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 2016 and Ralls County, Perry, New London, and Center participated in the multi-jurisdictional county-wide plan. The 2016 Hazard Mitigation Plan was consulted in development of the risk assessment and information included and updated where appropriate.

The MPC decided to include 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. FEMA Disaster Declarations that included Ralls County, Missouri, 1965-Present

Disaster Number	Description	Declaration Date Incident Period	Individual Assistance (IA) Public Assistance (PA)
DR-372-MO	Heavy Rains, Tornadoes, Flooding	04/19/73	PA
DR-439-MO	Severe Storms, Flooding	06/10/73	PA
EM-3017-MO	Drought	09/24/76	IA
DR-779-MO	Severe Storms, Flooding	10/14/86 09/18/86-10/15/86	PA
DR-989-MO	Severe Storms, Flooding	05/11/93 04/15/93-05/29/93	PA
DR-995-MO	Severe Storms, Flooding	07/09/93 06/10/93-10/25/93	PA
DR-1412-MO	Severe Storms, Tornadoes	05/06/02 04/24/02-06/10/02	PA
DR-1403-MO	Ice Storm	02/06/02	PA
DR-1463-MO	Severe Storms, Tornadoes, Flooding	05/06/03 05/04/03-05/30/03	IA and PA
EM-3232-MO	Hurricane Katrina Evacuation	09/10/05	PA
DR-1635-MO	Severe Storms, Tornadoes, Flooding	04/06/06 03/30/06-04/03/06	IA and PA
DR-1673-MO	Severe Winter Storms	12/29/06 11/30/06-12/02/06	PA
EM-3281-MO	Severe Winter Storms	12/12/07 12/08/07-12/15/07	PA
DR-1773-MO	Severe Storms, Flooding	06/25/08 06/01/08-08/13/08	IA and PA
DR-1934-MO	Severe Storms, Tornadoes, Flooding	08/17/10 06/12/10-07/31/10	PA
EM-3317-MO	Severe Winter Storms	02/03/11 01/31/11-02/05/11	IA
DR-1961-MO	Severe Winter Storms, Snow Storms	03/23/11 01/31/11-02/05/11	PA
DR-4130-MO	Severe Storms, Tornadoes, Straight-line Winds, Flooding	07/18/13 05/29/13-06/11/13	PA
DR-4200-MO	Severe Storms, Tornadoes, Straight-line Winds, Flooding	10/31/14 09/09/14-09/11/14	PA
DR-4238-MO	Severe Storms, Tornadoes, Straight-line Winds, Flooding	08/07/15 05/15/15-07/27/15	PA
EM-3374-MO	Severe Storms, Tornadoes, Straight-line Winds, Flooding	01/02/16 12/22/15-01/09/16	PA
DR-4317-MO	Severe Storms, Tornadoes, Straight-line Winds, Flooding	06/02/17 04/28/17-05/11/2017	PA
DR-4451-MO	Severe Storms, Tornadoes, Flooding	07/09/19 04/29/19-07/06/19	PA
EM-3482-MO	COVID-19	03/13/20 01/20/20-Present	PA
EM-4490-MO	COVID-19 pandemic	03/26/20 01/20/20-Present	PA
DR-4552-MO	Severe Storms, Tornadoes, Straight-line Winds, Flooding	07/09/20 05/03/20-05/04/20	PA

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

3.1.3 Research Additional Sources

The list below is 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 (April 2017)
- 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 Ralls County differ in their susceptibilities to certain hazards for example New London located downstream from the Mark Twain Lake Dam is more likely to experience significant flooding from dam failure than Perry which is upstream from the dam. The hazards identified were based on the input from the planning team members, available historical data and the hazard modeling results described within the hazard mitigation plans. The jurisdictions and hazards chosen that significantly impact the planning area is listed in alphabetical order in Table 3.2. The chart includes an “x” to indicate the jurisdiction is impacted by the hazard and a “-“indicates the hazard is not applicable to that jurisdiction.

Table 3.2. Hazards Identified for Each Jurisdiction

Jurisdiction	Dam Failure	Drought	Earthquake	Extreme Temperatures	Flooding (River and Flash)	Land Subsidence/Sinkholes	Levee Failure	Severe Winter Weather	Thunderstorm/Lightning/Hail/ High Wind	Tornado	Wildfire	Pandemic
Ralls County	x	x	x	x	x	x	x	x	x	x	x	x
Perry	-	x	x	x	-	x	-	x	x	x	x	x
Center	x	x	x	x	-	x	-	x	x	x	x	x
New London	x	x	x	x	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. Perry and New London are slightly more urbanized within the planning area and have more assets that are vulnerable to the weather-related hazards and varied development trends impact the future vulnerability. Similarly, more rural areas have more assets (crops/livestock) that are vulnerable to animal/plant/crop disease. These differences are discussed in greater detail in the vulnerability sections of each hazard.

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

<u>**Unincorporated County and Incorporated Cities**</u>

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	2019 Annual Population Estimate	Building Count	Building Exposure ($)	Contents Exposure ($)	Total Exposure ($)
Perry	695	520	53,795	30,479	84,273
New London	987	494	56,221	30,011	86,232
Center	506	313	33,253	18,428	51,681
Unincorporated Ralls County	10,309	11,202	532,779	301,751	834,530
Totals	12,497	12,529	676,068	380,669	1,056,716

Source: U.S. Bureau of the Census, Annual population estimates/ 5-Year American Community Survey 2019; 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
Center	$28,682	$3,676	$0	$48	$32,406
Perry	$44,305	$5,728	$1,458	$149	$51,640
New London	$51,767	$3,248	$243	$13	$55,371
Unincorporated Ralls County	$452,727	$27,868	$30,376	$17,237	$528,208
Totals	$577,481	$40,520	$32,077	$17,447	$667,625

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
City of Perry	380	67	6	59	512
City of New London	444	38	1	5	488
City of Center	246	43	0	19	308
Ralls County	3,883	326	125	6,843	11,177
City of Hannibal	129	49	56	3	237
Totals	5,082	523	188	6,929	12,722

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

Even though schools and special districts' total assets are included in the tables above, additional discussion is needed, based on the data that is available from the districts' completion of the Data Collection Questionnaire and district-maintained websites. The number of enrolled students at the participating public-school districts is provided in **Table 3.6** 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
Ralls County R-II	779	10

Source: http://mcds.dese.mo.gov/quickfacts/Pages/District-and-School-Information.aspx., select the file for the most recent year called "20xx Building Enrollment PK-12", filter the spreadsheet by selecting only the public school districts in the planning area. The Building Exposure, Contents Exposure, and Total Exposure amounts come from the completed Data Collection Questionnaires from Public School Districts. In general, the school districts obtain this information from their insurance coverage amounts.

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:

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

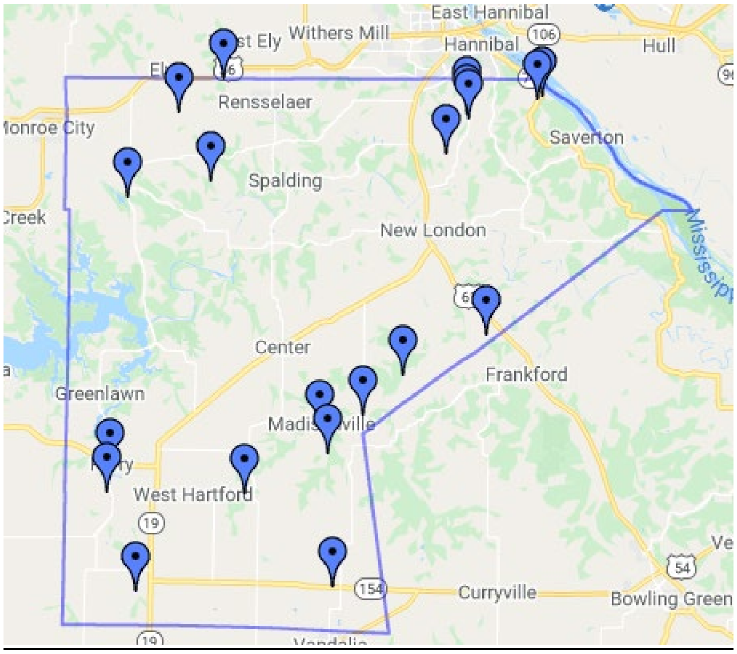
Table 3.7. Inventory of Critical/Essential Facilities and Infrastructure by Jurisdiction

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
Ralls County	-	-	X	X	X	X	X	X	X	X	X	X	-	X	X	X	-	X	-	X	-	-	X
Perry	-	-	X	X	-	X	X	X	X	X	X	X	-	X	-	-	-	-	-	-	-	-	-
New London	-	-	X	X	-	X	X	X	X	X	X	X	-	-	-	-	-	X	-	-	-	-	-
Center	-	-	X	-	-	-	X	X	X	-	-	X	-	-	X	-	-	-	-	-	-	-	-
Totals	0	0	5	3	1	3	4	4	4	3	3	4	0	0	2	1	0	2	0	0	0	0	1

Source: Data Collection Questionnaires

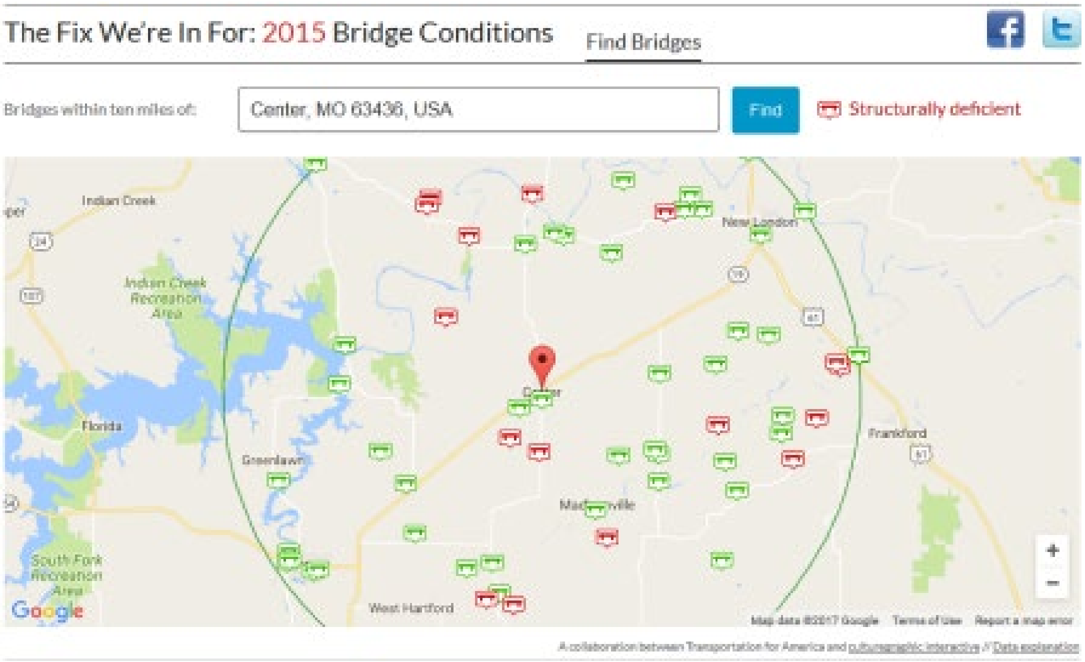
Bridges: This term refers to one of the database elements in the National Bridge Inventory. This element is quantified using a "scour index", which is a number indicating the vulnerability of a bridge to scour during a flood. Bridges with a scour index between 1 and 3 are considered "scour critical", or a bridge with a foundation determined to be unstable for the observed or evaluated scour condition. The map below displays all of Ralls County bridges, however, there were no bridges indicated as "scour critical" in the planning area.

Figure 3.1. Ralls County Bridges



Source: Bridgehunter.com

Figure 3.2. Ralls County Structurally Deficient Bridges



The Fix We're In For: 2015 Bridge Conditions

Bridges within ten miles of: Center, MO 63436, USA

3.2.3 Other Assets

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

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

Threatened and Endangered Species: **Table 3.8** includes Federally Threatened, Endangered, Proposed and Candidate Species in the Ralls County, Missouri.

Table 3.8. Threatened and Endangered Species in Ralls County

Common Name	Scientific Name	Status
Indiana Bat	Myotis sodalist	Endangered
Gray Bat	Myotis grisecens	Endangered
Northern Long-Eared Bat	Myotis septentrionalis	Threatened
Fat Pocketbook	Potamius capax	Endangered
Sheepnose Mussel	Plethobasus cyphuys	Endangered
Least tern	Sterna antillaqrum	Endangered
Piping Plover	Charadrius melodus	Threatened
Rufa Red Knot	Calidris Canutus Rufa	Threatened
Specaclecase	Cumberlandia monodonta	Endangered
Eastern Prairie Fringed Orchid	Platanthera leucophaea	Threatened

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

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

Table 3.9. Parks in Ralls County

Park / Conservation Area	Address	City
Anderson (Edward) CA	Highway 79	South Hannibal 10 miles
Indian Camp Access	Route O	New London
Monroe City (Route J Reservoir)	Route J	Monroe City
Thompson (Robert H) CA	Route E	New London
Upper Mississippi CA	Various Locations	
Bill Trower Memorial Park	East Main Street	Perry
Ruth & Roy Wright Park	4th Street	New London

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

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. Ralls County Properties on the National Register of Historic Places

Property	Address	City	Date Listed
James B. Brown House	2400 Carrs Lane	Hannibal	1/26/1984
John Garth House	S. of Hannibal off US 61	Hannibal	7/11/1977
Greenlawn Methodist Church & Cemetery	Jct. of J and County Road D	Perry	6/21/2007
Ilasco Historic District	10998 Ilasco Trail	Hannibal	6/16/2016
Lock and Dam No. 22 Historic District	Upper Mississippi	New London	3/10/2004
Ralls County Courthouse and Jail	Courthouse Square	New London	9/14/1972
St. Paul Catholic Church	W. of Center off SR EE	Center	5/31/1979
St. Peter's Catholic Church	Brush Creek Area	Rensselaer	11/14/1980
Saverton School	Jct. of CR N and E	Saverton	12/10/1998

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

Economic Resources: **Table 3.11** shows major non-governmental employers in Ralls County.

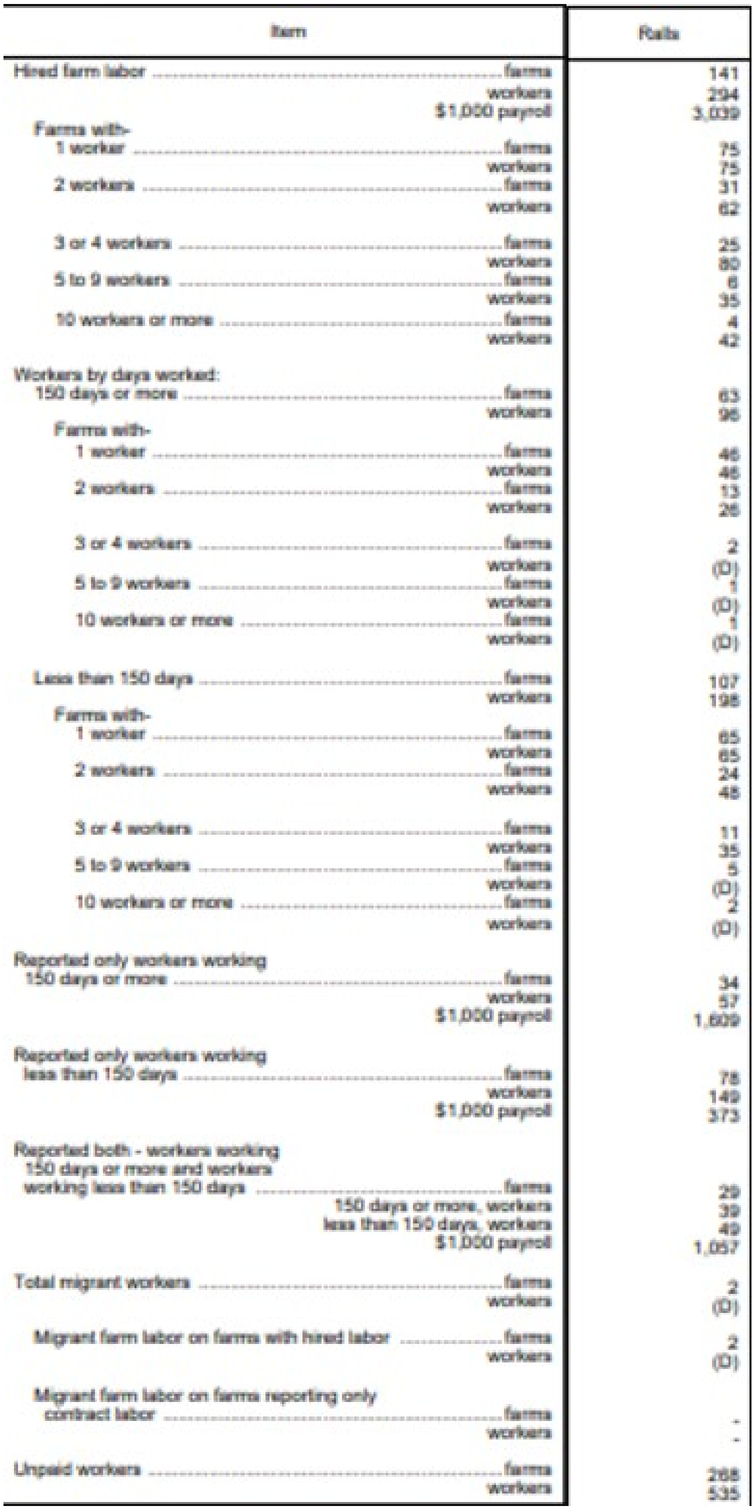
Table 3.11. Major Non-Government Employers in Ralls County

Employer Name	Main Locations	Product or Service	Employees
Perry Machine & Die	Perry	Plastic Injection Molding	65
General Mills	Hannibal	Food	249
Watlow	Hannibal	Electric heaters, sensors	285
Yancey Auto Parts	Perry	Auto Parts	30

Source: Data Collection Questionnaires; local Economic Development Commissions

Agriculture: Agriculture plays an important role in the planning area's economy. **Table 3.12** provides a summary of the agriculture-related jobs in Ralls County.

Table 3.12. Agriculture-Related Jobs in Ralls County



Item		Ralls
Hired farm labor	farms	141
	workers	294
	$1,000 payroll	3,039
Farms with-		
1 worker	farms	75
	workers	75
2 workers	farms	31
	workers	62
3 or 4 workers	farms	25
	workers	80
5 to 9 workers	farms	6
	workers	35
10 workers or more	farms	4
	workers	42
Workers by days worked:		
150 days or more	farms	63
	workers	96
Farms with-		
1 worker	farms	46
	workers	46
2 workers	farms	13
	workers	26
3 or 4 workers	farms	2
	workers	(D)
5 to 9 workers	farms	1
	workers	(D)
10 workers or more	farms	1
	workers	(D)
Less than 150 days	farms	107
	workers	198
Farms with-		
1 worker	farms	65
	workers	65
2 workers	farms	24
	workers	48
3 or 4 workers	farms	11
	workers	35
5 to 9 workers	farms	5
	workers	(D)
10 workers or more	farms	2
	workers	(D)
Reported only workers working 150 days or more	farms	34
	workers	57
	$1,000 payroll	1,609
Reported only workers working less than 150 days	farms	78
	workers	149
	$1,000 payroll	373
Reported both - workers working 150 days or more and workers working less than 150 days	farms	29
	150 days or more, workers	39
	less than 150 days, workers	49
	$1,000 payroll	1,057
Total migrant workers	farms	2
	workers	(D)
Migrant farm labor on farms with hired labor	farms	2
	workers	(D)
Migrant farm labor on farms reporting only contract labor	farms	-
	workers	-
Unpaid workers	farms	268
	workers	535

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**, Ralls County has experienced an increase in population.

Table 3.13. County Population Growth, 2010-2019

Jurisdiction	Total Population 2010	Total Population 2019	2010-2019 # Change	2000-2019 % Change
Ralls County	10,167	10,309	142	1%
Perry	693	695	2	1%
New London	974	987	13	1%
Center	508	506	-2	1%
Total	12,342	12,497	155	1%

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

Along with the population increase there has been an increase in the number of housing units except for the city of Center that saw an increase. **Table 3.14** provides the change in number of housing units in the planning area from 2010 to 2019.

Table 3.14. Change in Housing Units, 2010-2019

Jurisdiction	Housing Units 2010	Housing Units 2019	2010-2019 # Change	2000-2019 % Change
Ralls County	4,091	5,194	1,103	1.27%
Perry	323	323	0	0%
New London	417	467	50	1.12%
Center	270	268	-2	1%
Total	5,040	6,252	1,151	1.24%

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

The one school district in the planning area completed a major expansion and consolidation of school buildings. Included in the expansion was the construction of a saferoom and elementary school located at the new facility. The county and cities have not had any major changes in their development to impact the vulnerability to hazards.

3.3.2 Future Land Use and Development

Population growth or decline is generally accompanied by increases or decreases in the number of housing units. With the trend in population increase for the entire county it was a very small change and there is no reason to expect an increase in future development.

School District's Future Development

The only school district in the planning area recently completed an expansion and will not expand any further in the near future.

Special District’s Future Development

The Special District’s did not indicate any future development within the county.

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 Ralls County plan will also be based on:

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

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

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

- **Potential Losses to Existing Development:** This section provides the potential losses existing development.

- **Previous and Future Development:** This section will include information on how changes in development have impacted the community's vulnerability to this hazard.

- **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 will conclude with a brief summary of the problems created by the hazard in the planning area, and possible ways to resolve those problems. If the risk varies across the planning area jurisdiction-specific information will be included.

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.

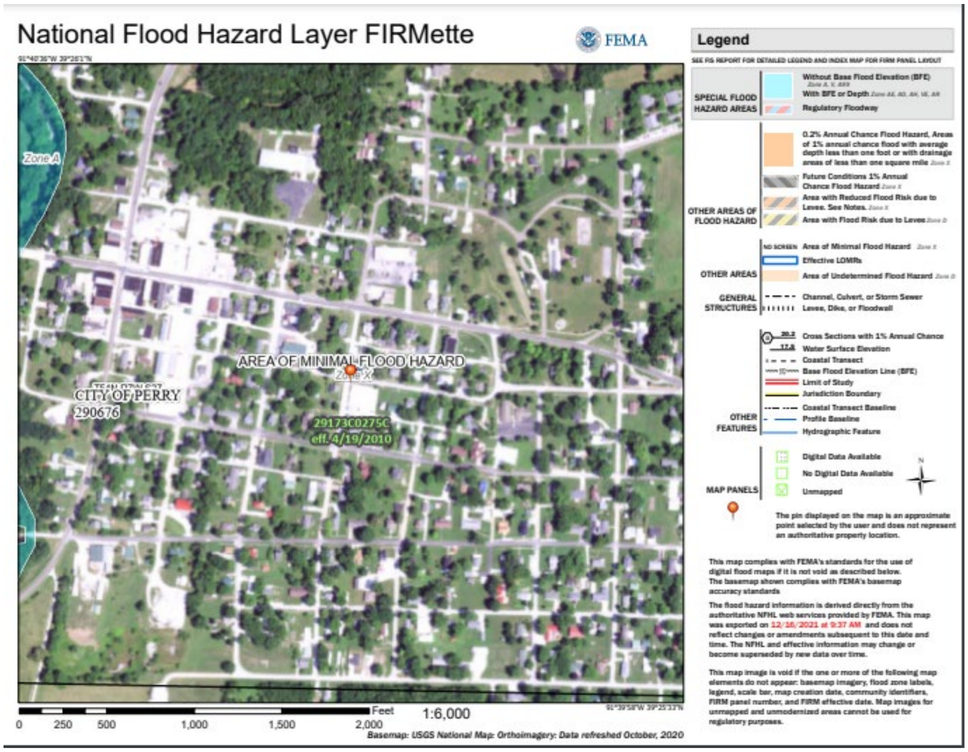
Most flash flooding is caused by slow-moving thunderstorms or thunderstorms repeatedly moving over the same area. Flash flooding is a dangerous form of flooding which can reach full peak in only a few minutes. Rapid onset allows little or no time for protective measures. Flash flood waters move at very 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 SFHA's. NCEI data includes events for flooding and for flash flooding. In order to obtain information for the following tables, consult event narratives. Those events without location-specific information will be tabulated under "unspecified" locations in the table. Generally, using a 20-year time frame for previous events is adequate. However, where flooding records are scanty, as many years as needed will be used for a solid probability calculation.



The pin displayed on the map is an approximate point selected by the user and does not represent an authoritative property location.

This map complies with FEMA's standards for the use of digital flood maps if it is not void as described below. The basemap shown complies with FEMA's basemap accuracy standards

The flood hazard information is derived directly from the authoritative NFHL web services provided by FEMA. This map was exported on 12/16/2021 at 9:37 AM and does not reflect changes or amendments subsequent to this date and time. The NFHL and effective information may change or become superseded by new data over time.

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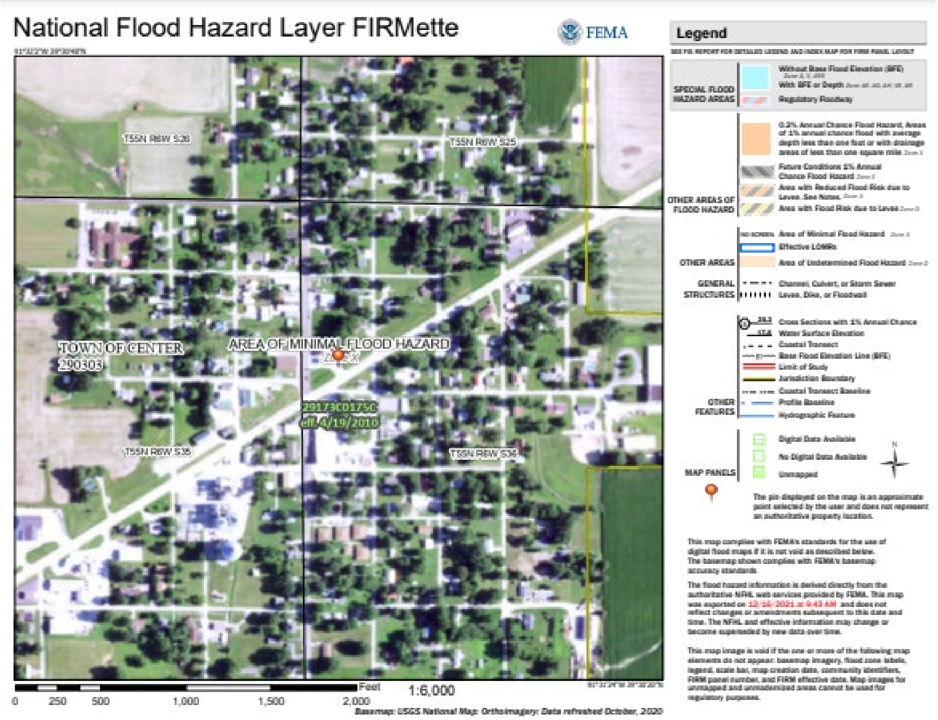
Basemap: USGS National Map: Orthoimagery: Data refreshed October, 2020



The pin displayed on the map is an approximate point selected by the user and does not represent an authoritative property location.

This map complies with FEMA's standards for the use of digital flood maps if it is not void as described below. The basemap shown complies with FEMA's basemap accuracy standards

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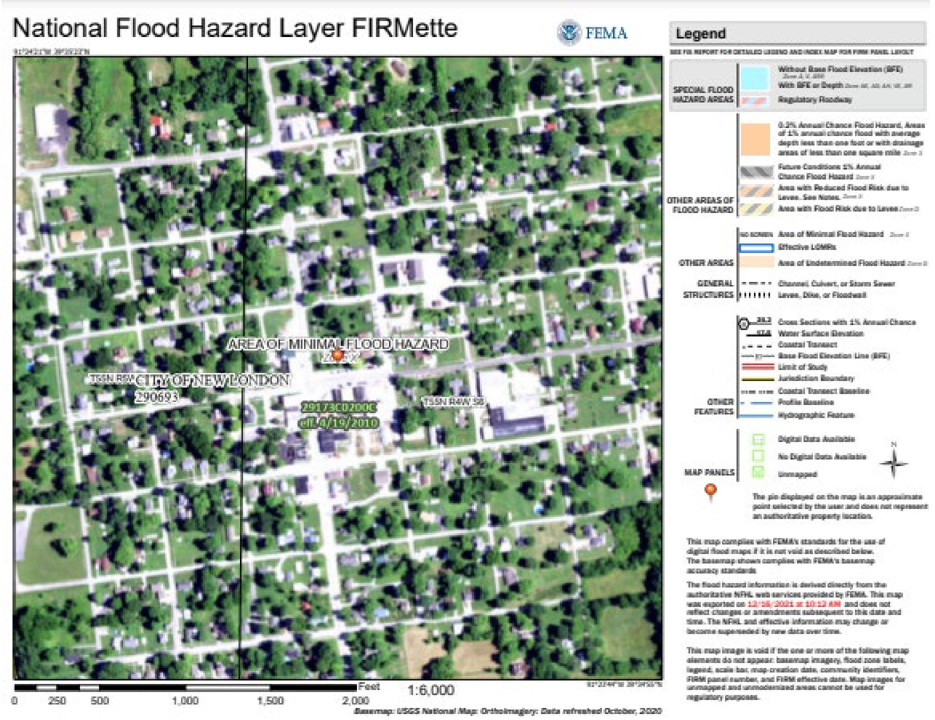
Basemap: USGS National Map: Orthoimagery: Data refreshed October, 2020



The pin displayed on the map is an approximate point selected by the user and does not represent an authoritative property location.

This map complies with FEMA's standards for the use of digital flood maps if it is not void as described below. The basemap shown complies with FEMA's basemap accuracy standards

The flood hazard information is derived directly from the authoritative NFHL web services provided by FEMA. This map was exported on 12/16/2021 at 10:12 AM and does not reflect changes or amendments subsequent to this date and time. The NFHL and effective information may change or become superseded by new data over time.

This map image is void if the one or more of the following map elements do not appear: basemap imagery, flood zone labels, legend, scale bar, map creation date, community identifiers, FIRM panel number, and FIRM effective date. Map images for unmapped and unmodernized areas cannot be used for regulatory purposes.

Basemap: USGS National Map: Orthoimagery: Data refreshed October, 2020

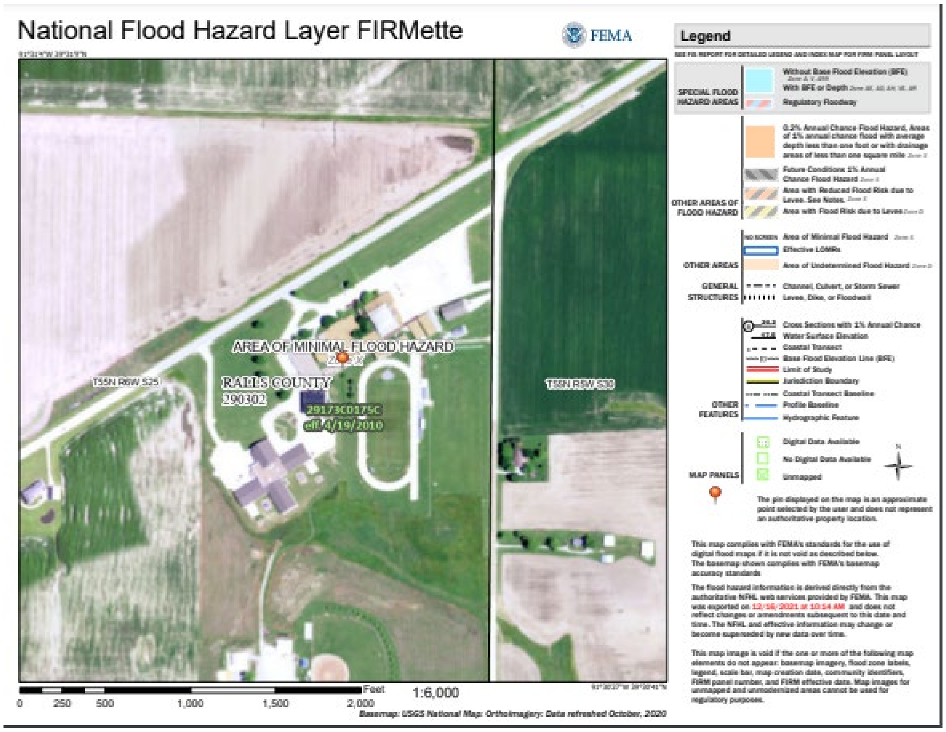


Table 3.15. Ralls County NCEI Flood Events by Location, 2001-2021

Location	# of Events
Ralls County	12
-Unincorporated County (unspecified)- 3 flood events	
-Unincorporated County (Hatch)- 1 flood events	
-Unincorporated County (Saverton)- 1 flood event	
-Unincorporated County (Ilasco)- 7 flood events	

Source: National Centers for Environmental Information, 08/24/21

Flash flooding occurs in SFHAs and low-lying locations in the planning area. They also occur in areas without adequate drainage to carry away the amount of water that falls during intense rainfall events. NCEI database was used to determine which jurisdictions are most prone to flash flooding during a 20-year time period. **Table 3.16** shows the number of flash flood events by location recorded in NCEI for the 20-year period.

Table 3.16. Ralls County NCEI Flash Flood Events by Location, 2001-2021

Location	# of Events
Unincorporated County	12
-Unincorporated County (unspecified)- 5 flood events	
-Unincorporated County (Ilasco)- 3 flood events	
-Unincorporated County (Hutchinson)- 2 flood events	
-Unincorporated County (Madisonville)- 1 flood events	
-Unincorporated County (Rensselaer)- 1 flood events	
Center	1

New London	1

Source: National Centers for Environmental Information, 08/30/21

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 Ralls County

Community ID #	Community Name	NFIP Participant (Y/N/Sanctioned)	Current Effective Map Date	Regular-Emergency Program Entry Date
290302	Ralls County	Yes	04/19/10	05/01/89
290693	New London	Yes	NSFHA	02/26/02
	Center	No		
290676	Perry	Sanctioned		2/7/1976

Source: NFIP Community Status Book, 09/14/21; 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

The City of Perry proposed to be a participant in the National Flood Insurance Program, but the citizens did not see the benefit. The City Council ultimately voted against being a participant as requested by the citizens.

Table 3.18. NFIP Policy and Claim Statistics as of Date

Community Name	Policies in Force	Insurance in Force	Closed Losses	Total Payments
Ralls County	27	$77,8722.73	37	$928,288.89

Source: NFIP Community Status Book, [11/4/21]; BureauNet, http://bsa.nfipstat.fema.gov/reports/reports.html; *Closed Losses are those flood insurance claims that resulted in payment.

Ralls County had the most insurance payments totaling $928,288.89.

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 7 repetitive loss properties. As of 11/04/21, 0 properties have been mitigated, leaving 7 un-mitigated repetitive loss properties.

Table 3.19. Ralls County Repetitive Loss Properties

Jurisdiction	# of Properties	Type of Property	# Mitigated	Building Payments	Content Payments	Total Payments	Average Payment	# of Losses
Ralls County	7	Single Family	0	$310,349.32	28,228.55	$338,577.87	$48,368.27	16

Source: Flood Insurance Administration as of 11/4/2021.

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.

Ralls County does not have any Severe Repetitive Loss properties.

Previous Occurrences

May 2003- (DR-1463) Federal Disaster declaration was issued for 74 counties in Missouri including Ralls County.

June 2008- (DR 1773) Federal Disaster declaration was issued on June 2008 due to flooding in Northern Missouri. Reports from the state indicated that 2,421 homes were impacted by the flooding with 582 being affected, 535 sustained major damage, 225 sustained major damage and 1,079 were destroyed. The flood prompted FEMA to buyout houses in Monkey Run that had suffered substantial damage during previous floods.

August 2010- (DR-1934) there was 90 approved projects for this declaration with more than 75% for repair of roads, damaged culverts and bridges.

July 2013- (DR-4130) a slow-moving storm system brought severe weather to Ralls County including several rounds of heavy rainfall resulting in areas of flash flooding.

August 2015- (DR-4238) Federal Disaster declaration was issued for several counties throughout Missouri. Numerous roads were closed in the planning area and the flooding caused a substantial amount of damage left to clean up.

Table 3.20. NCEI Ralls County Flash Flood Events Summary, 1991 to 2021

Year	# of Events	# of Deaths	# of Injuries	Property Damages	Crop Damages
1996	1	0	0	0	0
1998	1	0	0	0	0
2002	1	0	0	0	0
2003	1	0	0	0	0
2004	3	0	0	0	0
2008	2	0	0	0	0
2009	2	0	0	0	0
2010	1	0	0	0	0
2013	1	0	0	0	0
2018	1	0	0	0	0
2020	2	0	0	0	0
2021	1	0	0	0	0
Total	17	0	0	0	0

Source: NCEI, data accessed 11/1/21

Table 3.21. NCEI Ralls County Riverine Flood Events Summary, 2001 to 2021

Year	# of Events	# of Deaths	# of Injuries	Property Damages	Crop Damages
2001	2	0	0	0	0
2002	2	0	0	0	0
2007	1	0	0	0	0
2008	4	0	0	255K	10M
2010	1	0	0	0	0
2013	3	0	0	2K	10K

Source: NCEI, 11/4/2021.

Flood Events

June 2003- Heavy rain caused flooding across parts of Audrain and Ralls County. Highway 54 and 19 near the West Fork of the Cuivre River in Audrain County flooded. In Ralls County, Highway V at the Salt River was flooded and closed.

July 2008-Over 2 inches of rain fell in a short amount of time on already saturated soils in northern Ralls County. Several secondary roads were flooded for a time including Cedar Cove Place south of Highway M. Between 4 and 6 inches of rain fell in a short amount of time on already saturated soils causing flash flooding. Numerous roads were flooded including Highway 19 southwest of Center and Route B south of Perry. There was severe flooding on Lick Creek which washed away several large unoccupied camping trailers. One business in the area was inundated by 4 feet of water from Lick Creek in the office and shop area. Also, the water washed away around 140 boats from the business, though most only sustained minor damage from the flood waters. About 20 boats were severely damaged or destroyed. A nearby home was flooded as well. Highway 19 was closed due to 2 to 3 feet of water flowing over it southwest of Center. Two men had to be rescued from a tree after they drove into these flood waters and their vehicle was swept off Highway 19 near Route EE. A major rain event which brought up to a foot of rain across parts of North Central Missouri filled the Mark Twain Lake, above the Clarence Cannon Dam, above capacity and caused flooding on the Salt River and its tributaries both above and below the dam. This represented the first flooding of the Salt River since the dams completion in 1984. The crest at New London represented the 8th highest crest of record, resulting in the flooding of numerous farm houses and state roads.

April 2009- Between 2 and 3 inches of rain fell in a short amount of time causing flash flooding. A water rescue had to be performed due to someone driving into 3 feet of running water over Highway F, about 5 miles south of Highway 19. No injuries were sustained due to the water rescue.

July 2010- Up to 6 inches of rain fell in a short amount of time causing flash flooding. Numerous roads were flooded including Highway J near Lick Creek Bridge, Highway M west of U.S. Highway 61, Highway P between Center and Vandalia, and Highway 154 southeast of Perry. One person was evacuated along Flint Hill Road northeast of New London due to flooding.

April 2013- The Mississippi River rose to major flood levels along the border of Ralls County. The river crested on the 21st through 22nd, but continued above flood stage into May. Damage was limited to a few roads closed and flooding of agricultural lowlands.

Probability of Future Occurrence

With the extensive history of flooding in the planning area, it is likely that flooding of various levels will occur in the western part of the county. The probability of a flash flood event occurring in the planning area in any given year is 48%. Flood events occur in the planning area and have a 70% probability of occurring 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.

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

An estimate for the potential loss to existing development was not able to be obtained and included in this plan for Ralls County.

Impact of Previous and Future Development

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

Hazard Summary by Jurisdiction

Vulnerability to flood varies by jurisdiction. The floodplain map in the geographic location section shows the greatest risk to be along the Mississippi River and in the areas west of the Clarence Cannon Dam.

Problem Statement

Flooding or flash flooding affects the western part of Ralls County. The Mississippi River runs along the western border of Ralls County which is prone to flooding and education is deficient in what to do in the event of a flood. Possible solutions are to increase the education to residents, promote the use of social media or texting and work with officials to identify flood prone areas.

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

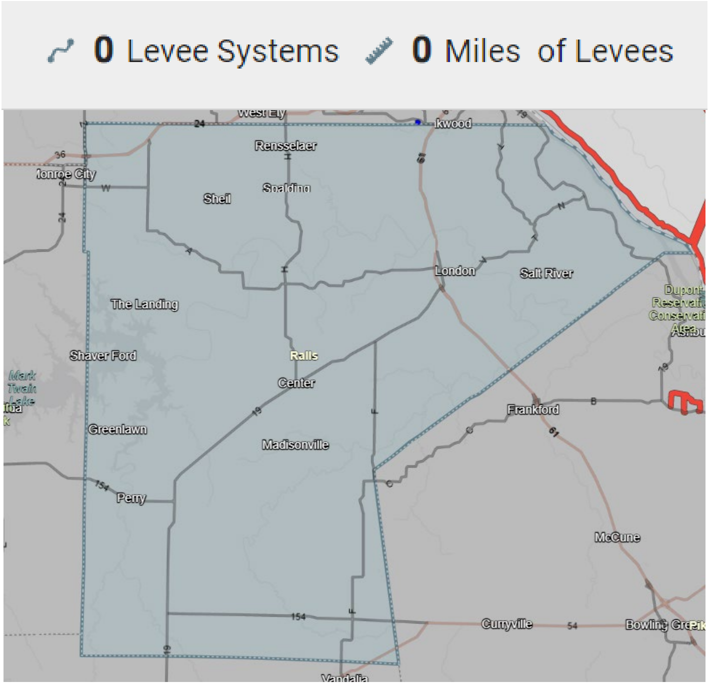
Missouri is a state with many levees. Currently, there is no single comprehensive inventory of levee systems in the state. Levees have been constructed across the state by public entities and private entities with varying levels of protection, inspection oversight, and maintenance. The lack of a comprehensive 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: https://levees.sec.usace.army.mil/#

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

The only levees in the planning area are low-head agricultural levees that are not tracked for breaches or incidents.

Probability of Future Occurrence

Due to the lack of information on low-head agricultural levees information on levee failure is unobtainable.

Changing Future Conditions Considerations

DThe 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.

Vulnerability

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 were not any levees in the planning area rated unacceptable.

Potential Losses to Existing Development

Levees have been constructed across the planning area by public entities and private entities with varying levels of protection, inspection oversight and maintenance. Due to only having low-head agricultural levees in the planning area damage is very minimal.

Impact of Previous and Future Development

Impact on future development in the planning area is directly related to the floodplain management and regulations set forth my Ralls County and individuals through levee management and regulations which are not clearly defined. It is difficult to predict the impact on future development due to most private levees are not regulated or inspected by one agency or on a regular basis. Any new construction that falls in the floodplain will have to adhere to Ralls County's construction and zoning regulations and most adhere to those regulations.

Hazard Summary by Jurisdiction

Currently no jurisdictions or areas in the planning area are protected by a levee.

Problem Statement

Low-head agricultural levees are not regulated or inspected on a regular basis.

Residents need to be informed on how to perform inspections on low-head agricultural levees.

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 Ralls County has been collected from two sources; a listing maintained by the Missouri Department of Natural Resources (MoDNR) and the National Inventory of Dams (NID). Each has its own system of classifying dams. For the purpose of planning, the NID information was used. Neither the MoDNR nor the NID hazard potential classification references the condition of the dame.

Table 3.22. MoDNR Dam Hazard Classification Definitions

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

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

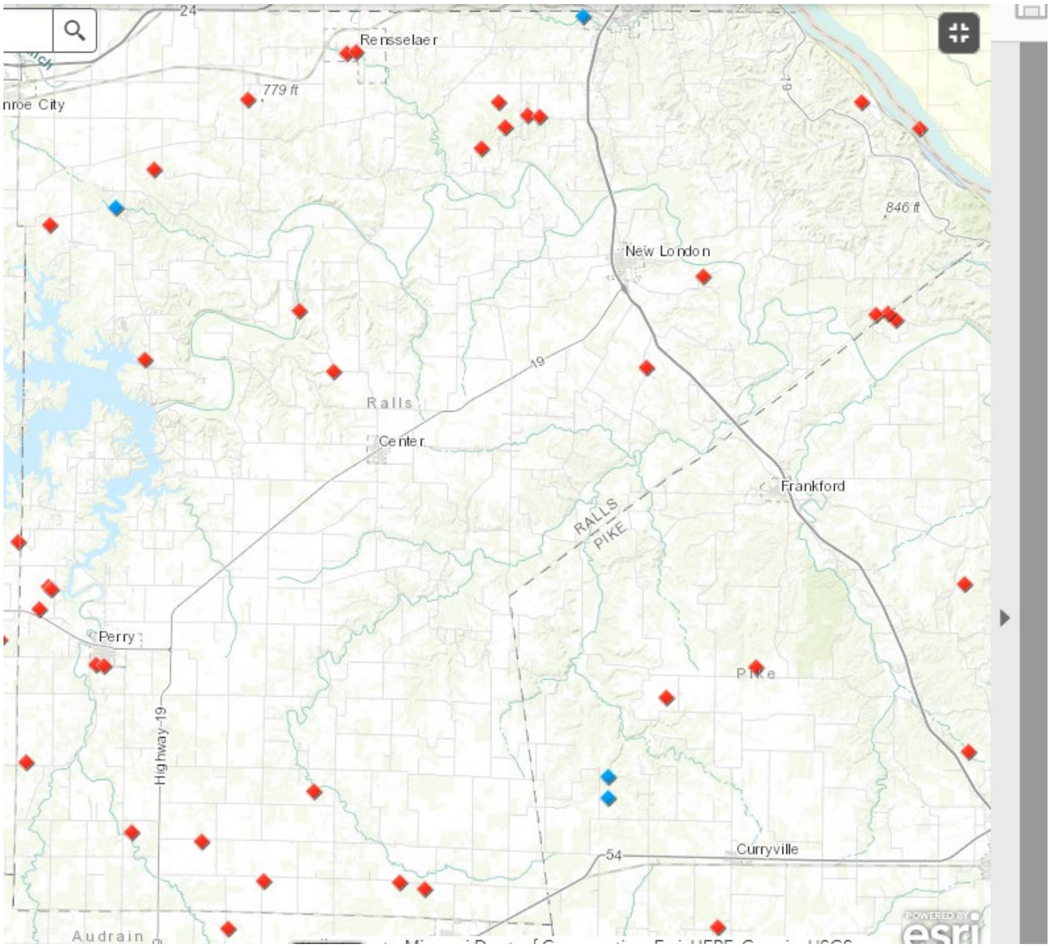
Table 3.23. NID Dam Hazard Classification Definitions

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

Source: National Inventory of Dams

Geographic Location

Dams Located Within the Planning Area



Ralls County has 2 state-regulated dams inside the county boundaries. The 2 state-regulated dams are the Bear Creek and Monroe City Dam. Within, the State of Missouri, the Department of Natural Resources maintains a Dam and Safety Program overseen by the Division of Geology and Land Survey. Chapter 236 Revised Statutes of Missouri state that a dam must be 35 feet or higher to be state regulated. The United States Army Corps of Engineers regulates the Lock and Dam #22 on the Mississippi River and the Clarence Cannon Dam.

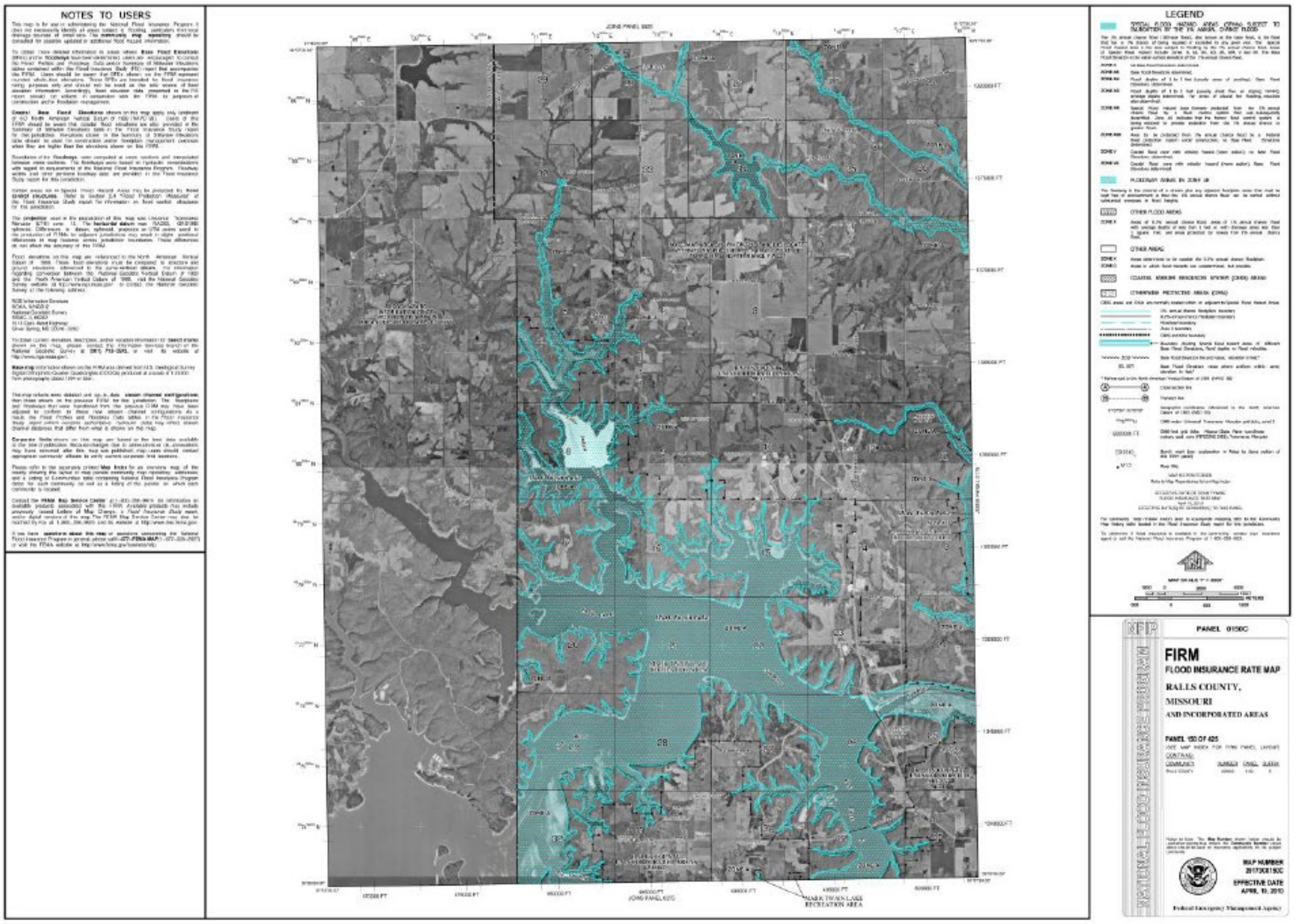
The NID Dam data for Ralls County includes the following 28 dams: MONOName 571, Mississippi River Dam 22, MONOName 572, Eisele Lake Dam, Lake Hannibal Dam, Central Stone Company Dam, Lake Hannibal Estates Upper Dam, Bear Creek Dam, Crystal Blue Lake Dam, Perry City Dam-Lower, Bowman Dam, Perry Lake Dam, Ashbury Lake Dam, Thompson Lake Dam, Perry City Dam No. 2, Carl Moore Lake Dam, Gibson Dam, Monroe City Dam, Jaynes Dam, Fertch Lake Dam, Woollen Lake Dam, Clarence Cannon Re-Regulation Dam, Luetkemeyer Dam, Clarence Cannon Dam, Griffith Lake Dam, Byers Lake and O’Keefe Lake Dam.

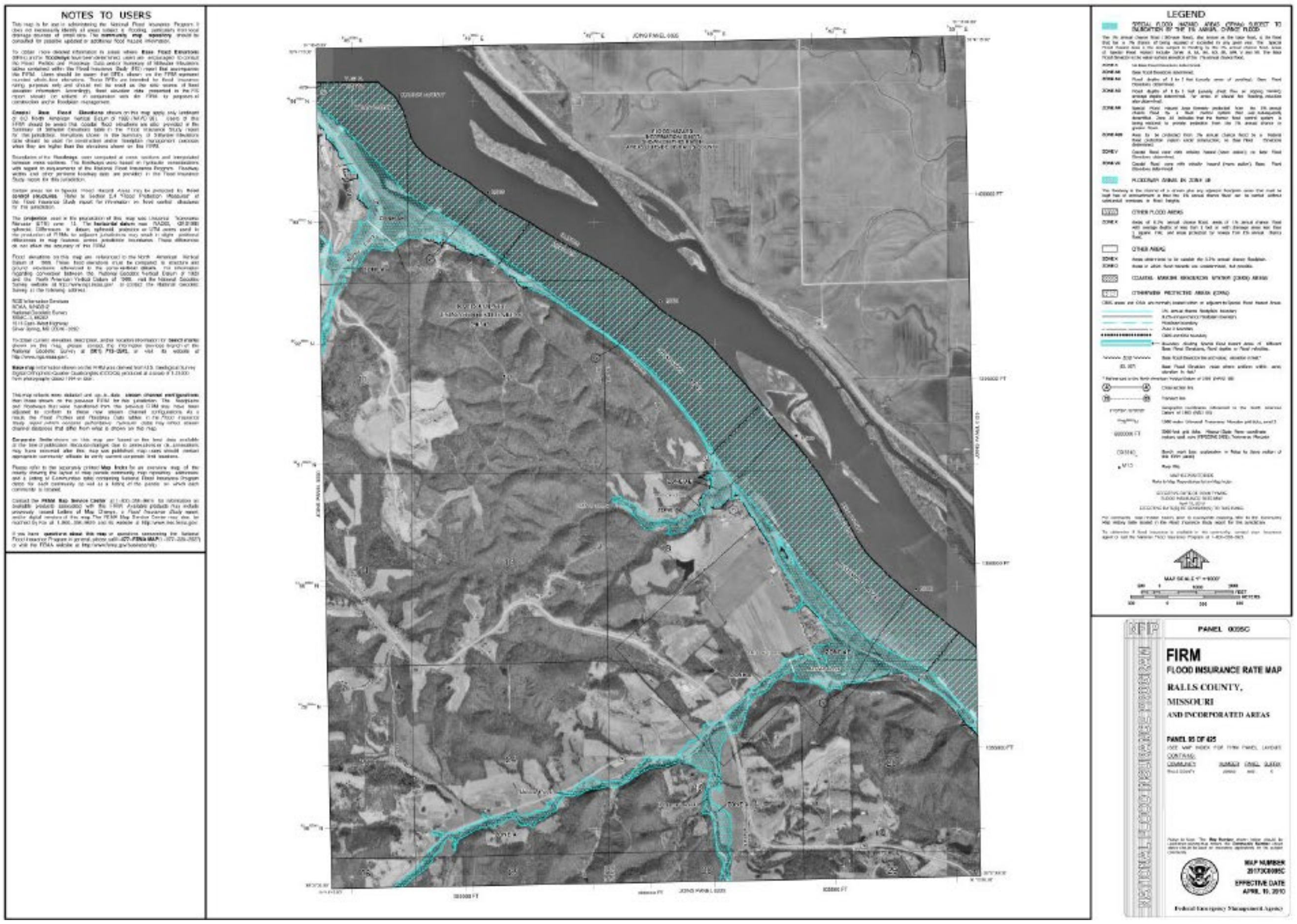
Table 3.24. High Hazard Dams in the Ralls County Planning Area

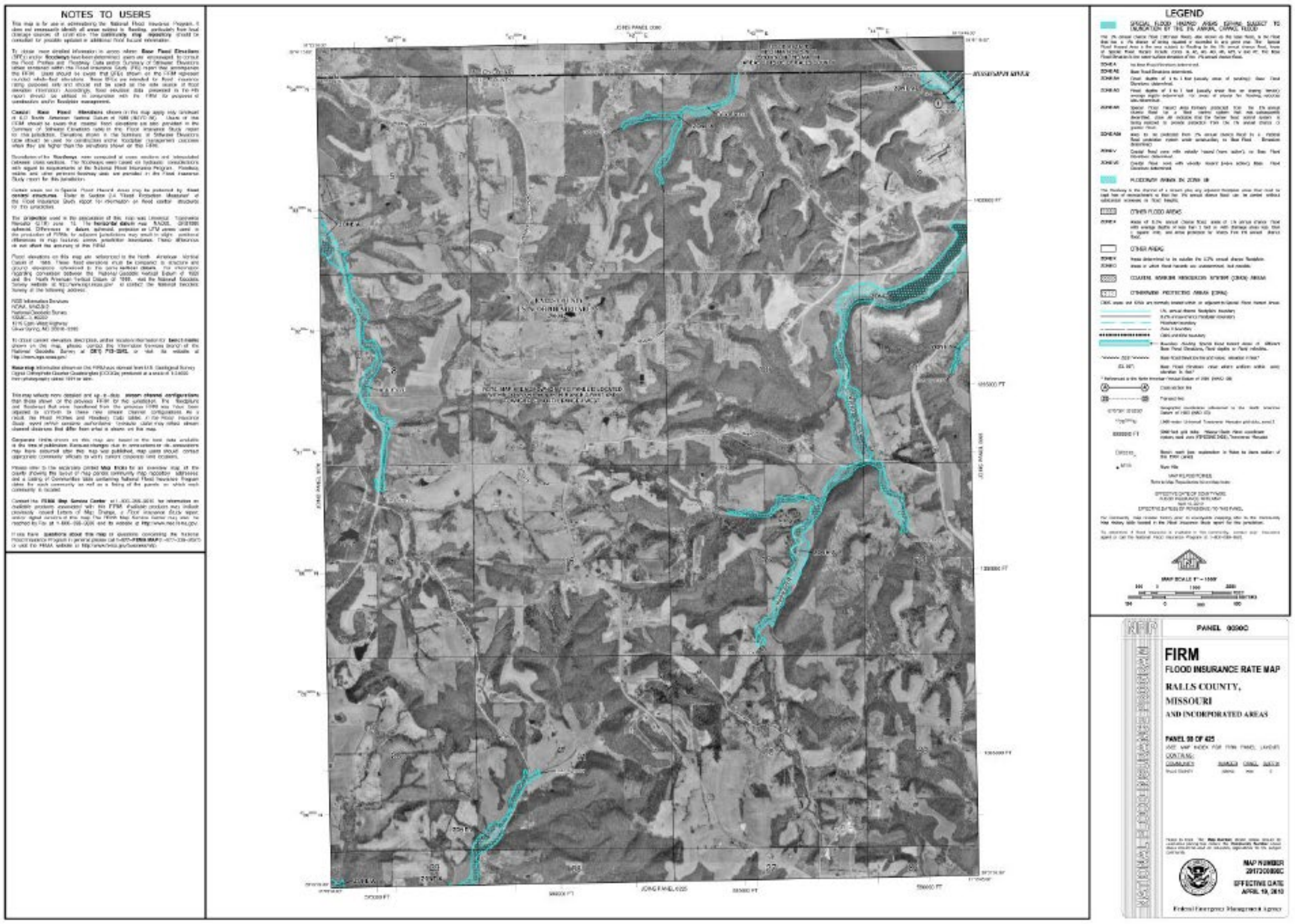
Dam Name	Emergency Action Plan (EAP)AP	Dam Height (Ft)	Normal Storage (Acre-Ft)	Last Inspection Date	River	Nearest Downstream City	Distance To Nearest City (Miles)	Dam Owner
Bear Creek Dam		65	545.40	1/20/15	Bear Creek	Hannibal	1	City of Hannibal
Lake Hannibal Estates Upper Dam		49	8,856		TR-Big Creek	Rensselaer	0	Tommy Hulse
Perry City Dam Lower		26	16	9/30/78	Mace Branch	Perry	1	City of Perry
Perry City Dam No. 2		13	1,865	7/12/80	Mace Branch	Perry	1	City of Perry
Wooleen Lake Dam		30			TR-Salt River	Louisiana	30	
Fertch Lake Dam		20						
Gibson Dam		28						
Lake Hannibal Dam		18			Big Creek	Rensselaer		
Eisele Lake Dam		12			Bear Branch	Hutchinson	3	
Ashbury Lake Dam		28			Purdy Creek	Perry	4	
Thompson Lake Dam		25			Nichols Creek	Hatch	3	

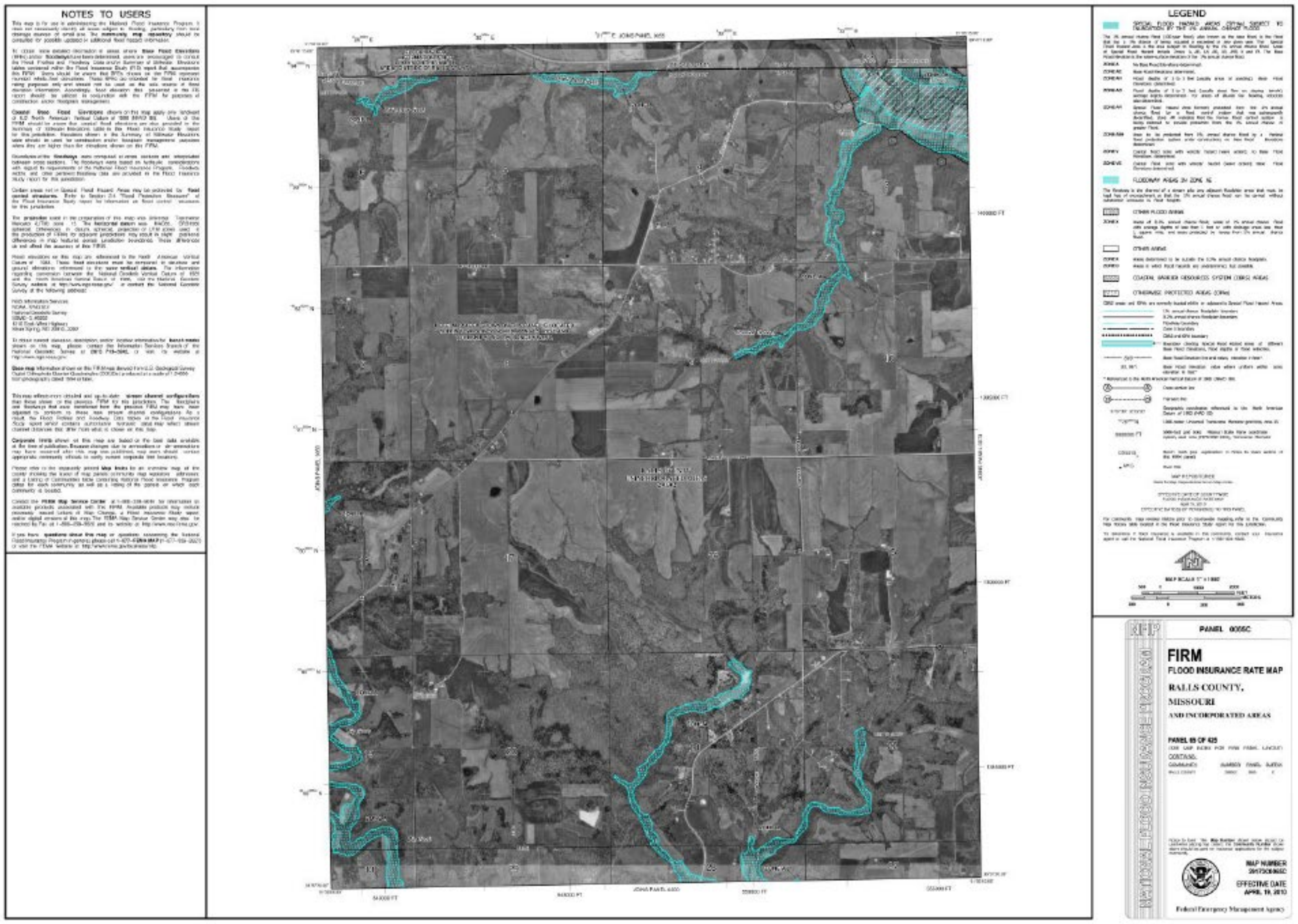
Sources: Missouri Department of Natural Resources, https://dnr.mo.gov/geology/wrc/dam-safety/damsinmissouri.htm and National Inventory of Dams, http://nid.usace.army.mil/cm_apex/f?p=838:12. Contact the MoDNR Dam and Reservoir Safety Program at 800-361-4827 to request the inundation maps for your county to show geographic locations at risk, extent of failure and to perform GIS analysis of those assets at risk to dam failure.

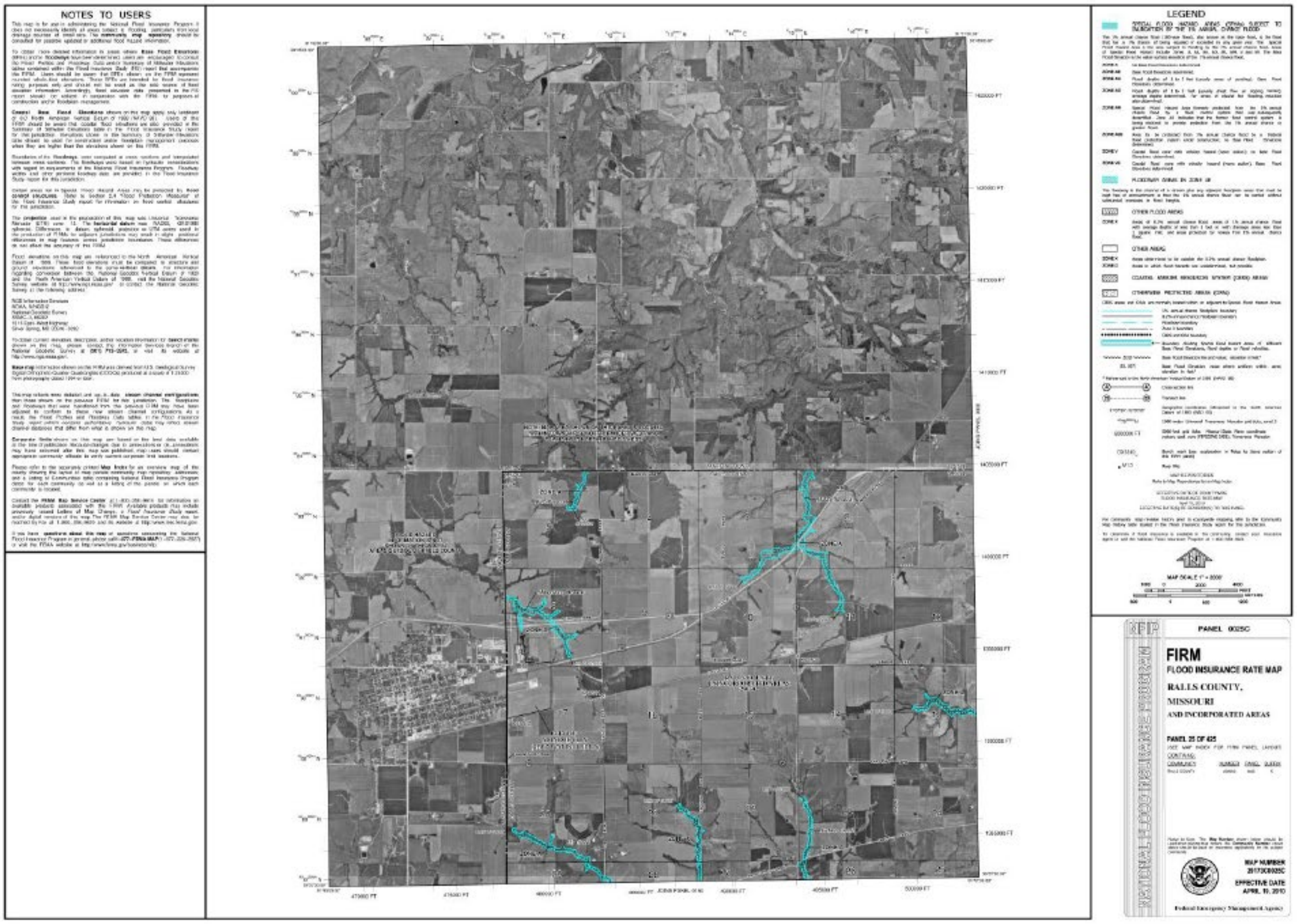
Figure 3.5. Inundation Maps for Ralls County.



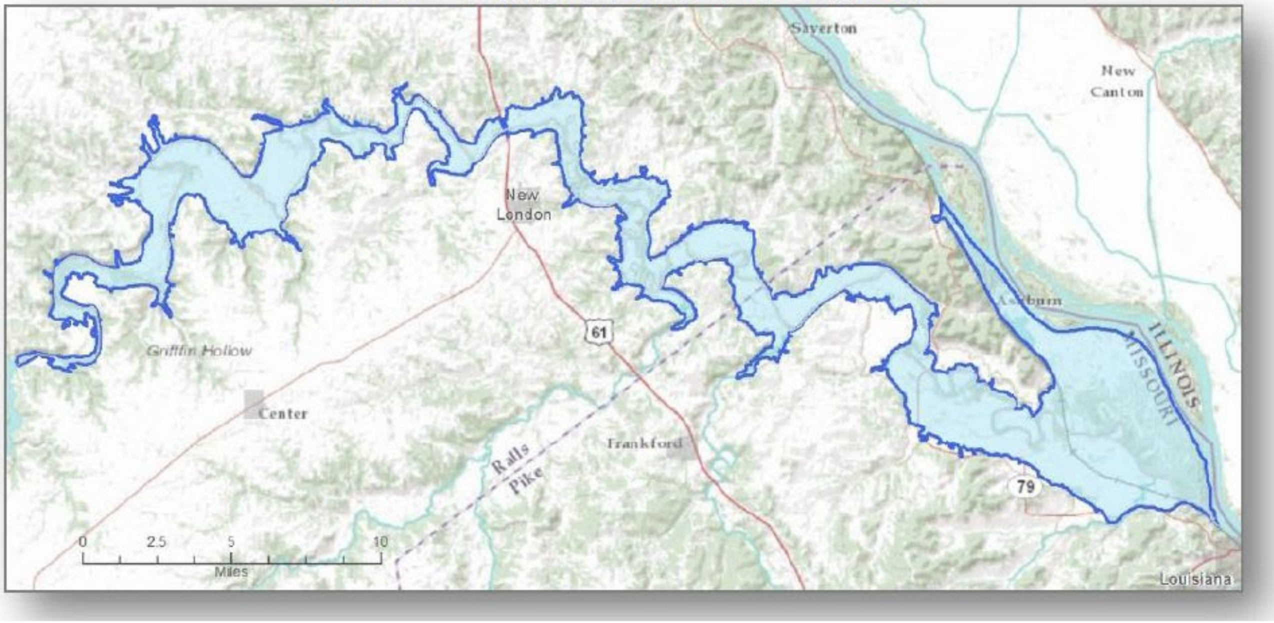

NOTES TO USERS
LEGEND
NFIP
PANEL 0095C
FIRM
FLOOD INSURANCE RATE MAP
RALLS COUNTY,
MISSOURI
AND INCORPORATED AREAS
PANEL 95 OF 425
MAP NUMBER
29173C0095C
EFFECTIVE DATE
APRIL 19, 2010
Federal Emergency Management Agency


NOTES TO USERS
LEGEND
MAP SCALE 1" = 1000'
PANEL 0090C
NATIONAL FLOOD INSURANCE PROGRAM
NFIP
FIRM
FLOOD INSURANCE RATE MAP
RALLS COUNTY, MISSOURI
AND INCORPORATED AREAS
PANEL 90 OF 425
MAP NUMBER 29173C0090C
EFFECTIVE DATE APRIL 19, 2010
Federal Emergency Management Agency


NOTES TO USERS
LEGEND
NFIP
NATIONAL FLOOD INSURANCE PROGRAM
PANEL 0065C
FIRM
FLOOD INSURANCE RATE MAP
RALLS COUNTY, MISSOURI
AND INCORPORATED AREAS
PANEL 65 OF 425
CONTAINS:
COMMUNITY NUMBER PANEL SUFFIX
MAP NUMBER 29173C0065C
EFFECTIVE DATE APRIL 19, 2010
Federal Emergency Management Agency



Salt River Inundation: Release Rate = 80,000 cfs



Source: Salt River & Mark Twain Lake Structures Inventory & Inundation Study Project Report

Strength/Magnitude/Extent

The severity/magnitude of dam failure would be similar in some cases to the impacts associated with flood events (see the flood hazard vulnerability analysis and discussion). Based on the hazard class definitions, failure of any of the High Hazard/Class I dams could result in a serious threat of loss of human life, serious damage to residential, industrial or commercial areas, public utilities, public buildings, or major transportation facilities. 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. Note that for this reason, dam failures could flood areas outside of mapped flood hazards.

Previous Occurrences

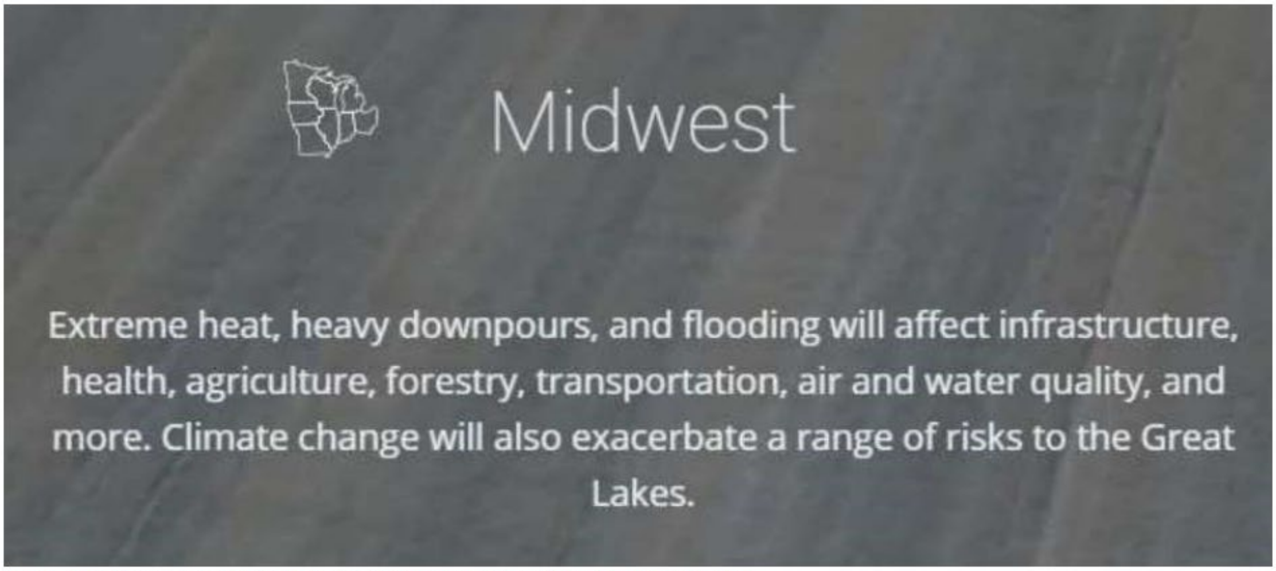
To determine previous occurrences of dam failure within Ralls County, the Ralls County 2016 Missouri Natural Hazard Mitigation Plan was consulted as well as the 2018 Missouri State Hazard Plan and the Stanford University's National Performance of Dams Program (http://npdp.stanford.edu/). No record of dam failure within Ralls County boundaries was found.

Probability of Future Occurrence

Based on the number of high hazard dams in the planning area (6) and no record of previous occurrences the probability of a future occurrence cannot be calculated. The Clarence Cannon Dam located outside of Perry, Missouri would have a catastrophic impact on the businesses and residents in the inundation area.

Changing Future Conditions Considerations

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



Midwest

Extreme heat, heavy downpours, and flooding will affect infrastructure, health, agriculture, forestry, transportation, air and water quality, and more. Climate change will also exacerbate a range of risks to the Great Lakes.

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

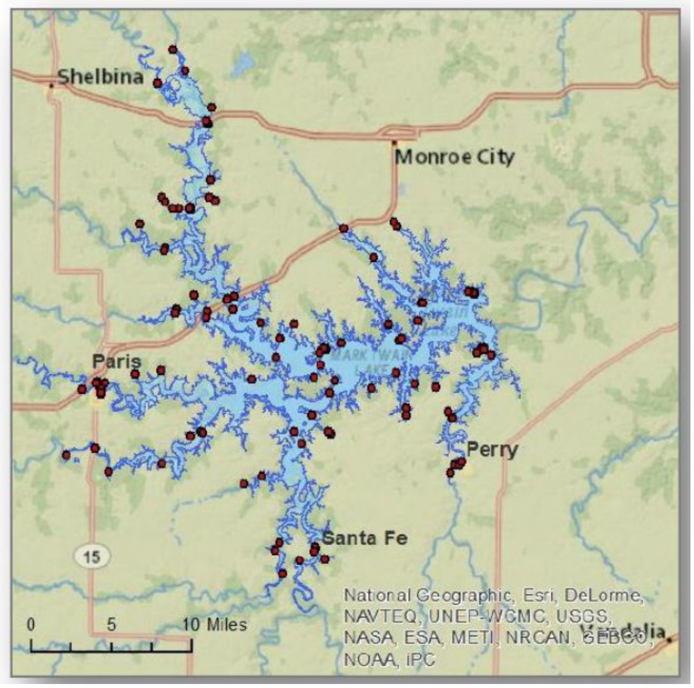
Vulnerability

Vulnerability Overview

Vulnerability to dam failure is limited to a very few areas in Ralls County, primarily in the inundation area of the Clarence Cannon Dam.

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

The inundation maps show the lost to existing development if the Clarence Cannon Dam would fail. The existing development impacted includes businesses, residential; roadways and it would be catastrophic for all areas downstream of the dam.



Red dots indicate impacted structures at 640'msl of the Mark Twain Lake.
Source: Salt River & Mark Twain Lake Structures Inventory & Inundation Study Project Report

Impact of Previous and Future Development

Future development in the City of New London, Perry and Hannibal could impact the amount of damages caused by a failure of the high hazard dams in Ralls County. Four of the high hazard dams are located within a mile of residents in Ralls County and 2 extremely large dams are located only 20 miles from the City of New London.

Hazard Summary by Jurisdiction

Vulnerability to dam failure is very minimal with the exception to the City of New London which is in the inundation path of 2 large dams. The remaining participating jurisdictions including school districts would be affected very minimally.

Problem Statement

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

3.4.4 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.

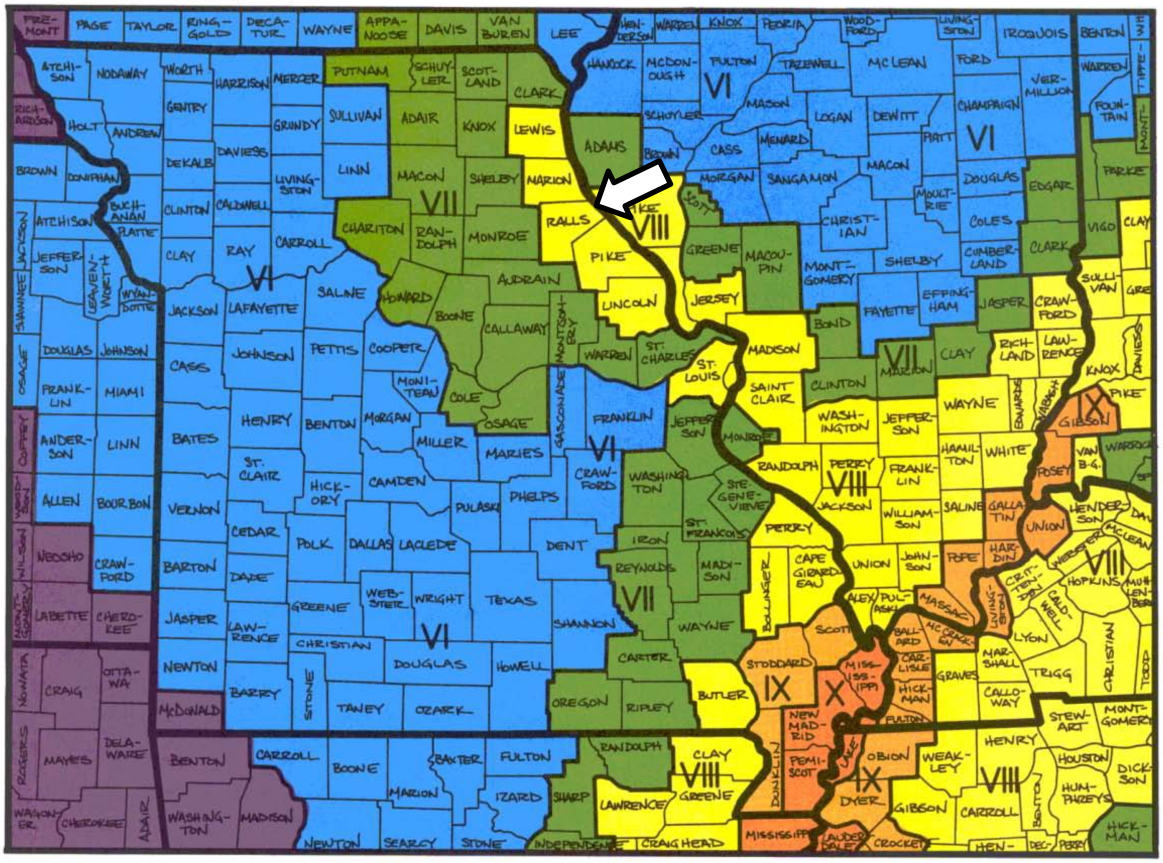
Some earthquakes occur in the middle of plates, as is the case for seismic zones in the Midwestern United States. The most seismically active area in the Midwest is the New Madrid Seismic Zone. The possibility of the occurrence of a catastrophic earthquake in the central and Eastern United States is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

Geographic Location

Seismic activity on the New Madrid Seismic Zone of Southeastern Missouri is very significant both historically and at present. On December 16, 1811 and January 23 and February 7 of 1812, three earthquakes struck the central U.S. with magnitudes estimated to be 7.5-8.0. These earthquakes caused violent ground cracking and volcano-like eruptions of sediment (sand blows) over an area of >10,500 km2 , and uplift of a 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 Ralls 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.

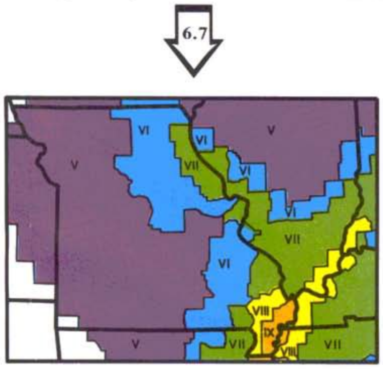
The following SEMA map (**Figure 3.6**) shows the highest projected Modified Mercalli intensities by county from a potential magnitude 7.6 earthquake whose epicenter could be anywhere along the length of the New Madrid Seismic Zone. The arrow indicates Ralls County and the affects that would be felt from the earthquake.

Figure 3.6. Impact Zones for Earthquake Along the New Madrid Fault

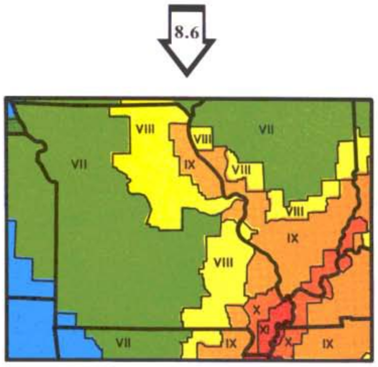


This map shows the highest projected Modified Mercalli intensities by county from a potential magnitude – 7.6 earthquake whose epicenter could be anywhere along the length of the New Madrid seismic zone.

7.6



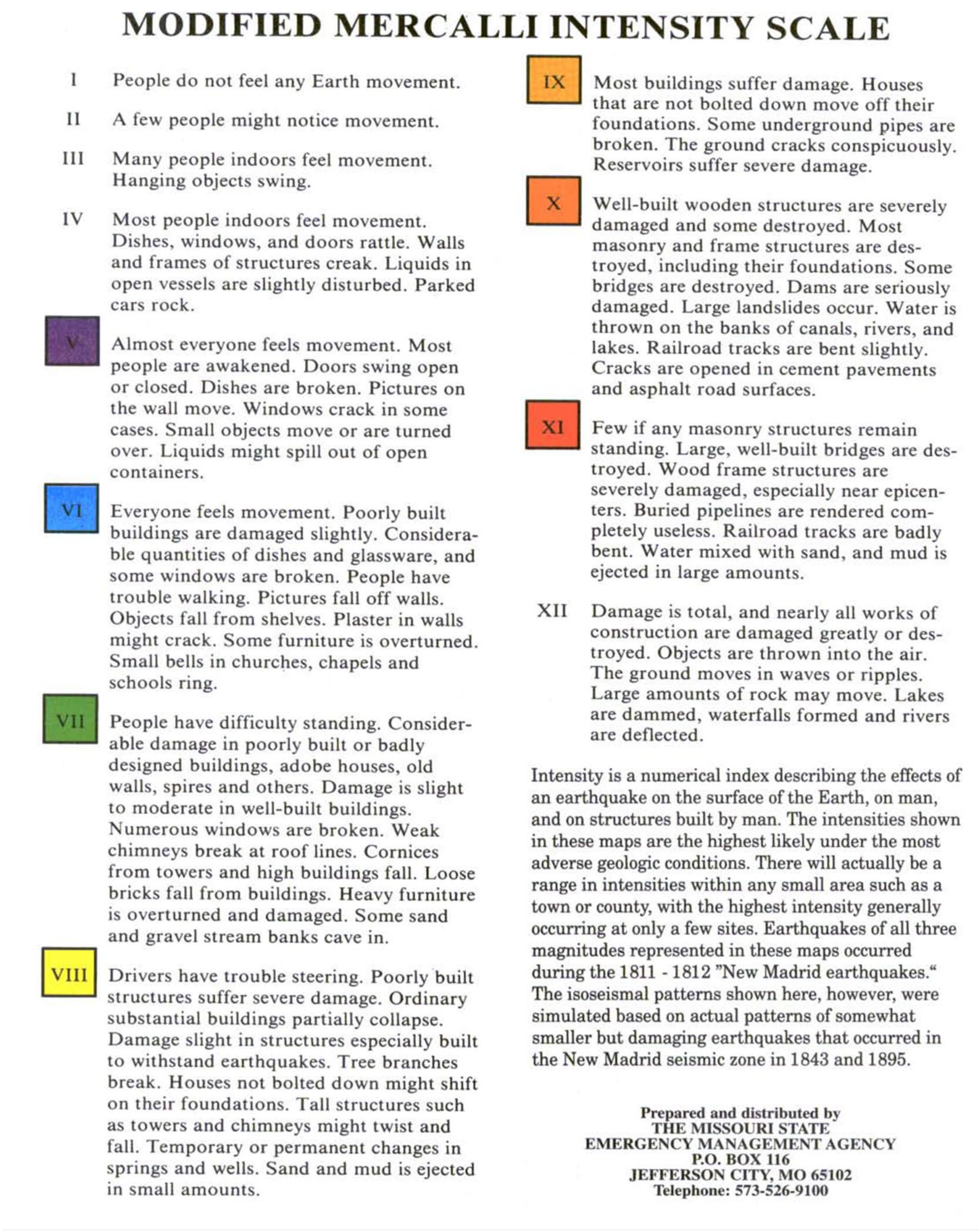
This map shows the highest projected Modified Mercalli intensities by county from a potential magnitude – 6.7 earthquake whose epicenter could be anywhere along the length of the New Madrid seismic zone.



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 3.7. Projected Earthquake Intensities



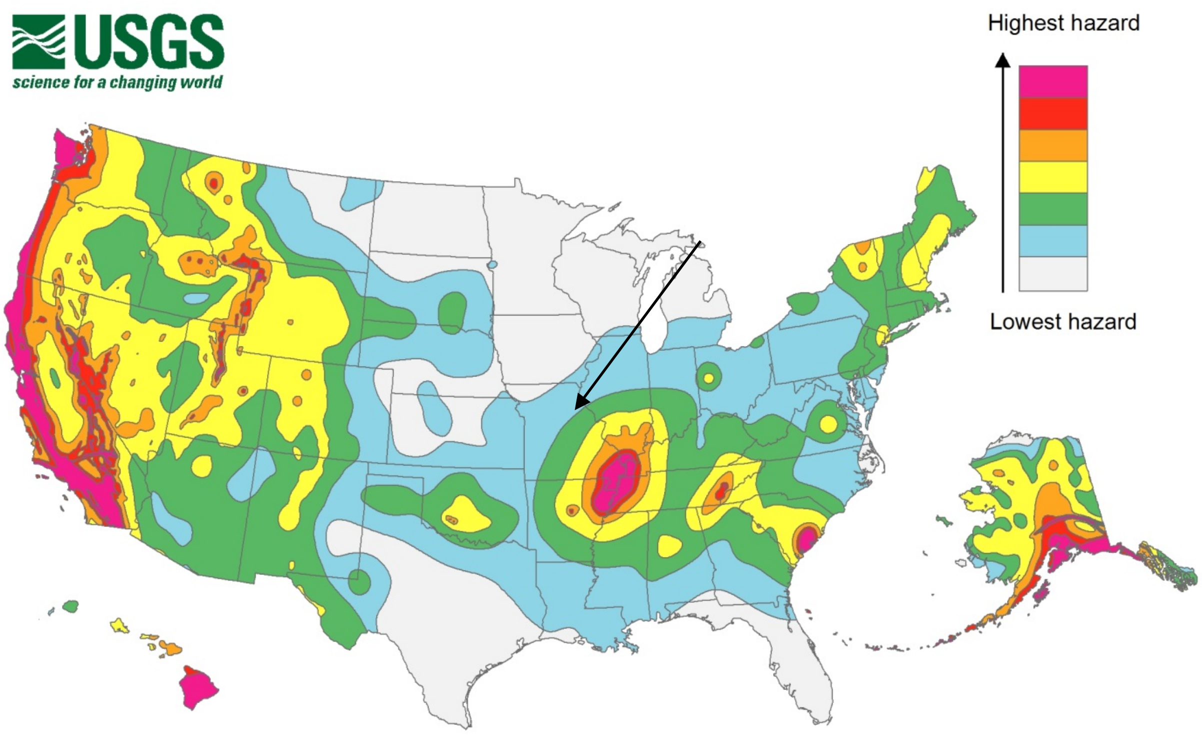
MODIFIED MERCALLI INTENSITY SCALE

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.

Prepared and distributed by
THE MISSOURI STATE
EMERGENCY MANAGEMENT AGENCY
P.O. BOX 116
JEFFERSON CITY, MO 65102
Telephone: 573-526-9100

Figure 3.8. 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 Ralls County since 1931.

http://www.homefacts.com/earthquakes/Missouri/Ralls-County.html

Probability of Future Occurrence

The figures above demonstrate the probability of an earthquake with a magnitude greater than 5.0 in Ralls County in a 50-year time period. The arrow shows the approximate Ralls County boundary. As shown in this graphic, the probability of a 5.0 Magnitude or greater earthquake in the next 50 years is .02 percent. The probability converts to an estimated maximum recurrence interval of 5,000 years. The probability of a significant earthquake in any given year is unlikely.

Changing Future Conditions Considerations

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

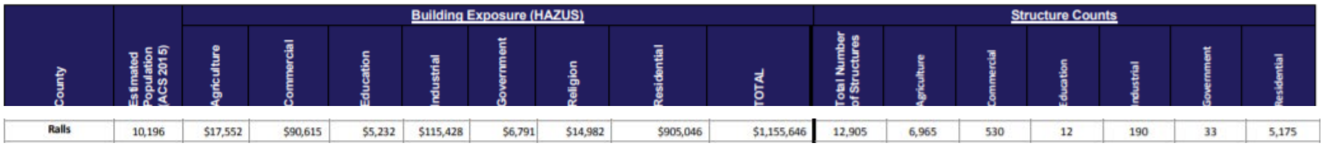
Vulnerability

Vulnerability Overview

According to the data obtained from the 2018 State Plan, Ralls County was listed as N/A for Hazard Ranking.
The State of Earthquake Coverage Report states that the average premium for earthquake coverage in Ralls County in 2014 was $56.

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.



		Building Exposure (HAZUS)								Structure Counts						
County	Estimated Population (ACS 2015)	Agriculture	Commercial	Education	Industrial	Government	Religion	Residential	TOTAL	Total Number of Structures	Agriculture	Commercial	Education	Industrial	Government	Residential
Ralls	10,196	$17,552	$90,615	$5,232	$115,428	$6,791	$14,982	$905,046	$1,155,646	12,905	6,965	530	12	190	33	5,175

Impact of Previous and Future Development

Overall, the planning area has a low vulnerability to earthquake risk. 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 the unlikely event.

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, the New London could see a greater amount of structural damage due to having a higher percentage (24.8%) of residences built prior to 1939 than other jurisdictions in the planning area. The City of Perry has a low percentage (18.9%) of residences built prior to 1939 putting them at a lower risk.

Problem Statement

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

3.4.5 Land Subsidence/Sinkholes

Hazard Profile

Hazard Description

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

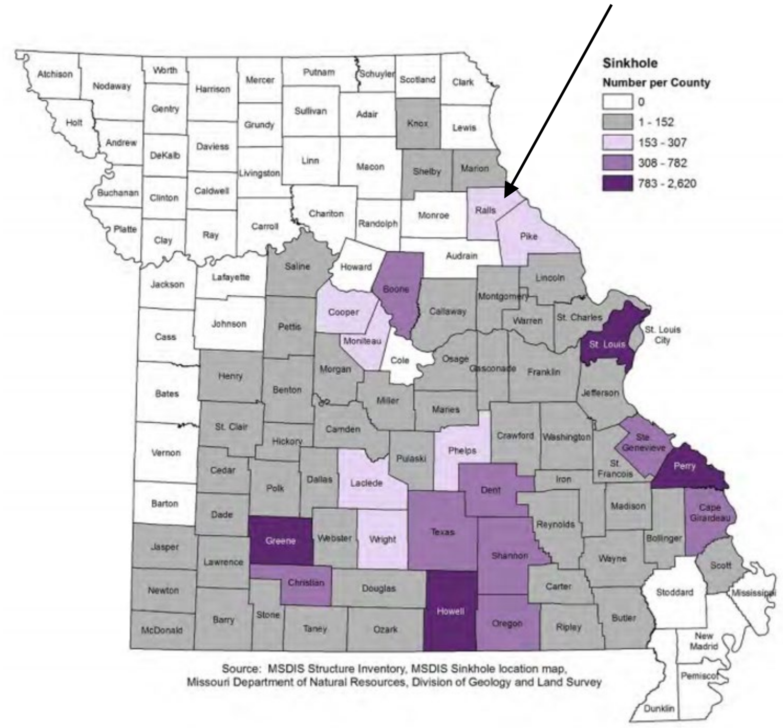
Land subsidence occurs slowly and continuously over time, as a general rule. On occasion, it can occur abruptly, as in the sudden formation of sinkholes. Sinkhole formation can be aggravated by flooding.

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

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

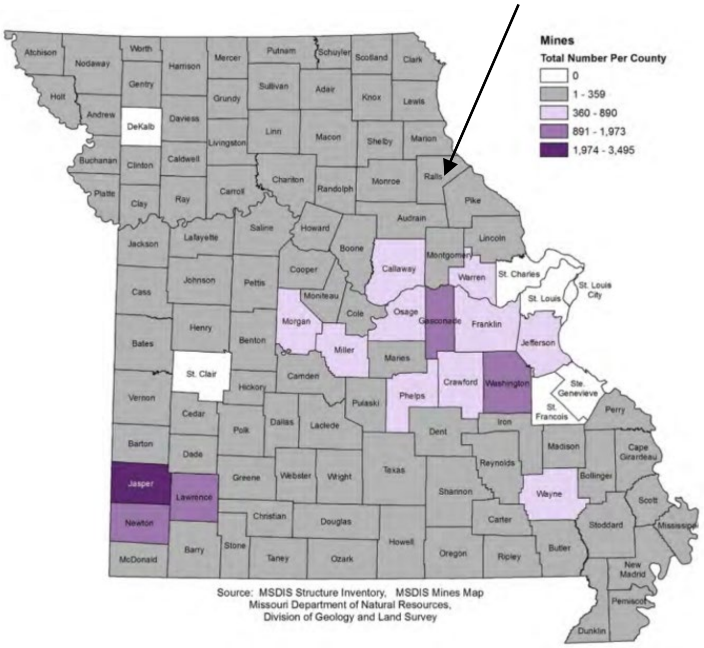
According to the 2018 Missouri State Hazard Mitigation Plan, there are 96 mines in Ralls County and 181 sinkholes.

Geographic Location



Source: MSDIS Structure Inventory, MSDIS Sinkhole location map,
Missouri Department of Natural Resources, Division of Geology and Land Survey

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



Source: MSDIS Structure Inventory, MSDIS Mines Map
Missouri Department of Natural Resources,
Division of Geology and Land Survey

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

Strength/Magnitude/Extent

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

Previous Occurrences

According to the 2018 Missouri State Plan sinkholes are a regular occurrence in Missouri but are rarely the events of any significance.
Although Ralls County has 200 sinkholes, they have not been a problem and the likeliness of a future occurrence would be considered negligible. However, the potential for this type of hazard to occur in Ralls County exists. There are portions of the county where sinkholes and underground caverns exist and can increase the likelihood of a sinkhole occurring.

Probability of Future Occurrence

The likelihood of a sinkhole occurring of any significance is low based on the past history of the sinkholes recorded. Due to data limitations precluding a probability calculation, such as the lack of a centralized database for sinkhole occurrences in the state.

Changing Future Conditions Considerations

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

Vulnerability

Vulnerability Overview

Sinkholes in the planning area are not common occurrence due to composition of the land. While some sinkholes may be considered a slow changing nuisance; other more sudden, catastrophic collapses can destroy property, delay construction projects and contaminate ground water resources.

Potential Losses to Existing Development

The potential impact of sinkholes on existing structures is difficult to determine due to the lack of data on historic damages caused by sinkholes and even either the mapping of potential sinkholes it is difficult if not impossible to predict where a sinkhole will collapse and how significant the collapse will be.

Because sinkhole collapse is not predictable and previous events have occurred in the rural area there is not significant data to estimate the future losses due to a sinkhole.

Impact of Previous and Future Development

As more development occurs on unmapped rural areas the vulnerability to the hazard will increase; however sinkholes are unpredictable and the development in rural areas is difficult to limit due to the lack of occurrence.

Ralls County is documented to have a large number of caves and future development over exiting caves can have an impact on this hazard. The installation of residential services such as septic tanks, lagoons, and structures can cause shifts in the karst deposit located in the planning area and allow the formation of a sinkhole.

Hazard Summary by Jurisdiction

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

Problem Statement

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

3.4.6 Drought

Hazard Profile

Hazard Description

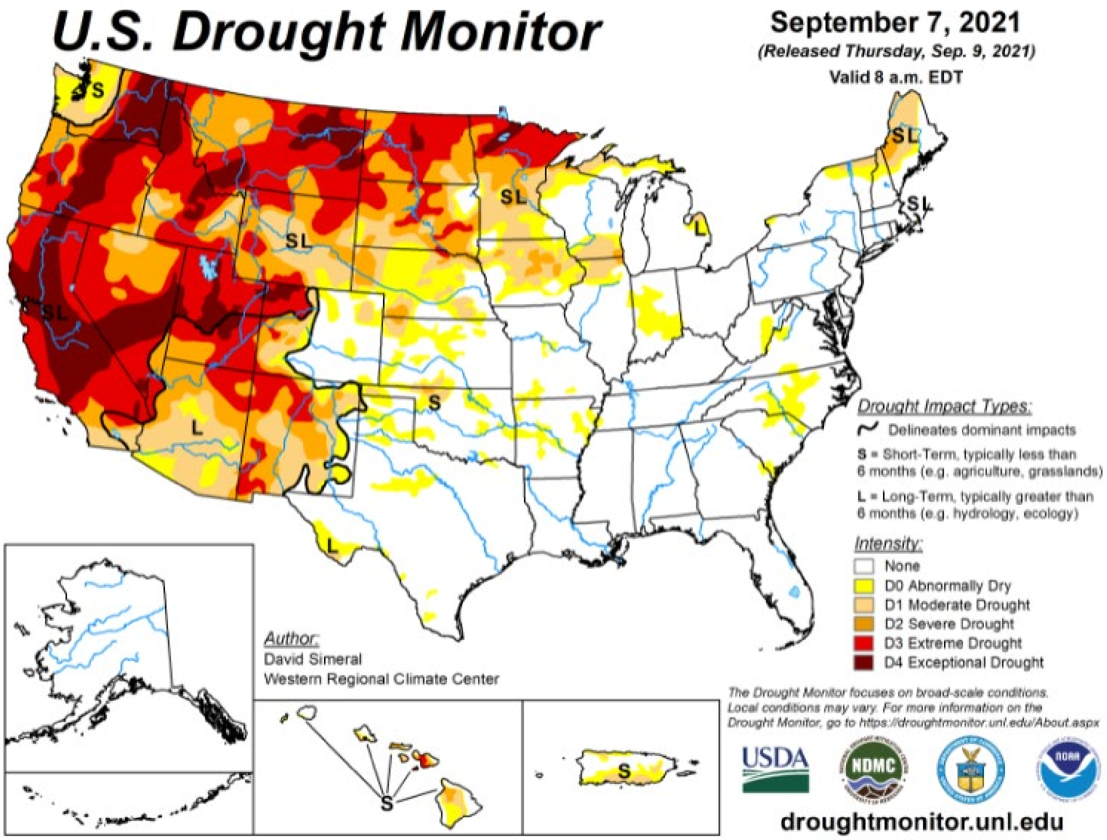
Drought is generally defined as a condition of moisture levels significantly below normal for an extended period of time over a large area that adversely affects plants, animal life, and humans. A drought period can last for months, years, or even decades. There are four types of drought conditions relevant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

- Meteorological drought is defined in terms of the basis of the degree of dryness (in comparison to some "normal" or average amount) and the duration of the dry period. A meteorological drought must be considered as region-specific since the atmospheric conditions that result in deficiencies of precipitation are highly variable from region to region.
- Hydrological drought is associated with the effects of periods of precipitation (including snowfall) shortfalls on surface or subsurface water supply (e.g., streamflow, reservoir and lake levels, ground water). The frequency and severity of hydrological drought is often defined on a watershed or river basin scale. Although all droughts originate with a deficiency of precipitation, hydrologists are more concerned with how this deficiency plays out through the hydrologic system. Hydrological droughts are usually out of phase with or lag the occurrence of meteorological and agricultural droughts. It takes longer for precipitation deficiencies to show up in components of the hydrological system such as soil moisture, streamflow, and ground water and reservoir levels. As a result, these impacts also are out of phase with impacts in other economic sectors.
- Agricultural drought focus is on soil moisture deficiencies, differences between actual and potential evaporation, reduced ground water or reservoir levels, etc. Plant demand for water depends on prevailing weather conditions, biological characteristics of the specific plant, its stage of growth, and the physical and biological properties of the soil.
- Socioeconomic drought refers to when physical water shortage begins to affect people.

Geographic Location

Droughts are regional in nature. All areas of the United States are vulnerable to the risk of drought and extreme heat. Droughts can be widespread or localized events. The extent of the droughts varies both in terms of the extent of the heat and range of precipitation. The severity of a drought depends on locations, duration, and geographical extent. Additionally, drought severity depends on the water supply, usage demands made by human activities, vegetation, and agricultural operations. Drought brings several different problems that must be addressed. The quality and quantity of crops, livestock and other agricultural assets will be affected during a drought. Drought can adversely impact forested areas leading to an increased potential for extremely destructive forest and woodland fires that could threaten residential, commercial, and recreational structures. According to the 2017 Census of Agriculture, Ralls County consist of 243,108 acres land in farms, crop sales generate $55,758,000 and livestock sales generate $23,118,000. A drought would directly impact livestock production and the agriculture economy in Ralls County.

Figure 3.9. U.S. Drought Monitor Map of Missouri on 09/14/21



Author:
David Simeral
Western Regional Climate Center

The Drought Monitor focuses on broad-scale conditions. Local conditions may vary. For more information on the Drought Monitor, go to https://droughtmonitor.unl.edu/About.aspx

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.

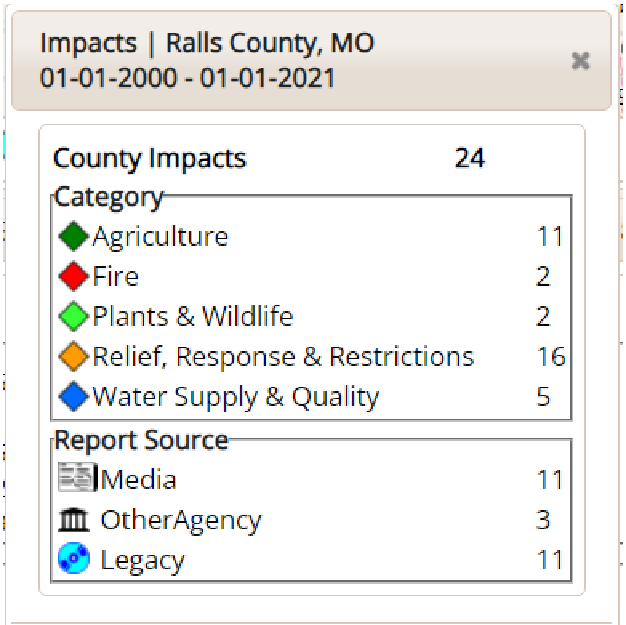
Palmer also developed a formula for standardizing drought calculations for each individual location based on the variability of precipitation and temperature at that location. The Palmer index can therefore be applied to any site for which sufficient precipitation and temperature data is available.

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 2013, 2005, and 1999. 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 21-year period from 2001 to 2021, Ralls County had 24 reported drought impacts. The following are the categories:

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



Impacts | Ralls County, MO
01-01-2000 - 01-01-2021

County Impacts 24

Category

◆ Agriculture	11
◆ Fire	2
◆ Plants & Wildlife	2
◆ Relief, Response & Restrictions	16
◆ Water Supply & Quality	5

Report Source

Media	11
OtherAgency	3
Legacy	11

Impacts of recent drought periods in Missouri that affected Ralls County are provided below. Unless otherwise indicated, these impacts are from the Drought Impact Reporter:

• Growing belief in Global Warming: October 31, 2015 - Some Americans, witnessing ongoing drought in parts of the U.S., have come to believe that global warming is real. Seven out of 10 people say that solid evidence for global warming exists. This is an uptick of 10 percent since fall 2014 and was nearing the record 72 percent in 2008. More than 60 percent of those acknowledging global warming say that severe drought had a “very large effect” on their view of the matter.

• Grass Growth Hampered, Hay Feeding Underway in Missouri: October 22, 2015 - Dry weather has hampered grass growth in Missouri, forcing farmers to begin feeding hay earlier than usual, which will add to farmers' winter feed bills. Fall grass often supports beef cattle into December. Spring grass production may also be affected by the fall drought.

• Water Restrictions Due to Drought Conditions: August 3, 2015 – Limited water supply due to recent drought conditions is causing governments to restrict the amount of water used by residents and businesses. Agricultural needs are a top priority with residential needs coming in second during drought conditions and water restrictions.

• US Cattle Herd Numbers: February 6, 2015 - Drought reduced the national cattle herd in recent years, but the number of cattle in the country climbed over the last year from 87.7 million to 89.8 million on Jan. 1, 2015, for an increase of one percent. This is the first uptick in cattle numbers since 2007 and shows that herds are being rebuilt faster than expected, say some meat industry publications. Beef prices continued to set new highs. Consult the USDA's Risk Management Agency concerning insured crop loss payments in the county as a result of drought during a period of years. Give total losses. Identify year(s) with the highest losses. A table can be inserted showing losses.

Probability of Future Occurrence

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

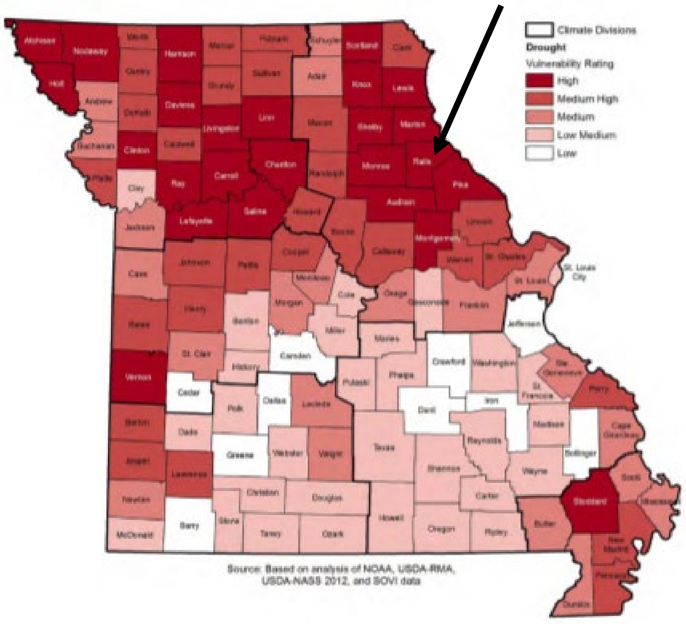
Changing Future Conditions Considerations

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

Vulnerability

Vulnerability Overview

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



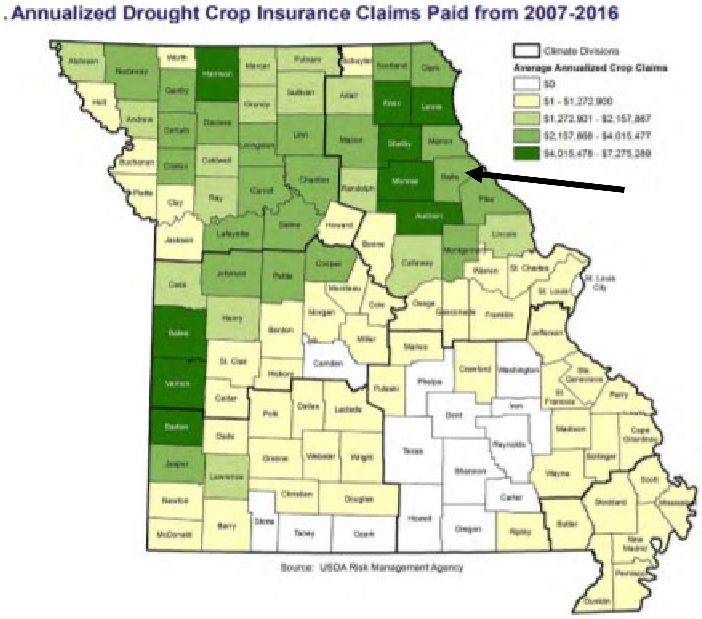
Source: Missouri State Hazard Mitigation Plan, 2018 *Arrow indicates Ralls County

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

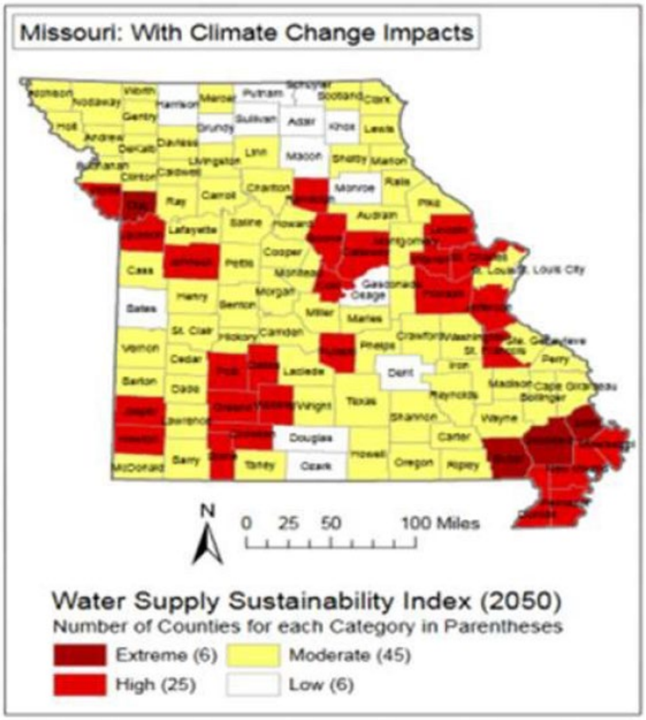
Future development will remain vulnerable to drought. Typically, some urban and rural areas are more susceptible than others. For example, urban areas are subject to water shortages during periods of drought. Excessive demands of the populated area place a limit on water resources. In rural areas, crops 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.



Source: Missouri State Hazard Mitigation Plan, 2018 *Arrow indicates Ralls 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 3.61 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.



Hazard Summary by Jurisdiction

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

Problem Statement

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

3.4.7 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 3.10** 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.

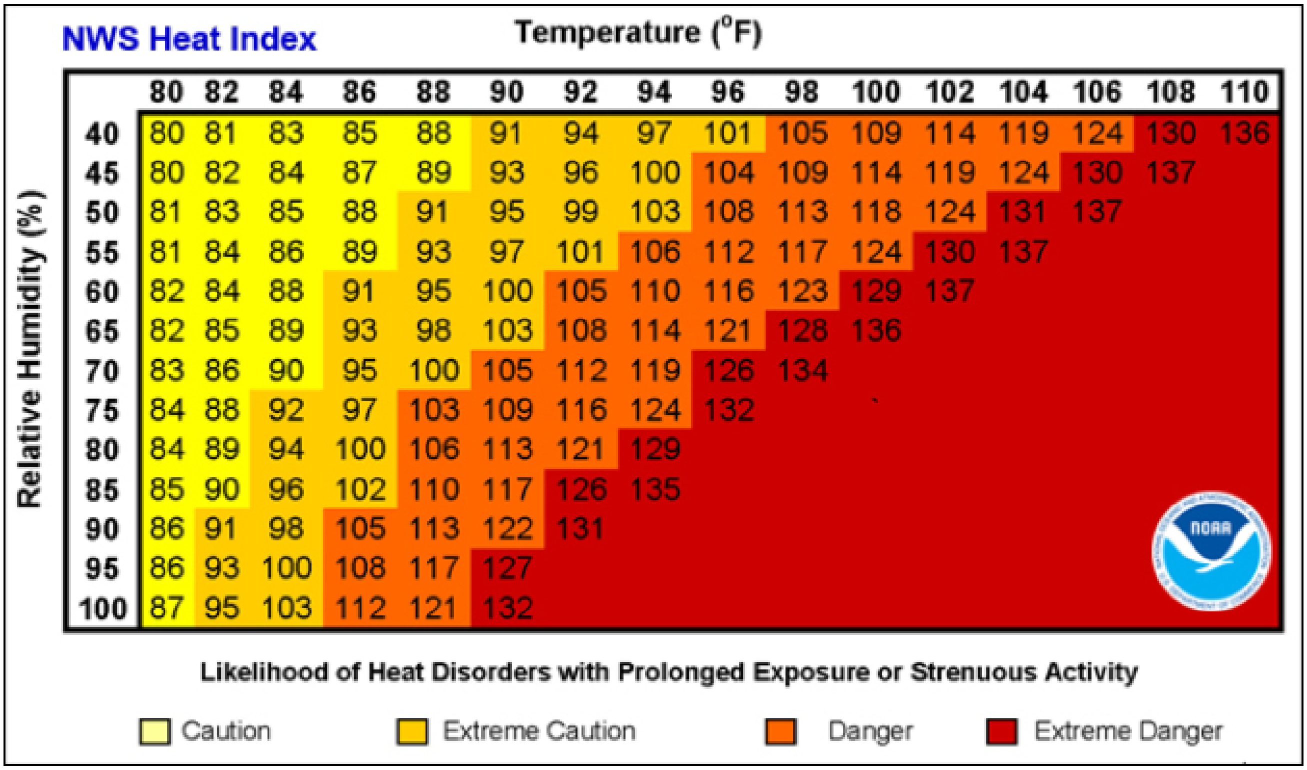
Geographic Location

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 3.10. 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										

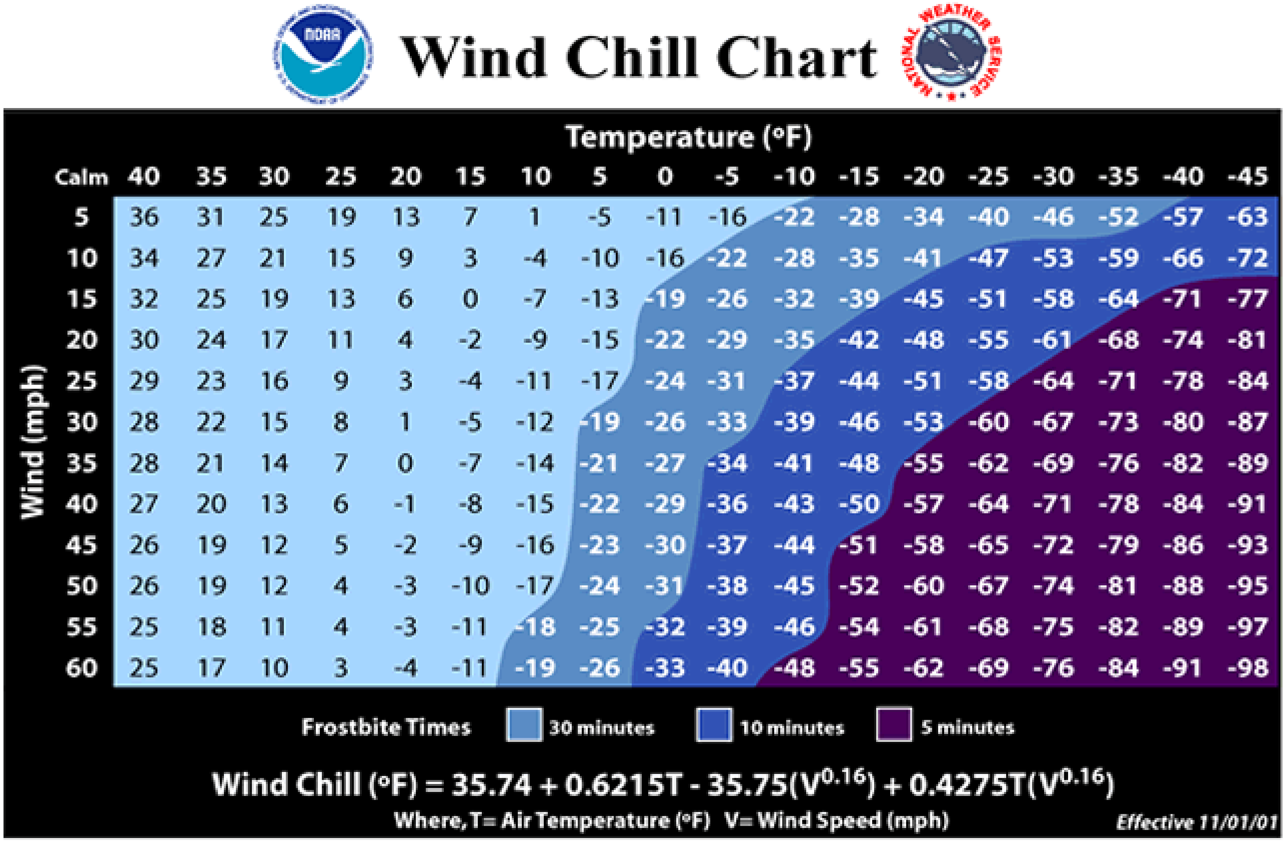
Likelihood of Heat Disorders with Prolonged Exposure or Strenuous Activity

🟨 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 3.11. 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

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

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

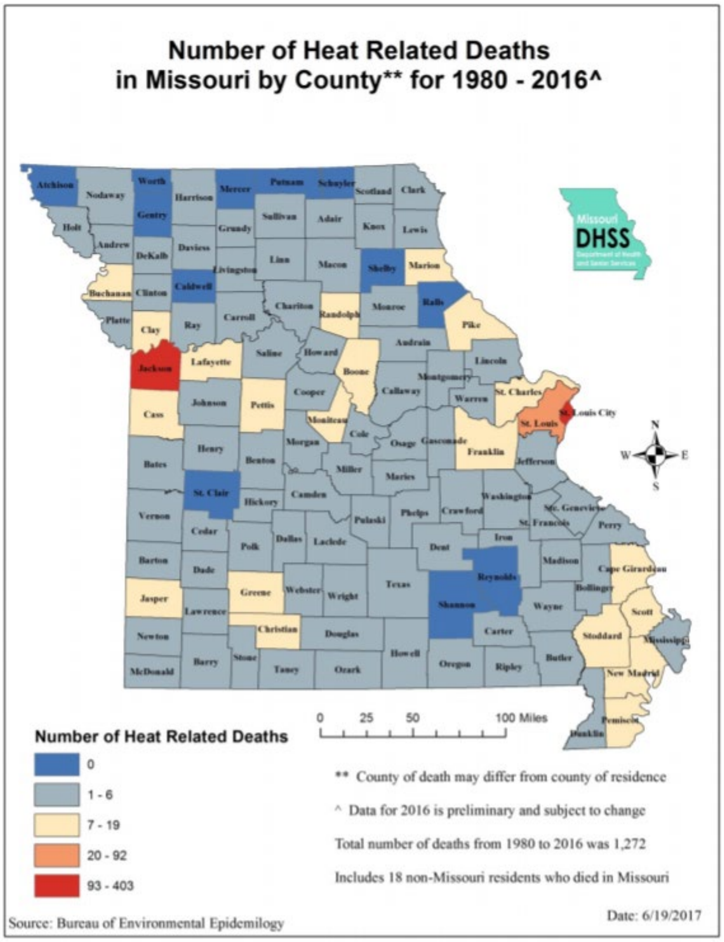
Effective 11/01/01

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 2001-2021. There was 0 deaths or injuries associated with these events. The NCEI database shows 0 recorded events of extreme cold/wind chill. **Figure 3.12** illustrates 0 heat related deaths in Ralls County between the time of 1980-2016, no supporting documentation could be found to include in this plan.

Figure 3.12. Heat Related Deaths in Missouri 2000 - 2016


Number of Heat Related Deaths in Missouri by County** for 1980 - 2016^

Number of Heat Related Deaths

🟦 0
▨ 1 - 6
🟨 7 - 19
🟧 20 - 92
🟥 93 - 403

** County of death may differ from county of residence

^ Data for 2016 is preliminary and subject to change

Total number of deaths from 1980 to 2016 was 1,272

Includes 18 non-Missouri residents who died in Missouri

Source: Bureau of Environmental Epidemilogy

Date: 6/19/2017

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

Extreme heat can cause stress to crops and animals. Losses to insurable crops during the 10-year time period were unable to be obtained. 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, few 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 2001 indicates 9 years with extreme heat events (2007, 2009, 2010, 2011, 2012, 2015, 2016, 2017). Based on this historical data, the calculated probability of an extreme heat event in any given year is 45%.

Changing Future Conditions Considerations

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

Vulnerability

Vulnerability Overview

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

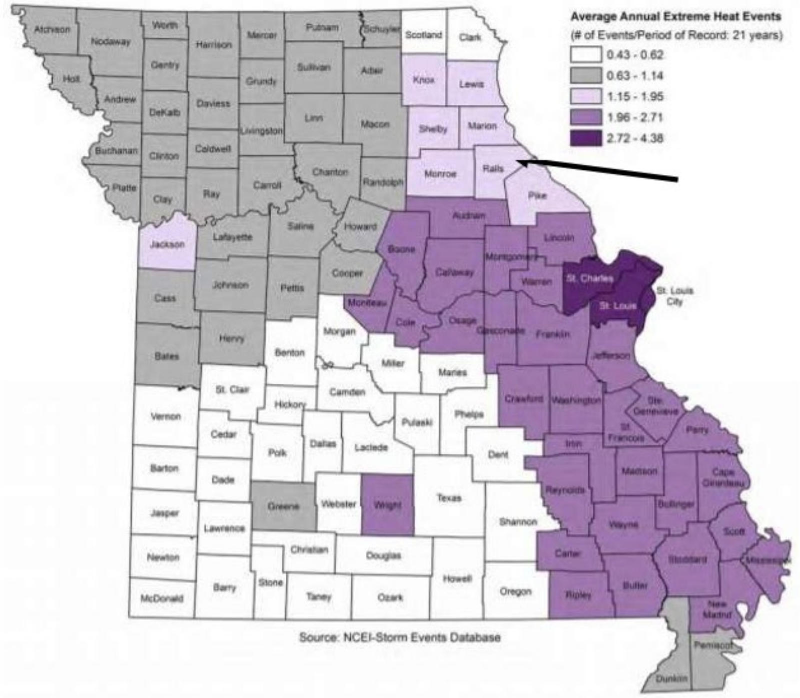
Table 3.31 lists typical symptoms and health impacts due to exposure to extreme heat.

Table 3.25. Typical Health Impacts of Extreme Heat

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

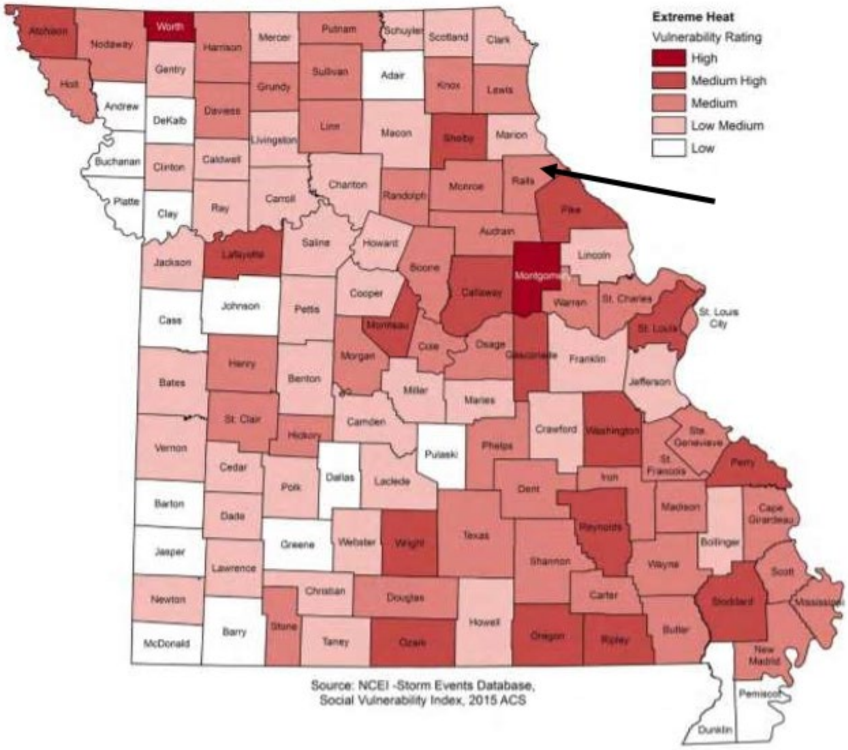
Source: National Weather Service Heat Index Program, www.weather.gov/os/heat/index.shtml

Figure 3.118. Average Annual Occurrence for Extreme Heat



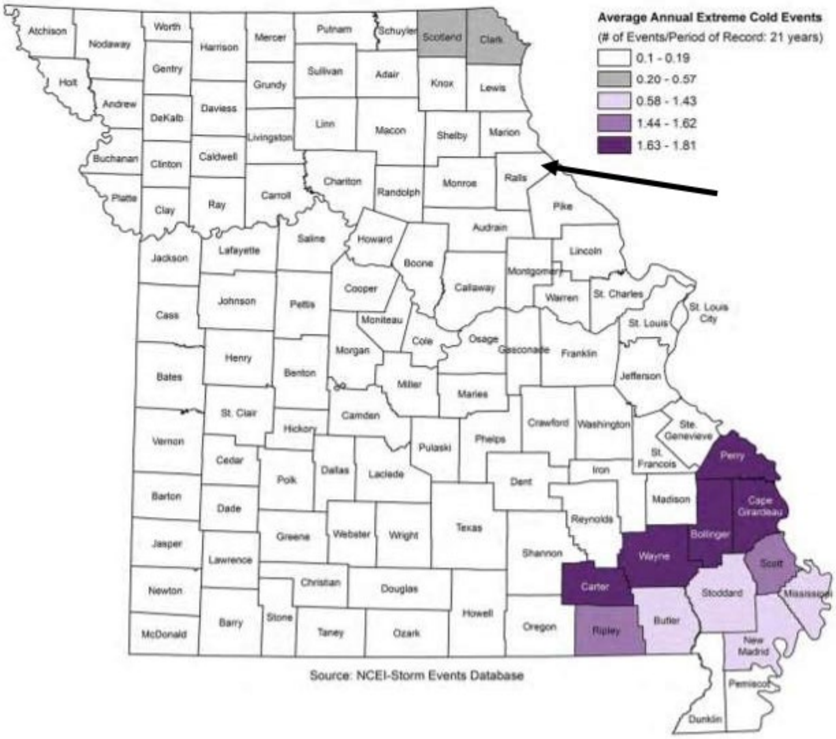
Source: NCEI-Storm Events Database

Figure 3.119. Vulnerability Summary for Extreme Heat



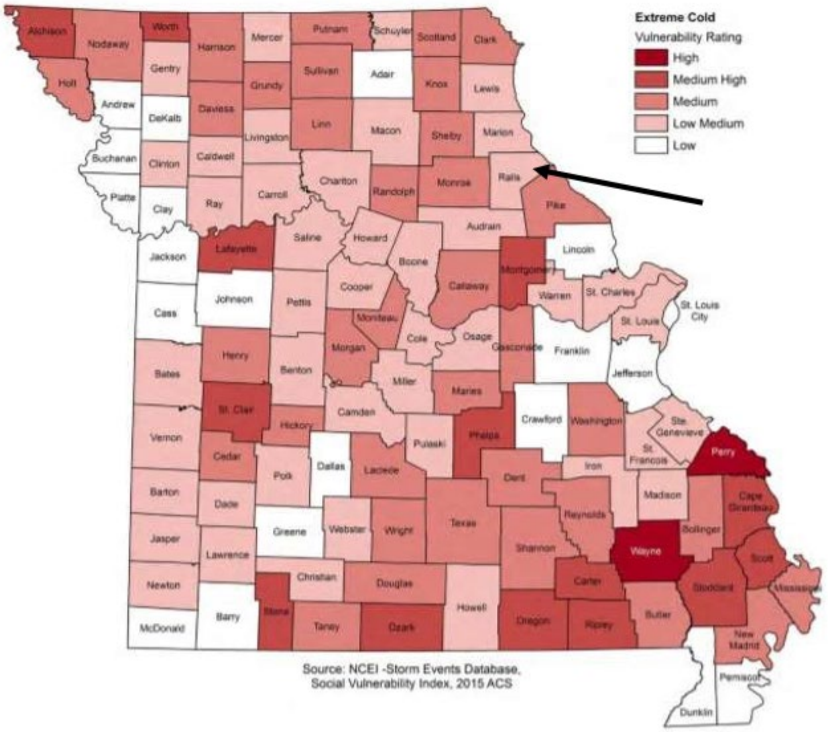
Source: NCEI -Storm Events Database,
Social Vulnerability Index, 2015 ACS

Figure 3.120. Average Annual Occurrence for Extreme Cold



Source: NCEI-Storm Events Database

Figure 3.121. Vulnerability Summary for Extreme Cold



Source: NCEI -Storm Events Database, Social Vulnerability Index, 2015 ACS

Potential Losses to Existing Development

Ralls County is considered to be one of the highest counties in insurance payments for extreme heat. The anticipated loss in any given year can be expected to be the annual average of $69,159. Illness and loss of life are the most concern with extreme heat however there has not been any injury or deaths related to extreme heat reported in the 20 year period reviewed.

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.

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 3.33 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 3.26. Ralls County Population Under Age 5 and Over Age 65, 2010 Census Data

Jurisdiction	Population Under 5 yrs	Population 65 yrs and over
*Ralls County	639	1,676
New London	68	145
Perry	38	159
Center	32	124
Rensselaer	17	21

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

All schools in Ralls 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

Not everyone in Ralls County utilizes social media and texting, elderly and young children are most vulnerable to a heat wave. Cooling locations in the County need to be identified and open to everyone for extended hours. Utilization of social media and texting needs to be promoted. Special attention needs to be paid to insuring the elderly and young children are kept cool and notified of the cooling locations. Education of the cooling locations needs to occur throughout the County.

3.4.8 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 3.4.10**).

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.

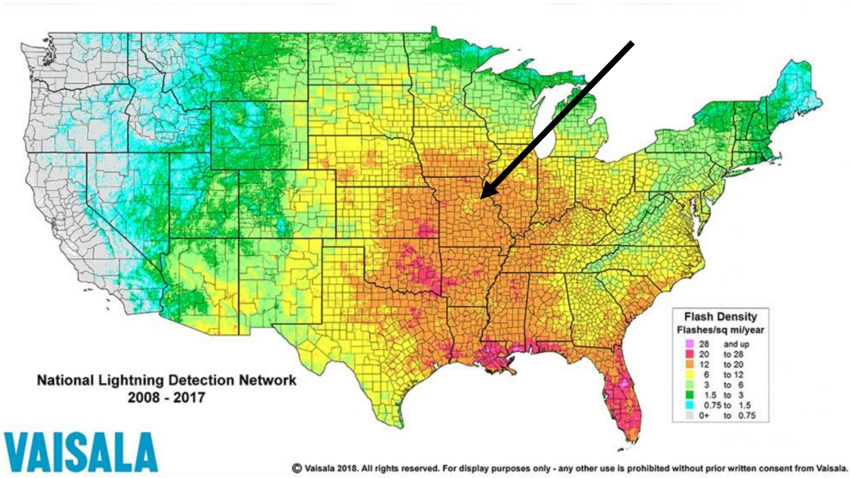
At the time when the updraft can no longer support the hailstone, it will fall down to the earth. For example, a ¼" diameter or pea sized hail requires updrafts of 24 miles per hour, while a 2 ¾" diameter or baseball sized hail requires an updraft of 81 miles per hour. According to the NOAA, the largest 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 Ralls 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 3.13 shows lightning frequency in the state.

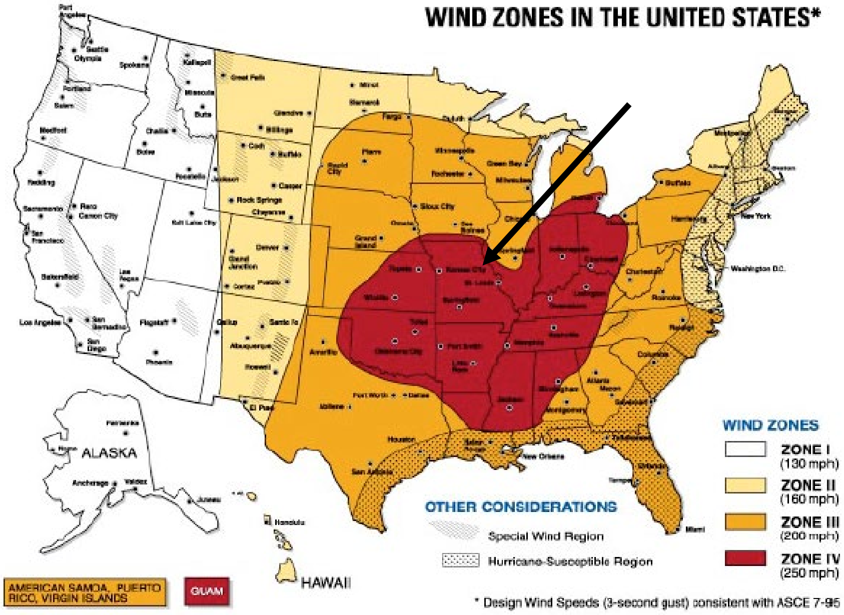
Figure 3.13. Location and Frequency of Lightning in Missouri



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 3.14 shows wind zones in the United States.

Figure 3.14. Wind Zones in the United States



* Design Wind Speeds (3-second gust) consistent with ASCE 7-95

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 3.34** below describes typical damage impacts of the various sizes of hail.

Table 3.27. 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

March 30, 2006- Thunderstorm winds blew down a power line at the intersection of Highways 61 and 19, as well as several trees.
July 19, 2010- Thunderstorm winds blew down several large trees and numerous large tree limbs. A couple of the trees fell onto unoccupied cars near the courthouse in New London. The 71 mph wind gust was recorded on a tow boat in the Saverton Lock and Dam.

June 9, 2011- A microburst occurred over northeastern Ralls County with damage spread out for about a mile. Initially some trees were uprooted west of U.S. Highway 61 along Trabue Lane, then as the downburst spread out to the east; numerous other trees were either snapped off or uprooted. Several homes along Stable Drive, which parallels U.S. Highway 61 to the west, were damaged, one significantly. The failure point on the house that was significantly damaged was the garage door facing to the east. The overhang was uplifted and set down. The homes on either side also had their overhangs uplifted and set back down. However the home in the middle also lost much of its roof with the roof tossed 40 to 50 yards to the west, with insulation thrown over a hundred yards to the west to the tree line. A bit further to the east along U.S. Highway 61, several billboards were destroyed and a number of trees and tree limbs were blown down up to a mile east of U.S. Highway 61. The width of the overall damage path was about three quarters of a mile. No injuries were reported.

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 (MCS). 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. Extensive damage to homes, buildings, power lines, trees, and crops were reported. 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.

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.

The tables below (**Table 3.35 through Table 3.37**) summarize past crop damages as indicated by crop insurance claims. The tables illustrate the magnitude of the impact on the planning area's agricultural economy.

Table 3.28. Crop Insurance Claims Paid in Ralls County from High Winds, 2005-2020

Crop Year	Crop Name	Cause of Loss Description	Insurance Paid
2005	Corn	Hot Wind	$21,231
2011	Wheat	Wind/Excess Wind	$1,250
2011	Corn	Wind/Excess Wind	$3,469
2011	Soybeans	Wind/Excess Wind	$1,074
2012	Corn	Hot Wind	$5,308
2013	Corn	Wind/Excess Wind	$27,392
Total			$59,724

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

Table 3.29. Crop Insurance Claims Paid in Ralls County from Lightning, 2005-2021

Crop Year	Crop Name	Cause of Loss Description	Insurance Paid
2014	Wheat	Other Possible Lightning	$715
2014	Wheat	Other Possible Lightning	$1,524
2014	Wheat	Other Possible Lightning	$15,587
Total			$17,826

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

Table 3.30. Crop Insurance Claims Paid in Ralls County from Hail, 2005-2021.

Crop Year	Crop Name	Cause of Loss Description	Insurance Paid
2007	Soybeans	Hail	$4,280
2010	Corn	Hail	$780
2011	Wheat	Hail	$743
2011	Corn	Hail	$3,991
2011	Soybeans	Hail	$53,938
2013	Corn	Hail	$19,097
2015	Wheat	Hail	$4,026
2015	Corn	Hail	$9,203
2015	Corn	Hail	$2,677
Total			$98,735

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

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.

Probability of Future Occurrence

Thunderstorms

Thunderstorm wind events 50 knots and greater have a probability of occurring 2.225 times per year in the planning area in any given year. These rates occurrences are expected to continue in the future.

Hail

Based on this data, there have been 40 events in a 20 year period, producing an average of 2 hail events each year in Ralls County. When limiting probability analysis to hail events producing hail 1.50

inches and larger, there have been 10 events in a 10-year period. Based on history, the probability of a destructive hail event in any given year is 100 percent. Thus, making the probability as likely in any given year.

Lightning

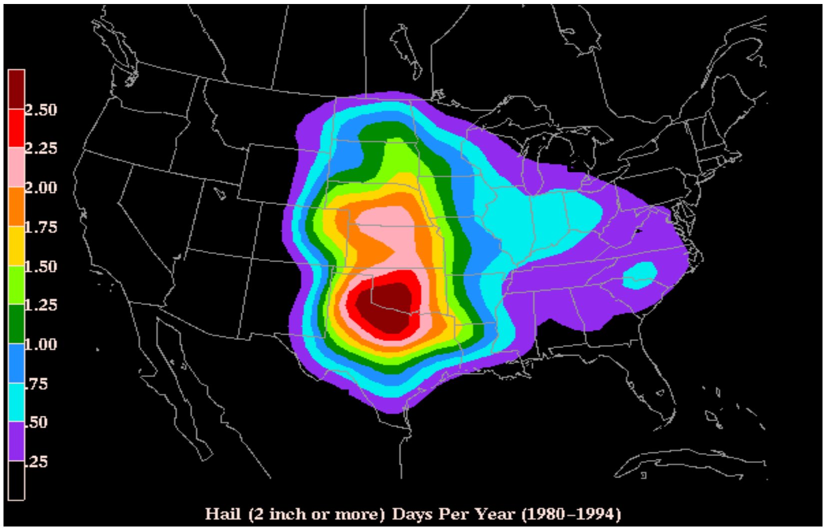
Based on this data, there has been 2 events in a 20-year period, producing an average of 0.05 lightning events each year in Ralls County. Based on history, the probability of a lightning event in any given year is 100 percent. Thus, making the probability as likely in any given year.

High Winds

Based on this data, there has been 1 event in a 20-year period, producing an average of 0.4 high wind events each year in Ralls County. Based on history, the probability of a high wind event in any given year is 100 percent. Thus, making the probability as likely in any given year.

Figure 3.15 is based on hailstorm data from 1980 -1994. The figure shows the probability of hailstorm occurrence (2" diameter or larger) based on number of days per year. Ralls County is located in the region to receive between .75 and 1 hailstorms annually. Include probability calculations for thunderstorms, high winds, hail, and lightning.

Figure 3.15. 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

Thunderstorms and Lightning

Most damages occur to electronic equipment located inside buildings, but structural damage can also occur when a lightning strike causes a building fire. Communications equipment and warning transmitters and receivers can also be knocked out by lightning strikes. There has not been any fatalities or injuries due to lightning in Ralls County during the 10-year period reviewed. No property or crop damage was reported during the 10-year reporting period.

Hail

No property or crop damage was reported during the 10-year reporting period. This amount does not take in account most buildings and structures that are privately insured thus insurance would help the building owner recover from hail damage.

High Winds

During the 10-year period reviewed there was one event with damage contributed to high winds. The mentioned event was destructive to the western part of Ralls County. There were millions of dollars reported in structural damages and damages to crops. Due to Changing Future Conditions, Ralls County may be more susceptible than ever to damaging high winds.

Previous and Future Development

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

Hazard Summary by Jurisdiction

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

Problem Statement

Thunderstorms can damage power lines with the high winds or fallen debris such as tree limbs. Not everyone in the county utilizes social media, texting or has access to a weather radio, smaller communities do not have warning sirens, and rural areas do not have warning sirens. Ralls County has a large number of campgrounds with seasonal campers that make them more vulnerable.

Possible solutions could be the installation of warning sirens in smaller communities or campgrounds, rural citizens are educated on how to utilize social media and texting, and warning sirens are installed in campgrounds and weather radios are accessed by residents more than what is currently being used.

3.4.9 Severe Winter Weather

Hazard Profile

Hazard Description

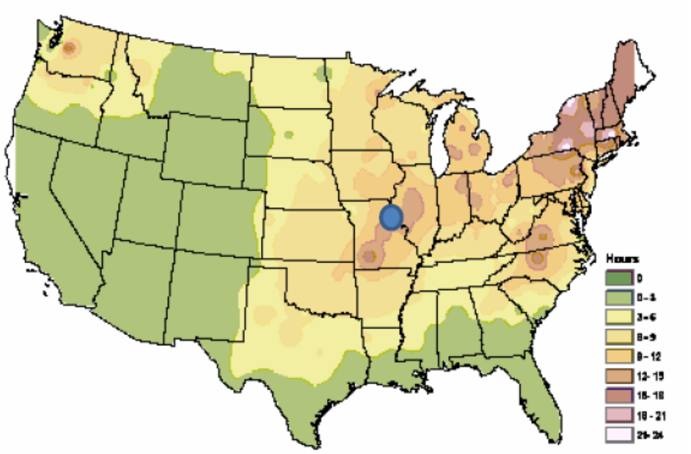
A major winter storm can last for several days and be accompanied by high winds, freezing rain or sleet, heavy snowfall, and cold temperatures. The National Weather Service describes different types of winter storm events as follows.

- **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 Ralls County 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 24, 2004 to as late as April 10, 1997.
Figure 3.16 shows the entire planning area (approximated within the blue circle) is in the orange-shaded area that receives 9-12 hours of freezing rain a year.

Figure 3.16. 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 3.31. NCEI Ralls County Winter Weather Events Summary, 07/01/2011-07/31/2021.

Type of Event	Inclusive Dates	Magnitude	# of Injuries	Property Damages	Crop Damages
Winter Storm	02/21/2013		0	0	0
Winter Storm	12/21/2013		0	0	0
Winter Storm	01/05/2014		0	0	0
Winter Storm	02/04/2014		0	0	0
Ice Storm	01/14/2017		0	0	0
Blizzard	11/25/2018		0	0	0
Winter Storm	01/01/2021		0	0	0

Source: NCEI, data accessed [11/4/2021]

January 31, 2011- The first true blizzard in many years hit from Central to Northeast Missouri. Up to 20 inches of snow fell along with winds gusting over 40 mph. For many counties it was a record snowfall event. I-70 was shut down from Warren County to just east of Kansas City. The National Guard was called out to help clear County roads and assist with emergency transportation. The region was brought to a standstill for several days. A Federal disaster declaration was obtained for many counties in order to assist with the cost of snow removal. Light freezing rain and sleet started on Monday 1/31 with an inch of sleet accumulating by the early morning hours of Tuesday (2/1). By midday Tuesday (2/1) the precipitation had changed to snow and the wind began increasing. By late Tuesday (2/1) afternoon travel became extremely dangerous. In the St. Louis Metro area from 2 - 3 inches of sleet fell followed by 2 to 3 inches of snow. Further south sleet accumulations ranged from 1 to 2 inches with from 1/2 to 3/4 inch of ice accumulation due to freezing rain.

January 1-5, 2014- A very strong winter storm dropped 6 - 12 inches of snow across East Central Missouri. Strong northerly winds produced snow drifts of 2 to 5 feet. All schools and most businesses were closed on the 5th and 6th, with many schools remaining closed for several days due to very cold temperatures and wind chills. The City of St. Louis estimated at least $1 million was spent on snow removal.

Winter storms, cold, frost and freeze take a toll on crop production in the planning area. According to the USDA's Risk Management Agency, payments for insured crop losses in the planning area as a result of winter storm and cold conditions from 2011 to 2021 totaled $542,107.

Table 3.32. Crop Insurance Claims Paid in Ralls County as a Result of Cold Conditions and Snow [2011-2021].

Crop Year	Crop Name	Cause of Loss Description	Insurance Paid ($)
2011	Corn, Wheat, Soybeans	Cold Wet Weather	$22,556
2012	Corn, Wheat, Soybeans	Cold Wet Weather	$21,439
2013	Wheat, Corn	Cold Wet Weather	$6,099
2014	Corn, Wheat, Soybeans	Frost	$178,126
2015	Wheat, Soybeans	Cold Wet Weather	$73,945
2016	Wheat, Corn, Soybeans	Cold Wet Weather	$75,245
2017	Corn, Soybeans	Cold Wet Weather	$22,253
2018	Wheat, Soybeans	Cold Wet Weather	$4,811
2019	Wheat, Corn	Cold Wet Weather	$55,117
2020	Wheat, Corn	Cold Wet Weather	$82,516
Total			$542,107

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

Probability of Future Occurrence

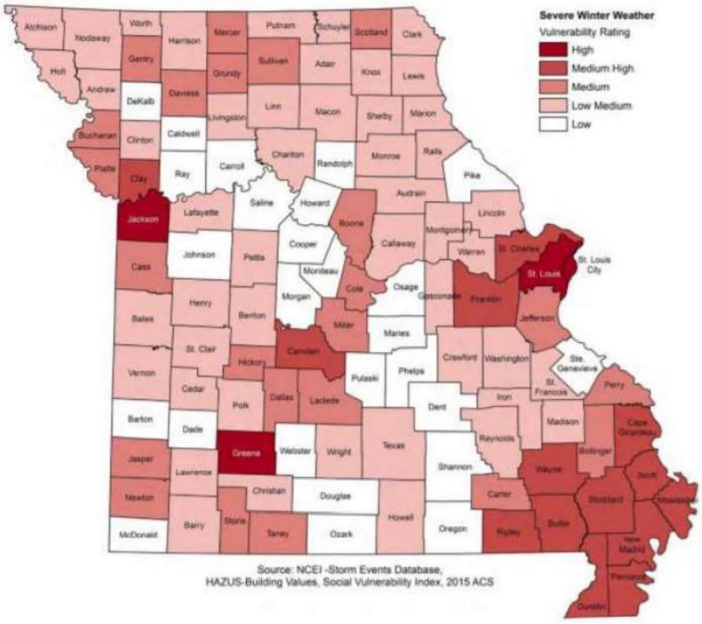
The entire planning area is vulnerable to the effects of winter storm/blizzard, ice storms, winter weather, cold/wind chill and heavy snow. All effects of winters tend to make driving more treacherous and can impact the response of emergency vehicles. The probability of utility and infrastructure failure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

Changing Future Conditions Considerations

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

Vulnerability

Vulnerability Overview



Source: NCEI -Storm Events Database,
HAZUS-Building Values, Social Vulnerability Index, 2015 ACS

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

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

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

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

Potential Losses to Existing Development

The next severe winter storm will most likely close schools and businesses for multiple days, and make roadways hazardous for travel. Heavy ice accumulation may damage electrical infrastructures causing prolonged power outages for large portions of the region. In addition, freezing temperatures make water lines vulnerable to freeze/thaw. Fallen tree limbs also pose a threat to various structures/infrastructures across the county.

Previous and Future Development

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

Hazard Summary by Jurisdiction

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

Problem Statement

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

3.4.10 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 3.33**) 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 3.33. 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 3.34**. 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 3.34. 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

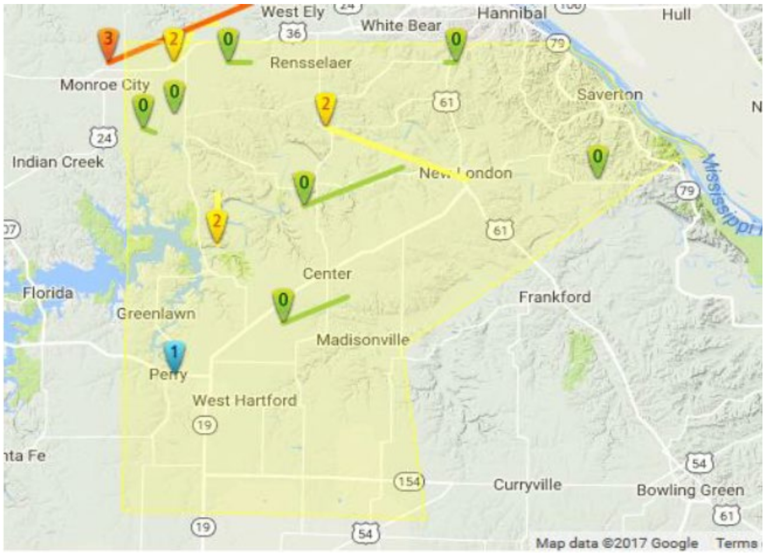
There are limitations to the use of NCEI tornado data that must be noted. For example, one tornado may contain multiple segments as it moves geographically. A tornado that crosses a county line or state line is considered a separate segment for the purposes of reporting to the NCEI. Also, a tornado that 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 3.35. Recorded Tornadoes in Ralls County, 1993 – Present

Date	Beginning Location	Ending Location	Length (miles)	Width (yards)	F/EF Rating	Death	Injury	Property Damage	Crop Damages
05/10/03	Hassard	Hassard	2.5	50	F0	0	0	0	0
05/24/03	Saverton	Saverton	0.2	40	F0	0	0	0	0
03/12/06	Hassard	Hassard	0.2	50	F0	0	0	0	0
04/02/06	Perry	Hatch	3.5	350	F2	0	0	0	0
05/30/08	Center	Center	3.25	50	EF0	0	0	$30,000	0
12/27/08	Center	New London	5.01	40	EF0	0	0	0	0
12/27/08	Flint Hill	Flint Hill	0.86	30	EF0	0	0	0	0
06/27/11	Hassard	Hassard	0.63	70	EF0	0	0	0	0
03/25/17	Perry	Joanna	6.76	20	EF0	0	0	0	0
	Total		22.91	700		0	0	$30,000	0

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

Figure 3.17. Ralls County Map of Historic Tornado Events



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

During the previous 21 years of data from the USDA Risk Management Agency Ralls County has not received any insurance payments for crop damages as a result of tornadoes.

Probability of Future Occurrence

The National Center for Environmental Information reported 11 tornadoes in Ralls County in a 65-year time period, which calculates to a 17 percent chance of a tornado in any given year. Therefore it is a low probability that some portion of Ralls County will experience tornado activity in any given year.

Changing Future Conditions Considerations

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

Vulnerability

Vulnerability Overview

Ralls County is located in a region of the U.S. with high frequency of dangerous and destructive tornadoes referred to as "Tornado Alley". **Figure 3.18** is based on areas where dangerous tornadoes are more likely to occur.

Figure 3.18. Tornado Alley in the U.S.

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

Potential Losses to Existing Development

In Ralls County, the NCEI estimate for past damages from 1950 to 2021 is $65,250 and the annualized property damage is $1,003.

To estimate vulnerability to tornadoes, the impacts of an F0 tornado due to this being the most common in the period reviewed tornado with wind speed of approximately 100 mph and a length of 1.9 miles and width of 83.8 yards in Ralls County. Based on data the nine tornadoes occurred in rural areas and did not directly affect the rural jurisdictions in the planning area.

Previous and Future Development

Vulnerability to tornadoes is anticipated to remain the same. Future development for public buildings such as schools, government offices, as well as buildings with high occupancy and campgrounds should consider including a tornado safe room to protect occupants in the event of a tornado. Ralls County is known to have a large number of campsites and as there is expanded in the future considerations should be made to shelter people utilizing the campgrounds.

Hazard Summary by Jurisdiction

Tornadoes can occur in the entire planning area however due to the large number of campgrounds the unincorporated area would suffer heavier damages. No damage from previous tornado occurrences was indicated on the Data Collection Questionnaire.

Problem Statement

Ralls County has inadequate tornado shelters throughout the county, not everyone utilizes social media and/or texting, the rural areas do not have warning sirens, smaller communities do not have warning sirens, lack of awareness for available shelters and more education needs to occur.

The Ralls County R-II School District recently built a new school with a tornado shelter. Possible solutions could be awareness made of existing tornado shelters, education on what to do in the event of a tornado and smaller communities could install warning sirens. The campgrounds could also install warning sirens. A strong emphasis could be made for everyone in the county to own a weather radio.

3.4.11 Wildfire

Hazard Profile

Hazard Description

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

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

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

Geographic Location

The term refers to the zone of transition between unoccupied land and human development and needs to be defined in the plan. Within the WUI, there are two specific areas identified: 1) Interface and 2) Intermix. The interface areas are those areas that abut wildland vegetation and the Intermix areas are those areas that intermingle with wildland areas.
As of November 2021 Ralls County, Missouri has approximately 28,000 acres active in CRP. This translates to 10% percent of the total 283,486 of land acres in the county.

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

Strength/Magnitude/Extent

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

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

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

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

Previous Occurrences

According to information obtained from the Missouri Division of Fire Safety (MDFS) Website as well as the Missouri Department of Conversation Wildfire Data Search there were 89 reported wildland or grass fires in Ralls County from 2005 to 2021. In total, these 89 fires burned 2,003.3 acres and no injuries were reported. Seventeen of the fires had an unknown cause for starting and burning 487.5 acres and 34 were started by debris. These 51 fires burned 1,307.1 acres during the 16-year reporting period. http://mdc4.mdc.mo.gov./applications/FireReporting/Report.aspx .

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 5.56 fires burning 125.19 acres per year. However, it was reported these fires did not result in major damages. The probability score to be likely in any given year that a wildfire could occur in the planning area.

Changing Future Conditions Considerations

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

Additionally, stated in the 2018 State Plan, higher temperatures will also reduce the number of days prescribed burning can be performed. Reduction of prescribed burning will allow for growth of understory vegetation – providing fuel for destructive wildfires. Drought is also anticipated to increase in frequency and intensity during summer months under projected future scenarios.

Drought can lead to dead or dying vegetation and landscaping material close to structures which creates fodder for wildfires within both the urban and rural settings.

Vulnerability

Vulnerability Overview

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 Ralls 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 is comprised of volunteers and is 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 and previous development in the wildland-urban interface would increase vulnerability to the hazard.

Hazard Summary by Jurisdiction

The rural jurisdictions in the planning area are all surrounded by undeveloped agricultural land and face the possibility of a wildfire. The school district is located in a rural area does not face danger of wildfire due to barriers in place around the school.

Problem Statement

Residents do not comply with burn bans, education is not available for the levels of burn bans, many residents lack education in fire safety and not all residents utilize social media and texting.

Education needs to occur on the dangers associated with not complying with the burn bans, more education for fire safety and encourage utilization of social media and texting.

3.4.12 Pandemic

Hazard Profile

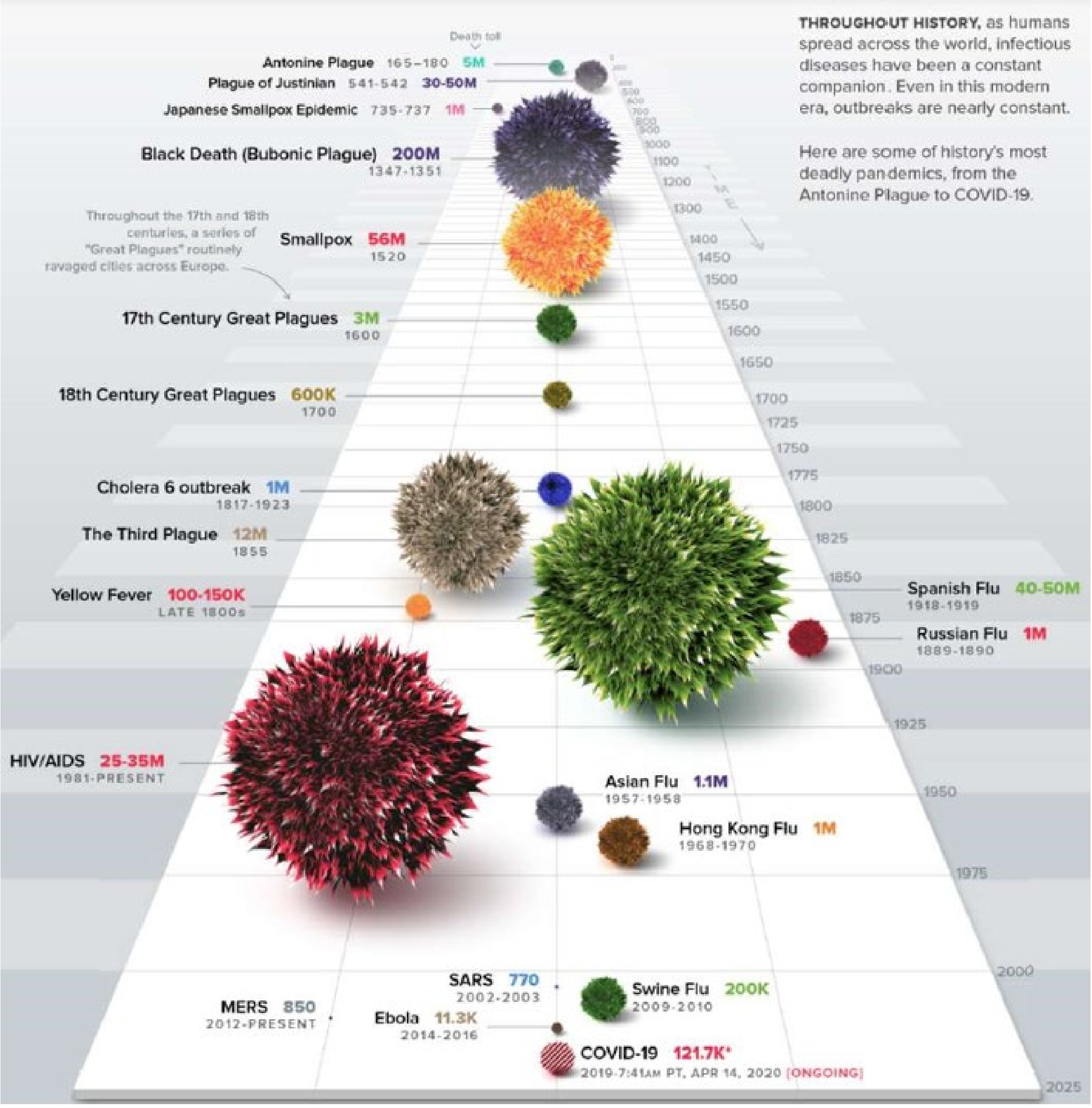
Hazard Description
According to the Center for Disease Control, a pandemic is a global outbreak of disease. Pandemics happen when a new virus emerges to infect people and can spread between people sustainably. Because there is little to no pre-existing immunity against the new virus, it spreads worldwide.

Geographic Location
All of Ralls County is 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 3.43 below outlines the history of pandemics dating back to 165.

Figure 3.43. History of Pandemics



THROUGHOUT HISTORY, as humans spread across the world, infectious diseases have been a constant companion. Even in this modern era, outbreaks are nearly constant.

Here are some of history's most deadly pandemics, from the Antonine Plague to COVID-19.

Throughout the 17th and 18th centuries, a series of "Great Plagues" routinely ravaged cities across Europe.

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

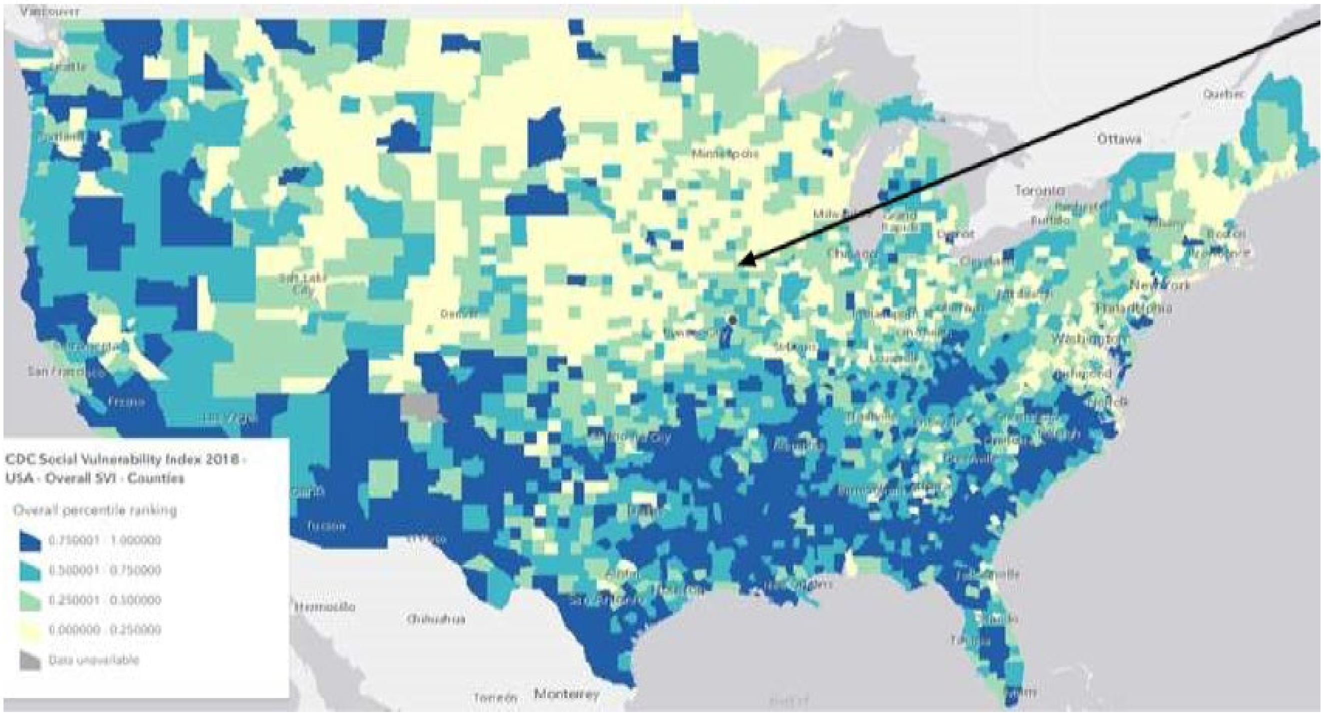
Climate change and weather patterns are widely thought to have direct impacts on the probability and severity of future pandemic outbreaks. Habitat loss due to climate is bringing animals that can transmit disease in contact with humans more often. Floods can enhance the spread of infectious agents like 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 3.44. Social Vulnerability Rating in the United States



Source: https://livingatlas.arcgis.com/policy/browse/?loc=-94.542,39.439,5&col=88f17b4580e846609f92c9f75a9d9eee,2c8fdc6267e4439e968837020e7618f3,48638a1be455429287d6756985013910,02a82293e2dd475391cb3699b5e82d61,d89c527f2e6b4d658db0948ea9d49cd9,48a70b524601428ba297e3106b751401,be559110b5c34591b1a767fbb807bcbf,e0427fbc472f4a45b7d94d182a5e9591,142e65436bed4063973380feae6ed248&viz=2c8fdc6267e4439e968837020e7618f3&hs=1 *Arrow indicates Ralls 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.