	S 5th St	Canton
Ewing Community Park	205 E Main St	Ewing
Monticello Park	Benton St	Monticello
Johnson Park	5th & Main St	La Belle

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. Lewis County Properties on the National Register of Historic Places

Property	Address	City	Date Listed
First Presbyterian Church	401 Jefferson	La Grange	8/28/2012
Williams Gray House	407 Washington	La Grange	6/3/1999
Dr J.A. Hay House	406 W Monroe	La Grange	6/3/1999
Henderson Hall	College Hill	Canton	10/2/1978
Joseph Hipkins House	500 S 3rd St	La Grange	5/8/2008
Lewis County Courthouse	100 E Lafayette St	Monticello	1/12/2005
Lincoln School	MO B	Canton	2/10/1983
Lock & Dam No 20 Historic District	North of Henderson St	Canton	3/10/2004
John McKoon House	500 W Monroe	La Grange	6/3/1999

Quincy, Missouri & Pacific Railroad Station	Off MO 16	Lewistown	5/7/1979
Freda Rhoda House	200 S Second St	La Grange	6/3/1999
A.C. Waltman House	302 Lewis St	La Grange	6/3/1999

Source: Missouri Department of Natural Resources – Missouri National Register Listings by County
http://dnr.mo.gov/shpo/mnrlist.htm

Economic Resources: The table below shows the major non-government employers in the planning area (**Table 3.11**).

Table 3.11. Major Non-Government Employers in Lewis County

Employer Name	Main Locations	Product or Service	Employees
Ayerco	Canton	Truck Stops	49
Mark Twain Casino	Lagrange	Casino	250
Charles Industries	Canton	Manufacturing	100

Source: Data Collection Questionnaires; MoDED

Agriculture The table below shows agriculture-related jobs in the Lewis County economy. **(Table 3.12)**

Table 3.12. Agriculture-Related Jobs in Lewis County

Item		Lewis
Hired farm labor	farms	141
	workers	355
	$1,000 payroll	3,578
Farms with-		
1 worker	farms	78
	workers	78
2 workers	farms	35
	workers	70
3 or 4 workers	farms	21
	workers	77
5 to 9 workers	farms	5
	workers	(D)
10 workers or more	farms	2
	workers	(D)
Workers by days worked:		
150 days or more	farms	61
	workers	144
Farms with-		
1 worker	farms	34
	workers	34
2 workers	farms	16
	workers	32
3 or 4 workers	farms	6
	workers	(D)
5 to 9 workers	farms	4
	workers	26
10 workers or more	farms	1
	workers	(D)
Less than 150 days	farms	106
	workers	211
Farms with-		
1 worker	farms	66
	workers	66
2 workers	farms	31
	workers	62
3 or 4 workers	farms	6
	workers	21
5 to 9 workers	farms	1
	workers	(D)
10 workers or more	farms	2
	workers	(D)
Reported only workers working 150 days or more	farms	35
	workers	62
	$1,000 payroll	964
Reported only workers working less than 150 days	farms	80
	workers	113
	$1,000 payroll	263
Reported both - workers working 150 days or more and workers working less than 150 days	farms	26
	150 days or more, workers	82
	less than 150 days, workers	98
	$1,000 payroll	2,351
Total migrant workers	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	farms	276
	workers	673

SOURCE:
HTTPS://WWW.NASS.USDA.GOV/PUBLICATIONS/AGCENSUS/2017/FULL_REPORT/VOLUME_1,_CHAPTER_2_COUNTY_LEVEL/MISSOURI/ST29_2_0007_0007.PDF

3.3 Land Use and Development

3.3.1 Development Since Previous Plan Update

Population data can sometimes be used to determine the potential for future development. An increase in population will spur a need for additional housing and attract commercial development. As indicated by the information in **Table 3.13** Lewis County has experienced a slight decrease in population.

Table 3.13. County Population Growth, 2010-2020

Jurisdiction	Total Population 2010	Total Population 2020	2010-2020 # Change	2010-2020 % Change
Lewis County	10,211	10,032	-179	-1.75%
Canton	2377	2,774	397	16.7%
Ewing	456	406	-50	-10.96%
La Belle	660	631	31	4.69%
La Grange	931	892	-39	-4.18%
Lewistown	546	522	-24	-4.39%
Monticello	98	104	6	6.12%

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. The cities of Canton, La Belle, La Grange & Lewistown all showed an increase in housing with Ewing, & Monticello reflecting a decline. Overall, there has been an increase in housing in Lewis County of 1.17% as shown in **Table 3.13.**

Table 3.14. Change in Housing Units, 2010-2020

Jurisdiction	Housing Units 2010	Housing Units 2020	2010-2020 # Change	2000-2020 % Change
Lewis County	4,584	4,544	-40	0.8%
Canton	954	978	28	2.93%
Ewing	252	194	-58	-23.01%
La Belle	214	336	122	57%
La Grange	194	318	124	63.99%
Lewistown	214	264	50	23.36%
Monticello	192	65	-127	-66.14%

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

3.3.2 Future Land Use and Development

School District's Future Development

Both School districts have completed renovations and but are not anticipating any future development. Canton R-V plans some building additions on the current campus.

Special District's Future Development

There were no Special districts indicating 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.

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:** In addition to the probability of future occurrence, changing future conditions should also be considered, including the effects of long-term changes in weather patterns and climate on the identified hazards

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 Lewis 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.

- **Vulnerability Overview:**
  The plan must provide an overall summary of each jurisdiction's vulnerability to the identified hazards. The overall summary of vulnerability identifies structures, systems, populations or other community assets as defined by the community that are susceptible to damage and loss for hazard events.

- **Potential Losses to Existing Development:**
  (Including types and numbers, of buildings, critical facilities, etc.) For each participating jurisdiction, the plan must describe the potential impacts of the hazard. Impact means the consequences of effect of the hazard on the jurisdiction and its assets. Assets are determined by the community and include, for example, people, structures, facilities, systems, capabilities, and/or activities that have value to the community. For example, impacts could be described by referencing historical disaster impacts and/or an estimate of potential future losses.

- **Previous and Future Development:**
  This section will include information on how changes in development have impacted the community's vulnerability to this hazard. Describe how any changes in development that occurred in known hazard prone areas since the previous plan have increased or decreased the community's vulnerability. Describe any anticipated future development in the county, and how that would impact hazard risk in the planning area.

- **Hazard Summary by Jurisdiction:**
  For hazard risks that vary by jurisdiction, this section will provide an overview of the variation and the factual basis for that variation.

Problem Statements

Each hazard analysis must conclude with a brief summary of the problems created by the hazard in the planning area, and possible ways to resolve those problems. Include jurisdiction-specific information in those cases where the risk varies across the planning area.

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.

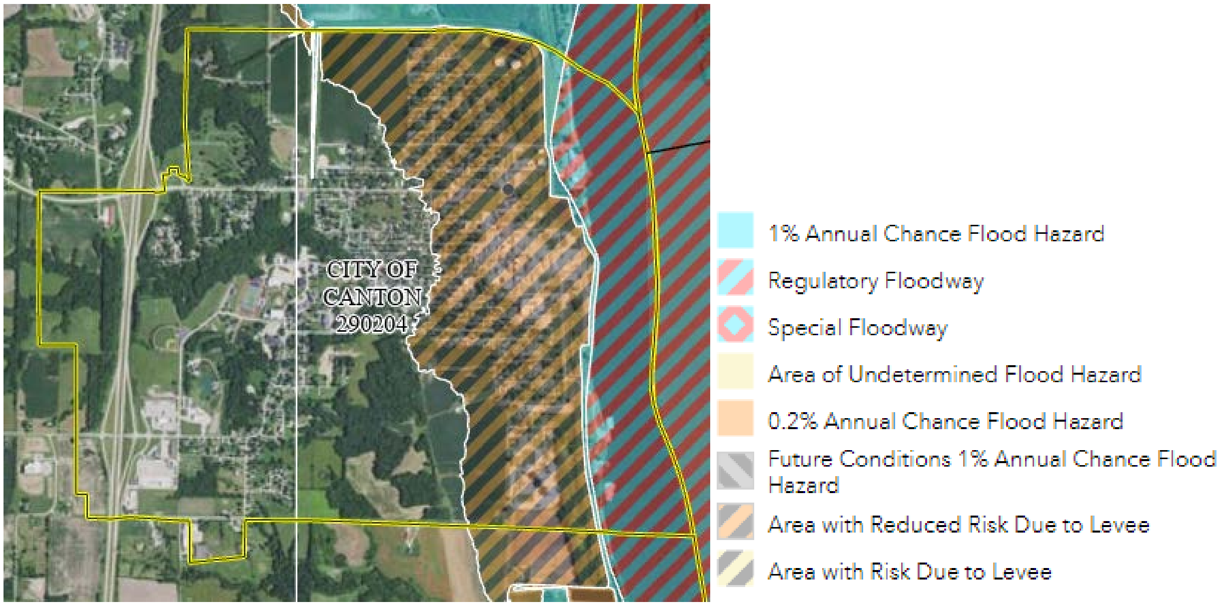
In certain areas, aging storm sewer systems are not designed to carry the capacity currently needed to handle the increased storm runoff. Typically, the result is water backing into basements, which damages mechanical systems and can create serious public health and safety concerns. This combined with 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.

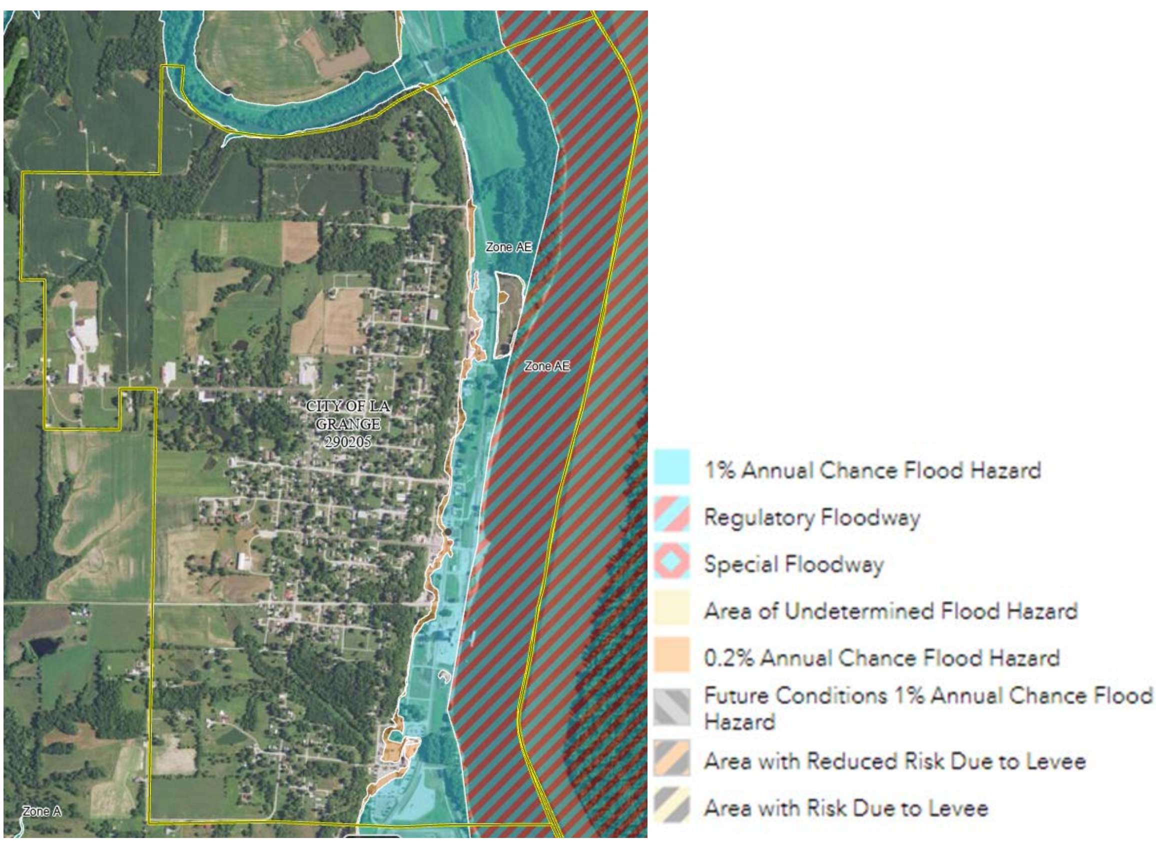
Geographic Location

Riverine flooding is most likely to occur in Special Flood Hazard Areas (SFHA's). Flood Plain maps of the 3 communities with SFHA's within their jurisdiction you will find below. LaBelle, Lewistown, and Ewing do not have SFHA's within their jurisdictions. Tables **3.15** and **3.16** shows Lewis County's flood history using a 20-year time frame for previous events.

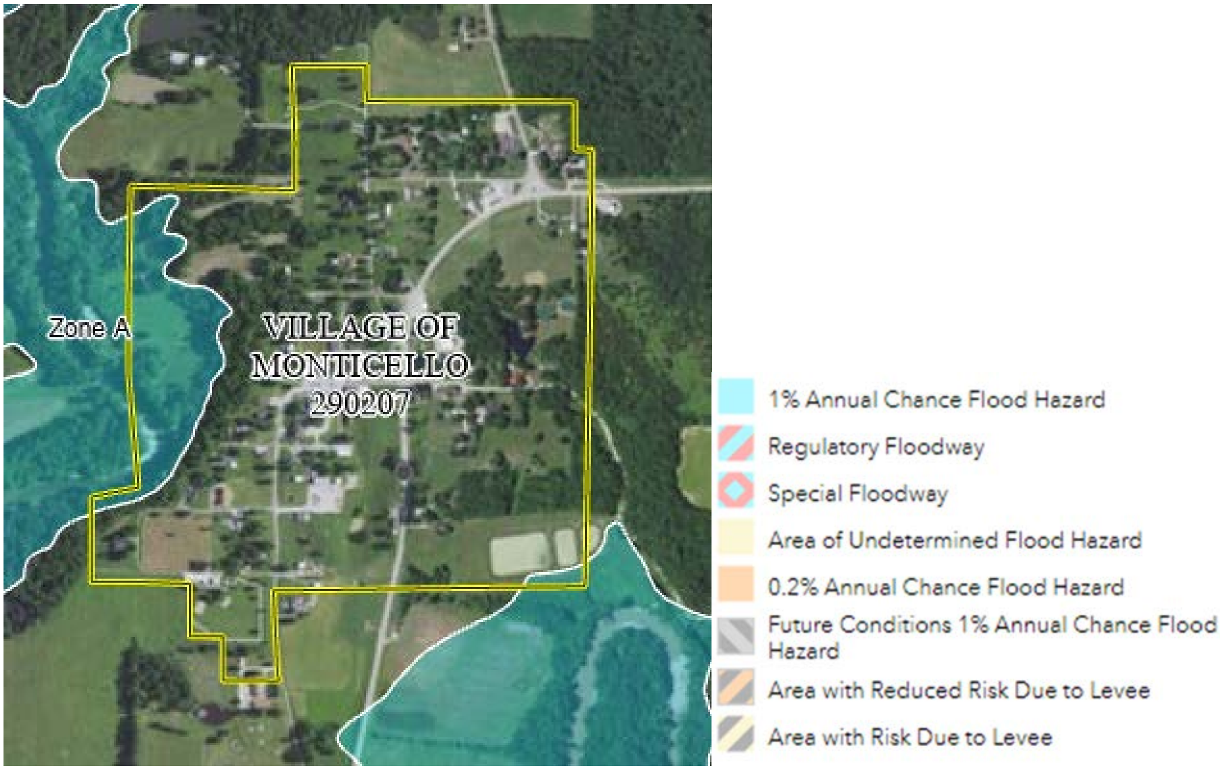
City of Canton Flood Hazard Map



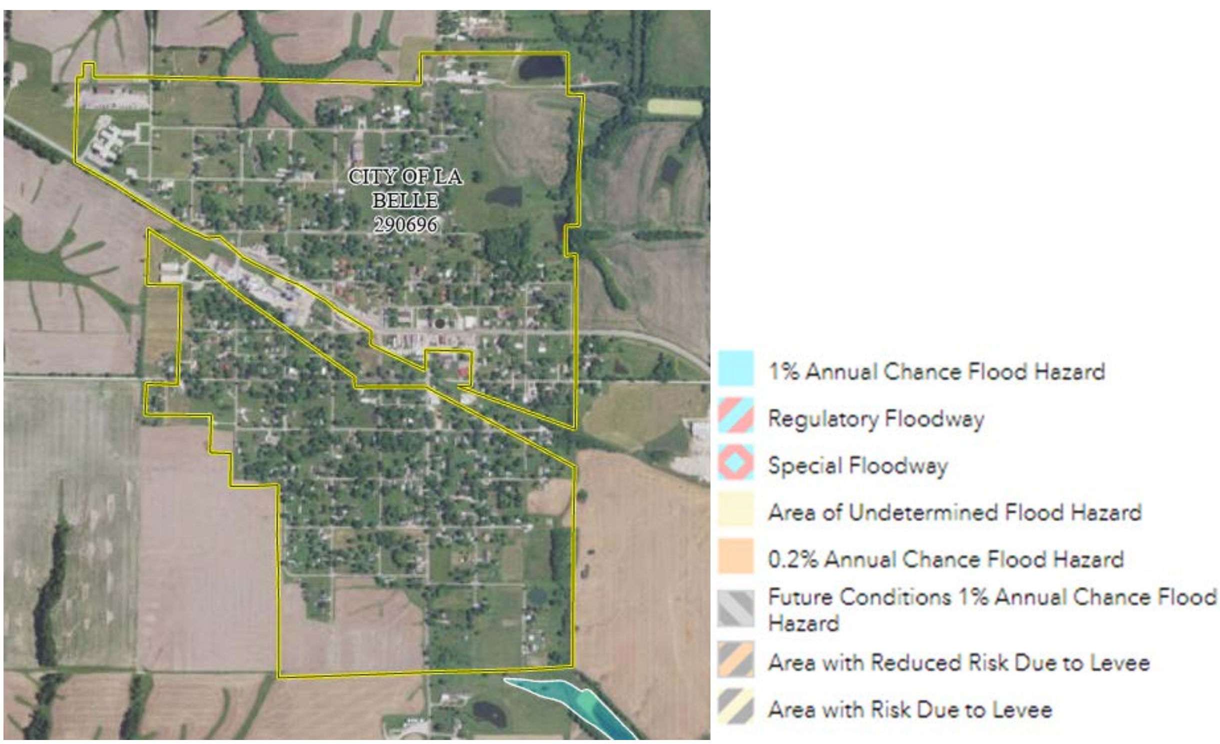
LaGrange Flood Hazard Map



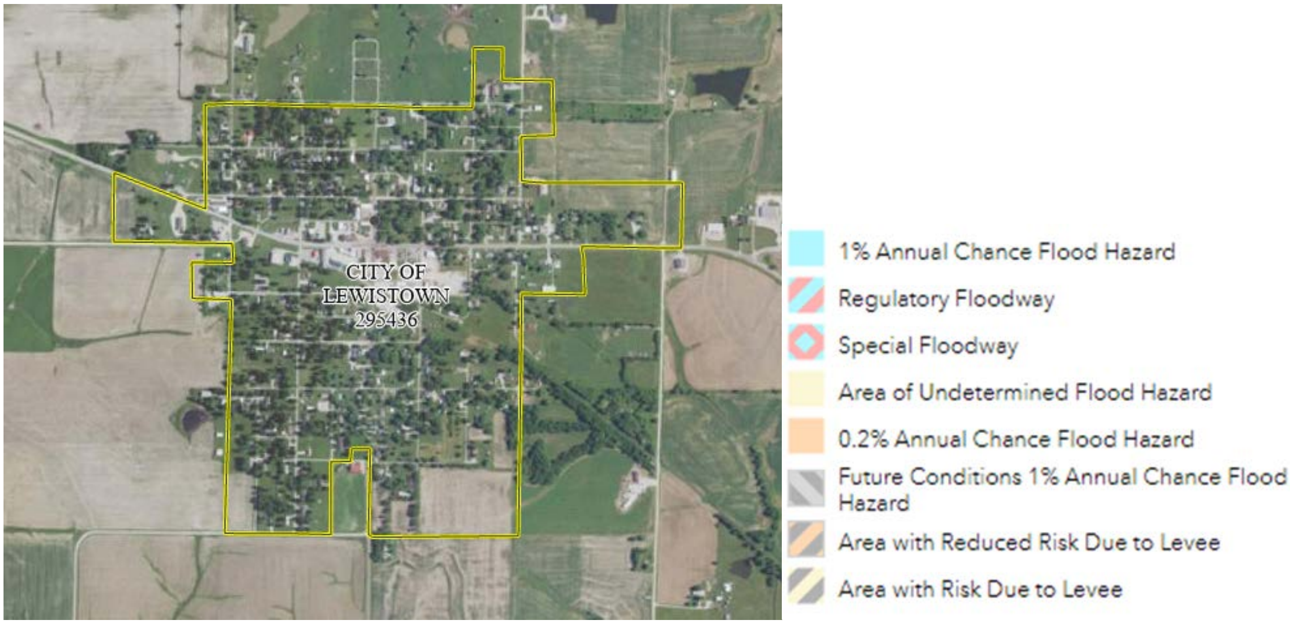
Monticello Flood Hazard Map



LaBelle Flood Hazard Map



Lewistown Flood Hazard Map



Ewing Flood Hazard Map

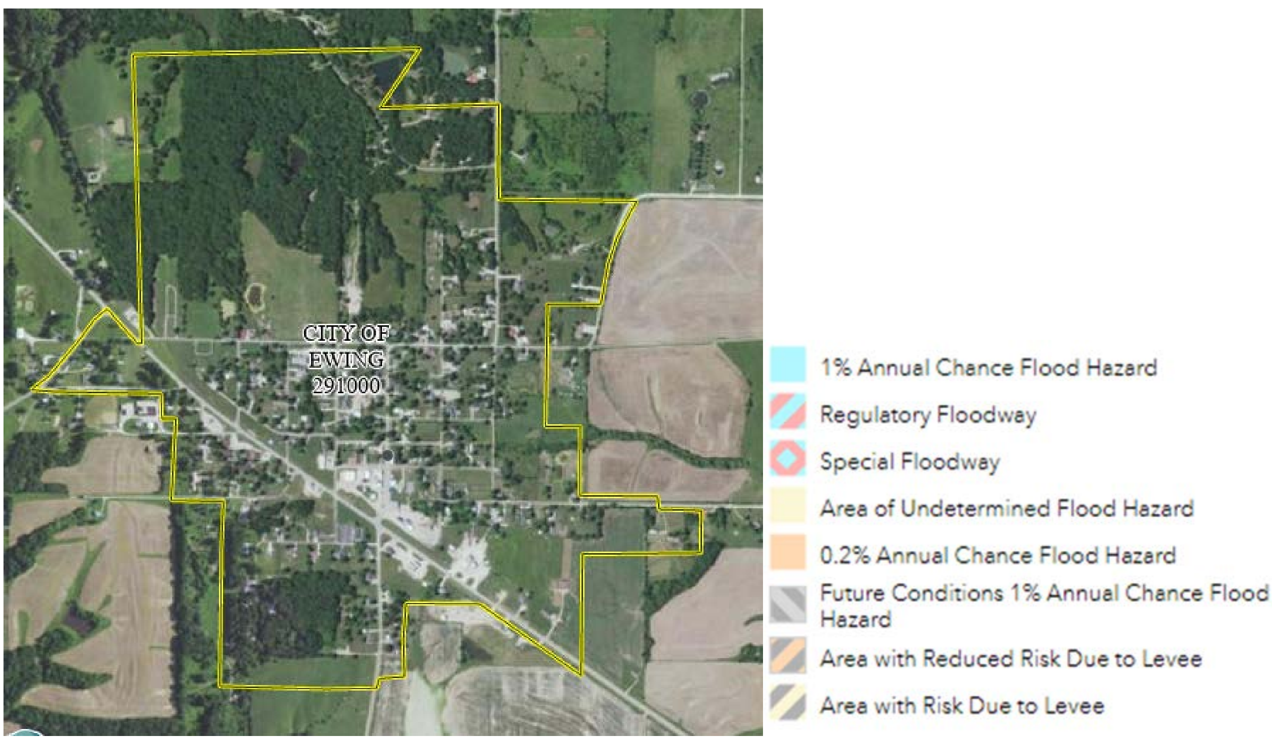


Table 3.15. Lewis County NCEI Flood Events by Location, 2002-2022

Location	# of Events
Unincorporated County	9
-Unincorporated County (unspecified)- 4 flood events	
-Unincorporated County (Fenway)- 3 flood events	
-Unincorporated County (Derrahs)- 1 flood events	
-Unincorporated County (Maywood)- 1 flood events	
Canton	1
Monticello	3

Source: National Centers for Environmental Information, 01/15/2023

Flash flooding occurs in SFHAs and those locations in the planned area that are low-lying. They also occur in areas without adequate drainage to carry away the amount of water that falls during intense rainfall events.

Table 3.16 shows the number of flash flood events by location recorded by NCEI for the 20-year period.

Table 3.16. Lewis County NCEI Flash Flood Events by Location, 2002-2022

Location	# of Events
Unincorporated County	18
-Unincorporated County (unspecified)- 4 flash flood events	
-Unincorporated County (Deer Ridge)- 7 flash flood events	
-Unincorporated County (Benjamin)- 1 flash flood events	
-Unincorporated County (Steffenville)- 1 flash flood events	
-Unincorporated County (Fenway)- 5 flash flood events	
Ewing	1
La Grange	2
La Belle	2

Source: National Centers for Environmental Information, 01/15/2023

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 details with the number of policies in force, amount of insurance in force, number of closed losses, and total payments for each jurisdiction, where applicable

Table 3.17. NFIP Participation in Lewis County

Community ID #	Community Name	NFIP Participant (Y/N/Sanctioned)	Current Effective Map Date	Regular-Emergency Program Entry Date
2908448	Lewis County	Y	01/16/15	09/01/89
2902048	Canton	Y	01/16/15	02/01/77
290205	La Grange	Y	03/02/12	07/13/76

Source: NFIP Community Status Book, 01/15/23; 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

Lewis County, Canton, and LaGrange a floodplain administrator regulates the continued compliance with the National Flood Insurance Program. Although the Village of Monticello is mapped, they are not participating in the National Flood Insurance Program. Monticello has not participated for several reasons including lack of staffing, local buy-in, and all 1% flood risk areas are in areas where there will never be development.

Lewis County and the jurisdictional floodplain administrators will continue to draft ordinances to enact regarding substantial damage and substantial improvement provisions following a flood event.

Table 3.18. NFIP Policy and Claim Statistics as of Date

Community Name	Policies in Force	Insurance in Force	Closed Losses	Total Payments
Lewis County	13	2,560,600	11	190,824.44
Canton	105	26,847,000	26	316,881.16
La Grange	19	2,560,600	67	1,347,366.65

Source: NFIP Community Status Book, 1/15/23; BureauNet, http://bsa.nfipstat.fema.gov/reports/reports.html; *Closed Losses are those flood insurance claims that resulted in payment.

Repetitive Loss/Severe Repetitive Loss Properties

Repetitive Loss Properties are those properties with at least two flood insurance payments of $1,000 or more in a 10-year period. According to the Flood Insurance Administration, jurisdictions included in the planning area have a combined total of 11 repetitive loss properties.

Table 3.19. Lewis County Repetitive Loss Properties

# of Properties	# of Losses	Total paid	Average Payment
11	35	$ 627,813.24	$ 17,937.52

Source: Flood Insurance Administration as of 2/10/2023

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.

Previous Occurrences

Disaster Number	Description	Declaration Date Incident Period	Individual Assistance (IA) Public Assistance (PA)
198	Floods	6/14/1965	NA
372	Heavy Rains, Tornadoes, Flooding	4/19/1973	IA,PA
407	Severe Storms, Flooding	11/1/1973	IA,PA
779	Severe Storms, Flooding	10/14/1986	PA
995	Severe Storms, Flooding	7/9/1993	IA,PA
1054	Severe Storm, Tornadoes, Hail, Flooding	6/2/1995	IA
1412	Severe Storm, Tornadoes & Flooding	5/6/2002	PA
1773	Severe Storms & Flooding	6/25/2008	IA,PA
1809	Severe Storms, Flooding & Tornado	11/13/2008	IA,PA
1847	Severe Storms, Flooding & Tornado	6/19/2009	PA
1934	Severe Storms, Flooding & Tornado	8/17/2010	PA
3325	Flooding	6/30/2011	NA
1934	Severe Storms, Flooding & Tornado	8/17/2010	PA
3325	Flooding	6/30/2011	NA
4130	Severe Storms, Straight-Line Winds, Tornado & Flooding	7/18/2013	PA
4200	Severe Storms, Straight-Line Winds, Tornado & Flooding	10/31/2014	PA
4238	Severe Storms, Straight-Line Winds, Tornado & Flooding	8/7/2015	PA
3374	Severe Storms, Straight-Line Winds, Tornado & Flooding	1/2/2016	NA
4451	Severe Storms, Tornadoes & Flooding	7/9/2019	IA,PA

Table 3.20. NCEI Lewis County Flash Flood Events Summary, 2003 to 2023

Year	# of Events	# of Deaths	# of Injuries	Property Damages	Crop Damages
2003	1	0	0	0	0
2004	1	0	0	0	0
2008	3	0	0	16.0k	0
2009	3	0	0	0	0
2010	1	0	0	0	0
2011	2	0	0	0	0
2013	1	0	0	0	0
2014	2	0	0	0	0
2015	4	1	0	0	0
2019	3	0	0	0	0

Source: NCEI, data accessed 2003-2023

Table 3.21. NCEI Lewis County Riverine Flood Events Summary, 2003 to 2023

Year	# of Events	# of Deaths	# of Injuries	Property Damages	Crop Damages
2007	1	0	0	0	0
2008	2	0	0	940.0K	8.9M
2010	2	1	0	0	0
2013	4	0	0	11.0K	75.0K

Source: NCEI, 2003-2023

On August 8th, 2007 Heavy rain upstream caused minor flooding on the Mississippi River from Northeast Missouri to just north of S. Louis. The river ranged from about 1 to 3 feet over flood stage with some areas still in flood when the month ended. Heavy rain upstream caused minor flooding on the Mississippi River. At Canton, the river peaked about 1.5 feet over flood stage.

On June 4th, 2008, The Mississippi River at Canton, MO crested at 27.73 feet on 6/18. This is the second highest crest ever recorded. A major sandbagging effort by the residents, the Missouri National Guard, and volunteers saved much of the town from flooding. Levee breaks upstream on the Illinois side also helped lower the crest, as initially, a record crest was expected. Further south, the town of LaGrange was not as lucky. At least 30 homes and 12 business were flooded. Damage to public infrastructure was estimated at $940,000. Agricultural damage was estimated at $8.9 million.

On July 8th, 2008, The Mississippi River crested at Canton, MO on July 1 at 20.95 ft. The river went below flood stage on July 8.

On June 14th, 2010, moderate flooding affected areas along the Mississippi River from mid-June through the end of the month. There was little damage other than some roads near the river being closed and some low-land farm fields flooded.

On April 18th 2013, Heavy rain pushed the North and Middle Fabius Rivers to major flood levels. Damage was limited to some closed roads and flooded farmland. The North Fabius River rose to major flood levels in Lewis County. The river crested on April 20th. Damage was limited to some closed roads and flooded farmland.

Probability of Future Occurrence

With the history of flooding in the planning area, it is likely that flooding of various levels will occur. The probability of a flash flood event occurring in the planning area in any given year is 50%. Although flood events occur in the planning area there is only a 20% probability 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. If these trends continue Canton, LaGrange, and Monticello could see larger impacts since located in specific flood hazard areas. This could also put jurisdictions that are not in specific flood hazard areas more at risk to flash flooding and the possibility of near SPHA's getting closer to jurisdictions.

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.

Potential Losses to Existing Development

The HAZUS-MH analysis provides the number of buildings impacted, estimates of building repair costs, and the associated loss of building contents and business inventory. Income loss data accounts for losses such as business interruption and rental income losses as well as the resources associated with damage repaid and job and housing losses. The displaced population is based on the inundation area.

Structural Damage	Contents Damage	Inventory Loss	Total Direct Loss	Total income Loss	Total Direct and income Loss	Calc Loss Ratio	Bldgs Risk	# substantially damaged
4,055,000	6,384,000	273,000	10,712,000	8,172,000	18,884,000	0.96%	15	1

Total of Displaced People	People with shelter needs
426	121

Impact of Previous and Future Development

Due to the prevalence of flooding, historically, development in Lewis County is highly regulated. Future development should not impact or be impacted by flash and riverine flooding, as such development will be located out of the flood plain, protected by levees, elevated, or otherwise flood proofed in some way to mitigate potential flooding impacts.

EMAP Consequence Analysis

For communities with emergency management programs seeking EMAP accreditation, complete Table 3.22 to summarize the detrimental impacts from flooding.

Table 3.22. 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

Flood risk is high in the eastern side of Lewis County (where the Mississippi river and its adjacent floodplain are located) and highest in those communities that lie along that area. Canton is protected by a levee which has held through recent historical floods, while La Grange has no such protection and has seen a portion of its downtown area swallowed by Mississippi floodwaters in 1993 and 2001, and 2008. Monticello has some slight flash flood risk, and flash flood is a risk at various points in the county, generally located in low lying areas near bridge crossings.

Problem Statement

Lewis County's location along the Mississippi river carries with it a risk of massive flooding, however, this is a risk that's been recognized and dealt with for many decades, and the most recent incidents of disastrous flooding in Missouri in 1993 and 1995 simply drove home the need for robust planning, mitigation, and response capabilities in Lewis County. While it is still possible that an unfortunate series of events could conspire to create flooding issues in Lewis County, the truth is that the County and the river side communities in it have spent decades and millions of local, State, and Federal dollars constructing the elaborate flood control structures along the Mississippi to protect lives and property. The Lock and Dam and levee systems have kept residents safe and will likely continue to do so for the foreseeable future. Tight regulation and oversight on development will ensure that growth in the industrial, commercial, and housing sectors doesn't increase vulnerability to flood impacts.

3.4.2 Levee Failure

Hazard Profile

Hazard Description

Levees are earth embankments constructed along rivers and coastlines to protect adjacent lands from flooding. Floodwalls are concrete structures, often components of levee systems, designed for urban areas where there is insufficient room for earthen levees. When levees and floodwalls and their appurtenant structures are stressed beyond their capabilities to withstand floods, levee failure can result in injuries and loss of life, as well as damages to property, the environment, and the economy.

Levees can be small agricultural levees that protect farmland from high-frequency flooding. Levees can also be larger, designed to protect people and property in larger urban areas from less frequent flooding events such as the 100-year and 500-year flood levels. For purposes of this discussion, levee failure will refer to both overtopping and breach as defined in FEMA's Publication "So You Live Behind a Levee" (http://mrcc.isws.illinois.edu/1913Flood/awareness/materials/SoYouLiveBehindLevee.pdf).

Following are the FEMA publication descriptions of different kinds of levee failure.

> **Overtopping: When a Flood Is Too Big**
>
> Overtopping occurs when floodwaters exceed the height of a levee and flow over its crown. As the water passes over the top, it may erode the levee, worsening the flooding and potentially causing an opening, or breach, in the levee.
>
> **Breaching: When a Levee Gives Way**
>
> A levee breach occurs when part of a levee gives way, creating an opening through which floodwaters may pass. A breach may occur gradually or suddenly. The most dangerous breaches happen quickly during periods of high water. The resulting torrent can quickly swamp a large area behind the failed levee with little or no warning.

Earthen levees can be damaged in several ways. For instance, strong river currents and waves can erode the surface. Debris and ice carried by floodwaters—and even large objects such as boats or barges—can collide with and gouge the levee. Trees growing on a levee can blow over, leaving a hole where the root wad and soil used to be. Burrowing animals can create holes that enable water to pass through a levee. If severe enough, any of these situations can lead to a zone of weakness that could cause a levee breach. In seismically active areas, earthquakes and ground shaking can cause a loss of soil strength, weakening a levee and possibly resulting in failure. Seismic activity can also cause levees to slide or slump, both of which can lead to failure.

Geographic Location

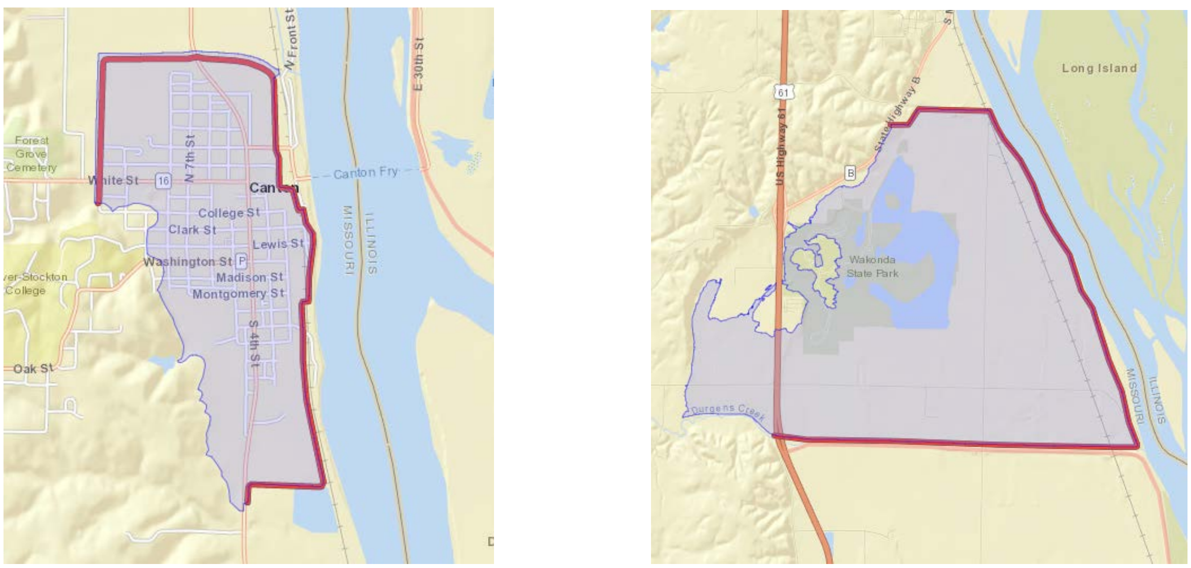
Missouri is a state with many levees. Currently, there is no single comprehensive inventory of levee systems in the state. Levees have been constructed across the state by public entities and private entities with varying levels of protection, inspection oversight, and maintenance. The lack of a comprehensive levee inventory is not unique to Missouri.

There are two concurrent nation-wide levee inventory development efforts, one led by the United State Army Corps of Engineers (USACE) and one led by Federal Emergency Management Agency (FEMA). The National Levee Database (NLD), developed by USACE, captures all USACE related levee projects, regardless of design levels of protection. The Midterm Levee Inventory (MLI), developed by FEMA, captures all levee data (USACE and non-USACE) but primarily focuses on levees that provide 1% annual-chance flood protection on FEMA Flood Insurance Rate Maps (FIRMs).

It is likely that agricultural levees and other non-regulated levees within the planning area exist that are not inventoried or inspected. These levees that are not designed to provide protection from the 1-percent annual chance flood would overtop or fail in the 1-percent annual chance flood scenario. Therefore, any associated losses would be taken into account in the loss estimates provided in the Flood Hazard Section.

For purposes of the levee failure profile and risk assessment, those levees indicated on the Preliminary DFIRM as providing protection from at least the 1-percent annual chance flood will be discussed and further analyzed. It is noted that increased discharges are being taken into account in revision of the flood maps as part of the RiskMap efforts. This may result in changes to the flood protection level that existing levees are certified as providing.

Figure 3.3. County Levees Shown on DFIRM as Providing Protection from the 1-Percent Annual Chance Flood



Source: National Levee Database, 1/15/2023

Strength/Magnitude/Extent

Levee failure is typically an additional or secondary impact of another disaster such as flooding or earthquake. The main difference between levee failure and losses associated with riverine flooding is magnitude. Levee failure often occurs during a flood event, causing destruction in addition to what would have been caused by flooding alone. In addition, there would be an increased potential for loss of life due to the speed of onset and greater depth, extent, and velocity of flooding due to levee breach.

As previously mentioned, agricultural levees and levees that are not designed to provide flood protection from at least the 1-percent annual chance flood likely do exist in the planning area. However, none of these levees are shown on the Preliminary DFIRM, nor are they enrolled in the USACE Levee Safety Program. As a result, an inventory of these types of levees is not available for analysis. Additionally, since these types of levees do not provide protection from the 1-percent annual chance flood, losses associated with overtopping or failure are captured in the Flood Section of this plan.

Previous Occurrences

A great historical flood in Lewis County in 1929 was caused by a levee break. Within an hour of the break two square miles of the town of Canton and surrounding countryside were underwater, including more than 200 homes and the Canton school building were lost, but miraculously there were no recorded casualties. Periodic flooding of the downtown Canton area happened again after World War II, but was largely ended by construction of a bigger and stronger levee in the 1960s. Due to the new levee the Mississippi Flood of 1973, the Great Flood of 1993 and the June 2008 Midwest floods left Canton with far less damage than previous events and spared the town from the fates of other river towns. Downstream, the City of La Grange lacks the protection of any levee system and for that reason has experienced more frequent flooding, seeing a portion of its downtown area swallowed by floodwater in 1993 and 2001, and 2008.

Probability of Future Occurrence

The lack of a centralized database for Missouri levees and no records of previous levee failure events in Lewis County render it impossible to accurately calculate probability. The probability of levee failure increases with the severity of the flooding that typically causes levee failure and any decrease in inspection and maintenance.

Changing Future Conditions Considerations

The impact of changing future conditions on levee failure will most likely be related to changes in precipitation and flood likelihood. Climate change projections suggest that precipitation may increase and occur in more extreme events, which may increase risk of flooding, putting stress on levees and increasing likelihood of levee failure.

<u>Vulnerability</u>

Vulnerability Overview

The USACE regularly inspects levees within its Levee Safety Program to monitor their overall condition, identify deficiencies, verify that maintenance is taking place, determine eligibility for federal rehabilitation assistance (in accordance with P.L. 84-99), and provide information about the levees on which the public relies. Inspection information also contributes to effective risk assessments and supports levee accreditation decisions for the National Flood Insurance Program administered by the Federal Emergency Management Agency (FEMA).

The USACE now conducts two types of levee inspections. Routine Inspection is a visual inspection to verify and rate levee system operation and maintenance. It is typically conducted each year for all levees in the USACE Levee Safety Program. Periodic Inspection is a comprehensive inspection led by a professional engineer and conducted by a USACE multidisciplinary team that includes the levee sponsor. The USACE typically conducts this inspection every five years on the federally authorized levees in the USACE Levee Safety Program.

Both Routine and Periodic Inspections result in a rating for operation and maintenance. Each levee segment receives an overall segment inspection rating of Acceptable, Minimally Acceptable, or Unacceptable. **Figure 3.4** below defines the three ratings.

Figure 3.4. Definitions of the Three Levee System Ratings

Levee System Inspection Ratings	
Acceptable	All inspection items are rated as Acceptable.
Minimally Acceptable	One or more levee segment inspection items are rated as Minimally Acceptable or one or more items are rated as Unacceptable and an engineering determination concludes that the Unacceptable inspection items would not prevent the segment/system from performing as intended during the next flood event.
Unacceptable	One or more levee segment inspection items are rated as Unacceptable and would prevent the segment/system from performing as intended, or a serious deficiency noted in past inspections (previous Unacceptable items in a Minimally Acceptable overall rating) has not been corrected within the established timeframe, not to exceed two years.

There are no levees in the planning area rated as unacceptable.

Potential Losses to Existing Development

Losses to significantly built-up areas seem to be limited to the downtown area of Canton, on the city's east side directly adjacent to the river.

Impact of Previous and Future Development

Development is strictly regulated due to the decades-long history of flooding along the Mississippi river.

EMAP Consequence Analysis

For communities with emergency management programs seeking EMAP accreditation, complete Table 3.23 to summarize the detrimental impacts from levee failure.

Table 3.23. EMAP Impact Analysis: Levee 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.
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 adversely affect confidence in local, state, and federal government, regardless of the levee owner.

Hazard Summary by Jurisdiction

The only community protected by a levee in Lewis County is the City of Canton, which has remained relatively unscathed since the initial construction of the current levee system in the 1960s.

Problem Statement

Currently the levee systems in place in Lewis County seem to be functioning properly and have protected their assigned areas in the face of even severe flooding, evidenced in the differences between the flooding history of the City of Canton, which has a levee, and its downstream neighbor LaGrange which does not. LaGrange will continue to experience flood issues until it, too, is protected by a levee structure similar to the one surrounding the City of Canton. In the absence of a levee structure, the systematic relocation of homes and businesses out of the floodplain area immediately adjacent to the river is the only way to mitigate future damages.

3.4.3 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.

Data on Dams in Lewis County has been drawn from two sources; a listing maintained by the Missouri Department of Natural Resources (MoDNR) and the Army Corps of Engineers' National Inventory of Dams (NID). Each has its own system of classifying dams. Neither the MDNR nor the NID hazard potential classification references the condition of the dam

Table 3.24. 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 3.25. 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

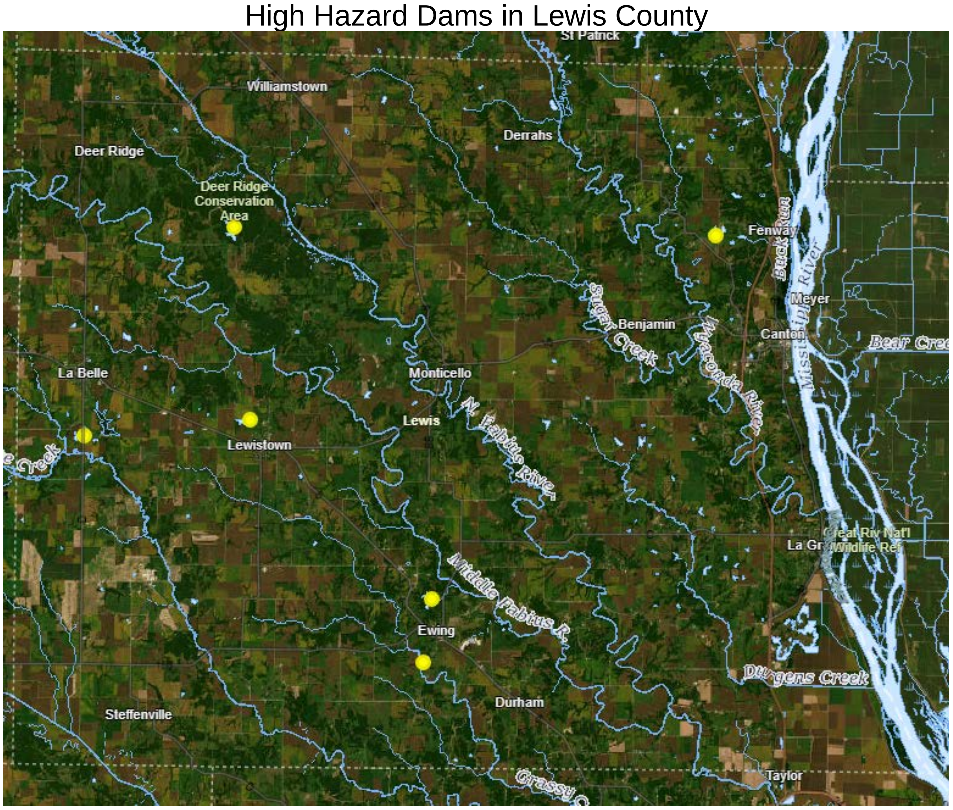
Table 3.26. High Hazard Dams in the Lewis County Planning Area

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
Ewing Lake Dam	Yes	39	881	5/12/2015	TR-MIDDLE FABIUS RIVER	Taylor	16	Private
City of Lewistown Dam	No	25	468	NA	TR-MIDDLE FABIUS RIVER	Taylor	20	City of Lewistown
Deer Ridge Community Lake Dam	Yes	38	608	7/13/2016	TR-NORTH FABIUS RIVER	MONTICELLO	8	Mo Dept. of Conservation
LaBelle Old City Lake Dam	Yes	35	339	5/31/2011	TR TROUBLESOME CREEK	STEFFENVILLE	11	City of LaBelle
Buck-Doe Run Watershed Structure #27a	Not Required	27	144	NA	ARTESIAN BRANCH	Canton	3	BUCK DOE RUN WSD SUBDST
Klocke Lake Dam	Not Required	18	67	NA	TR-GRASSY CREEK	Hannibal	25	RICHARD KLOCKE

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. Contact the MoDNR Dam and Reservoir Safety Program at 800-361-4827 to request the inundation maps for your county to show geographic locations at risk, extent of failure and to perform GIS analysis of those assets at risk to dam failure.

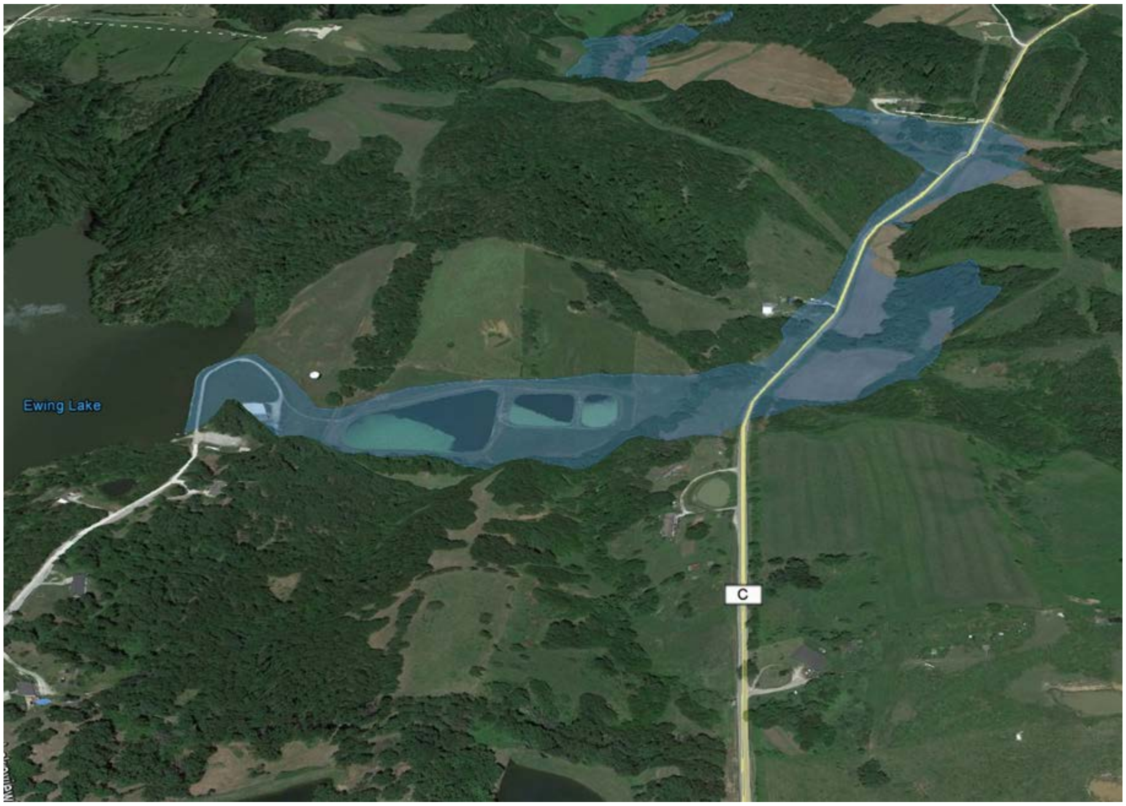
Figure 3.5. High Hazard Dam Locations in Lewis County and Areas Impacted in the Event of Breach.

High Hazard Dams in Lewis County



Source: U.S. Army Corps of Engineers

Ewing Lake Dam Inundation Area



Deer Ridge Community Lake Dam Inundation Area

La Belle Old City Lake Dam Inundation Area

Buck-Doe Run Watershed Structure #27a Inundation Area

City of Lewistown Dam Inundation Area

Klocke Lake Dam Inundation Area

Upstream Dams Outside the Planning Area

Upstream dams that could affect Lewis County are related to flood control on the Mississippi River. Failure on the part of Lock and Dam infrastructure upstream or a decision by the Army Corps to release increased amounts of water into the Mississippi River from flood control reservoirs could create issues along the river which forms the eastern border of Lewis County.

Figure 3.6. Upstream Dams Outside Lewis County

Source: U.S. Army Corps of Engineers, Missouri Department of Natural Resources

Strength/Magnitude/Extent

None of the high hazard dams in Lewis County appear to have inundation areas that threaten any populated area or any infrastructure, with the exception of a portion of Hwy C which could be inundated by water from the Ewing City Lake Dam in the event of a catastrophic failure at that location. However, catastrophic failure of any high hazard dams has the potential to result in greater destruction due to the potential speed of onset and greater depth, extent, and velocity of flooding. For this reason, dam failures could flood areas outside of mapped flood hazards.

Previous Occurrences

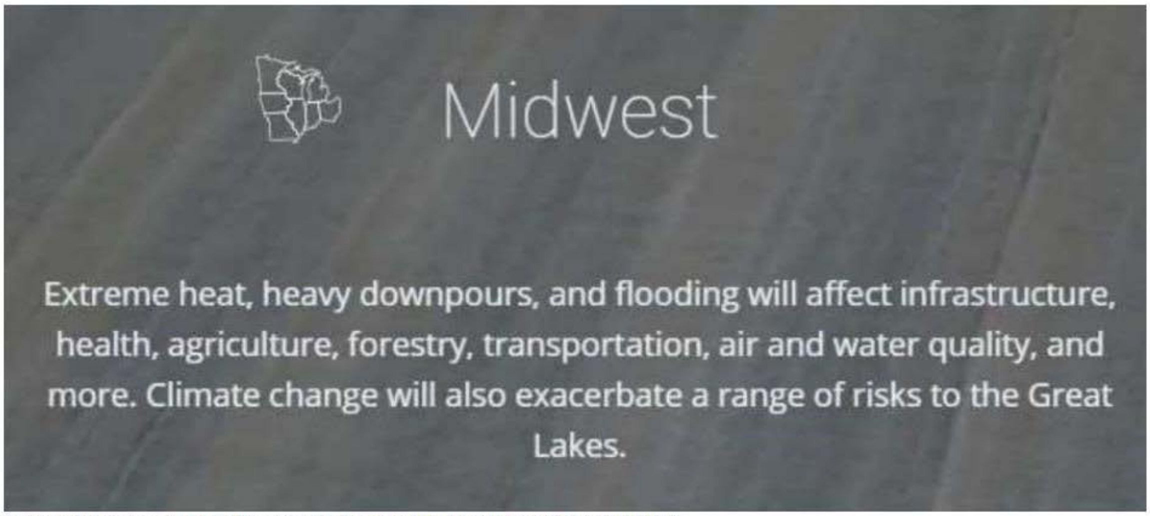
According to Stanford University's National Performance of Dams Program, there were 82 dam incidents in Missouri from 1975 to 2013. Of these 82 incidents, 17 percent were failures. According to that same database, none of these incidents involved any high hazard dams in Lewis County.

Probability of Future Occurrence

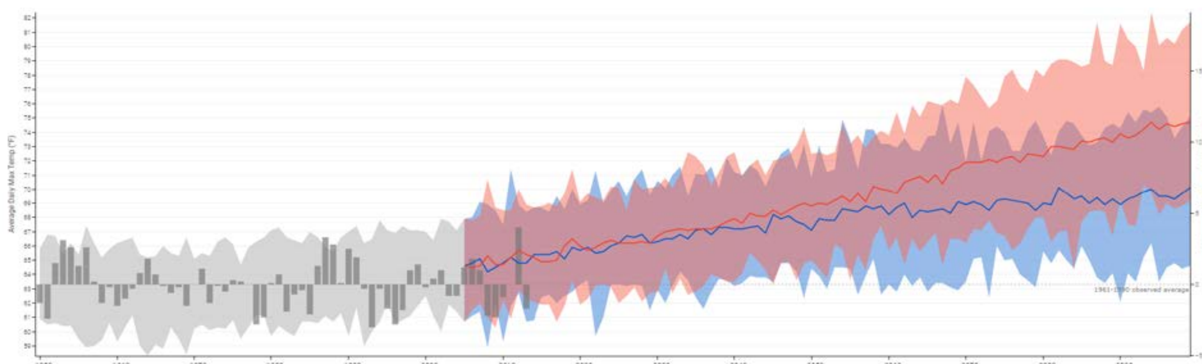
As there are no records of dam failure in Lewis County on which to calculate probability a probability calculation is not possible.

Changing Future Conditions Considerations

According to the National Climate Assessment, extreme rainfall events and flooding have increased during the last century. These trends are expected to continue and have an effect on current infrastructure.



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



Vulnerability

Vulnerability Overview

None of the high hazard dams in Lewis County appear to have inundation areas that threaten any populated area or any infrastructure, with the exception of a portion of Hwy C which could be inundated by water from the Ewing City Lake Dam in the event of a catastrophic failure at that location. However, catastrophic failure of any high hazard dams has the potential to result in greater destruction due to the potential speed of onset and greater depth, extent, and velocity of flooding. For this reason, dam failures could flood areas outside of mapped flood hazards.

Potential Losses to Existing Development:

There does not appear to be development at risk to dam failure, with respect to the high hazard dams in the MoDNR and US Army Corps records. Lock and Dam No. 20 could fail and cause flooding along the Mississippi river to the south, in Canton and Lagrange – Riverine flood risk is analyzed in the flooding section of this document.

Impact of Previous and Future Development

Future development in the county should have little impact on the number of damages caused by a dam failure in the planning area, as the hazard zones are well known and development in those areas should be limited, prohibiting occupancies such as residential, commercial, or industrial structures.

EMAP Consequence Analysis

For communities with emergency management programs seeking EMAP accreditation, complete Table 3.27 to summarize the detrimental impacts from dam failure.

Table 3.27. 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

Even in areas where there are high hazard dams, there is very little threat that an inundation would present a threat to human life. The only area with any mentionable risk is Hwy C near Ewing, which could be inundated by waters from the Old City Lake in the event of a catastrophic failure of that structure.

Problem Statement

While there are a small number of high hazard dams in Lewis County, there does not appear to be any development at risk to dam failure, as these dams are located in unpopulated rural areas and there appear to be no structures or infrastructure of any kind within the areas that may become inundated in the event of a dam breach. Lock and Dam No. 20 on the Mississippi River north of Canton could fail and cause flooding along the river to the south, in Canton and La Grange. Riverine flood risk is analyzed in the flooding section of this document.

3.4.4 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.

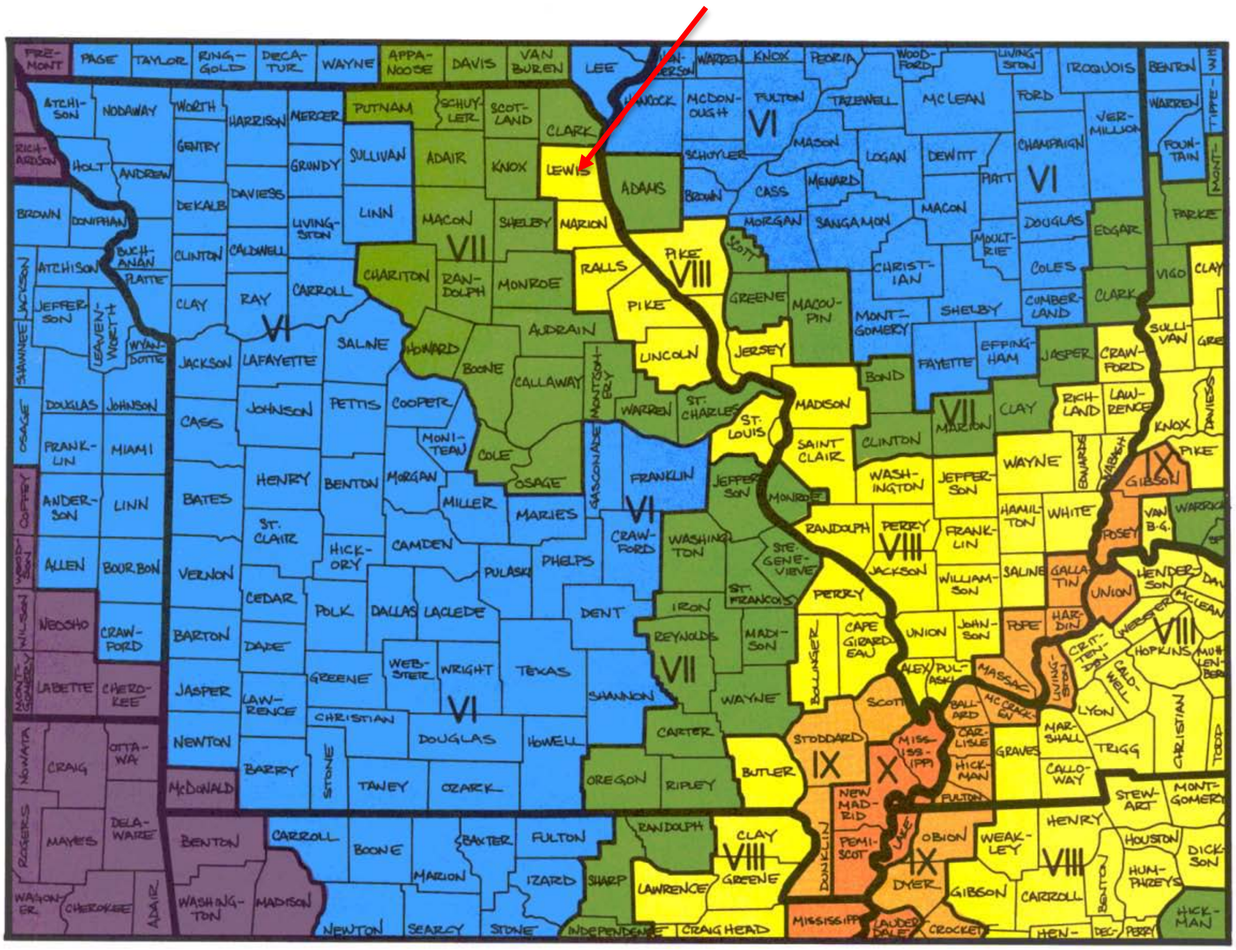
Missouri holds the record for the most devastating earthquake in the history of post- settlement North America. The New Madrid 1811-1812 earthquake series included five earthquakes of magnitude 8.0 (Modified Mercalli Intensity Scale) or higher occurring in the period December 16, 1811 through February 7, 1812. These earthquakes affected an estimated 600,000 square kilometers. Movement was felt as far away as Quebec, and damage was reported Charleston, South Carolina, and Washington D.C.

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 50 km 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 Shelby 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.

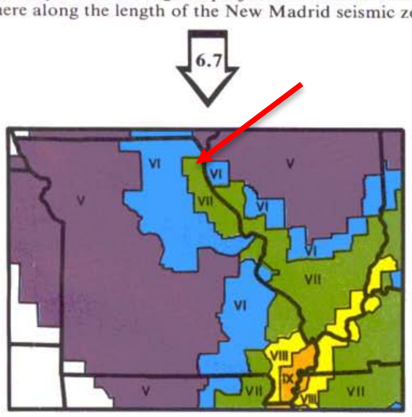
The following SEMA map (**Figure 3.7**) shows the highest projected Modified Mercalli intensities by county from a potential magnitude 7.6 earthquake whose epicenter could be anywhere along the length of the New Madrid Seismic Zone. The secondary maps in **Figure 3.7** on page 3.98 show the same regional intensities for 6.7 and 8.6 earthquake, respectively. Insert arrows or outline the planning area or use narrative to describe what the following maps illustrate about the planning area.

Figure 3.7. Impact Zones for Earthquake Along the New Madrid Fault

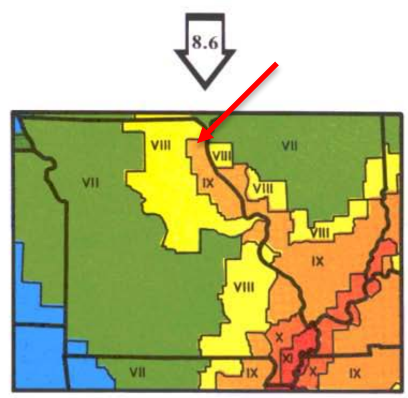


This map shows the highest projected Modified Mercalli intensities by county from a potential magnitude – 7.6 earthquake whose epicenter could be anywhere along the length of the New Madrid seismic zone.

7.6



This map shows the highest projected Modified Mercalli intensities by county from a potential magnitude – 6.7 earthquake whose epicenter could be anywhere along the length of the New Madrid seismic zone.



This map shows the highest projected Modified Mercalli intensities by county from a potential magnitude – 8.6 earthquake whose epicenter could be anywhere along the length of the New Madrid seismic zone.

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

Figure 3.8. Projected Earthquake Intensities

MODIFIED MERCALLI INTENSITY SCALE

I People do not feel any Earth movement.

II A few people might notice movement.

III Many people indoors feel movement. Hanging objects swing.

IV Most people indoors feel movement. Dishes, windows, and doors rattle. Walls and frames of structures creak. Liquids in open vessels are slightly disturbed. Parked cars rock.

V Almost everyone feels movement. Most people are awakened. Doors swing open or closed. Dishes are broken. Pictures on the wall move. Windows crack in some cases. Small objects move or are turned over. Liquids might spill out of open containers.

VI Everyone feels movement. Poorly built buildings are damaged slightly. Considerable quantities of dishes and glassware, and some windows are broken. People have trouble walking. Pictures fall off walls. Objects fall from shelves. Plaster in walls might crack. Some furniture is overturned. Small bells in churches, chapels and schools ring.

VII People have difficulty standing. Considerable damage in poorly built or badly designed buildings, adobe houses, old walls, spires and others. Damage is slight to moderate in well-built buildings. Numerous windows are broken. Weak chimneys break at roof lines. Cornices from towers and high buildings fall. Loose bricks fall from buildings. Heavy furniture is overturned and damaged. Some sand and gravel stream banks cave in.

VIII Drivers have trouble steering. Poorly built structures suffer severe damage. Ordinary substantial buildings partially collapse. Damage slight in structures especially built to withstand earthquakes. Tree branches break. Houses not bolted down might shift on their foundations. Tall structures such as towers and chimneys might twist and fall. Temporary or permanent changes in springs and wells. Sand and mud is ejected in small amounts.

IX Most buildings suffer damage. Houses that are not bolted down move off their foundations. Some underground pipes are broken. The ground cracks conspicuously. Reservoirs suffer severe damage.

X Well-built wooden structures are severely damaged and some destroyed. Most masonry and frame structures are destroyed, including their foundations. Some bridges are destroyed. Dams are seriously damaged. Large landslides occur. Water is thrown on the banks of canals, rivers, and lakes. Railroad tracks are bent slightly. Cracks are opened in cement pavements and asphalt road surfaces.

XI Few if any masonry structures remain standing. Large, well-built bridges are destroyed. Wood frame structures are severely damaged, especially near epicenters. Buried pipelines are rendered completely useless. Railroad tracks are badly bent. Water mixed with sand, and mud is ejected in large amounts.

XII Damage is total, and nearly all works of construction are damaged greatly or destroyed. Objects are thrown into the air. The ground moves in waves or ripples. Large amounts of rock may move. Lakes are dammed, waterfalls formed and rivers are deflected.

Intensity is a numerical index describing the effects of an earthquake on the surface of the Earth, on man, and on structures built by man. The intensities shown in these maps are the highest likely under the most adverse geologic conditions. There will actually be a range in intensities within any small area such as a town or county, with the highest intensity generally occurring at only a few sites. Earthquakes of all three magnitudes represented in these maps occurred during the 1811 - 1812 "New Madrid earthquakes." The isoseismal patterns shown here, however, were simulated based on actual patterns of somewhat smaller but damaging earthquakes that occurred in the New Madrid seismic zone in 1843 and 1895.

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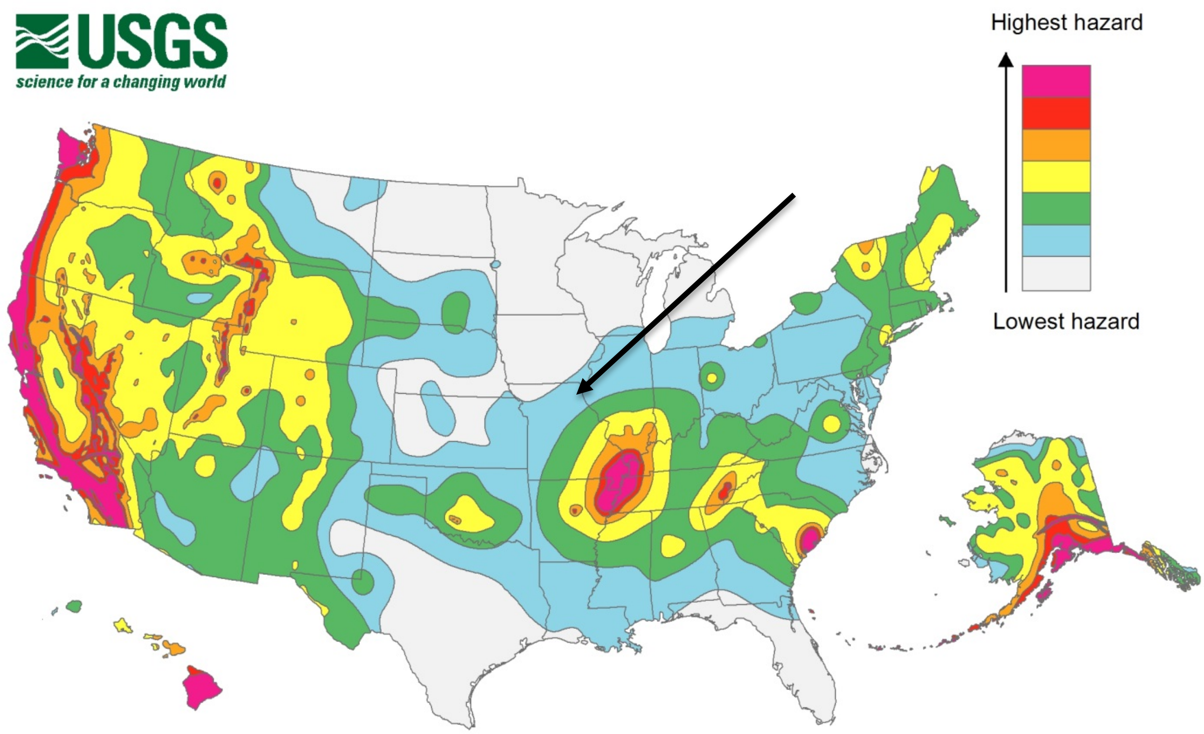
Telephone: 573-526-9100

Figure 3.9 illustrates seismicity in the United States. The Arrow indicates that the Lewis County Planning Area is in a relatively low hazard area.

Figure 3.9. 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.

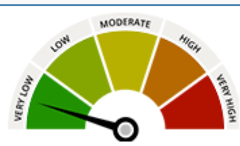
Modified Mercalli Intensity Scale

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 recorded in Lewis County since 1931.

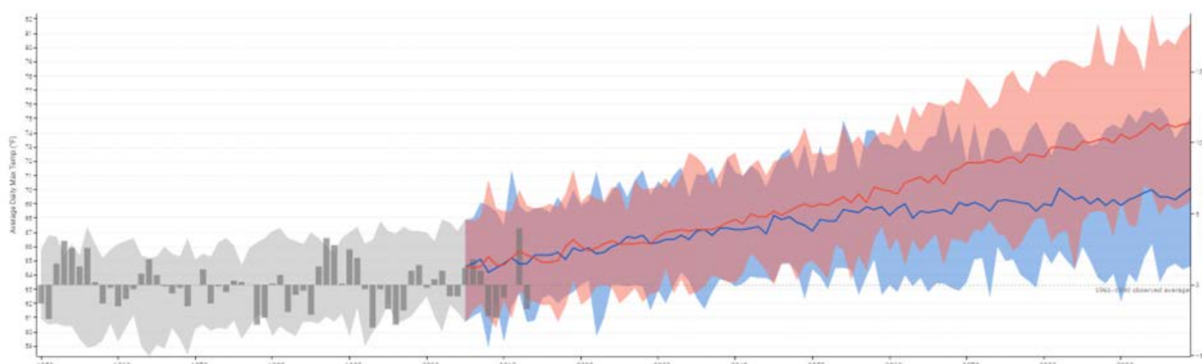
Probability of Future Occurrence

Risk Level: **Very Low**	Total Number of Earthquakes in Lewis County since 1931	Probability of A 5.0 Earthquake within next 50 years
	**0**	**0.23%**

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.

According to the National Climate Assessment, earthquakes have increased during the last century, and these trends are expected to continue, as depicted below.



Vulnerability

Vulnerability Overview

According to the data obtained from the 2018 Missouri State Plan, Lewis County was rated as very low risk on the Earthquake Risk Rating.

The State of Earthquake Coverage Report states that the average premium for earthquake coverage in Lewis County was $55 in 2014.

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. Data is included for the planning area from State Plan Tables 3.60, 3.61, 3.62, 3.63 and Figures 3.91, 3.92, 3.93, and 3.94.

Table 3.60. HAZUS-MH Earthquake Loss Estimation: Annualized Loss Scenario

County	Total Losses, in $ Thousands	Loss Per Capita, in $ Thousands	Loss Ratio, in $ per Million
Lewis	$15	$0.0015	$15

Table 3.61. Hazus Earthquake Loss Estimation 2% Probability of Exceedance in 50 Years Scenario Results – Summary of Overall Impacts in Missouri

Type of Impact	Summary of Modeled Impacts
Total Buildings Damaged	Slight: 372,790 Moderate: 223,225 Extensive: 88,883 Complete: 47,549
Building and Income Related Losses	$51.4 billion
Total Economic Losses (includes building, income and lifeline losses)	$63.4 billion
Casualties (based on 2 a.m. time of occurrence)	Without requiring hospitalization: 15,454 Requiring hospitalization: 3,855 Life threatening: 512 Fatalities: 999
Casualties (based on 2 p.m. time of occurrence)	Without requiring hospitalization: 21,732 Requiring hospitalization: 5,727 Life threatening: 833 Fatalities: 1,606
Casualties (based on 5 p.m. time of occurrence)	Without requiring hospitalization: 15,480 Requiring hospitalization: 4,020 Life threatening: 574 Fatalities: 1,090
Damage to Schools	339 with at least moderate damage*
Damage to Medical Facilities	159 with at least moderate damage*
Damage to Fire Stations	194 with at least moderate damage*
Damage to Transportation Systems	819 highway bridges, at least moderate damage* 464 highway bridges, complete damage* 4 railroad bridges, moderate damage 12 airport facilities, moderate damage
Households without Power/Water Service (based on 2,375,611 households)	Power loss, Day 1: 364,335 Water loss, Day 1: 753,546 Water loss, Day 3: 730,857 Water loss, Day 7: 687,407 Water loss, Day 30: 549,352 Water loss, Day 90: 254,958
Displaced Households	48,730
Shelter Requirements	32,237 people out of 5,988,927 total population
Debris Generation	16.2 million tons

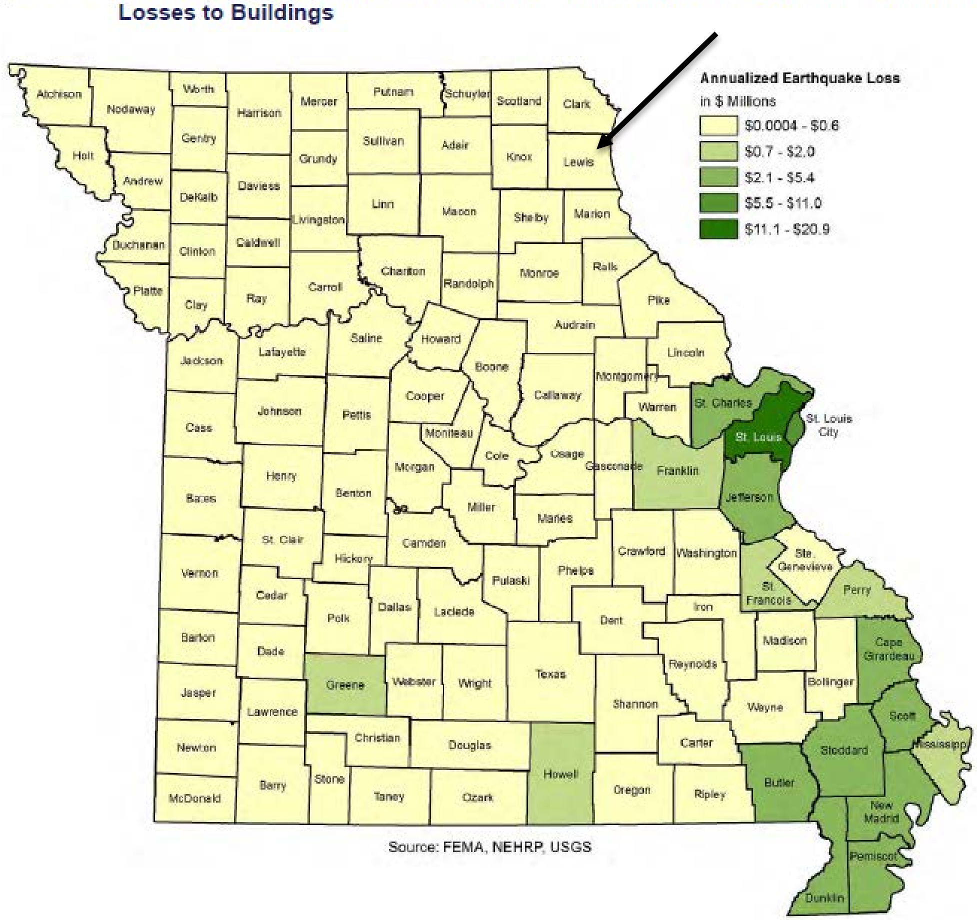
Table 3.62. Hazus Earthquake Loss Estimation 2% Probability of Exceedance in 50 Years Scenario Results – Summary of by Occupancy Class (Millions of Dollars)

Category	Area	Single Family	Other Residential	Commercial	Industrial	Others	Total
Income Losses	Wage	$0.00	$137.35	$1,494.55	$82.36	$119.30	$1,833.52
	Capital-Related	$0.00	$58.59	$1,217.03	$50.99	$30.64	$1,357.23
	Rental	$610.67	$425.50	$666.99	$30.81	$55.85	$1,789.81
	Relocation	$2,089.36	$380.76	$1,107.27	$147.23	$460.23	$4,184.85
	Subtotal	**$2,700.03**	**$1,002.20**	**$4,485.84**	**$311.39**	**$666.02**	**$9,165.41**
Capital Stock Losses	Structural	$3,581.98	$879.63	$2,018.83	$573.42	$605.33	$7,659.20
	Non-Structural	$12,295.72	$3,928.15	$5,230.69	$1,737.85	$1,559.66	$24,752.07
	Content	$3,915.69	$1,007.10	$2,641.24	$1,170.28	$799.40	$9,533.72
	Inventory	$0.00	$0.00	$72.52	$199.57	$15.57	$287.66
	Subtotal	**$19,793.39**	**$5,814.88**	**$9,963.28**	**$3,681.12**	**$2,979.96**	**$42,232.65**
	Total	**$22,493.42**	**$6,817.08**	**$14,449.12**	**$3,992.51**	**$3,645.98**	**$51,398.06**

Table 3.63. HAZUS-MH Earthquake Loss Estimation 2% Probability of Exceedance in 50 Years Scenario Direct Economic Losses Results Summary by County (All values in thousands)

County	Cost Structural Damage	Cost Non-Structural Damage	Cost Contents Damage	Inventory Loss	Loss Ratio %	Relocation Loss	Capital Related Loss	Wages Losses	Rental Income Loss	Total Loss
Lewis	$1,750	$3,777	$1,131	$40	0.56	$1,026	$261	$313	$421	$8,719

Figure 3.91. HAZUS-MH Earthquake Loss Estimation: Annualized Loss Scenario—Direct Economic Losses to Buildings



Source: FEMA, NEHRP, USGS

Figure 3.92. HAZUS- MH Earthquake 2% Probability of Exceedance in 50 Years —Ground Shaking and Liquefaction Potential

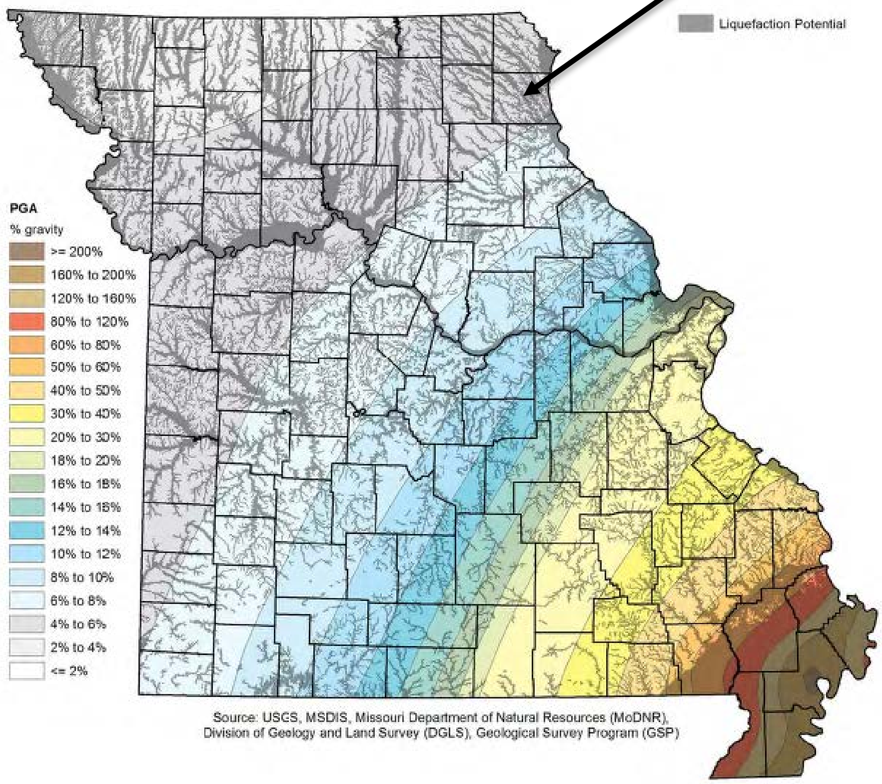


Figure 3.93. HAZUS-MH Earthquake Loss Estimation with a 2% Probability of Exceedance in 50 Years Scenario—Total Building Loss

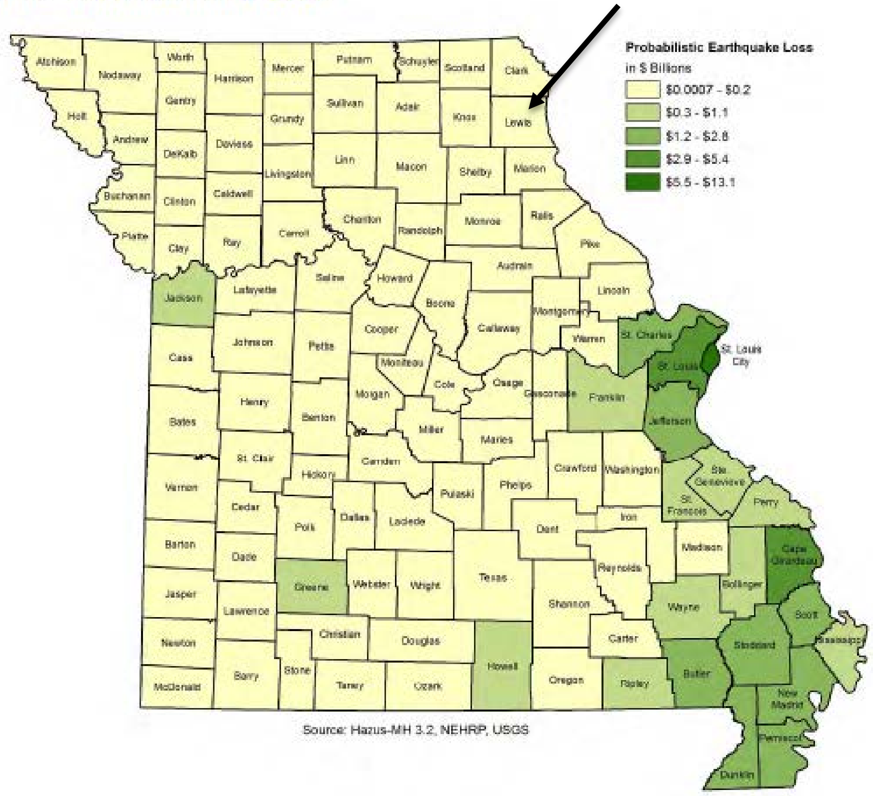
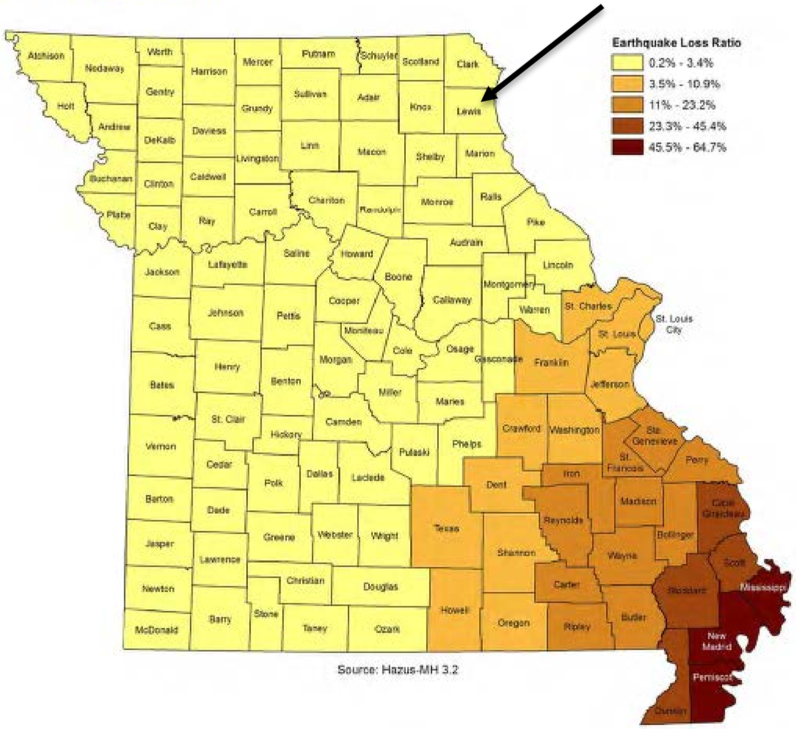


Figure 3.94. HAZUS-MH Earthquake Loss Estimation with a 2% Probability of Exceedance in 50 Years Scenario—Loss Ratio



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 3.28. 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

The earthquake intensity is not likely to vary greatly throughout the planning area and all jurisdictions within the planning area will be the same throughout. However, La Grange could see a greater amount of structural damage due to having a higher percentage (29%) of residences built prior to 1939 than other jurisdictions in the planning area. In Monticello, 26.7% of the residences were built prior to 1939 and could see higher damage than the City of Ewing since only 13.4% of the residences built prior to 1939, which puts them at a lower risk.

Problem Statement

The risk of direct impact to Lewis County is low (less than 25%) but the severity of impacts by such an event if it does occur will range from moderate to severe. In addition, a seismic event of lesser magnitude may not inflict much direct damage on Lewis County but the county's proximity to affected areas will likely see great demand for mutual-aid via emergency response assets and sheltering resources.

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.

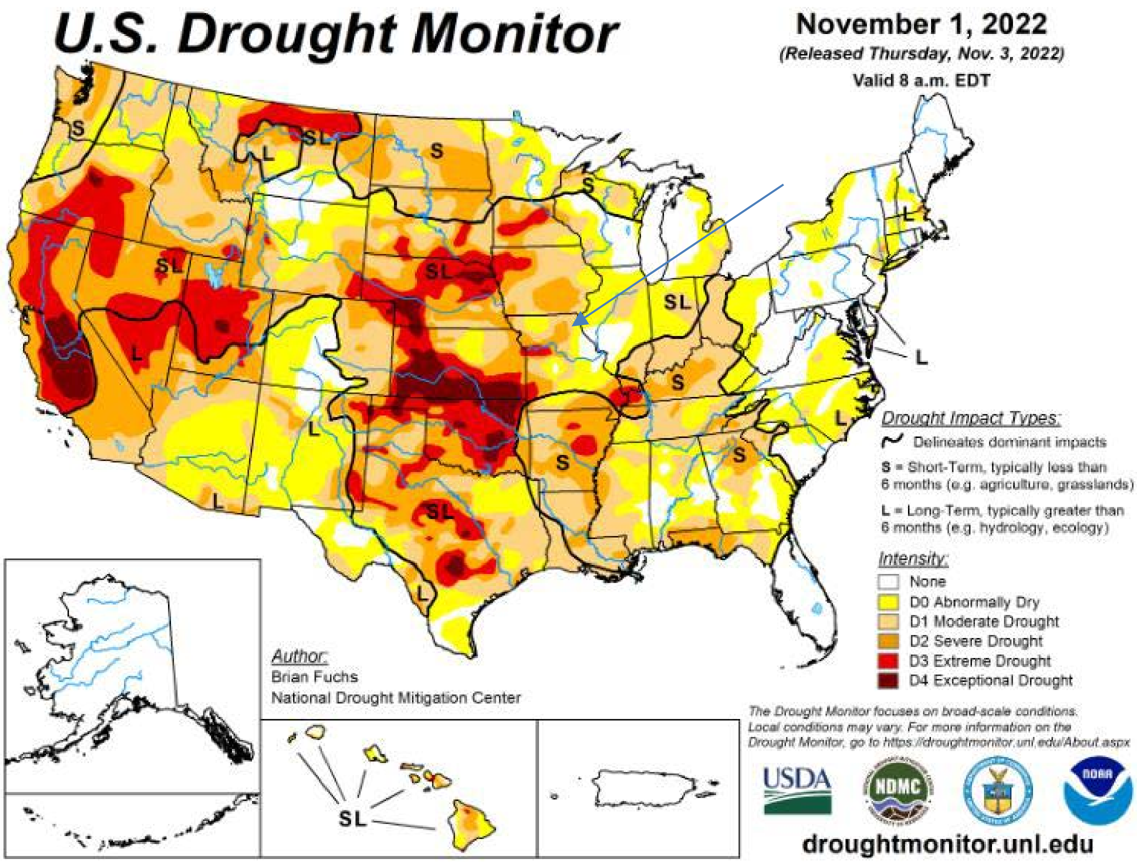
- Agricultural drought focus is on soil moisture deficiencies, differences between actual and potential evaporation, reduced ground water or reservoir levels, etc. Plant demand for water depends on prevailing weather conditions, biological characteristics of the specific plant, its stage of growth, and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

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

Geographic Location

Because of the broad scope of drought, all of Lewis County is susceptible to this hazard. Agricultural land is extremely vulnerable to drought impacts, and according to US Census data 78% of Lewis County total land area is classified as farmland, making the impact of drought one that is acutely felt by County residents.

Figure 3.10. U.S. Drought Monitor Map of Missouri on Date



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.

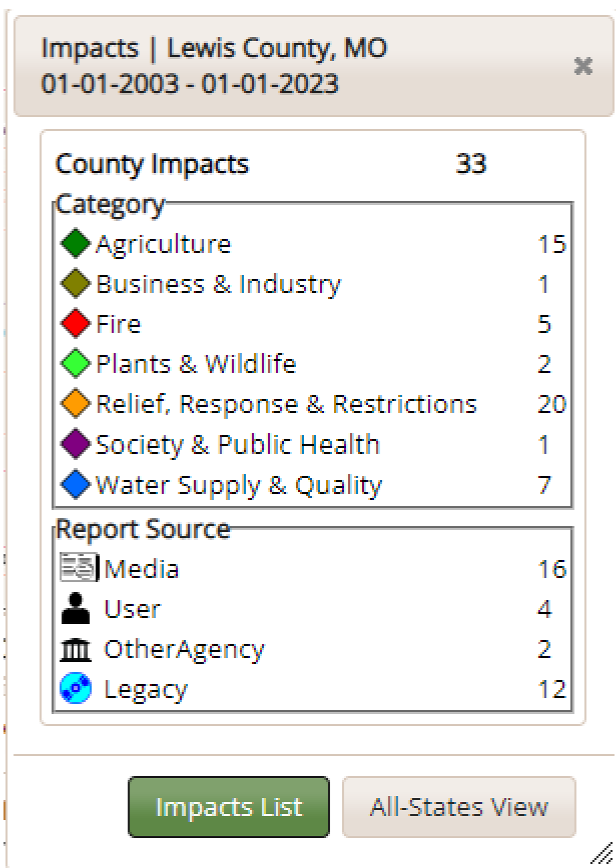
Previous Occurrences

Drought occurs periodically in Missouri with the most severe and costly in historical times occurring in 2018. Other major droughts, usually characterized by deficient rainfall combined with unusually high summer temperatures were in 2013 and 2005. 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 the National Center for Environmental Information, during the 20-year period from 2003 to 2023, Lewis County had 33 reported drought impacts. The following are the categories:

- Agriculture
- Business and Industry
- Fire
- Plants & Wildlife
- Relief, Response, & Restrictions
- Society and Public Health
- Water Supply & Quality

Figure 3.11. NCEI Drought Impacts



Probability of Future Occurrence

Over a 20-year period Lewis County experienced six drought events, indicating a 30% annual average percentage probability of drought occurring in the planning area. This is considered a "low moderate" probability.

Changing Future Conditions Considerations

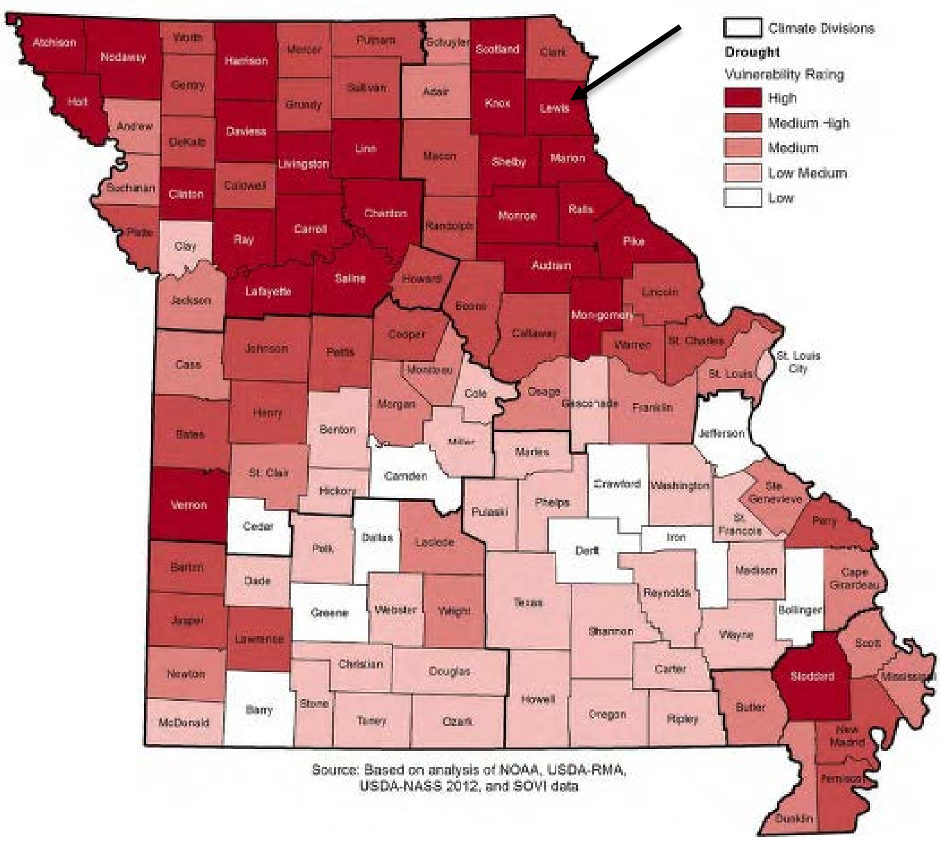
The 2018 State Plan, states that severe drought, a natural part of Missouri's climate, is a risk to this agriculture dependent state. Future increases in evaporation rates due to higher temperatures may increase the intensity of naturally occurring droughts. The number of heavy rainfall events is predicted 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.

<u>Vulnerability</u>

Vulnerability Overview

According to the analysis from the 2018 State Plan, Lewis County is a High Vulnerability County for droughts.

Figure 3.12. Missouri Drought Vulnerability by County



Source: Missouri State Hazard Mitigation Plan, 2018, Arrow Indicates Lewis County

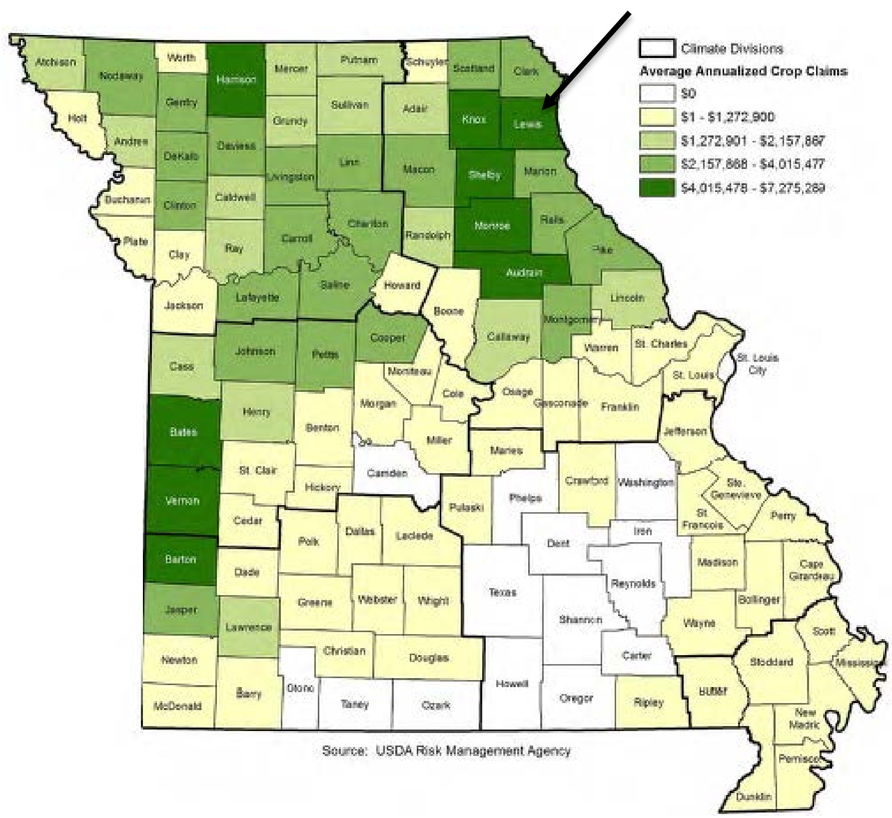
Potential Losses to Existing Development

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 3.13. Annualized Drought Crop Insurance Claims Paid 2007-2016

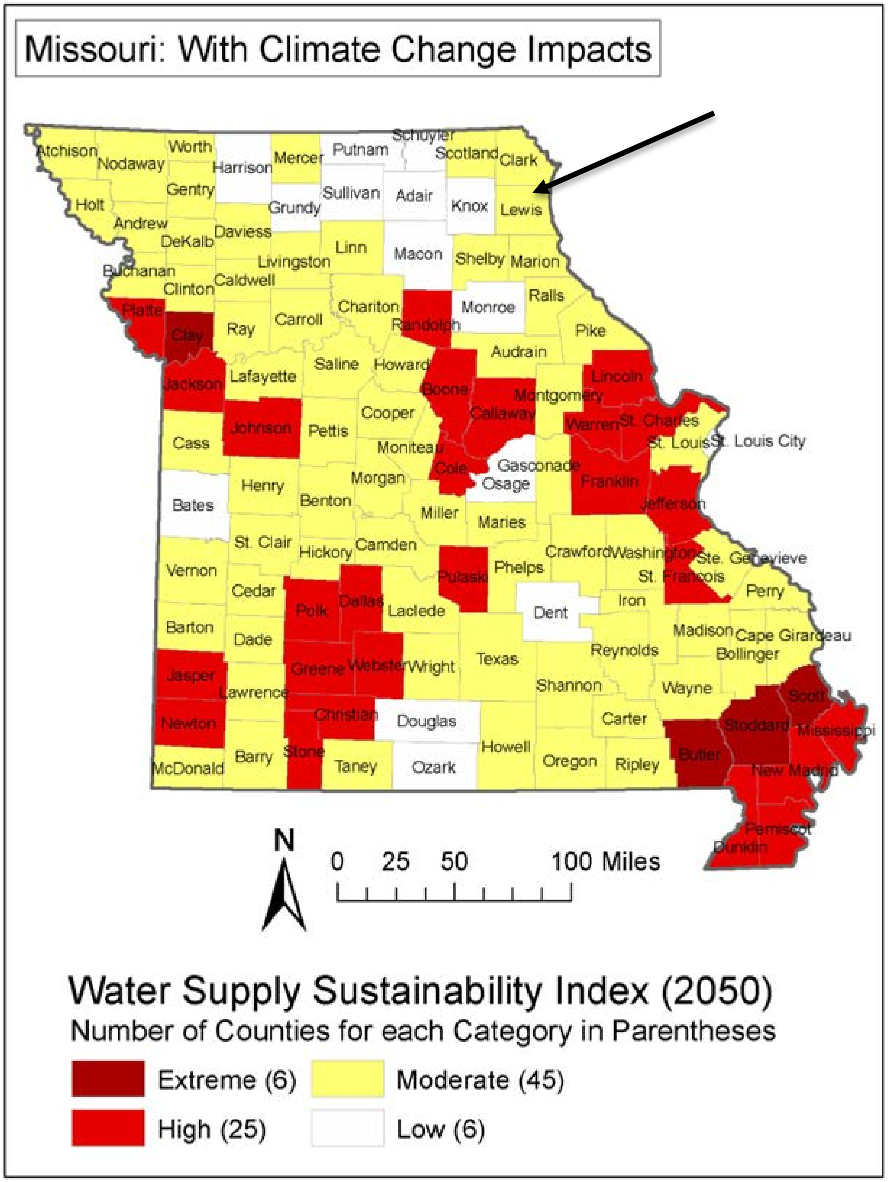


Source: Missouri State Hazard Mitigation Plan, 2018, Arrow Indicates Lewis County

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 3.14** ranks Lewis County as moderate on the Water Supply Sustainability Index.

Figure 3.14. Climate Change Impacts on Water Supply in Missouri



EMAP Consequence Analysis

Table 3.29. 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.
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

There is no variance by jurisdiction to this threat. Drought conditions would be the same in small communities as those experienced in rural areas, but the magnitude would be different with only lawns and local gardens impacted. In addition, building foundations could be weakened due to shrinking and expanding soils.

Problem Statement

Lewis County does not have severe drought vulnerability. Surface and groundwater resources are abundant and typically supply enough water only for domestic needs and irrigation even during drought conditions.

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 3.15** 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 3.15. Heat Index (HI) Chart

NWS Heat Index

Temperature (°F)

Relative Humidity (%)	80	82	84	86	88	90	92	94	96	98	100	102	104	106	108	110
40	80	81	83	85	88	91	94	97	101	105	109	114	119	124	130	136
45	80	82	84	87	89	93	96	100	104	109	114	119	124	130	137	
50	81	83	85	88	91	95	99	103	108	113	118	124	131	137		
55	81	84	86	89	93	97	101	106	112	117	124	130	137			
60	82	84	88	91	95	100	105	110	116	123	129	137				
65	82	85	89	93	98	103	108	114	121	128	136					
70	83	86	90	95	100	105	112	119	126	134						
75	84	88	92	97	103	109	116	124	132							
80	84	89	94	100	106	113	121	129								
85	85	90	96	102	110	117	126	135								
90	86	91	98	105	113	122	131									
95	86	93	100	108	117	127										
100	87	95	103	112	121	132										

Likelihood of Heat Disorders with Prolonged Exposure or Strenuous Activity

Caution | Extreme Caution | Danger | Extreme Danger

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 3.16. Wind Chill Chart

Wind Chill Chart

Temperature (°F)

Wind (mph) / Calm	40	35	30	25	20	15	10	5	0	-5	-10	-15	-20	-25	-30	-35	-40	-45
5	36	31	25	19	13	7	1	-5	-11	-16	-22	-28	-34	-40	-46	-52	-57	-63
10	34	27	21	15	9	3	-4	-10	-16	-22	-28	-35	-41	-47	-53	-59	-66	-72
15	32	25	19	13	6	0	-7	-13	-19	-26	-32	-39	-45	-51	-58	-64	-71	-77
20	30	24	17	11	4	-2	-9	-15	-22	-29	-35	-42	-48	-55	-61	-68	-74	-81
25	29	23	16	9	3	-4	-11	-17	-24	-31	-37	-44	-51	-58	-64	-71	-78	-84
30	28	22	15	8	1	-5	-12	-19	-26	-33	-39	-46	-53	-60	-67	-73	-80	-87
35	28	21	14	7	0	-7	-14	-21	-27	-34	-41	-48	-55	-62	-69	-76	-82	-89
40	27	20	13	6	-1	-8	-15	-22	-29	-36	-43	-50	-57	-64	-71	-78	-84	-91
45	26	19	12	5	-2	-9	-16	-23	-30	-37	-44	-51	-58	-65	-72	-79	-86	-93
50	26	19	12	4	-3	-10	-17	-24	-31	-38	-45	-52	-60	-67	-74	-81	-88	-95
55	25	18	11	4	-3	-11	-18	-25	-32	-39	-46	-54	-61	-68	-75	-82	-89	-97
60	25	17	10	3	-4	-11	-19	-26	-33	-40	-48	-55	-62	-69	-76	-84	-91	-98

Frostbite Times: 30 minutes / 10 minutes / 5 minutes

Wind Chill (°F) = $35.74 + 0.6215T - 35.75(V^{0.16}) + 0.4275T(V^{0.16})$

Where, T = Air Temperature (°F) V = Wind Speed (mph)

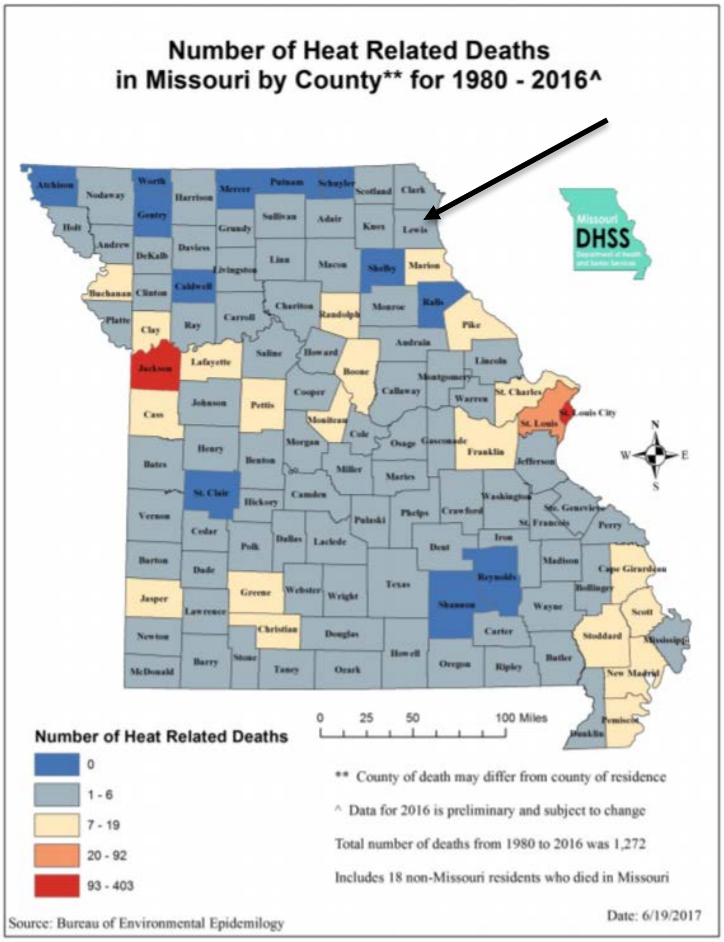
Effective 11/01/01

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 20 recorded events of excessive heat in the 20-year period of 2003-2023. There were 0 deaths or injuries associated with these events. The NCEI database shows 0 recorded events of extreme cold/wind chill. **Figure 3.17** illustrates 1-6 heat related deaths in Lewis County between the time of 1980-2016, no supporting documentation could be found to elaborate on any incident.

Figure 3.17. Heat Related Deaths in Missouri 2000 - 2016



Source: https://health.mo.gov/living/healthcondiseases/hyperthermia/pdf/stat-report.pdf

Extreme heat can cause stress to crops and animals. According to USDA Risk Management Agency, losses to insurable crops during the 10-year time period from 2013 to 2022 were $1,620,401. 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.

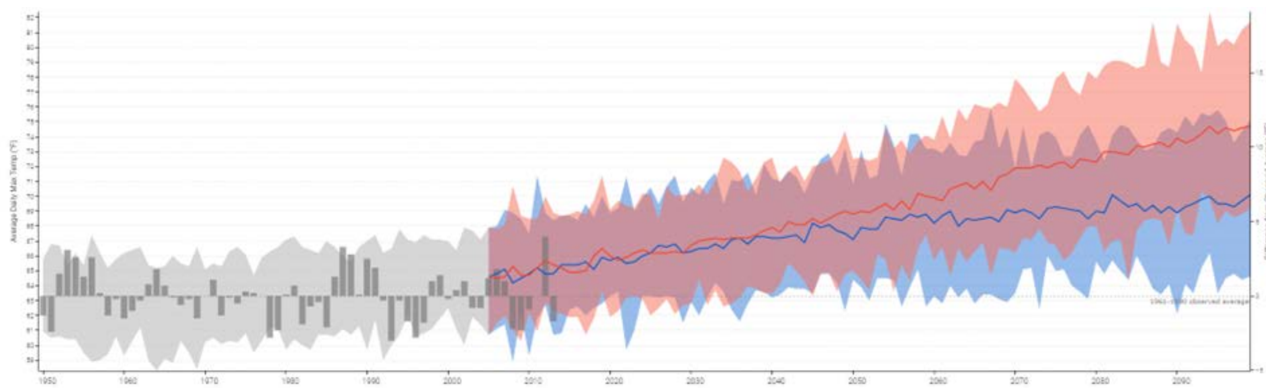
Probability of Future Occurrence

NOAA information dating back to 2002 indicates 9 years with extreme heat events (2007, 2009, 2010, 2011, 2012, 2014, 2015, 2016). Based on this historical data, the calculated probability of an extreme heat event in any given year is 40%.

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 when people attempt 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.

According to the National Climate Assessment, extreme temperature events have increased during the last century, and these trends are expected to continue, as depicted below.



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

Table 3.30. 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

Potential Losses to Existing Development

Extreme heat can impact agriculture in a significant way, especially as extreme heat events often coincide with drought (see drought section).

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.

EMAP Consequence Analysis

For communities with emergency management programs seeking EMAP accreditation, complete Table 3.31 to summarize the detrimental impacts from extreme temperatures.

Table 3.31. 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 3.32** 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 3.32. Lewis County Population Under Age 5 and Over Age 65, 2021 Census Data

Jurisdiction	Population Under 5 yrs	Population 65 yrs and over
Lewis County	563	1,932
Canton	94	463
Ewing	40	67
La Belle	37	135
La Grange	6	227
Lewistown	30	90
Monticello	18	16

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

All schools in Lewis County have air conditioning which does not put school age children at risk during extreme temperatures. Due to this, the schools do not have a policy in affect to close if there are extreme temperatures.

Problem Statement

All areas of Lewis County are at equal risk to the hazards of extreme heat –however, those with larger numbers of children and elderly among the population may be more vulnerable. The City of Canton, being the most populous community, is the most vulnerable according to these criteria.

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.

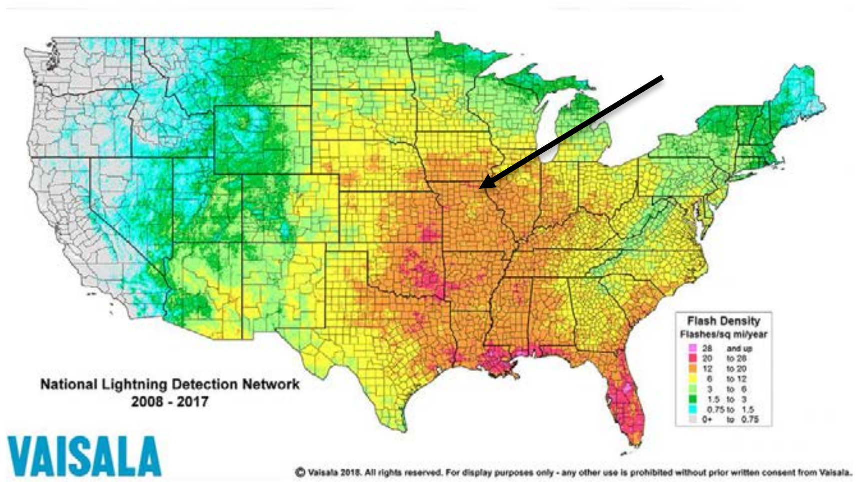
At the time when the updraft can no longer support the hailstone, it will fall down to the earth. For example, a ¼" diameter or pea sized hail requires updrafts of 24 miles per hour, while a 2 ¾" diameter or baseball sized hail requires an updraft of 81 miles per hour. According to the NOAA, the largest 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

All of Lewis County is susceptible to thunderstorms/high winds/hail and lighting events. 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 3.18 shows lightning frequency in the nation. The arrow indicates the Lewis County Planning area.

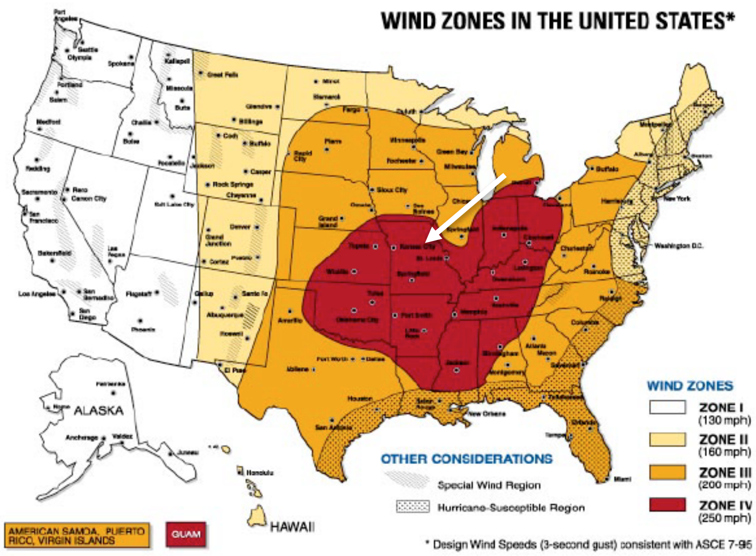
Figure 3.18. Location and Frequency of Lightning in Missouri



Source: National Weather Service, http://www.vaisala.com/en/products/thunderstormandlightningdetectionsystems/Pages/NLDN.aspx .
Note: indicate location of planning area with a colored square or arrow.

Figure 3.19 shows wind zones in the United State. The arrow indicates Lewis County.

Figure 3.19. 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 3.33** below describes typical damage impacts of the various sizes of hail.

Table 3.33. 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

Table 3.34. Reported Events and Damages Lewis County from Thunderstorms 2013-2023

Wind Magnitude	Number of Events	Property Damage	Crop Damages
35 kts	1	0	0
52 kts	1	0	0
56 kts	12	7.00K	0
61 kts	4	15.00K	0

August 18, 2022 - A cold front moved southeast through the region with storms developing along and ahead of the boundary. Some of the storms became severe with isolated reports of large hail and damaging winds over portions of northeast Missouri as well as west central Illinois. Thunderstorm winds caused moderate damage to a farm outbuilding.

August 20, 2021 - Thunderstorm winds blew down several large trees as well as a couple of power poles around the town of Canton.

July 9, 2021 - On the evening of July 9th, intense thunderstorms developed rapidly along a warm front draped from northwest to southeast across the area. There were two rounds of thunderstorms, the first being discrete, rotating storms called supercells. These supercell thunderstorms dropped large hail across portions of western Illinois (Mt. Sterling area) and also across the western St. Louis metro area. Hail in excess of 2 inches was noted in both of these supercells. Over time, the storms congealed into a large complex of thunderstorms known as a mesoscale convective complex (MCC). This line of storms contained damaging, sometimes destructive winds as they quickly pushed southeast across east-central Missouri into southwest Illinois. The worst damage was noted from Rensselaer, MO southward to Perry, MO, where straight-line winds of 90 mph were found. This same line of storms also affected the St. Louis metro area, bringing widespread 60-70 mph winds across the metro causing many large tree limbs to fall and many to be without power. Thunderstorm winds blew down numerous tree limbs around town in the city of Ewing.

Table 3.35. Reported Events and Damages in Lewis County from High Winds 2013-2023

No Data Available for High Wind Incidents

Table 3.36. Reported Events and Damages in Lewis County from Hail 2013-2023. Events Summarized by Size

Hail Size (inches)	Number of Events	Property Damages	Crop Damages
.88	2	0	0
1.00	16	0	0
1.25	1	0	0
1.50	2	0	0
1.75	9	0	0

Table 3.37. Reported Events and Damages in Lewis County from Lightning 2013-2023

No Data or Incidents Reported. Limitations to the use of NCEI reported lightning events include the fact that only lightning events that result in fatality, injury and/or property and crop damage are in the NCEI.

Table 3.38. Crop Insurance Claims Paid in Lewis County from High Winds, 2013-2022

Crop Year	Crop Name	Cause of Loss Description	Insurance Paid
2013	Corn	Wind/Excess Wind	$4,684
2014	Corn	Wind/Excess Wind	$109,218
2016	Corn	Wind/Excess Wind	$49,032
2021	Corn	Wind/Excess Wind	$4,483
2022	Soybeans	Wind/Excess Wind	$6,807
2022	Soybeans	Hot Wind	$62,595
Total			**$236,819**

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

Table 3.39. Crop Insurance Claims Paid in Lewis County from Hail, 2013-2022.

Crop Year	Crop Name	Cause of Loss Description	Insurance Paid
2018	Soybeans	Hail	$1,372
2021	Corn	Hail	$12,525
Total			**$13,897**

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

Probability of Future Occurrence

Thunderstorms

Thunderstorm wind events 50 knots and greater have a probability of occurring 1.7 times per year in any given year. These rates are expected to continue in the future.

High Winds

The probability of high winds is low but could not be calculated since there had not been an event in the planning area over the last 10 years.

Lightning

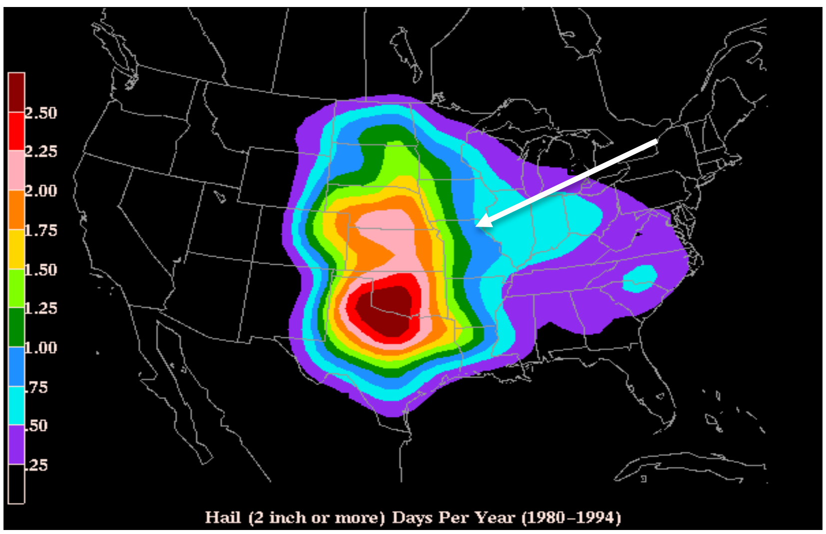
The probability of lightning events is low but could not be calculated since there had not been an event in the planning area over the last 10 years.

Hail

Based on the date, there have been 28 events in a 10-year period producing an average of 1.00 hail in Lewis County planning area. Based on this history there is a probability of 2.8 events per year in the planning area.

Figure 3.20 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. Lewis County is located in the region to receive between .75 and 1 hailstorms annually.

Figure 3.20. Annual Hailstorm Probability (2" diameter or larger), U 1980- 1994



Source: NSSL, http://www.nssl.noaa.gov/users/brooks/public_html/bighail.gif Note:

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

Over the last 10 years Lewis County has 46 thunderstorm events that caused a reported $22,000 in damages, an average annual loss of approximately $2,200 dollars.

Previous and Future Development

There is no significant development anticipated which would result in an increase in population or increased exposure to damage.

EMAP Consequence Analysis

For communities with emergency management programs seeking EMAP accreditation, complete Table 3.39 to summarize the detrimental impacts from severe thunderstorms.

Table 3.40. 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.

Subject	Detrimental Impacts
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

Thunderstorm /high winds/lightning/hail events are area-wide; NCEI data did not seem to indicate that any particular community had significantly higher vulnerability than any other, beyond larger communities having more structures that could be damaged.

Lewis County C-1 School district has one high school campus and one elementary school campus, both located in Lewistown. Canton R-V has one main building, as well as a daycare, bus garage, Vo-Ag building and a Greenhouse located in Canton.

Problem Statement

The county is vulnerable to the high winds, lighting, and hail associated with thunderstorms – particularly winds and hail, which can cause extensive damage to agricultural assets, particularly crops.

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.

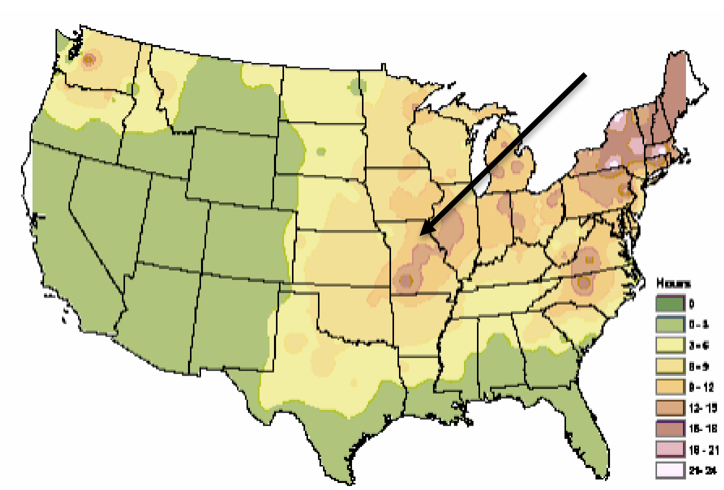
- **Blizzard**—Winds of 35 miles per hour or more with snow and blowing snow reducing visibility to less than ¼ mile for at least three hours.
- **Blowing Snow**—Wind-driven snow that reduces visibility. Blowing snow may be falling snow and/or snow on the ground picked up by the wind.
- **Snow Squalls**—Brief, 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 Lewis County planning area is vulnerable to heavy snow, extreme temperatures and freezing rain. The snow season normally extends from late November through mid-March, but significant snows have fallen as early as November 24th to as late as April 4th.

Figure 3.21 shows the average number of hours per year with freezing rain. Lewis County receives approximately 9-12 hours of freezing rain per year.

Figure 3.21. 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 3.41 includes NCEI reported events and damages for the past 10 years.

Table 3.41. NCEI Lewis County Winter Weather Events Summary, 2013-2022

Type of Event	Inclusive Dates	Magnitude	# of Injuries	Property Damages	Crop Damages
Winter Storm	2/21/2013		0	0	0
Winter Storm	12/21/2013		0	0	0
Winter Storm	2/4/2014		0	0	0
Winter Storm	1/1/21		0	0	0
Winter Storm	12/22/22		0	0	0
Heavy Snow	2/25/2013		0	0	0
Heavy Snow	3/24/2013		0	0	0
Heavy Snow	4/1/2018		0	0	0
Heavy Snow	1/11/2019		0	0	0
Heavy Snow	2/1/22		0	0	0
Heavy Snow	2/17/2022		0	0	0
Blizzard	11/25/2018		0	0	0

Source: NCEI, data accessed 1/15/2023

11/25/2018 - A strong area of low pressure tracked east across Kansas, Missouri, and central Illinois on November 25th, bringing heavy snowfall and gusty winds to the region. This caused blizzard conditions across portions of central and northeast Missouri, as well as west central Illinois, with less than a quarter of a mile visibility at times during the afternoon and evening. Strong northwest winds between 25 and 35 mph with gusts near 50 mph at times were reported during the storm. The heaviest snowfall reports were over portions of northeast Missouri and west central Illinois. Before the precipitation changed over to snow, there were a few strong to severe storms, but no reports of severe weather were received. Up to 8 inches of snow fell across Lewis County with winds gusting up to 50 mph at times. This caused reduced visibilities of less than a quarter of a mile at times and hazardous driving conditions.

2/4/2014 - An early February winter storm dropped from 6 to 13 inches of snow across Central and Northeast Missouri. Travel was very difficult and most schools in rural areas were closed the rest of the week.

Table 3.42 showing 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 10 years.

Table 3.42. Crop Insurance Claims Paid in Lewis County as a Result of Cold Conditions and Snow 2013-2022

Crop Year	Crop Name	Cause of Loss Description	Insurance Paid ($)
2013	Soybeans	Cold Wet Weather	$4,430
2013	Corn	Cold Wet Weather	$4,136
2013	Wheat	Cold Wet Weather	$44,575
2014	Soybeans	Cold Wet Weather	$9,957
2014	Wheat	Cold Wet Weather / Cold Winter	$394,568
2015	Wheat	Cold Winter	$8,243
2015	Corn	Cold Wet Weather	$103,317
2016	Corn	Cold Wet Weather	$6,010
2016	Soybeans	Cold Wet Weather	$3,903
2017	Corn	Cold Wet Weather	$3,258
2018	Wheat	Cold Wet Weather / Cold Winter	$9,243
2018	Corn	Cold Wet Weather	$37,359
2019	Wheat	Cold Wet Weather	$7,076
2019	Corn	Cold Wet Weather	$4,256
2020	Corn	Cold Wet Weather	$100,304
2020	Soybeans	Cold Wet Weather	$45,758
2021	Corn	Cold Wet Weather	$59,728
2021	Soybeans	Cold Wet Weather	$95,824
Total			**$941,945**

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

Probability of Future Occurrence

According to NCEI, during the 10-year period from 2013-2023 the planning area experienced 12 winter storm events. This means there is a probability of 1.2 events any given year in the Lewis County planning area.

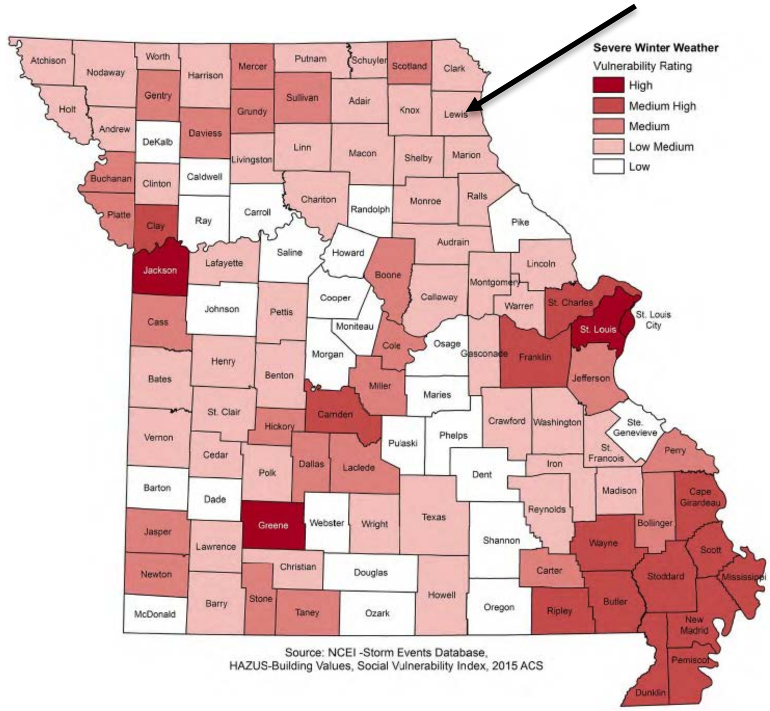
Changing Future Conditions Considerations

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.

<u>Vulnerability</u>

Vulnerability Overview

Figure 3.22. Severe Winter Weather Vulnerability by 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

NCEI reflects no property damage in the past 10 years. Under-reporting and other data limitations may have caused this, but the fact remains that most damages associate with severe winter weather involve automobile accidents and injuries incurred as people try to travel through the winter environment or compensate for the low temperatures, rather than directly being a result of the winter weather. Potential losses in Lewis County due to severe winter weather are on the low side, comparative to the damages that may accompany hazard events like tornados and hail storms.

Previous and Future Development

No development resulting in a significant increase in population (and therefore increased exposure to damage) is expected.

EMAP Consequence Analysis

For communities with emergency management programs seeking EMAP accreditation, complete Table 3.43 to summarize the detrimental impacts from severe winter weather.

Table 3.43. 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

Severe Winter Weather tends to affect all jurisdictions equally.

<u>Problem Statement</u>

Lewis County does have some vulnerability to severe winter weather, particularly in regards to transportation concerns. Excessive snowfall can overwhelm road crews, hamper emergency response, and bring commerce to a temporary halt.

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

Tornadoes can occur in the entire planning area and no area is immune from tornado damage.

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 and 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 3.44**) 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 3.44. 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 3.45**. 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 3.45. 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

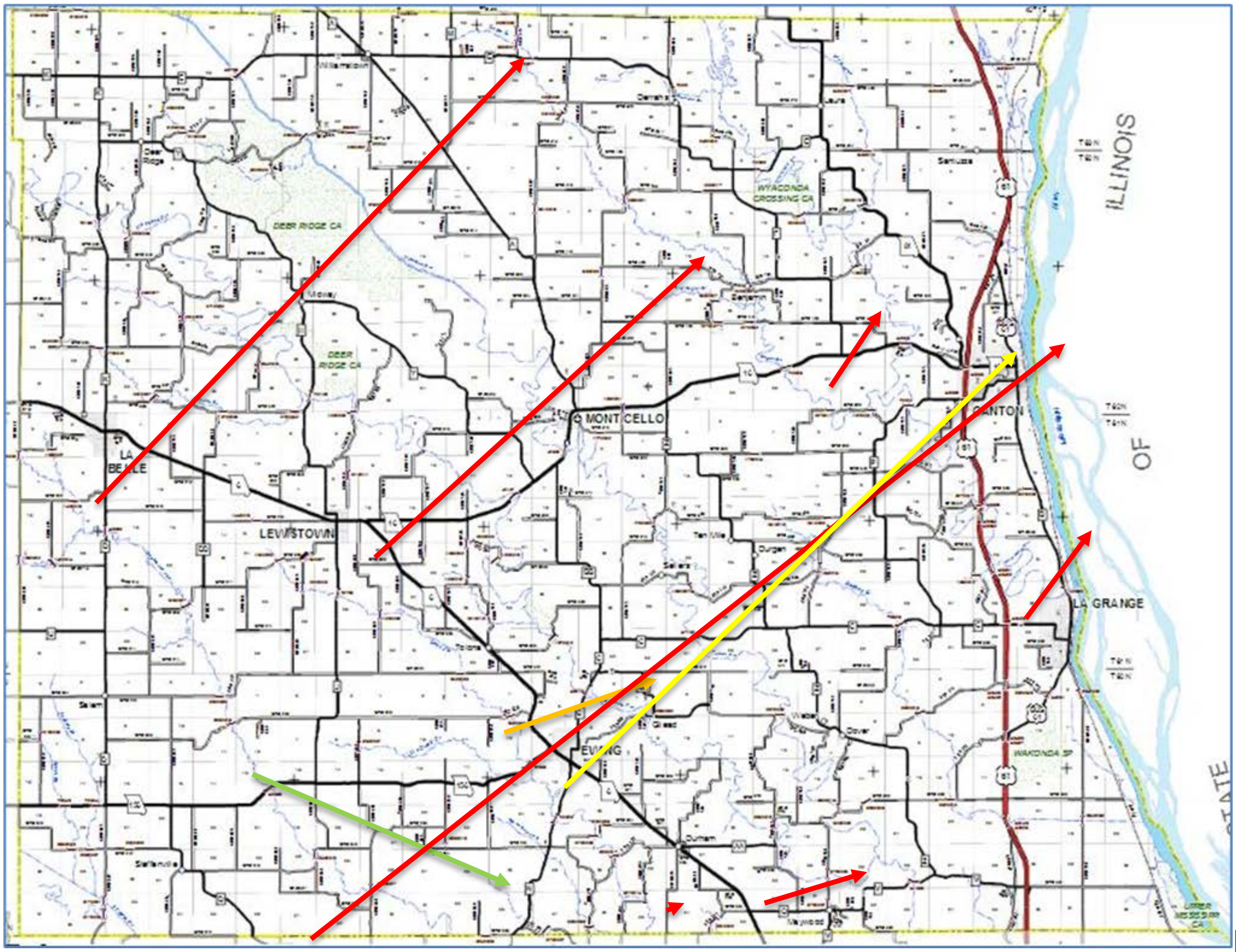
There are limitations to the use of NCEI tornado data that must be noted. For example, one tornado may contain multiple segments as it moves geographically. A tornado that crosses a county line or state line is considered a separate segment for the purposes of reporting to the NCEI. Also, a tornado that 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 3.46. Recorded Tornadoes in Lewis County, 1993 – Present

Date	Beginning Location	Ending Location	Length (miles)	Width (yards)	F/EF Rating	Death	Injury	Property Damage	Crop Damages
4/30/1997	Ewing	N of Canton	15	100	F1	0	1	200K	0
4/30/1997	W of LaGrange	N of LaGrange	1	50	F0	0	0	20K	0
6/14/1998	E of Lewistown	NE of Monticello	9.5	75	F1	0	0	0	0
4/8/1999	S of LaBelle	N of Monticello	16	150	F2	0	2	2.1M	0
6/4/1999	W of Canton	WNW of Canton	.5	50	F0	0	0	0	0
5/10/2003	SE of Steffenville	NE of Canton	20	200	F2	0	6	5M	0
5/10/2003	NE of Steffenville	S of Ewing	4	50	F0	0	0	0	0
8/8/2007	S of Durham	S of Durham	.1	10	EF0	0	0	0	0
5/30/2008	NW of Ewing	NE of Ewing	3.35	70	EF1	0	0	10K	0
4/27/2016	WNW of Maywood	NNE of Maywood	2.01	150	EF1	0	0	0	0
Total			**71.46**	**905**		**0**	**9**	**7.33M**	**0**

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

Figure 3.23. Lewis County Map of Historic Tornado Events



Source: NCEI Maps

During the time period from 2013 to 2022 the USDA Risk Management Agency shows there have been zero payments made for Tornado damage in Lewis County.

Probability of Future Occurrence

Over the course of the last 30 years there have been 10 tornado events in Lewis County. Those numbers would suggest there is 33% chance that any given year there could be a tornado in the Lewis County Planning Area.

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

Lewis County is located in a region of the U.S. with high frequency of dangerous and destructive tornadoes referred to as “Tornado Alley”. The high frequency has been determined by looking at the total number of tornadoes in the 17 states included in tornado alley. **Figure 3.24** illustrates the areas where dangerous tornadoes historically have occurred.

Figure 3.24. Tornado Alley in the U.S.

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

Potential Losses to Existing Development

In Lewis County, the NCEI estimated damages from 1993-2023 is $7,330,000 with the annualized property damage at $244,333 per year.

Previous and Future Development

There is no significant development anticipated which would result in an increase in population or increased exposure to damage.

EMAP Consequence Analysis

For communities with emergency management programs seeking EMAP accreditation, complete Table 3.47 to summarize the detrimental impacts from tornadoes.

Table 3.47. 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.

Subject	Detrimental Impacts
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.
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

A tornado event could occur anywhere in the planning area, but some jurisdictions could suffer heavier damages because of the age, type, and density of the housing. The greater the population, the greater the structure density and the greater the risk of damage.

Problem Statement

Tornadoes are common hazards in Lewis County and all of Missouri, and all geographic areas within the County are equally prone to experiencing such an event. Vulnerability to such an event tends to depend on the infrastructure present in the area where the event occurs, cropland and built-up areas each represent a significant economic vulnerability to Tornadoes, but human life is more important and that risk runs parallel to the population density of the affected areas.

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.

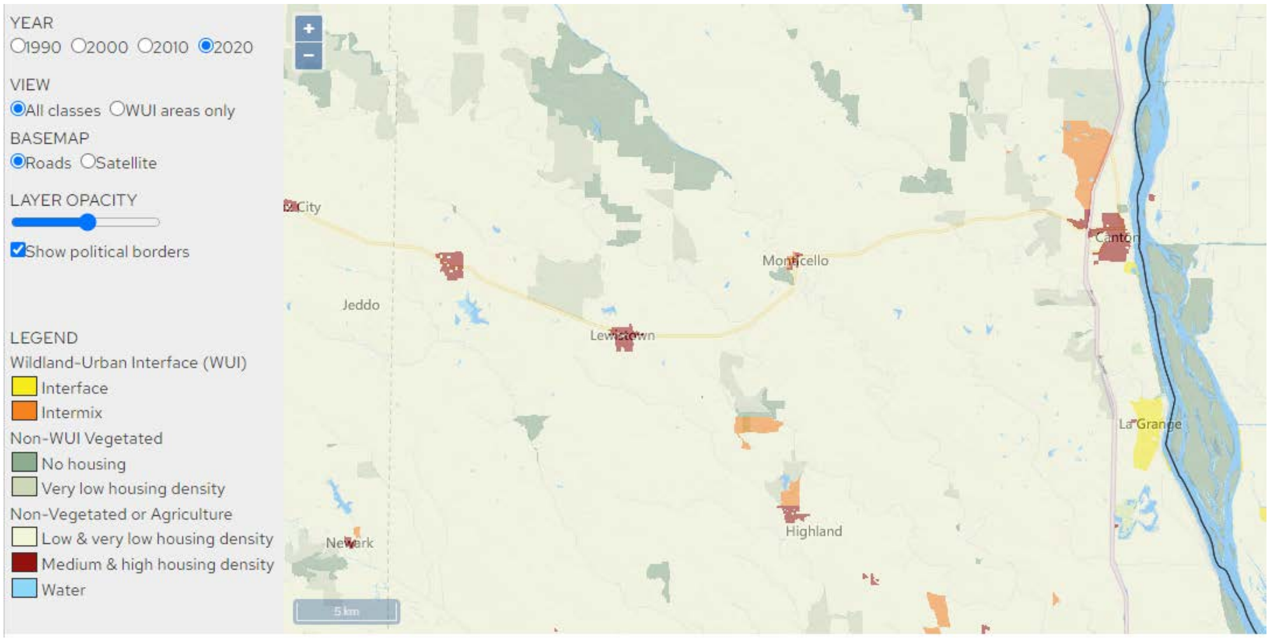
The Forestry Division of the Missouri Department of Conservation (MDC) is responsible for protecting privately owned and state-owned forests and grasslands from wildfires. To accomplish this task, eight forestry regions have been established in Missouri for fire suppression. The Forestry Division works 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

Wildland-Urban Interface 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.

Figure 3.25. Wildland-Urban Interface for Lewis 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.

At this time, no information is available on the severity of damages from the planning area on wildfires.

Previous Occurrences

According to information obtained from the Missouri Division of Fire Safety (MDFS) Website as well as the Missouri Department of Conversation Wildfire Data Search, there were 125 reported wildland or grass fires in Lewis County from 2013 to 2023. In total, these 159 fires burned 1,898 acres and no injuries were reported.

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

When analyzing the wildland fires, there has been an average of 15.8 fires burning 189.8 acres per year. However, it was reported these fires did not result in major damages.

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.

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

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.

As outlined in the Missouri 2018 State Plan, Lewis County was given a low vulnerability rating being based on housing, density, likelihood, building exposure, annualized property loss ratio, and death/injury factor. The data for wildfires are insufficient due to only 57% of fire departments in Missouri reporting to the National Fire Incident Reporting System. The majority of the fire departments in the planning area are comprised of volunteers and are limited on the time spent to report information.

Potential Losses to Existing Development

The potential loss to existing development due to wildfire is difficult to determine due to lack of sufficient historical data. An average number of fires per year have been determined; however, there are no losses reported associated with the data. Information on historical losses was sought after through various sources including the Missouri Division of Fire Safety and The Missouri Department of Conservation.

Impact of Previous and Future Development

Future development in the Wildland-Urban Interface would increase hazard vulnerability.

EMAP Consequence Analysis

Table 3.48. 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

A small area near the City of Canton is the only designated wildland-urban interface area in the County. This area has an increased risk compared to the County overall.

Problem Statement

Lewis County does experience Wildland fire events on a regular basis, but the acreage destroyed in these events is relatively small, though a disproportionate number of structures seem to have been affected. The risk of more seriously damaging events is fairly low, though it is higher in the designated Wildland-urban interface near Canton.

3.4.11 Pandemic

Hazard Profile

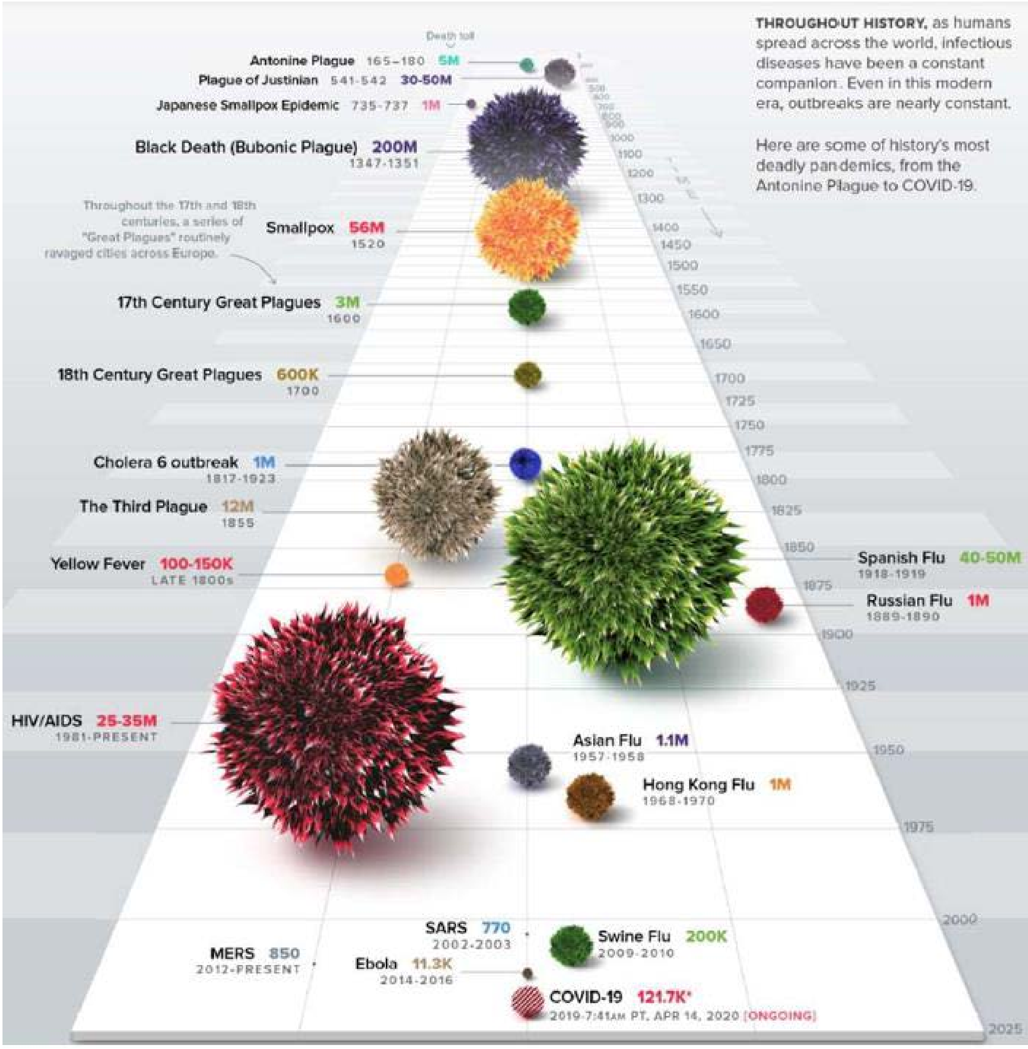
Hazard Description
According to the Center for Disease Control, a pandemic is a global outbreak of disease. Pandemics happen when a new virus emerges to infect people and can spread between people sustainably. Because there is little to no pre-existing immunity against the new virus, it spreads worldwide.

Geographic Location
All of Lewis County are susceptible to a pandemic outbreak due to its main characteristic of being on a global level.

Strength/Magnitude/Extent
Risk depends on characteristics of the virus, including how well it spreads between people; the severity of resulting illness; and the medical or other measures available to control the impact of the virus (for example, vaccines or medications that can treat the illness) and the relative success of these. In the absence of vaccine or treatment medications, nonpharmaceutical interventions become the most important response strategy. These are community interventions that can reduce the impact of disease.

Previous Occurrences
The planning area, in addition to others across the globe, is currently in the midst of a pandemic. The virus that causes COVID-19 is infecting people and spreading easily from person-to-person. On March 11, 2020, the COVID-19 outbreak was characterized as a pandemic by the World Health Organization. According to the Center for Disease Control, this is the first pandemic known to be caused by a new coronavirus. In the past century, there have been four pandemics caused by the emergence of new influenza viruses. As a result, most research and guidance around pandemics is specific to influenza, but the same premises can be applied to the current COVID-19 pandemic. Pandemics of respiratory disease follow a certain progression outlined in a “Pandemic Intervals Framework.” Pandemics begin with an investigation phase, followed by recognition, initiation, and acceleration phases. The peak of illnesses occurs at the end of the acceleration phase, which is followed by a deceleration phase, during which there is a decrease in illnesses. Different countries can be in different phases of the pandemic at any point in time and different parts of the same country can also be in different phases of a pandemic.
As humans have spread across the world, so have infectious diseases. Even in this modern era, outbreaks are nearly constant, though not every outbreak reaches pandemic level. Figure 3.26 below outlines the history of pandemics dating back to 165.

Figure 3.26.   History of Pandemics



Source: https://www.visualcapitalist.com/history-of-pandemics-deadliest/

Probability of Future Occurrence

The threat of pandemics in the planning area, and across the globe, remains a concern.

Changing Future Conditions Considerations

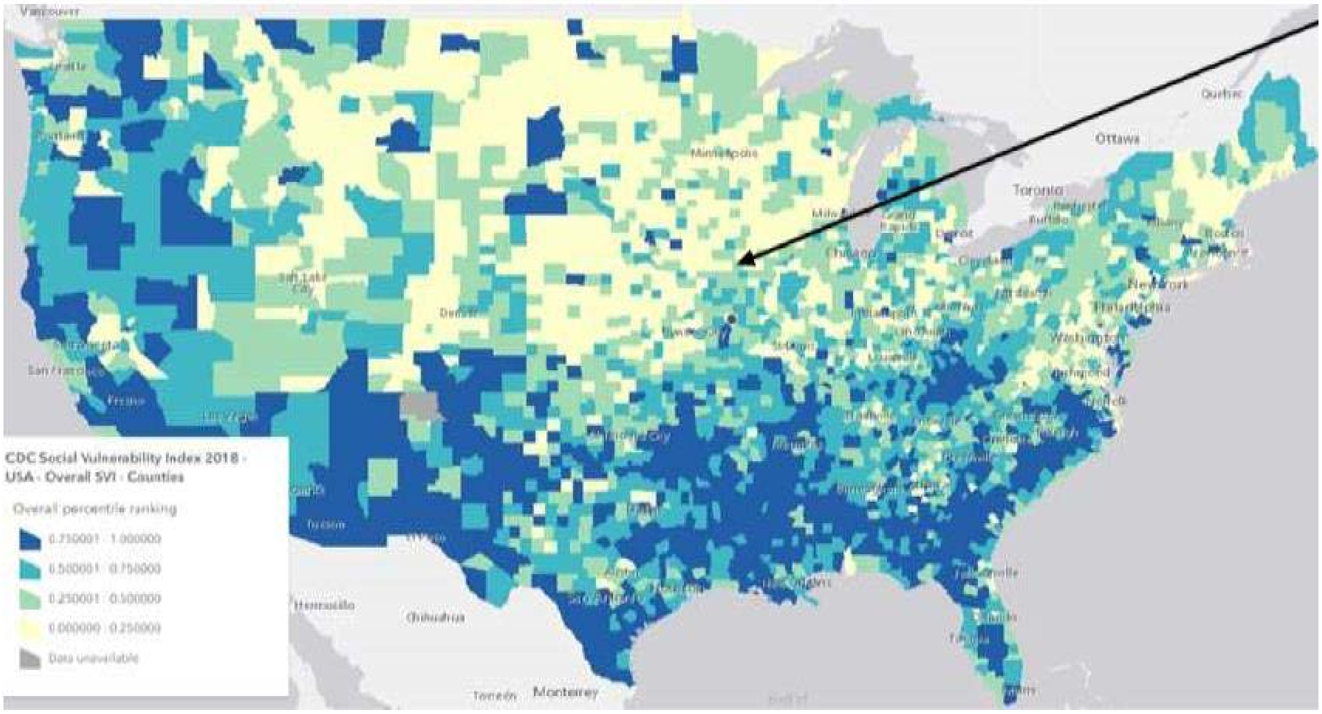
Climate change and weather patterns are widely thought to have direct impacts on the probability and severity of future pandemic outbreaks. Habitat loss due to climate is bringing animals that can transmit disease in contact with humans more often. Floods can enhance the spread of infectious agents like insects, bacteria, and viruses. Increasing temperatures and humidity affect the development, survival and spread of not only pathogens, but also their hosts (often animals).

Vulnerability

Vulnerability Overview

Each jurisdiction and its population, businesses, and school districts are vulnerable to a pandemic outbreak. Due to an increasing elderly population throughout the planning area, an outbreak of an infectious or viral disease could have major impacts on the communities and the assets each possess.

Figure 3.27. Social Vulnerability Rating in the United States



Source: https://livingatlas.arcgis.com/policy/browse/?loc=94.542,39.439,5&col=88f17b4580e846609f92c9f75a9d9eee,2c8fdc6267e4439e96883702 0e7618f3,48638a1be455429287d6756985013910,02a82293e2dd475391cb3699b5e82d61,d89c527f2e6b4d658db0948ea9d49cd9,48a70b 524601428ba297e3106b751401,be559110b5c34591b1a767fbb807bcbf,e0427fbc472f4a45b7d94d182a5e9591,142e65436bed406397338 0feae6ed248&viz=2c8fdc6267e4439e96883702 0e7618f3&hs=1 *Arrow indicates Lewis County

Potential Losses to Existing Development

During a pandemic, COVID-19 for example, people have been ordered to stay home, schools adjourned the remainder of the year, restaurants and bars are forced to close their doors. It is very likely the livelihood of the population and some of the planning area's most beloved assets and businesses will not be able to recover the pandemic due to extreme economic loss and health threats.

Impact of Previous and Future Development

Pandemics create unprecedented disruption for global health and the development of communities. Urbanization in the developing world is bringing more and more rural residents into denser neighborhoods, while population increases are putting greater pressure on the environment. In conjunction, air traffic nearly doubled in the past decade. These macro trends are having major impacts on the spread of infectious disease.

Hazard Summary by Jurisdiction

The planning area is largely rural, and many have a sense of "safeness" when it comes to an infectious or viral pandemic, in the sense that most of the population can securely distance themselves from one another, whereas larger cities do not have that luxury. Unfortunately, pandemics happen on a global level and no community is immune.

Problem Statement

In order to keep transmission rates low during a pandemic outbreak, residents need to safely distance themselves as best as possible and follow the numerous Center for Disease Control guidelines. Due to the lack of accessibility to ongoing public health information and broadband connectivity, it is especially challenging to inform residents about current and upcoming pandemic updates. It is an issue in rural America to convey the severity of pandemic outbreaks and provide preparedness instruction because social media, website posts, podcasts, etc. are not an option for every resident in the planning area.