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 Laclede County, 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 Laclede County 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 Laclede County and provides a factual basis for elimination of hazards from further consideration;

- **Section 3.2 Assets at Risk** provides Laclede County's total exposure to natural hazards, considering critical facilities and other community assets at risk;

- **Section 3.3 Future Land Use and Development** discusses areas of planned future development

- **Section 3.4 Hazard Profiles and Vulnerability Analysis** provides more detailed information about the hazards impacting Laclede County. For each hazard, there are three sections:

  1) Hazard Profile provides a general description and discusses the threat to Laclede County, the geographic location at risk, potential severity/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 hazards identified in the 2019 Laclede County Hazard Mitigation Plan and the State Plan were reviewed at the second meeting, held on July 19, 2023. All hazards identified from the 2019 plan are identified in the 2018 Missouri State Hazard Mitigation Plan. Hazards that are included in the State Plan but not the Laclede County Plan include:

- Scour Critical Bridges
- Attack (Nuclear, Conventional Chemical, and Biological)
- Civil Disorder
- Cyber Disruptions
- Hazardous Materials Release (Fixed Facility Accidents)
- Mass Transportation Accidents
- Nuclear Power Plants (Emergencies and Accidents)
- Public Health Emergencies/Environmental Issues
- Special Events
- Terrorism
- Utilities (Interruptions and System Failures)

In Missouri, local plans customarily include only natural hazards, as only natural hazards are required by federal regulations to be included. Since this is the requirement, and Laclede County is mostly rural, it was determined to only include natural hazards.

Natural hazards not included in this plan update include:

- Landslides
- Coastal Storms
- Hurricanes

- Tsunamis
- Avalanche
- Volcanic Activity

Due to lack of previous events and therefore low risk of future occurrences, the aforementioned hazards were not included in the 2024 update of the plan.

3.1.2 Review Disaster Declaration History

Laclede County has experienced FEMA declarations from severe storms, floods, severe winter storms, and drought. Federal and/or state 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 damage and institutions or industrial sectors affected.

Since 1973, Laclede County has experienced twenty three (23) hazard events that triggered federal disaster declarations. The most recent occurred on July 9, 2020. Almost all disaster declarations involve severe storms, with 15 including flooding and 10 including tornadoes.

Table 3.1 lists the federal FEMA disaster declarations that included the planning area from 1965 to present.

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

Disaster Number	Description	Declaration Date Incident Period	Individual Assistance (IA) Public Assistance (PA)
4552	Severe Storms, Tornadoes, Straight-Line Winds, and Flooding	July 9, 2020	Public Assistance
4490	Biological, Missouri COVID 19 Pandemic	March 26, 2020	Individual & Public Assistance
3482	Biological, Missouri COVID 19	March 13, 2020	Neither
4451	Severe Storms, Tornadoes, and Flooding	July 9, 2019	Individual & Public Assistance
4250	Severe Storms, Tornadoes, Straight-Line Winds, and Flooding	January 21, 2016	Individual & Public Assistance
3374	Severe Storms, Tornadoes, Straight-Line Winds, and Flooding	January 2, 2016	Neither
4238	Severe Storms, Tornadoes, Straight-Line Winds, and Flooding	August 7, 2015	Public Assistance

4144	Severe Storms, Straight-Line Winds, and Flooding	September 6, 2013	Public Assistance
1961	Severe Winter Storm and Snowstorm	March 23, 2011	Public Assistance
3317	Severe Winter Storm	February 3, 2011	Neither
1847	Severe Storms, Tornadoes, and Flooding	June 19, 2009	Individual & Public Assistance
3303	Severe Winter Storm	January 30, 2009	Neither
1749	Severe Storms and Flooding	March 19, 2008	Individual & Public Assistance
1742	Severe Storms, Tornadoes, and Flooding	February 5, 2008	Public Assistance
3281	Severe Winter Storms	December 12, 2007	Neither
1728	Severe Storms and Flooding	September 21, 2007	Public Assistance
1676	Severe Winter Storms and Flooding	January 15, 2007	Public Assistance
3232	Hurricane Katrina Evacuation	September 10, 2005	Public Assistance
1463	Severe Storms, Tornadoes, and Flooding	May 6, 2003	Individual & Public Assistance
1412	Severe Storms, Tornadoes, and Flooding	May 6, 2002	Public Assistance
995	Severe Storms and Flooding	July 9, 1993	Neither
3017	Drought	September 24, 1976	Neither
372	Heavy Rains, Tornadoes, and Flooding	April 19, 1973	Neither

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

3.1.3 Research Additional Sources

Many resources were used to find data on natural hazards. Primary sources included FEMA, SEMA, and National Oceanic and Atmospheric Administration (NOAA). Other information sources included Laclede County and local officials, and regional and state plans. Additional sources of data on locations and past impacts of hazards in Laclede County include:

- Missouri Hazard Mitigation Plans (2010, 2013, 2018, and 2023)
- Previously approved Laclede County Hazard Mitigation Plan (2019)
- Federal Emergency Management Agency (FEMA)
- Missouri Department of Natural Resources (MDNR)
- National Drought Mitigation Center Drought Reporter
- US Department of Agriculture's (USDA) Risk Management Agency Crop Insurance Statistics
- National Agricultural Statistics Service (Agriculture production/losses)
- Data Collection Questionnaires completed by each jurisdiction
- State of Missouri GIS data

- Environmental Protection Agency
- Flood Insurance Administration
- Hazards US (HAZUS)
- Missouri Department of Transportation
- National Fire Incident Reporting System (NFIRS)
- National Oceanic and Atmospheric Administration's (NOAA)
- National Centers for Environmental Information (NCEI)
- Laclede 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 (citations to sources will be 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 Laclede County differ in their susceptibilities to certain hazards. The hazards identified were based on the input from the planning team members, available historical data and the hazard modeling results described with the hazard mitigation plans. The jurisdictions and hazards chosen that significantly impact the planning area are 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

	Dam Failure	Drought	Earthquake	Extreme Temperatures	Flooding (River and Flash)	Land Subsidence/Sinkholes	Severe Winter Weather	Thunderstorm/Lightning/ Hail/High Wind	Tornado	Wildfire	Levee Failure
Laclede County	x	x	x	x	x	x	x	x	x	x	
City of Lebanon	X	X	X	X	X	X	X	X	X	X	-
City of Conway	-	X	X	X	-	-	X	X	X	X	-
City of Stoutland	-	X	X	X	-	-	X	X	X	X	-
City of Richland	-	X	X	X	-	-	X	X	X	X	-
Village of Phillipsburg	-	X	X	X	X	-	X	X	X	X	-
Schools and Special Districts											
Laclede County C-5 School District	-	-	X	X	-	X	X	X	X	X	-
Lebanon R-III School District	-	-	X	X	X	X	X	X	X	X	-
Richland R-IV School District	-	-	X	X	-	-	X	X	X	X	-
Plato R-5 School District	-	-	X	X	X	X	X	X	X	X	-
Gasconade C-4 School District	-	-	X	X	X	X	X	X	X	X	-
Laclede County R-1 School District	-	-	X	X	-	-	X	X	X	X	
Stoutland R-II School District	-	-	X	X	X	X	X	X	X	X	-

3.1.5 Multi-Jurisdictional Risk Assessment

This hazard mitigation plan is an update of the 2019 Laclede County Hazard Mitigation Plan. This is a multi-jurisdictional plan that applies to the participating jurisdictions of the unincorporated area of Laclede County, the three communities, and five school districts within. Each hazard has a profile in which the risks are assessed on a planning area wide basis since the hazards identified have the same probability of occurrence throughout the county. The hazards that vary across Laclede County in terms of risk include dam failure, flash flood, grass or wildland fire, levee failure, river flood, flash flood, and sinkholes/land subsidence. These differences are detailed in each hazard profile under geographic location and vulnerability.

The climate within Laclede County is uniform, with high temperatures in the summer and mild winters. The topography is also uniform, with most of the county having hills, streams, and rivers.

Lebanon is the most urbanized area and experiences more construction than the rest of the communities in the county. The city plans to continue growing, increasing the population and amount of assets, and thus increasing the vulnerability to all weather-related hazards. The rest of the communities within Laclede County experience very little to no growth and development, however it is possible that certain communities near Lebanon will experience some growth because of expansion. However, even if these communities experience no growth, they are still vulnerable to natural hazards since agriculture is a prime industry in the county. Hazards such as drought and hail especially threaten the rural regions. The differences in vulnerability across the jurisdictions will be discussed in greater detail within the vulnerability section 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 of natural hazards. Table 3.3 shows the total population, building count, estimated value of buildings, estimated value of contents and estimated total exposure to parcels by jurisdiction.

3.2.1 Total Exposure of Population and Structures

Unincorporated Laclede County and Incorporated Cities

In the following three tables, population data is based on 2020 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 Laclede County assessor's 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 Laclede 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 Laclede County and each city in the planning area broken down by usage type. Finally, **Table 3.5** provides the building count total for the Laclede 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	2020 Annual Population Estimate	Building Count	Building Exposure ($)	Contents Exposure ($)	Total Exposure ($)
City of Conway	729	337	$47,932	$29,668	$77,600
City of Lebanon	15,013	6,098	$871,180	$564,714	$1,435,894
City of Richland	1,734	38	$5,136	$3,687	$8,823
City of Stoutland	209	31	$4,464	$2,869	$7,333
Village of Phillipsburg	164	104	$10,266	$6,705	$16,971
Unincorporated Laclede County	18,190	17,757	$1,035,650	$558,482	$1,594,132
Totals	36,039	24,365	$1,974,624	$1,166,125	$3,140,753

Source: U.S. Bureau of the Census, Annual population estimates/ 5-Year American Community Survey 2020; 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
City of Conway	$32,372	$9,873	$1,679	$55	$43,979
City of Lebanon	$613,187	$170,388	$55,398	$380	$839,353
City of Richland	$4,017	$0	$1,119	$0	$5,136
City of Stoutland	$3,190	$1,274	$0	$0	$4,464
Village of Phillipsburg	$7,798	$1,274	$839	$82	$9,993
Unincorporated Laclede County	$914,936	$75,162	$16,508	$26,552	$1,033,158
Totals	$1,575,500	$257,971	$75,543	$27,069	$1,936,083

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 Conway	274	31	6	20	331
City of Lebanon	5,190	535	198	139	6,062
City of Richland	34	0	4	0	38
City of Stoutland	27	4	0	0	31
Village of Phillipsburg	66	4	3	30	103
Unincorporated Laclede County	7,744	236	59	9,713	17,752
Totals	13,335	810	270	9,902	24,317

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

The number of enrolled students at the participating public-school districts is provided in **Table 3.6** below. Additional information includes the number of buildings, building values (building exposure) and contents value (contents exposure). These numbers will represent the total enrollment and building count for the public-school districts regardless of the county in which they are located.

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

Public School District	Enrollment	Building Count	Building Exposure ($)	Contents Exposure ($)	Total Exposure ($)
Gasconade C-4 School District	71	2	4,345,339	453,971	4,799,310
Joel E. Barber Laclede County	462	3	11,035,000	11,035,000	22,070,000
Laclede County R-I School	763	4	26,014,186	4,589,776	30,603,962
Lebanon R-III School District	4,196	25	183,691,068	26,985,403	210,676,471
Richland R-IV School District*	433	6	-	-	-
Stoutland R-II School District	374	2	11,349,470	3,060,741	14,410,211
Plato R-5 School District	560		-	-	-

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

3.2.2 Critical and Essential Facilities and Infrastructure

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

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

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

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:

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

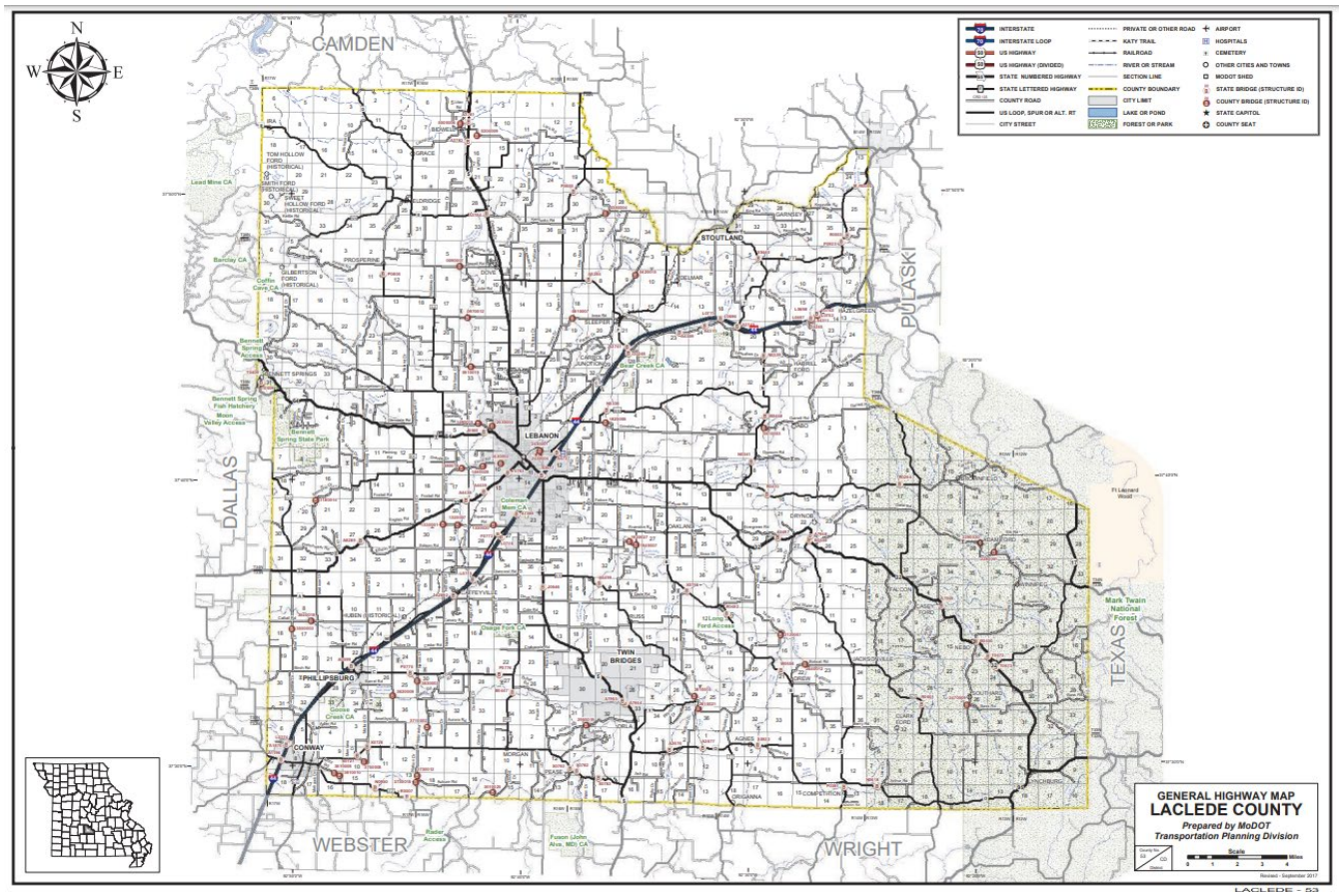
Jurisdiction	Airport Facility	Bus Facility	Childcare Facility	Communications Tower	Electric Power Facility	Emergency Operations	Fire Service	Government	Housing	Shelters	Highway Bridge	Hospital/Health Care	Military	Natural Gas Facility	Nursing Homes	Police Station	Potable Water Facility	Rail	Sanitary Pump Stations	School Facilities	Stormwater Pump Stations	Tier II Chemical Facility	Wastewater Facility	TOTAL
Unincorporated						1		1			5			1				1						9
City of Conway				5			1			1	1				1	1		1	1	4	1		1	18
City of Lebanon	1	1	18	4		1	1	1	1		1	1						1	1	1	1		1	35
City of Richland	1		1	1	1	1	1	2	1			2		1	2	1		1		4				20
Village of Phillipsburg				1			1				1							1	1	1				6
City of Stoutland							1				1				1			1	1	1				6
Totals	2	1	19	11	1	3	5	4	2	1	9	3	0	2	4	2	0	6	4	11	2	0	2	94

Source: Missouri 2023 State Hazard Mitigation Plan and Hazard Mitigation Viewer; Data Collection Questionnaires; Hazus, etc.

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

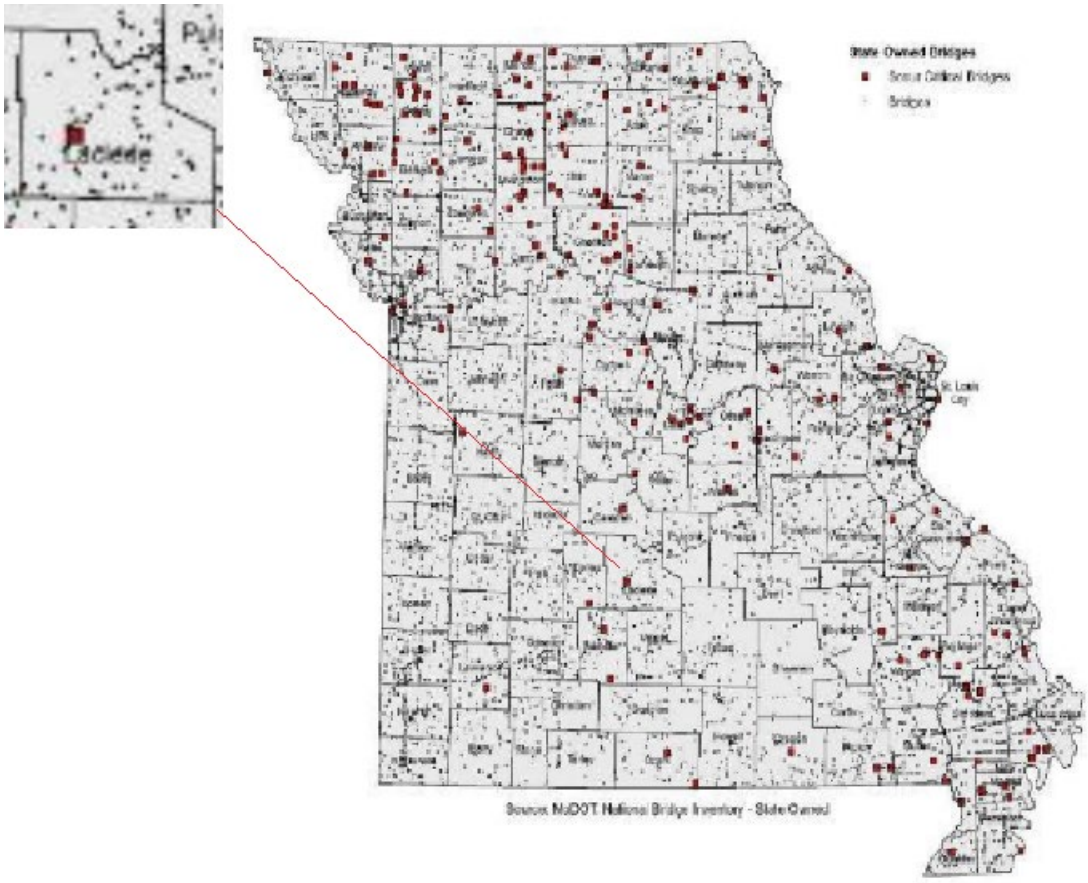
Figure 3.1 is a map depicting Laclede County Bridges. Bridges are denoted by a red or white “B” symbol. (full page document available in Appendix B)

Figure 3.1. Laclede County Bridges



Source: https://www.modot.org/sites/default/files/documents/LacledeCo2022.pdf

Figure 3.2. Laclede County Structurally Deficient Bridges



Source: 2023 Missouri State Hazard Mitigation Plan

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 damage is higher.
- The rules for reconstruction, restoration, rehabilitation, and/or replacement are often different for these types of designated resources.
- The presence of natural resources can reduce the impacts of future natural hazards, such as wetlands and riparian habitats which help absorb floodwaters.
- Losses to economic assets like these (e.g., major employers or primary economic sectors) could have severe impacts on a community and its ability to recover from disaster.

Threatened and Endangered Species: **Table 3.8** shows Federally Threatened, Endangered, Proposed and Candidate Species in the county.

Table 3.8. Threatened and Endangered Species in Laclede County

Common Name	Scientific Name	Status
Gray Bat	Myotis grisescens	Endangered
Indiana Bat	Myotis sodalis	Endangered
Northern Long-eared Bat	Myotis septentrionalis	Threatened
Niangua Darter	Etheostoma nianguae	Threatened
Scaleshell Mussel	Leptodea leptodon	Endangered
Spectaclecase (mussel)	Cumberlandia monodonta	Endangered
Tricolored Bat	Perimyotis subflavus	Proposed Endangered
Monarch Butterfly	Danaus plexippus	Candidate
Eastern Hellbender	Crytobranchus alleganiensis	Endangered

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

Natural Resources: 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 locations of parks and conservation areas in Laclede County.

Table 3.9. Parks in Laclede County

Park / Conservation Area	Address	City
Anna M Adams Access	Off of Dawn Road	Richland
Bear Creek Conservation Area	Off of County Road MM-325	Lebanon
Bennett Springs State Park	26250 MO-64A	Lebanon
Coffin Cave Conservation Area	Off of County Road 64-999	Lebanon
Coleman Memorial Conservation Area	Off of Coach Road	Lebanon
Davis Ford Access	Off of State Highway AC	Lebanon
Goose Creek Conservation Area	Off of State Highway CC	Phillipsburg
Hazelgreen Access	Off of Heartwood Road	Richland
Hull Ford Access	Off of State Highway N	Richland
Long Ford Access	Off of State Highway 8	Lebanon
Osage Fork Conservation Area	Off of State Highway C	Lebanon
Prosperine Access	Off of Kinfolk Road	Eldridge
Mary Lawson Conservation Area		

Source: http://mdc7.mdc.mo.gov/applications/moatlas/AreaList.aspx?txtUserID=guest&txtAreaNm=s , https://mdc.mo.gov/conservation-areas-search?title=&field_county=1201&field_geofield_lat_lng_proximity%5Bvalue%5D=0&field_geofield_lat_lng_proximity%5Bsource_configuration%5D%5Borigin_address%5D=&faux_select_geofield=0&field_accessible=All&page=1 and county/community websites.

Park Name	Address	City
Atchley Park	1805 Lynn Street	Lebanon
Boswell Park	1205 Kent Drive	Lebanon
Gasconade Park	Fourth Street and Van Buren Street	Lebanon
Harke Park	2901 National Street	Lebanon
Nelson Park	1523 Maple Lane	Lebanon
Palmer Park	500 E. Elm Street	Lebanon
Spiller Park	488 Spiller Street	Lebanon
Wallace Park	325 Harwood Avenue	Lebanon
W.T. Vernon Park	Mayfield Street	Lebanon

Source: https://www.lebanonmissouri.org/263/Parks-Recreation

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.

The properties in Laclede County that are on the National Register of Historic Places are listed in **Table 3.10.**

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

Property	Address	City	Date Listed
Bennett Spring State Park Hatchery-Lodge Area Historic District	Off MO 64	Lebanon	3/04/1985
Ralph E. Burley House	389 S Adams Avenue	Lebanon	7/07/1994
Joe Knight Building	201 W. Commercial Street	Lebanon	9/06/2005
Laclede County Jail	Adams and 3rd Streets	Lebanon	3/27/1980
Ploger-Moneymaker Place	291 Harwood Avenue	Lebanon	9/23/1982
Wallace House	230 Harwood Avenue	Lebanon	3/22/1984

Source: Missouri Department of Natural Resources – Missouri National Register Listings by County http://dnr.mo.gov/shpo/mnrlist.htm https://mostateparks.com/page/84706/laclede-county-national-register-listings

Economic Resources: Most manufacturing companies and businesses in Laclede County are located within the City of Lebanon. **Table 3.11** lists the employers with the largest work forces.

Table 3.11. Major Non-Government Employers in Laclede County

Employer Name	Main Locations	Product or Service	Employees
Tracker Marine	Lebanon	Aluminum Fishing and Pleasure Boats	1,150
Detroit Tool Metal Products	Lebanon	Metal stamping, fabrication, and robotic welding	320
Regal-Rexnord	Lebanon	Electric Motors	150
Lowe Boats	Lebanon	Aluminum Fishing and Pleasure Boats	400
Independent Stave Company	Lebanon	White oak barrels for wine and spirits industry	550
Marine Electrical Products	Lebanon	Fiberglass assemblies and wiring harnesses for the boating industry	280
The Durham Company	Lebanon	Electric metering bases and devices	433
Detroit Tool Engineering	Lebanon	Metal stamping, tool design, and automation systems	95
Lebanon Publishing Company	Lebanon	Newspaper and other print media publishing	10
Sign-Fab	Stoutland	Outdoor advertising signage	60
Carmeco, Inc.	Lebanon	Metal fabrication, stamping, and welding	85
Metaltech Products, Inc.	Lebanon	Metal fabrication, stamping, and welding	120

G3 Boats	Lebanon	Aluminum Fishing and Pleasure Boats	341
Copeland	Lebanon	Residential AC Compressors	825
Mercy Lebanon	Lebanon	Hospital	661
Lebanon R-3	Lebanon	School District	667
The Ice Cream Factory	Lebanon	Ice Cream Factory	40

Source: Data Collection Questionnaires; local Economic Development Commissions

Agriculture: **Table 3.12** provides a summary of agriculture in Laclede County. Agriculture is an important industry within Laclede County and the surrounding areas; however, most farms employ a small number of workers, and a high number of those workers report working less than 150 days of the year.

Table 3.12. Agriculture-Related Jobs in Laclede County

Employment Information	Farms	Workers	$1,000 Payroll
Hired Farm Labor	183	446	1,243
Farms with One Worker	94	94	-
Farms with Two Workers	52	104	-
Farms with Three or Four Workers	23	78	-
Farms with Five to Nine Workers	12	Withheld to avoid disclosing data for individual farms	-
Farms with 10 Workers or More	2	Withheld to avoid disclosing data for individual farms	-
Reported Only Workers Working 150 Days or More	38	144	698
Reported Only Workers Working Less Than 150 Days	132	241	308
Reported Both	13	61	238
Unpaid Workers	591	1,339	-

https://www.nass.usda.gov/Publications/AgCensus/2017/Full_Report/Volume_1,_Chapter_2_County_Level/Missouri/st29_2_0007_0007.pdf,
https://www.nass.usda.gov/Publications/AgCensus/2017/Full_Report/Volume_1,_Chapter_2_County_Level/Missouri/mointro.pdf

3.3 Land Use and Development

3.3.1 Development Since Previous Plan Update

Laclede County as a whole has experienced a slight increase in population since 2010, rising about 1.9% from 35,357 to 36,039. Although the county overall shows a population incline, Stoutland and Unincorporated Laclede County have seen a slight population decrease since

2010. **Table 3.13** provides the population growth statistics for all cities in Laclede County well as the Laclede County as a whole.

Table 3.13. County Population Growth, 2010-2020

Jurisdiction	2010 Population	2020 Population	# Change (2010-2020)	% Change (2010-2020)
Laclede County	35,357	36,039	682	1.9%
City of Conway	699	729	30	4.3%
City of Lebanon	14,211	15,013	802	5.6%
City of Richland*	1,728	1,734	6	.3%
City of Stoutland*	253	209	-44	-17.4%
Village of Phillipsburg	128	164	36	28.1%
Unincorporated	18,338	18,190	-148	.80%

Source: U.S. Bureau of the Census, Decennial Census, annual population estimates/ 5-Year American Community Survey 2020;
*population includes the portions of these cities in adjacent counties

Population growth or decline is generally accompanied by increases or decreases in the number of housing units. This trend was followed for Lebanon, increasing in population and housing units, Laclede County as a whole, increasing slightly in both population and housing units. However, this trend did not apply to Conway or Richland, both experiencing an increase in population with a decrease in housing units. Stoutland showed a decrease in population with a slight increase in housing units. Phillipsburg decreased in population and housing units. **Table 3.14** provides the change in numbers of housing units in the planning area from 2010 to 2020.

Table 3.14. Change in Housing Units, 2010-2020

Jurisdiction	Housing Units 2010	Housing Units 2020	2010-2020 # Change	2010-2020 % Change
Laclede County	15,778	15,908	130	.82%
City of Conway	362	359	-3	-.83%
City of Lebanon	6,728	6,831	103	1.5%
City of Richland	926	863	-63	-6.8%
City of Stoutland	104	105	1	.96%
Village of Phillipsburg	82	71	-11	13.4%

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
https://data.census.gov/table?q=housing%20units%20in%20Laclede%20County,%20Missouri&mode=results

Overall, the jurisdictions within Laclede County have shown varying degrees of growth and decline since the last plan. The City of Lebanon has experienced most of the growth and development, and the cities of Conway, Stoutland, Richland and Village of Phillipsburg have experienced some growth. A summary for each jurisdiction is provided below.

City of Conway

Conway has experienced an increase in population since the last plan. However, there was no reported significant residential, commercial, or industrial development since the previous plan, and housing units have decreased according to the U.S. Census Bureau.

City of Lebanon

Lebanon has seen the most growth overall out of all of the communities; both population and housing units in the area have increased. As previously stated, Lebanon holds most of the employment for Laclede County. Lebanon also sits just off Interstate-44 and has three exits, which can pull in the industrial and tourist traffic. The development of new businesses leads to increased population, which can overall increase vulnerability and potential damage from natural hazards.

City of Richland

Although Richland has experienced an increase in population since the previous plan, no new development has been reported in the city.

City of Stoutland

Stoutland has experienced a decrease in population since the previous plan. According to the U.S. Census Bureau, the city has seen a decrease in most industries since 2015, so there is no expected development in the future.

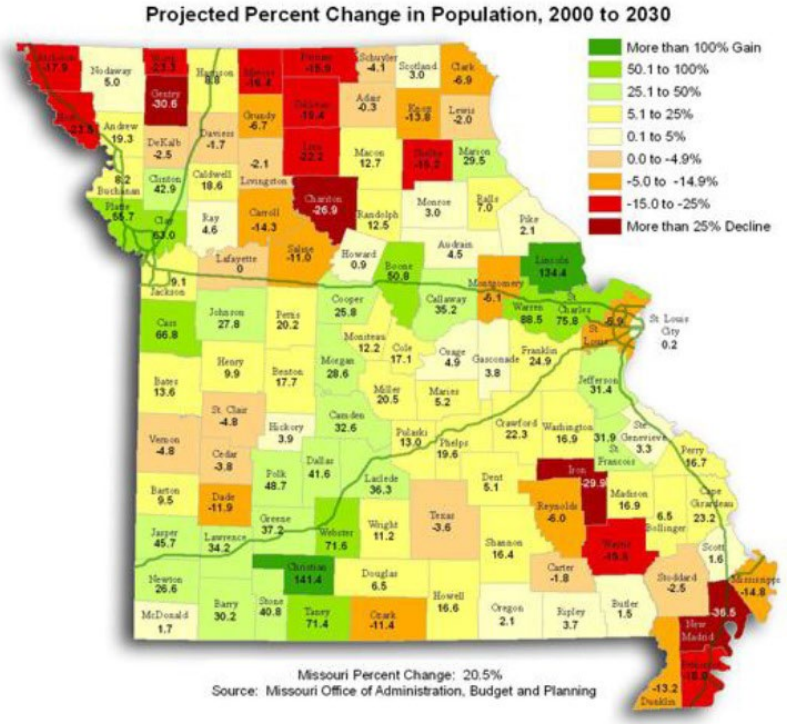
Village of Phillipsburg

The Village of Phillipsburg has seen an incline in population. Since this area of the county is rural, there is no significant growth expected in the near future.

3.3.2 Future Land Use and Development

Laclede County is expected to experience growth over the next decade. The U.S. Census Bureau shows an increase in population for the county overall since 2010, the Missouri Office of Administration, Budget, and Planning projected that Laclede County would see around a 36.3% population increase between 2000 and 2030.

Figure 3.3. Projected Population Change, 2000 to 2030



Current land use reflects that 65%, or 320,136 acres of all land within Laclede County is used in some form of agricultural production. There is limited and often no mapping in regard to commercial, residential, and other development within the county. Much of the commercial developments are in areas that are located near major highway, including the City of Lebanon. Of the farmland identified within Laclede County, there is relatively consistent share between usages between cropland, woodland, and pasture.

The remaining discussion in this section provides future growth and development information, if available, for each jurisdiction. Much of the information included is from plans published online and the data questionnaires.

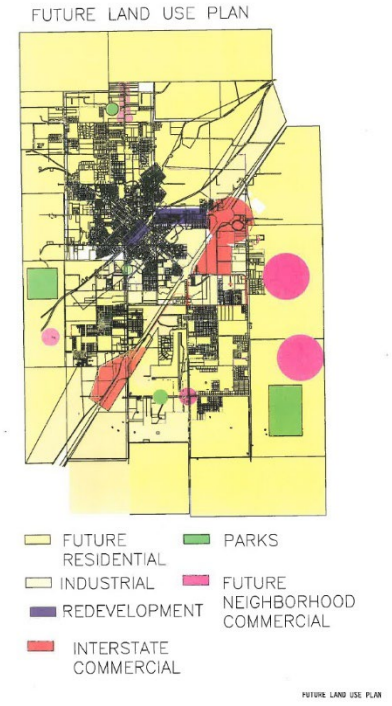
City of Conway

Conway has experienced a 4% population increase between the 2010 Census and the 2020 American Community Survey. Due to the slight increase in population, the City of Conway is slightly more vulnerable to hazards. Although there are no comprehensive plans for the city available, it is possible that this city could continue growing in the future.

City of Lebanon

Lebanon has experienced the most growth out of all jurisdictions and hosts the largest amount of industry in the county. Although the population increase has been minor, the addition of new businesses and homes could lead to additional growth in population. The existing development along with the proximity to Interstate 44 makes the City of Lebanon a hub for growth in Laclede County. Due to the slight increase in population, location, and building in the past 5 years, overall the City of Lebanon is slightly more vulnerable to hazards. According to Lebanon's 2005 Comprehensive Plan, future land use includes mostly residential and industrial development, with zones of redevelopment, interstate commercial, park, and future neighborhood commercial identified. **Figure 3.4** below shows the diagram used in the 2005 Comprehensive Plan.

Figure 3.4. City of Lebanon Future Land Use Plan, 2005 ***Source: City of Lebanon Comprehensive***



City of Richland

Richland has seen a 0.3% population increase according to the 2020 Census. Due to their minimal population change, the City of Richland's vulnerability to hazards has remained the same. Richland's proximity to Fort Leonard Wood and Interstate 44 allows some military members to reside in this town, which could lead to slow growth over time. However, no comprehensive plans are known, and there are no plans for future development at this time.

City of Stoutland

Stoutland's population has decreased from 253 to 209 between 2010 and 2020. The city is also close to Fort Leonard Wood and Interstate 44, however, the lack of growth, combined with the small population allows little room for development for the city. All factors considered, the City of Stoutland has experienced a decrease in vulnerability to hazards.

Village of Phillipsburg

Phillipsburg has seen an incline in population since 2010. Phillipsburg sits right off of Interstate 44 and is about 10 miles southwest of Lebanon; however, it is not likely that Phillipsburg will experience any growth in the near future. Due to their minimal population change, the Village of Phillipsburg's vulnerability to hazards has remained the same.

School District's Future Development

Gasconade C-4 School District

The district expects the enrollment to remain around the same and does not have any ongoing projects or plans for construction in the future. No new construction has occurred since the last plan was completed in 2018. Due to their minimal expected growth and past growth, the school district's vulnerability to hazards has remained the same.

Laclede County C-5 School District

The school district recently received a FEMA-funded storm shelter, which was recently completed. Otherwise, the district has no plans for future construction, and expects enrollment to see little or no change within the next five years. Due to their minimal expected growth and past growth, the school district's vulnerability to hazards has remained the same.

Laclede County R-1 School District

This school district plans to see a 0-5% increase in enrollment over the next five years. Since the last plan, there have been elementary additions and a FEMA cafeteria/kitchen addition. They also have future plans of construction within the next 5 years. Due to their minimal expected growth and past growth, the school district's vulnerability to hazards has remained the same.

Lebanon R-III School District

Since the last plan, this school district has constructed Lebanon Middle School, equipped with a saferoom. The saferoom however was not constructed in accordance with FEMA standards. Currently, the district has constructed a storm shelter gym and classroom addition at Maplecrest Elementary, a new media and FEMA Shelter at Boswell Elementary, and new construction at Robert W. Plaster Center for Student Success. The district is expecting little or no increase in enrollment within the next five years. Due to their minimal expected growth and past growth, the school district's vulnerability to hazards has remained the same.

Richland R-IV School District

This district plans on seeing little or no change with enrollment over the next five years. The district

has a 10-year plan, which can include building upgrades and improvements; they completed a FEMA Shelter at their Elementary Campus. Due to their minimal expected growth and past growth, the school district's vulnerability to hazards has remained the same.

Plato R-5 School District

This district plans on seeing little or no change with enrollment over the next five years. The district completed a FEMA Shelter at their Middle School Campus. Due to their minimal expected growth and past growth, the school district's vulnerability to hazards has remained the same.

Special District's Future Development

There were no special districts indicating future development.

3.4 HAZARD PROFILES, VULNERABILITY, AND PROBLEM STATEMENTS

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

Hazard Profiles

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

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

- **Hazard Description:** This section consists of a general description of the hazard and the types of impacts it may have on a community or school/special district.
- **Geographic Location:** This section describes the geographic areas in the planning area that are affected by the hazard. Where available, maps are used 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 also includes 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 occurrences, changing future conditions are also 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 of damage from natural hazards. The vulnerability assessments will be based on the best available data. The vulnerability assessments can also be based on data that was collected for the 2023 State Hazard Mitigation Plan Update. With the 2023 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 2023 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 and https://sema.dps.mo.gov/docs/programs/LRMF/mitigation/MO_Hazard_Mitigation_Plan_2023-2028.pdf.

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

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

Vulnerability Overview:

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 to 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 concludes with a brief summary of the problems created by the hazard in the planning area, and possible ways to resolve those problems. Jurisdiction-specific information in those cases where the risk varies across the planning area is 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

Floodplain mapping and participation in the National Flood Insurance Program (NFIP) both play a major role in flood mitigation. The objectives of flood mitigation are to keep people, property, and possessions out of the floodplain area where reasonably achievable.

Participation in the NFIP requires that floodplain ordinances, which regulate development in the floodplain, be adopted and enforced by each community. The standard regulations require that buildings be constructed at least 1 foot above the Base Flood Elevation (BFE). [The BFE is the flood level associated with the 1% flood (formerly known as the “100 year flood”).]

Below are maps of the Laclede County and each individual jurisdiction showing either the Natural Hazard Flood Layer (NFHL) from September 29, 2010 datasets or the Digital Flood Insurance Rate Maps from November 14, 2017 datasets (DFIRM). Participating jurisdictions in the National Flood Insurance Program (NFIP) are labeled as DFIRM (with the exception of Conway, see note on the map) and ones who do not participate to show the natural hazard flood layer labeled as NFHL. Within these maps, BFE stands for base flood elevations, Zone A represents the area inundated by 100-year flooding for which no BFE's have been established, and Zone AE represents the area inundated by 100-year flooding which BFE's have been established.

Figure 3.1. Laclede County NFHL Flood Map

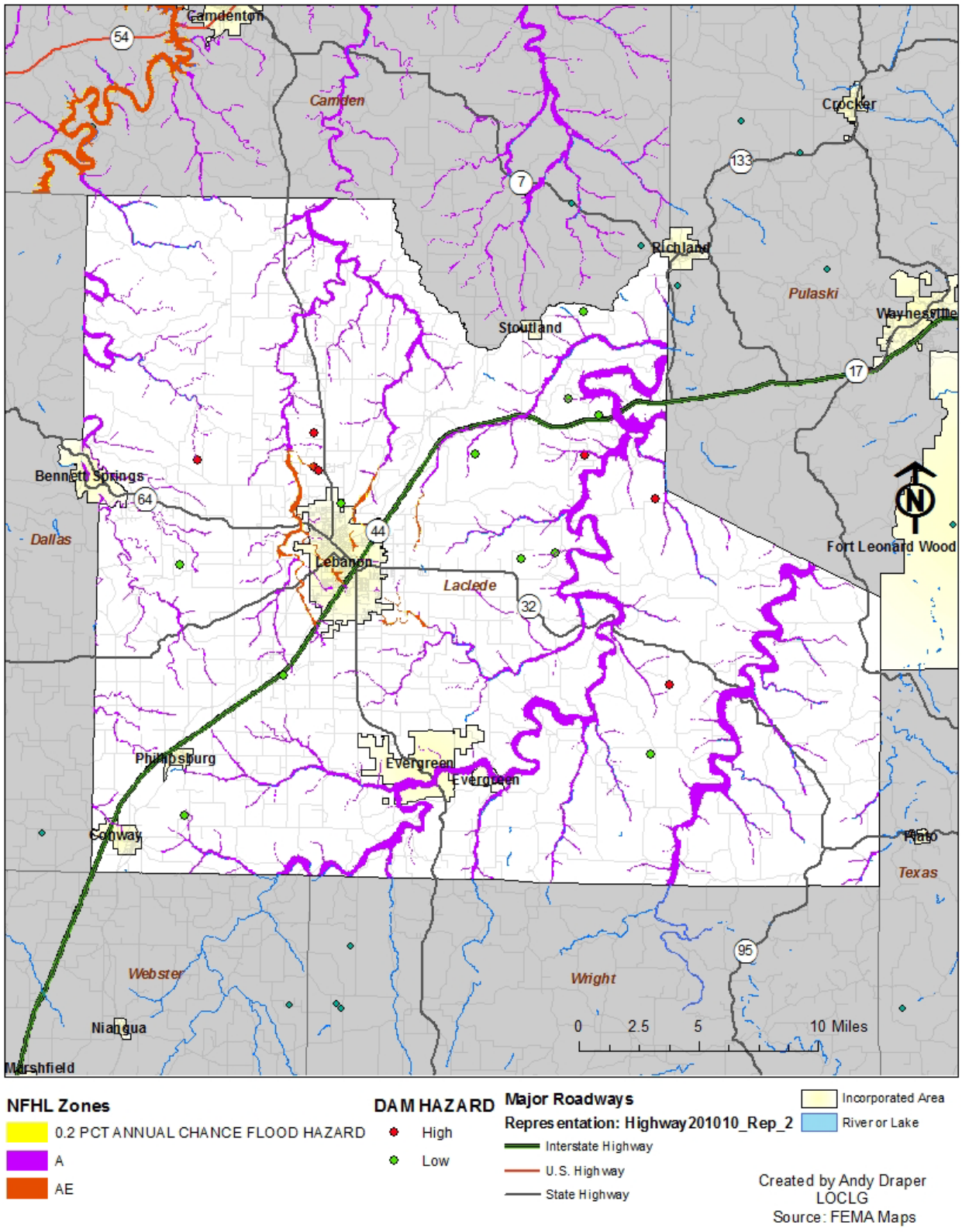
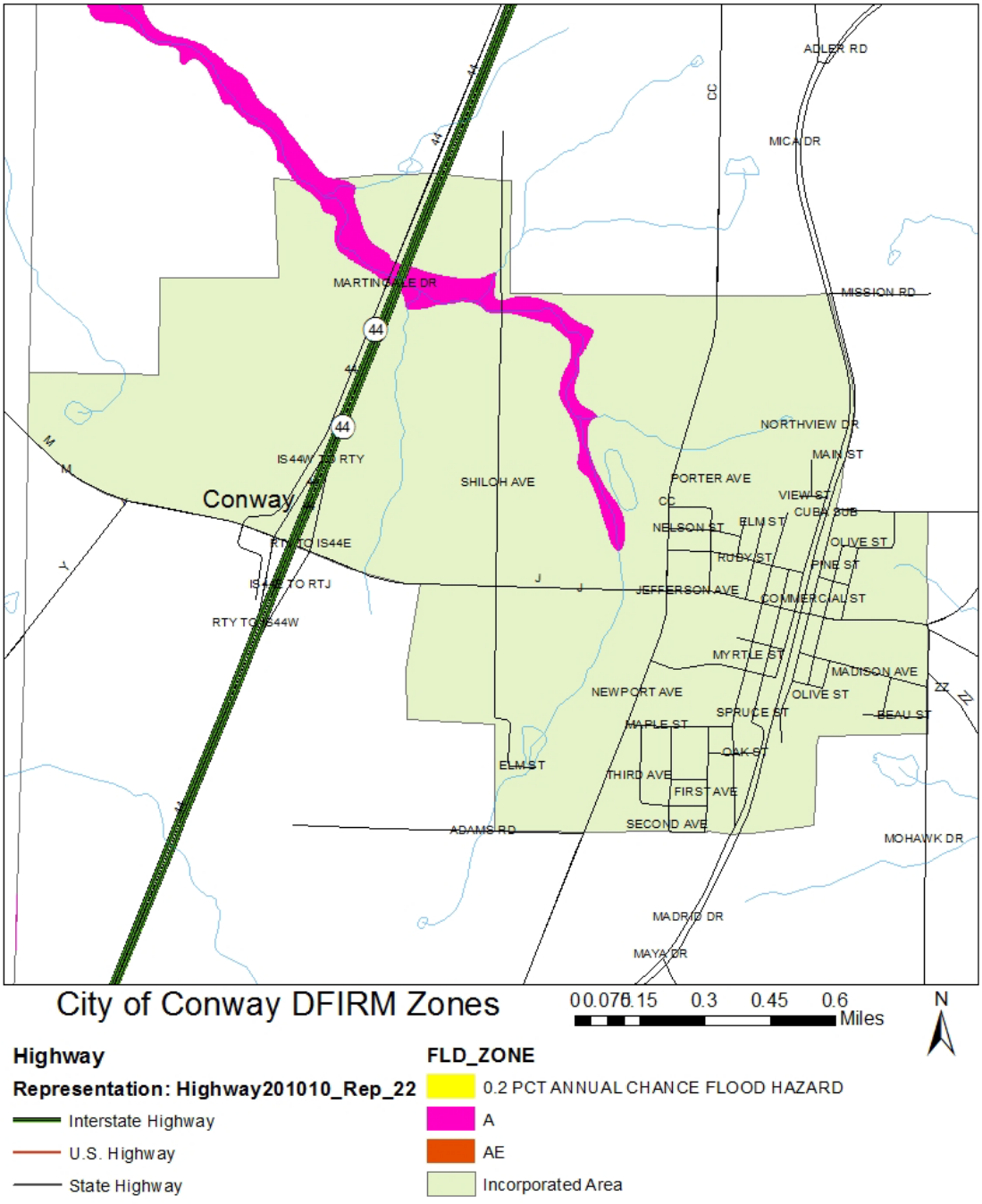


Figure 3.2. City of Conway DFIRM Map*



**The city of Conway has DFIRM maps available and was provided information about the National Flood Insurance Program from SEMA but chose not to participate.*

Figure 3.3. City of Lebanon DFIRM Map

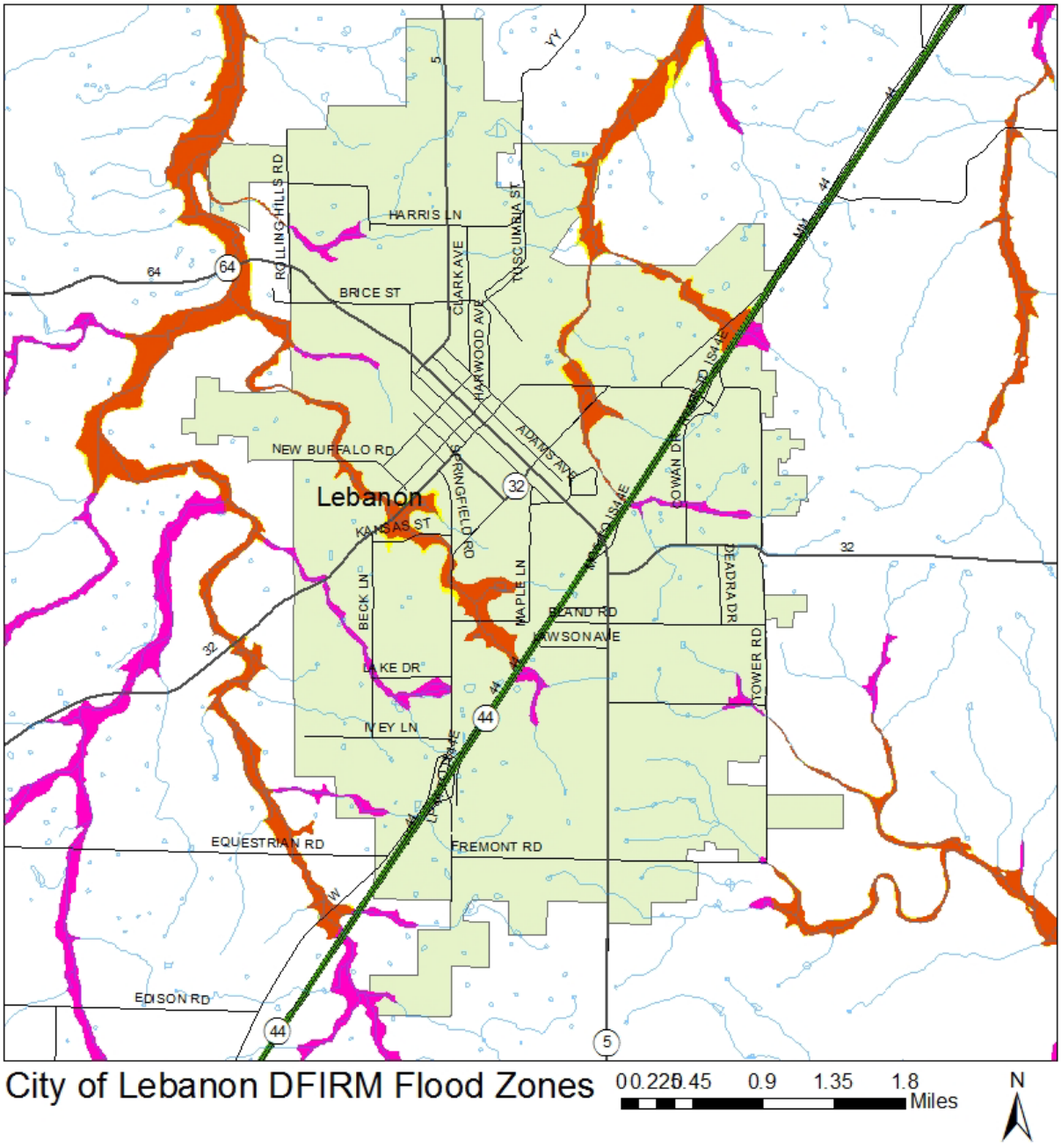


Figure 3.4. City of Richland DFIRM Map

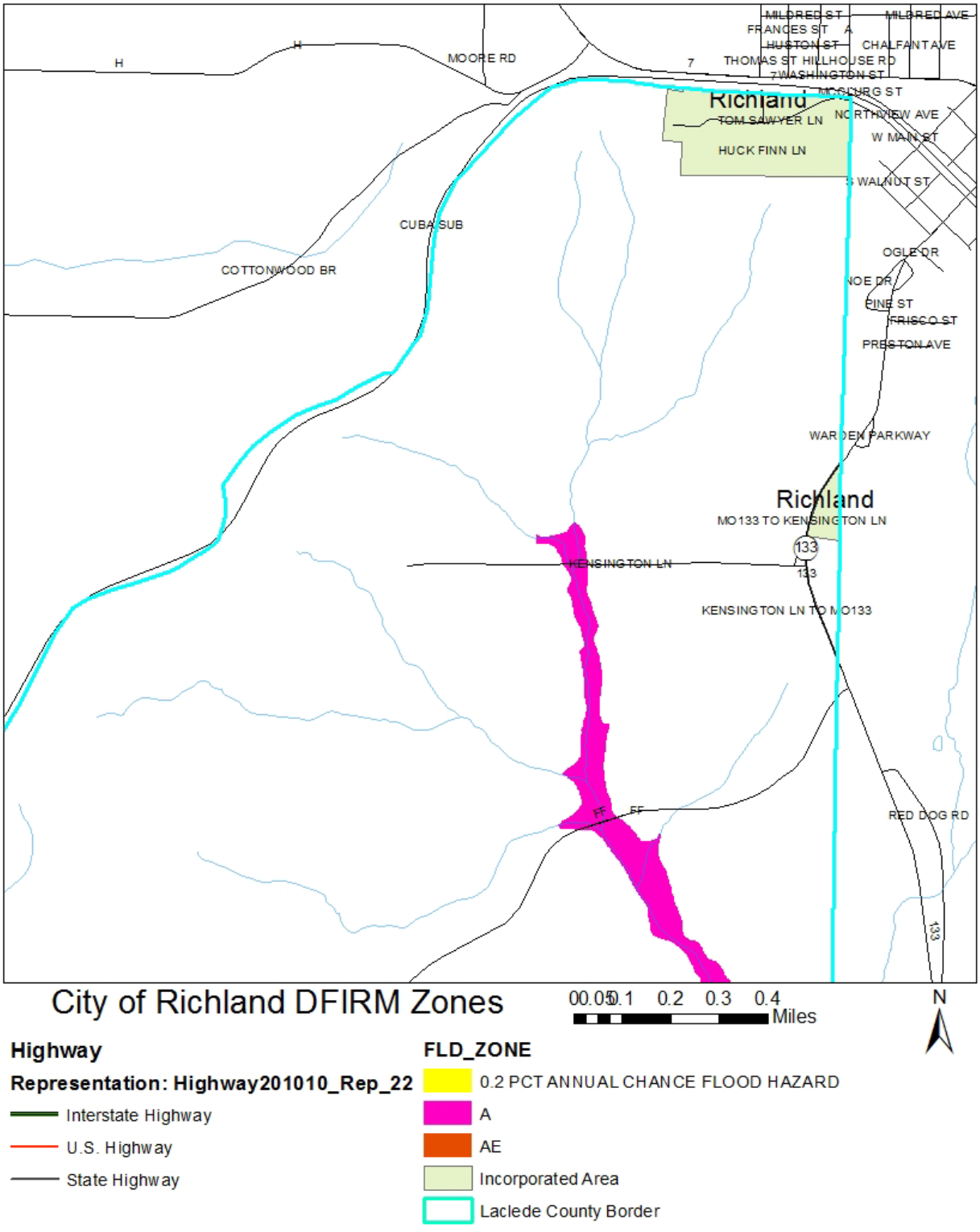


Figure 3.5. City of Stoutland NFHL Map

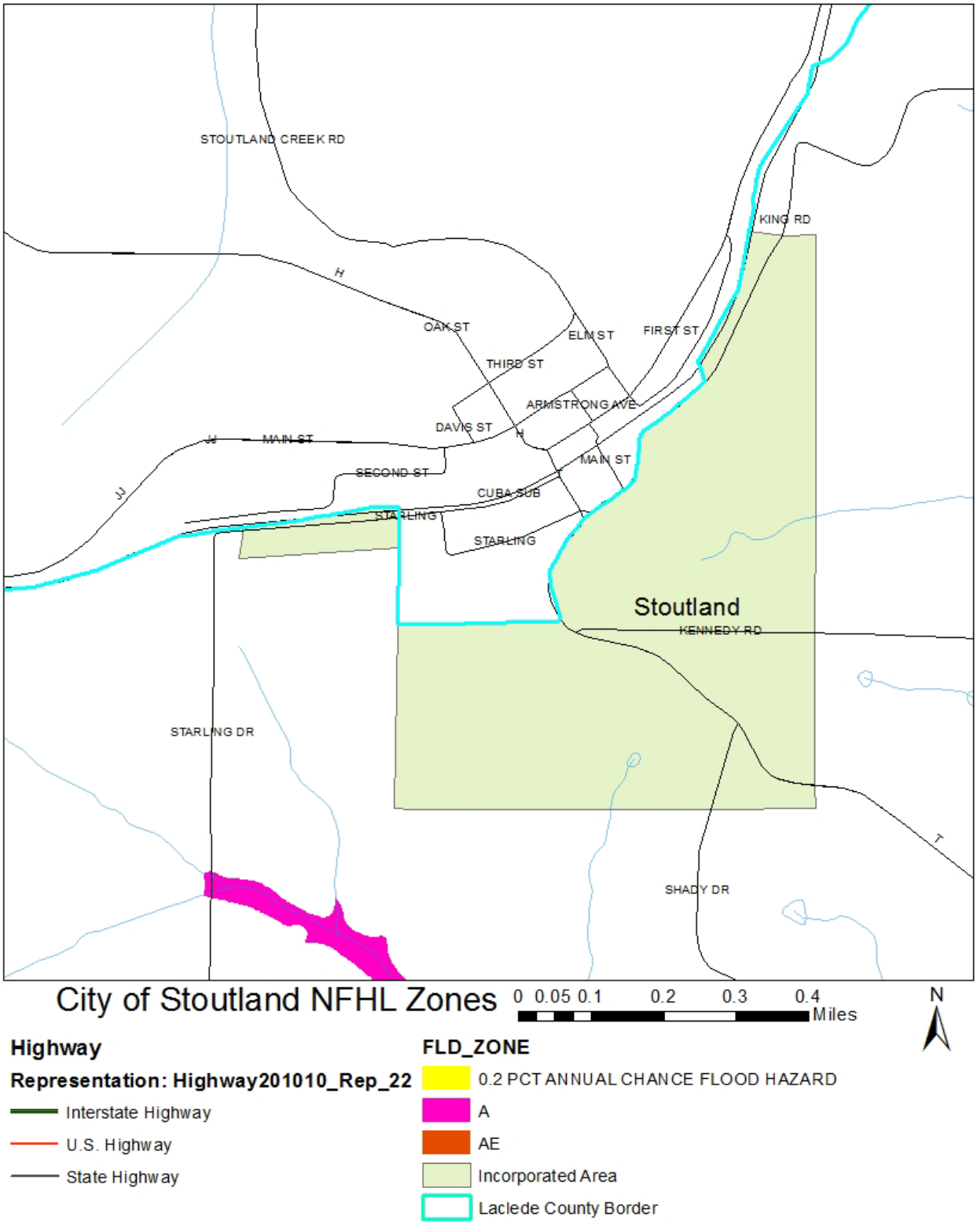
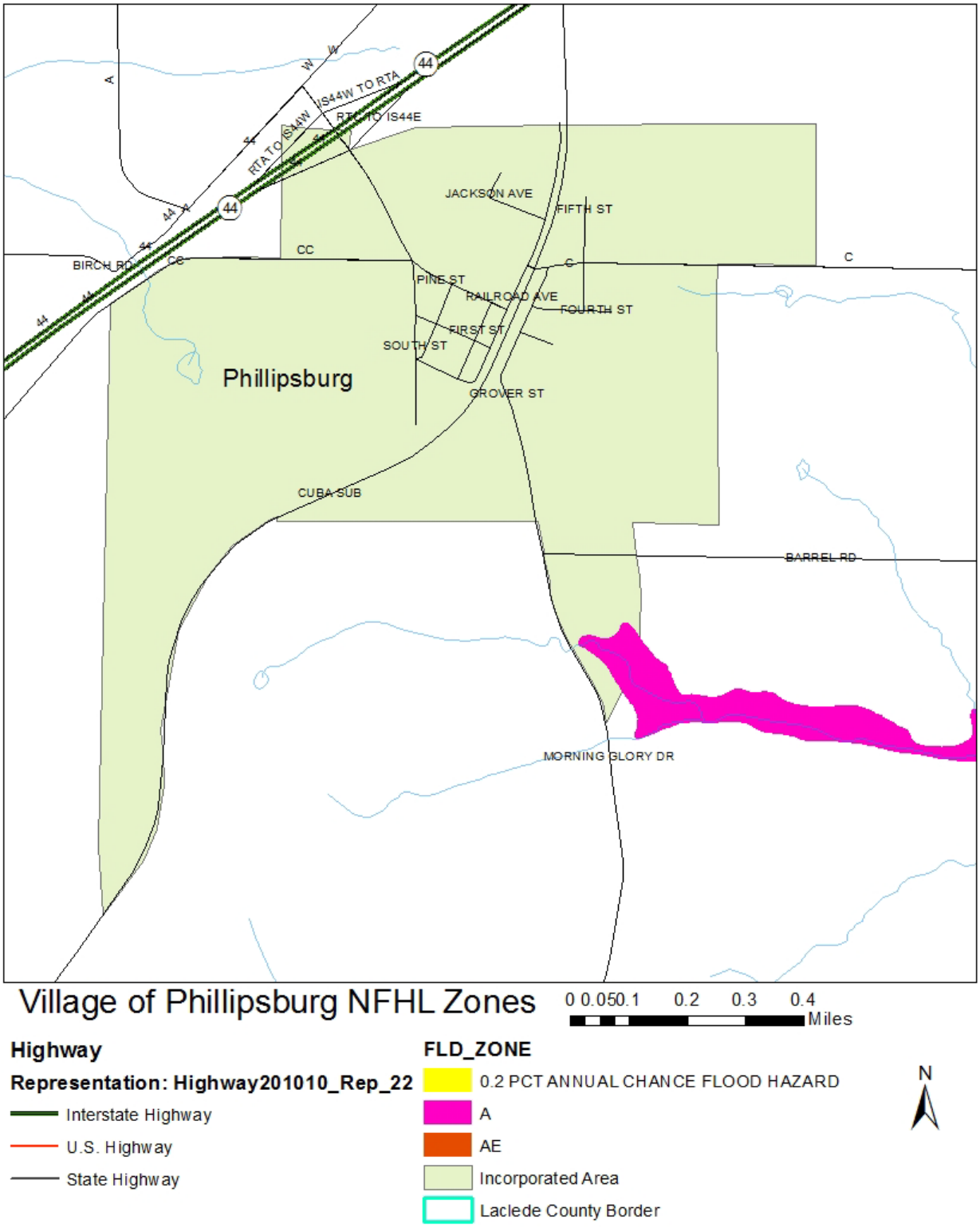


Figure 3.6. Village of Phillipsburg NFHL Map



Laclede County is prone to both flooding and flash flooding events. A review of the NCEI Storm Event Database determined which jurisdictions and regions are most prone to flooding and flash flooding from January 2003 to November 2023 and are listed below. **Table 3.15** lists all of the flooding events recorded in the NCEI storm event database over the last 20 years.

Table 3.15. Laclede County NCEI Flood Events by Location, 2003-2023

Location	# of Events
Unincorporated Laclede County	60
-Unincorporated County (unspecified)- 2 flood events	
-Unincorporated County (Dove)- 8 flood events	
-Unincorporated County (Jacksonville)- 2 flood events	
-Unincorporated County (Winnipeg)- 1 flood events	
-Unincorporated County (Hazelgreen)- 14 flood events	
-Unincorporated County (Sleeper)- 4 flood events	
-Unincorporated County (Falcon)- 2 flood events	
-Unincorporated County (Pease)- 12 flood events	
-Unincorporated County (Abo)- 2 flood events	
-Unincorporated County (Drynob)- 2 flood events	
-Unincorporated County (Russ)- 9 flood events	
-Unincorporated County (Bennett Spgs)- 1 flood events	
-Unincorporated County (Orla)- 1 flood events	

Source: National Centers for Environmental Information, 11/28/2023

Flash flooding occurs in low-lying areas and in areas without adequate drainage to carry away the amount of water that falls during intense rainfall events. Flash flooding events pose the most pervasive hazard of the two flood types because they are caused by a large amount of rainfall over a small period of time. Permeability of soils, slops, increasing urban development, and extensive stream networks all contribute to flash flood vulnerability. **Table 3.16** shows the number of flash flood events by location recorded in NCEI for the 20-year period.

Table 3.16. Laclede County NCEI Flash Flood Events by Location, 2003-2023

Location	# of Events
Unincorporated Laclede County	62
-Unincorporated County (unspecified)- 1 flood events	
-Unincorporated County (Sleeper)- 8 flood events	
-Unincorporated County (Competition)- 2 flood events	
-Unincorporated County (Eldridge)- 4 flood events	
-Unincorporated County (Morgan)- 5 flood events	
-Unincorporated County (Ira)- 1 flood events	
-Unincorporated County (Prosperine)- 2 flood events	
-Unincorporated County (Abo)- 3 flood events	
-Unincorporated County (Jacksonville)- 2 flood events	
-Unincorporated County (Dove)- 5 flood events	
-Unincorporated County (Hazelgreen)- 7 flood events	
-Unincorporated County (Bennett Springs)- 1 flood events	
-Unincorporated County (Pease)- 7 flood events	
-Unincorporated County (Agnes)- 2 flood events	
-Unincorporated County (Russ)- 7 flood events	
-Unincorporated County (Oria)- 2 flood events	
-Unincorporated County (Drynob)- 1 flood events	
-Unincorporated County (Falcon)- 2 flood events	
Lebanon	16
-Lebanon (unspecified)- 16 flood events	
Conway	8
-Conway (unspecified)- 8 flood events	

Phillipsburg -Phillipsburg (unspecified)- 4 flood events	4

Source: National Centers for Environmental Information, 11/28/2023

The NCEI Storm Event Database lists flash flood events according to the nearest community or place. Most of these events cover larger areas than smaller geographic areas reported in the data. Some specific locations are listed within the narratives. Although some of these events may not be inside the corporate limits of the community identified, they are in such proximity that the community named would be the most affected by impassable roads.

Strength/Magnitude/Extent

Missouri has a long and active history of flooding over the past century, according to the 2023 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 community in Laclede County. **Table 3.18** shows 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 Laclede County

Community ID #	Community Name	NFIP Participant (Y/N/Sanctioned)	Current Effective Map Date	Regular-Emergency Program Entry Date
290811	Laclede County	Y	09/29/2010	02/24/1993
290197	City of Lebanon	Y	09/29/2010	06/01/1982
290656	City of Richland	Y	05/03/2010	09/10/1984

Source: NFIP Community Status Book, PIVOT (information from STATE) Community Status Book | FEMA.gov; M= No elevation determined – all Zone A, C, and X: NSFHA = No Special Flood Hazard Area; E=Emergency Program

County of Laclede

a. Adoption of minimum NFIP floodplain management criteria* by local regulation – February 24, 1993
b. Adoption of latest FIRM – September 29, 2010
c. Designee to implement and enforce local floodplain management regulations – Randy Rowe
d. Designee to implement NFIP commitments/requirements – Randy Rowe
e. Created an action item to revise local floodplain ordinances to include substantial improvement/substantial damage provisions and address development in the SFHA. Randy Rowe, Director of Office of Emergency Management, 471-532-6992

City of Lebanon

a. Adoption of minimum NFIP floodplain management criteria* by local regulation – June 1, 1984
b. Adoption of latest FIRM – September 29, 2010
c. Designee to implement and enforce local floodplain management regulations – Richard Shockley
d. Designee to implement NFIP commitments/requirements – Richard Shockley
e. Created an action item to revise local floodplain ordinances to include substantial improvement/substantial damage provisions and address development in the SFHA. Richard Shockley, Director of Public Works, 417-991-3900

City of Richland

a. Adoption of minimum NFIP floodplain management criteria* by local regulation – September 10, 1984
b. Adoption of latest FIRM – May 3, 2010
c. Designee to implement and enforce local floodplain management regulations – Betty Godfrey
d. Designee to implement NFIP commitments/requirements – Betty Godfrey
e. Created an action item to revise local floodplain ordinances to include substantial improvement/substantial damage provisions and address development in the SFHA. Betty Godfrey, City Clerk, 573-765-5187

Village of Phillipsburg – Does not participate in the NFIP due to not having a flood plain administrator.
City of Conway – Does not participate in the NFIP due to not having a flood plain administrator.

Table 3.18. NFIP Policy and Claim Statistics as of 2023

Community Name	Policies in Force	Insurance in Force	Closed Losses	Total Payments
Laclede County	18	$3,912,000		
Lebanon, City of	10	$1,922,000		
Total			20	$653,500.02

Source: NFIP Community Status Book, [11/22/23]; PIVOT (information from STATE), Community Status Book | FEMA.gov *Closed Losses are those flood insurance claims that resulted in payment.

Repetitive Loss/Severe Repetitive Loss Properties

Repetitive Loss Properties are those properties with at least two flood insurance payments of $1,000 or more in a 10-year period. According to the Flood Insurance Administration, jurisdictions included in the planning area have a combined total of 4 repetitive loss properties. As of 12/08/2023, 0 properties have been mitigated, leaving 4 un-mitigated repetitive loss properties.

Table 3.19. Laclede County Repetitive Loss Properties

Jurisdiction	# of Properties	Type of Property	# Mitigated	Building Payments	Content Payments	Total Payments	Average Payment	# of Losses
Lebanon, City of	2	Unknown	0	Unknown	Unknown	$33,241.99	$16,620.99	4
Laclede County	2	Unknown	0	Unknown	Unknown	$480,427.70	$240,213.85	7

Source: Flood Insurance Administration as of 12/08/2023

Severe Repetitive Loss (SRL): A SRL property is defined it as a single family property (consisting of one-to-four residences) that is covered under flood insurance by the NFIP; and has (1) incurred flood-related damage for which four or more separate claims payments have been paid under flood

insurance coverage with the amount of each claim payment exceeding $5,000 and with cumulative amounts of such claims payments exceeding $20,000; or (2) for which at least two separate claims payments have been made with the cumulative amount of such claims exceeding the reported value of the property.

Laclede County does not currently have any Severe Repetitive Loss (SRL) properties.

Due to Federal restrictions on data sharing, the state was unable to provide full Repetitive Loss data or current Severe Repetitive Loss data. The Property Type was not available for Repetitive Loss properties and the Severe Repetitive Loss data, which was obtained from the 2023 MO State Hazard Mitigation Plan, does not specify if the properties are mitigated or non-mitigated.

Previous Occurrences

Table 3.20 and Table 3.21 shows the Flash Flood and Riverine Flood events for a 20-year period.

Table 3.20. NCEI Laclede County Flash Flood Events Summary, 2003-2023

Year	# of Events	# of Deaths	# of Injuries	Property Damages	Crop Damages
2005	3	0	0	0	0
2006	6	1	2	10.00K	0
2007	5	1	0	5.500M	0
2008	11	0	0	1.75M	0
2009	5	0	0	100.00K	0
2010	2	0	0	0	0
2011	3	0	0	10.00K	0
2013	12	0	0	750.00K	0
2015	17	0	0	1.57M	0
2016	9	0	0	63.00K	0
2017	3	0	0	1.00M	0
2019	2	0	0	0	0
2020	11	1	0	10.00K	0
2021	1	0	0	0	0

Source: NCEI, data accessed 12/31/2023

08/20/2007 - Tropical Storm Erin remnants impacted areas of Laclede County. Flash flooding occurred county wide causing road closures to a section of Highway 32 near Pinetree Road, West Elm Road between Drury Road and Springfield Road, a section of Route BB northwest of Sleeper and north of Route F, the intersection of Highway 32 and Highway K, the intersection of Route BB and Highway F, the intersection of Route T and Highway FF, the outer road of interstate 44 at Route N, and a section of a secondary road near Sleeper. A United State Postal employee delivering rural mail drove into a washed-out bridge and was swept away by flood water.

12/26/2015 - A slow moving and strong weather system caused several rounds of very heavy and record-breaking rainfall to occur across the Missouri Ozarks which led to historic and deadly flooding. Route B was closed due to flooding at North Cobb Creek. Nearly all low water crossings across the county were flooded. There were numerous county roads that had flood damage. There was extensive damage to the campgrounds at Bennett Spring State Park including the fish hatchery and cabins.

Table 3.21. NCEI Laclede County Riverine Flood Events Summary, 2003-2023

Year	# of Events	# of Deaths	# of Injuries	Property Damages	Crop Damages
2005	2	0	0	0	0
2008	2	0	0	0	0

2009	1	0	0	0	0
2010	2	0	0	0	0
2011	9	0	0	250.00K	0
2012	1	0	0	50.00K	0
2013	4	0	0	0	0
2015	8	0	0	250.00K	0
2017	1	0	0	0	0
2018	8	0	0	0	0
2019	1	0	0	0	0
2020	2	0	0	0	0
2021	7	0	0	0	0
2022	6	0	0	0	0
2023	9	0	0	0	0

Source: NCEI, 12/31/2023

05/24/2011 – Multiple rounds of thunderstorms produced very heavy rainfall across the Ozarks over the course of a week. A persistent trough over the central plains brought multiple upper-level storm systems over the region which produced intense thunderstorms with very heavy rainfall. Some areas saw storm total rainfall amounts up to a foot or more. Evacuations occurred at several resorts along the Gasconade River near Falcon as the river rose rapidly.

05/07/2015 - A slow moving front caused multiple rounds of thunderstorms which led to severe weather and flash flooding across the Missouri Ozarks. Route J was closed at the Osage Fork of the Gasconade River due to flooding. Numerous roads, bridges, and low water crossings were heavily damaged.

Probability of Future Occurrence

With the history of flooding in the planning area, it is likely that flooding of various levels will occur. The probability of a flash flood event occurring in the planning area in any given year is 70% and 75% probability that a flood event will occur in any given year.

Changing Future Conditions Considerations and the Impact of Climate Change

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 has been included in most of the disaster declarations involving Laclede County. Riverine flooding occurs less frequently than flash flooding in Laclede County and usually causes less damage. Flooding, especially flash flooding, in the area leads to the washing out of low-lying crossings, roads, and bridges, and creates a severe threat to motorists, especially those that attempt to cross a flooded roadway. The threat of flooding to roadways is not limited, as seen in the maps above, roadways of all classifications have been flooded in the past, putting all motorists at risk during flood events.

Potential Losses to Existing Development

Since Phillipsburg, Richland, and Stoutland have little existing development and do not lie along a floodplain, the potential losses to existing development for these jurisdictions are low. Conway faces more risk to existing development since the floodplain extends into the city. The floodplain

ends outside of the more populated downtown area and misses any critical infrastructure. Lebanon is the city that faces the highest potential losses to existing development from riverine flooding since they have the most development and floodplains extend through the city. The floodplains could impact one critical facility, as identified during the planning process which is the school building located at 695 Millcreek Road in the City of Lebanon. The remainder of the infrastructure within the City that could potentially be impacted and cause significant damage are residential properties and businesses within the city. Since the City of Lebanon participates in the NFIP program these homeowners and business owners have the opportunity to purchase flood insurance if the property is located in a flood zone. The agricultural sector faces potentially high risk from flooding in the future based on past events.

Impact of Previous and Future Development

Future development could impact flash and riverine flooding in all areas of Laclede County. Development in low-lying areas near rivers and streams or where interior drainage systems are not adequate during heavy rainfall events will be at risk of flooding. Future development would also increase impervious surfaces causing additional water run-off and drainage problems during heavy rainfall events.

EMAP Consequence Analysis

Table 3.22. EMAP Impact Analysis: Flooding

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

Hazard Summary by Jurisdiction

According to the DFIRM maps located above for each jurisdiction, Phillipsburg, Richland, and Stoutland face few risks for riverine flooding. The risk is low since there are no floodplains that extend into the community. Conway is more at risk of riverine flooding, since there is a section of the floodplain that extends into the city from the northwest corner. An in-depth look at each property location within all the school districts was conducted using the FEMA Map Service Center and the school building location addresses. All the school building in Laclede County state that the area in which the school buildings are located are in "an area of minimal flood hazard" with the

exception on one building in the Lebanon R-III School system which is the Boswell Elementary School located at 695 Millcreek Road in Lebanon. This property is in a Zone AE floodplain. The Superintendent of the school he shared that there is indeed a creek that flows to the south of the building and with heavy rains the soccer field and the outdoor public restrooms have occasionally flooded but there is really nothing that can be damaged with the flooding. The school building was built in 1950 is up on a “drastic slope” with significant swale that diverts the water away from the building. According to the district, minimal flooding damages would occur if any at all within Lebanon R-III School District. The floodplain extends across the City of Lebanon and there is more exposure in Lebanon than any other jurisdiction in Laclede County. The major damage experienced in unincorporated areas of Laclede County are on the gravel roads which often experience significant damage during flooding events.

Problem Statement

Both riverine and flash floods are frequent events in Laclede County and have been included in most of the disaster declarations thus far. The greatest risks from flooding stem from rivers and creeks quickly overflowing on roadways, putting a large population of the county at risk of being stranded or swept away. To reduce the damage of floods to infrastructure and human life, several strategies can be implemented, such as raising low water crossings, having an efficient alert system in place, and improving storm water management. Laclede County is a participant in the NFIP along with the City of Lebanon and the City of Richland. Participation in the NFIP enables residents to purchase flood insurance, which can help mitigate the impacts of flooding. Projects focused on the improvements to river/stream embankments can also reduce flooding to surrounding properties.

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 damage 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).

The 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.

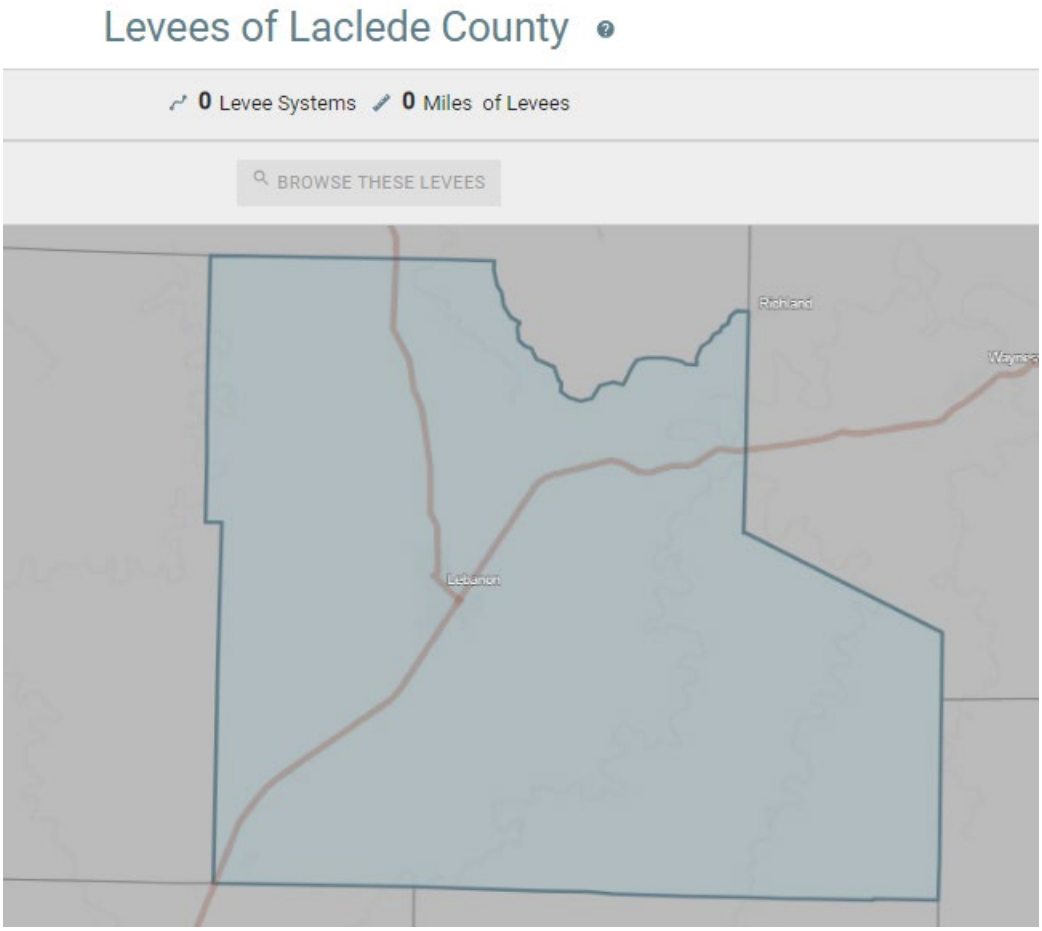
Geographic Location

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.

Figure 3.7. County Levees Shown on DFIRM as Providing Protection from the 1-Percent Annual Chance Flood



Source: FEMA Flood Insurance Rate Map, 12/10/2023, 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. A breach or incident would not cause widespread damage.

Probability of Future Occurrence

Due to the lack of information on low-head agricultural levees, the probability of future occurrence of levee failure cannot be calculated.

Changing Future Conditions Considerations and the Impact of Climate Change

As stated in the 2023 Missouri State Hazard Mitigation Plan, the impact of changing future conditions on levee failure will most likely be related to changes in precipitation and flood likelihood. Climate change projections suggest that precipitation may increase and occur in more extreme events, which may increase the risk of flooding, putting stress on levees and increasing likelihood of levee failure. Furthermore, aging levee infrastructure and a lack of regular maintenance (including checking for seepage and removing trees, roots and other vegetation that can weaken a levee) coupled with more extreme weather events may increase risk of future 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 3.88** below defines the three ratings.

Figure 3.8. 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 is no specific information on levees that exist within the Laclede County planning area.

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 by Laclede 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 not being regulated or inspected by one agency or on a regular basis. Any new construction that falls in the floodplain will have to adhere to Laclede County's construction and zoning regulations.

EMAP Consequence Analysis

Table 3.23. EMAP Impact Analysis: Levee Failure

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

Hazard Summary by Jurisdiction

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.

According to the Missouri Department of Natural Resources National Inventory of Dams, as of July 2017, Laclede County holds eighteen dams. Out of those eighteen dams, only one is state regulated. Dams that fall under state regulation are non-federally regulated dams that are more than 35 feet in height. The Department maintains the Dam and Reservoir Safety Program in Missouri, which ensures that dams over 35 feet in height are safely constructed, operated, and maintained pursuant to Chapter 236 of Revised Statutes of Missouri. Whether regulated or unregulated, the Department of Natural Resources provides information about both types of dams, including dam dimensions, date of construction, approximate reservoir volume, and more.

Table 3.24 below shows the system of classification used by the Missouri Department of Natural Resources. A hazard classification is assigned to each dam during the initial permit process. Out of the eighteen dams listed by MDNR, seven are ranked as Class II and eleven are ranked as Class III.

Table 3.24. MoDNR Dam Hazard Classification Definitions

Hazard Class	Definition
Class I	The area downstream from the dam that would be affected by inundation contains ten (10) or more permanent dwellings or any public building. Inspection of these dams must occur every two years.
Class II	The area downstream from the dam that would be affected by inundation contains one to nine permanent dwellings, or one (1) or more campgrounds with permanent water, sewer, and electrical services or one (1) or more industrial buildings. Inspection of these dams must occur once every three years.
Class III	The area downstream from the dam that would be affected by inundation does not contain any of the structures identified for Class I or Class II dams. Inspection of these dams must occur once every five years.

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

Table 3.25. NID Dam Hazard Classification Definitions

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

Source: National Inventory of Dams

In addition, U.S. Army Corps of Engineers maintains the National Inventory of Dams (NID) for the United States. This inventory includes all dams meeting at least one of the following criteria:

1. High hazard classification - loss of human life is likely if the dam fails
2. Significant hazard classification - no probable loss of human life but can cause economic loss, environmental damage, disruption of lifeline facilities, or impact other concerns
3. Equal or exceed 25 feet in height and exceed 15 acre-feet in storage
4. Equal or exceed 50 acre-feet storage and exceed 6 feet in height

Geographic Location

Dams Located Within the Planning Area

There are eighteen dams recorded in Laclede County in both the MDNR and the NID database. Seven of the dams are classified as high hazard, zero are classified as significant hazard, and eleven are classified as low hazard. The U.S. Army Corps of Engineers own none of the dams in Laclede County.

Table 3.26 provides the names, locations, and other pertinent information for all high hazard dams in the planning area. An acre-foot is defined as the volume of one acre of surface area to the depth of one foot.

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

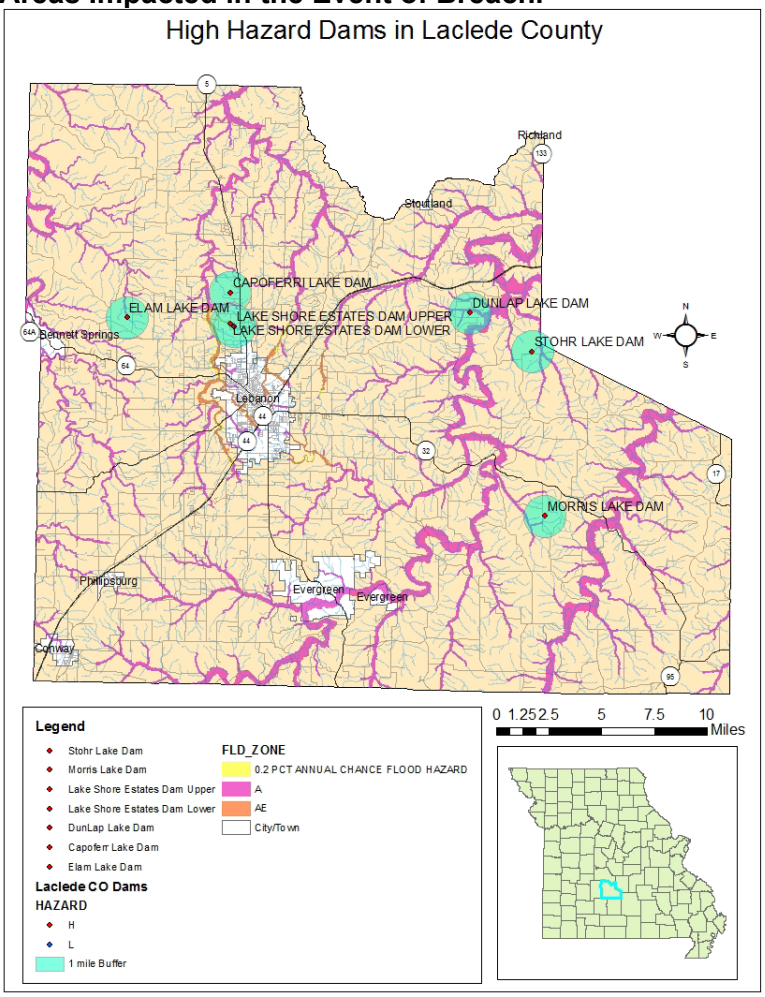
Dam Name	Emergency Action Plan (EAP)AP	Dam Height (Ft)	Normal Storage (Acre-Ft)	Last Inspection Date	River	Nearest Downstream City	Distance To Nearest City (Miles)	Dam Owner
Capoferri Lake Dam	NR	16	128	-	Goodwin Hollow Creek	Lebanon	6	E. L. Capoferri
Elam Lake Dam	NR	30	144	-	Mountain Creek	Eldridge	8	William J. Elam
Lake Shore Estates Dam Lower	NR	20	160	-	Goodwin Hollow Creek	Lebanon	4	Rec Assc of Lake Shore

Lake Shore Estates Dam Upper	NR	15	120	-	Goodwin Hollow Creek	Lebanon	4	Rec Assc of Lake Shore
Dunlap Lake Dam	NR	25	107	-	Similin Creek	Stoutland	6	Paul D. Dunlap
Stohr Lake Dam	NR	25	67	-	Praire Creek	Stoutland	9	Paul E. Stohr
Morris Lake Dam	NR	25	107	-	Gasconade River	Falcon	0	Darrell E. Morris

Sources: Missouri Department of Natural Resources, https://dnr.mo.gov/geology/wrc/dam-safety/damsinmissouri.htm and National Inventory of Dams, https://nid.sec.usace.army.mil/#/dams/search/sy=@countyState:Laclede,%20Missouri&viewType=map&resultsType=dams&advanced=false&hideList=false&eventSystem=false

Figure 3.99 provides the locations of NID high hazard dams located in the planning area. The figure shows that the dams have a considerable distance between them and any of the communities, school districts, and special districts within the county. It is unlikely that any of the cities, schools, or special districts would be impacted by dam failure in Laclede County. However, three of the dams are located within a mile of Route 5, which is a common road traveled for work and tourism, so the failure of these dams would lead to flooding on these roads and potential injury or loss of life. There will be information on the assets that would be impacted by a dam failure in the vulnerability assessment section.

Figure 3.9. High Hazard Dam Locations in Laclede County and Areas Impacted in the Event of Breach.

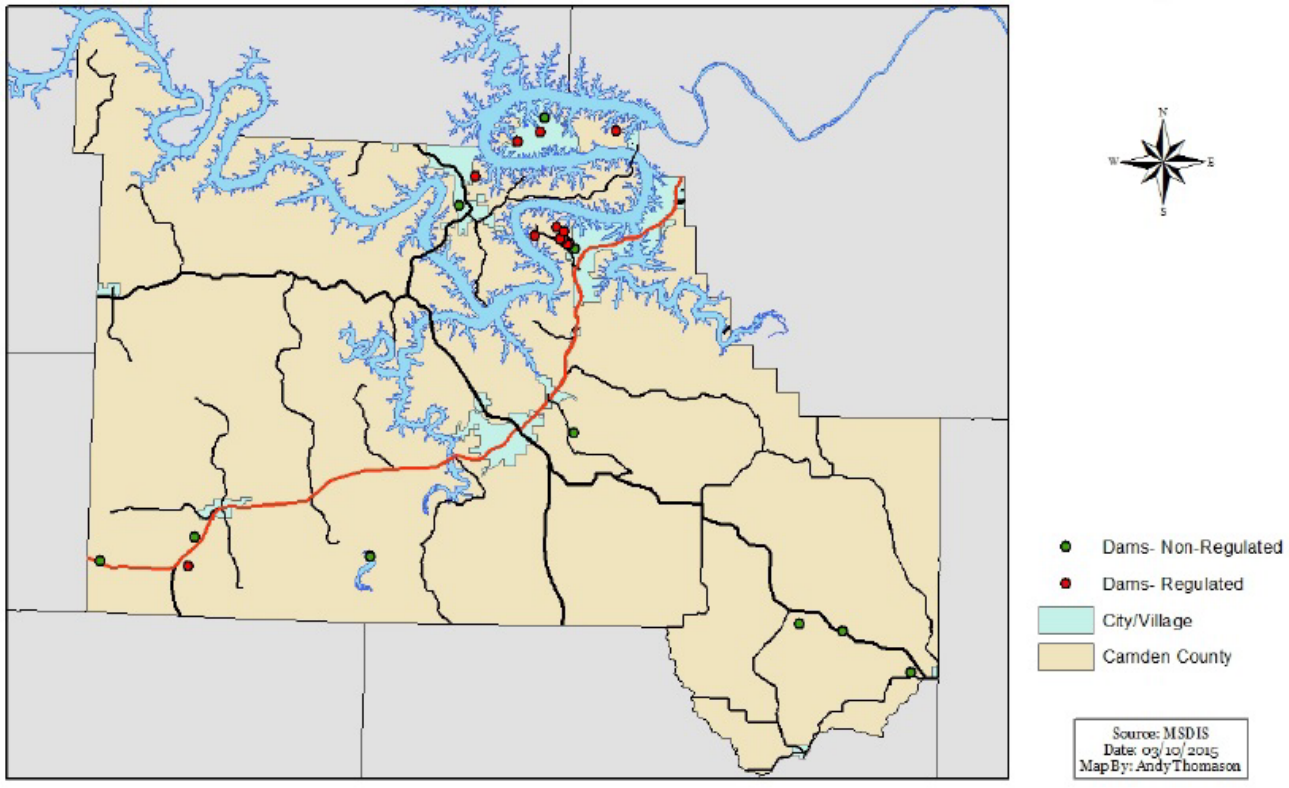


Source: U.S. Army Corps of Engineers, Missouri Department of Natural Resources

Upstream Dams Outside the Planning Area

Camden County sits just north of Laclede County and has 22 dams that are either regulated or inventoried by the Missouri Department of Natural Resources (DNR). **Figure 3.10** below shows the regulated and inventoried dams. Four dams are relatively close to Laclede County and are non-regulated; however, the risk is low because of the dam sizes and lack of infrastructure immediately surrounding. Overall, the threat of upstream dam failure is minor, if not non-existent, for Laclede County.

Figure 3.10. Upstream Dams Outside Laclede County



Source: Camden County Hazard Mitigation Plan

Strength/Magnitude/Extent

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

Previous Occurrences

Dam failure incidents in the United States have caused death, injury, and billions of dollars in property damage. Missouri has been subjected to these impacts multiple times with incidents including dam failure at Lawrenceton in 1968, Washington County in 1975, and Fredericktown in 1977, and more recently Taum Sauk in 2005. Failed sensors at the Taum Sauk Hydroelectric Plant led to overflowing and eventual collapse of a restrictive wall. The flood was stopped by the lower reservoir; however, homes were still damaged and a family of five suffered injuries. Fortunately, there have been no recorded incidents of dam failure in Laclede County which caused injury, loss of life, or significant property damage.

Probability of Future Occurrence

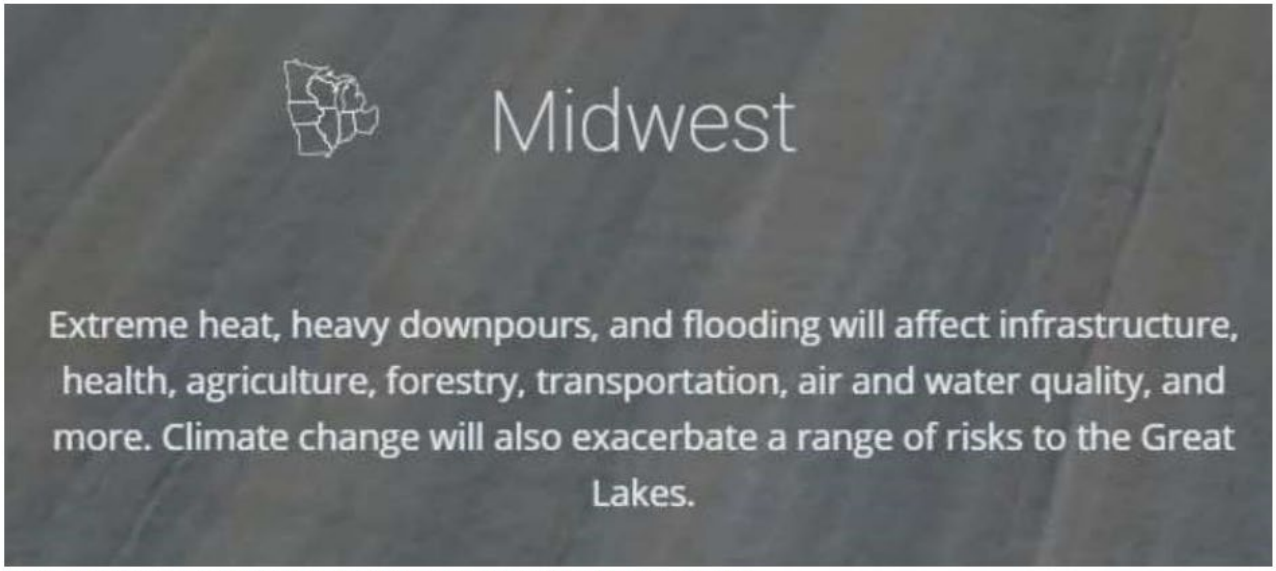
Currently, there are no records of dam failure in Laclede County, making the probability 0% (0 events/100 years = 0% probability). All of the dams were constructed in the 1960's and 1970's, so lack of regulation and maintenance could possibly lead to dam failure. For the purposes of this assessment, dam failure and its associated impacts cannot be neglected. The probability of this event will be placed as less than 10% to allow for a risk assessment.

Changing Future Conditions Considerations and the Impact of Climate Change

According to the 2023 Missouri State Hazard Mitigation Plan, studies have been conducted to investigate the impact of climate change scenarios on dam safety. Dam failure is already tied to flooding and the increased pressure flooding places on dams. The impacts of changing future conditions on dam failure will most likely be those related to changes in precipitation and flood likelihood. Changing future conditions projections suggest that precipitation may increase and occur in more extreme events, which may increase risk of flooding, putting stress on dams and increasing likelihood of dam failure.

The safety of dams for the future climate can be based on an evaluation of changes in design floods and the freeboard available to accommodate an increase in flood levels. The results from the studies indicate that the design floods with the corresponding outflow floods and flood water levels will increase in the future, and this increase will affect the safety of the dams in the future. Studies concluded that the total hydrological failure probability of a dam will increase in the future climate and that the extent and depth of flood waters will increase by the future dam break scenario.

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



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

Vulnerability

Vulnerability Overview

There is only one state regulated dam in Laclede County, which is a Class 3, and according to the 2023 Missouri State Hazard Mitigation Plan, there are no structures or populations at risk if this dam was to fail. As for the other six high hazard dams, the possibility of failure still does not threaten much infrastructure or population. Both the Lake Shore Estates upper and lower dams are four miles from the City of Lebanon. These two dams are the closest to city limits compared to the other five high-hazard dams within Laclede County. However, most damage from failure would most likely be in residential areas and on major roads, including Route 5.

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

There is only one state-regulated dam in Laclede County, ranked Class 3. This means that for Class 3 dams, the number of structures in the inundation area was estimated to be 0 buildings since Class 3 dams do not have any structures within their inundation area.

Impact of Previous and Future Development

The main area of Laclede County that will likely see the most growth in the future is the City of Lebanon. Three high risk dams sit directly north of the city, so any residential or industrial growth north of the city may be placing itself at risk of dam failure. Currently, the building permit data on Lebanon's website shows permit information for within the city limits. Although it seems that most growth and development will take place within city limits, it is possible that future development will start to spread farther north of the city, which could put any new infrastructure at risk of dam failure.

Table 3.27. EMAP Impact Analysis: Dam Failure

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

Hazard Summary by Jurisdiction

The jurisdiction that is most at risk for dam failure is Lebanon. If the three high hazard dams north of Lebanon failed, there could be some minor flooding in the extreme north region of Lebanon. There are no schools located in this area, so most damage, if any, would be to residences or businesses.

Problem Statement

Overall, dam failure is a relatively low risk to Laclede County and incorporated communities. Regular inspections and maintenance of dams may reduce the likelihood of a dam failure event. Although the probability of dam failure is low, there is still potential damage that could occur if a dam in the county was to fail.

The dams that could cause the most risk are Capoferri Lake Dam, Lake Shore Estates Upper Dam, and Lake Shore Estates Lower Dam since they are high risk and sit just north of Lebanon. The residents, business owners, and schools that may have buses travel in this area should be familiar with a dam emergency action plan in case of failure. If an emergency action plan is not available, then there should at least be a notification system in place for local law enforcement, government agencies, and residents. It would be beneficial for jurisdictions, especially Lebanon, to work closely with dam operators and participate in emergency exercises.

3.4.4 Earthquakes

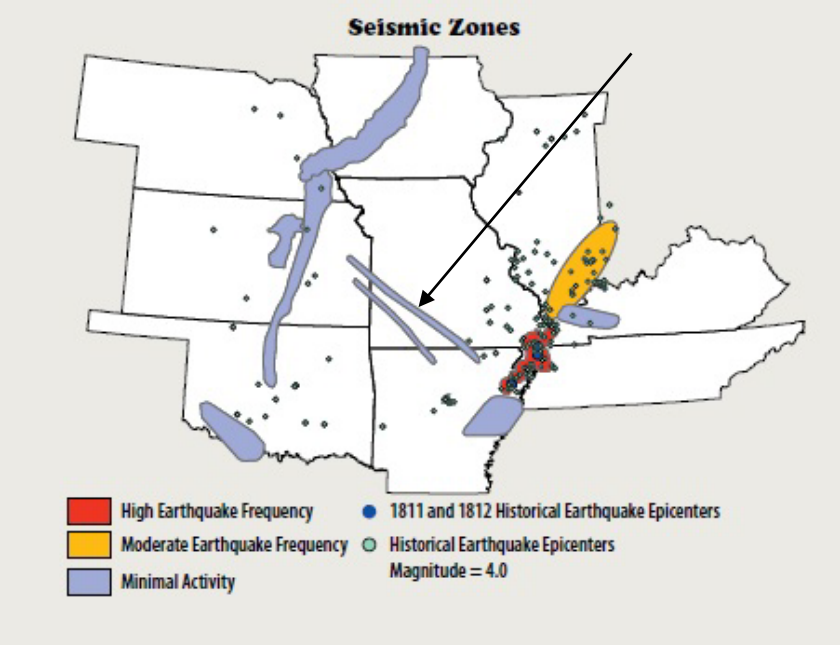
Hazard Profile

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. The 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 energy to buildings and other structures on the earth's surface.

According to the Missouri Department of Natural Resources, Missouri experiences small earthquakes nearly every day. Most of these earthquakes are too small to be felt but are still recorded in seismographs. In Missouri, the most common seismic zone is the New Madrid Seismic Zone in southeast Missouri. This seismic zone was responsible for the 1811-1812 New Madrid earthquakes, which was a series of earthquakes that began with an earthquake of magnitude 7.5-7.9 and was followed by a 7.4 aftershock on December 16, 1811. Although this is the largest earthquake we have recorded from this seismic zone, smaller earthquakes have continued to occur since. **Figure 3.11** shows the seismic zones in and around Missouri, the only moderate and high earthquake frequencies lie along the New Madrid Seismic Zone. Smaller seismic zones cut through southwest Missouri, relatively close to Laclede County, however, are only minimally active.

Figure 3.11. Seismic Zones Surrounding Laclede County



Source: DNR Publication Geologic Hazards, https://dnr.mo.gov/pubs/pub2467.pdf

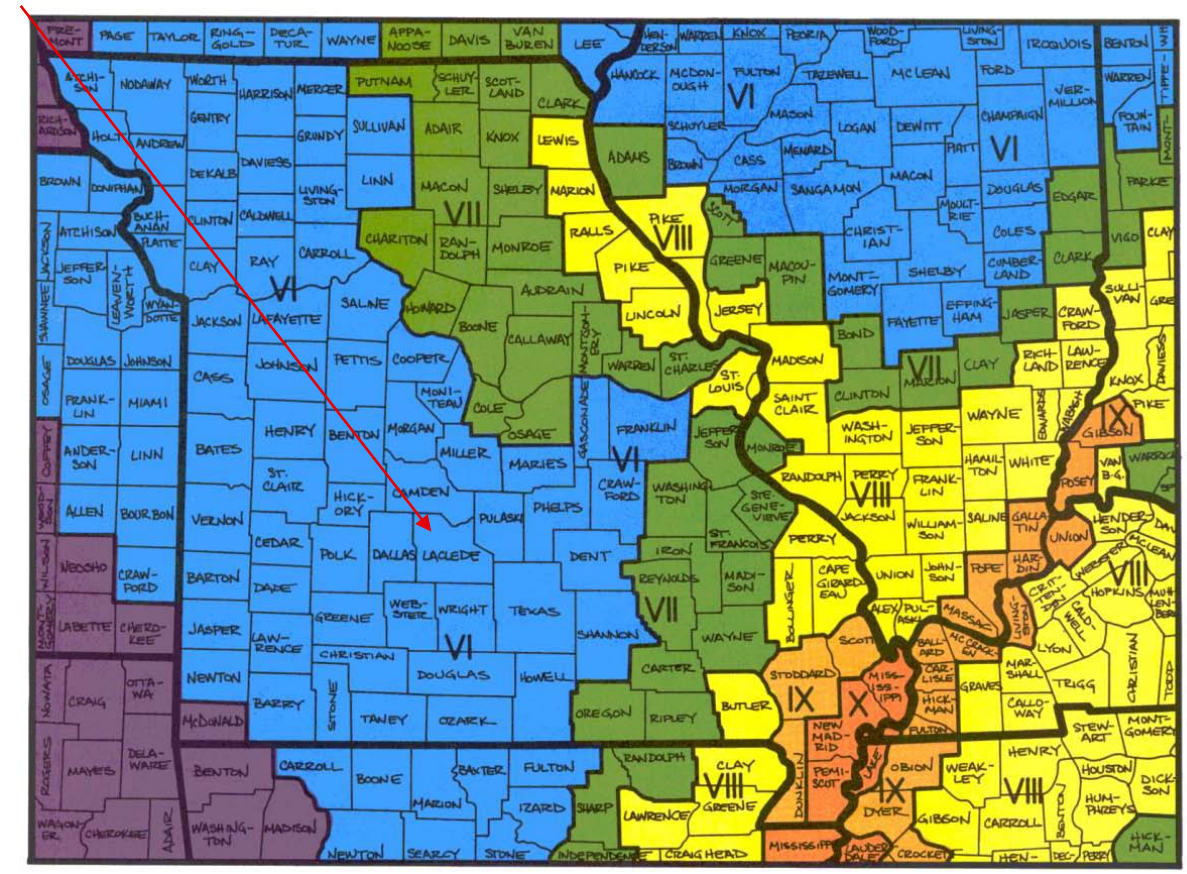
Geographic Location

The greatest earthquake hazard to Laclede County comes from the New Madrid Seismic Zone located at

the southeast corner of Missouri. The potential of high magnitude earthquakes and the high frequency of earthquakes present uniform risk across the county. The Nemaha Ridge runs through Kansas and Oklahoma but does not produce enough high magnitude earthquakes to present considerable risk to Laclede County.

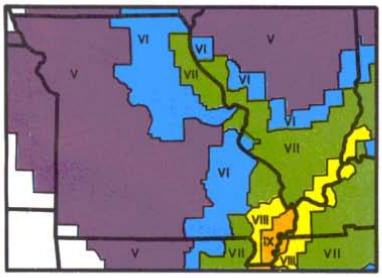
Figure 3.12 shows the highest projected Modified Mercalli intensities by county from a potential magnitude 7.6 earthquake whose epicenter could be anywhere along the length of the New Madrid Seismic Zone. The secondary maps in **Figure 3.12** show the same regional intensities for 6.7 and 8.6 earthquakes, respectively. Laclede County is located in Zone VI for a potential magnitude 7.6 earthquake along the New Madrid Seismic Zone. According to the Modified Mercalli Intensity Scale, regions within Zone VI would experience physical movement, objects falling from shelves, minor to moderate damage to buildings, fallen tree limbs, isolated rockfalls and landslides, and isolated liquefaction.

Figure 3.12. 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.

6.7

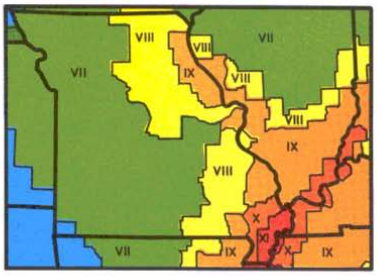


This map shows the highest projected Modified Mercalli intensities by county from a potential magnitude – 6.7 earthquake whose epicenter could be anywhere along the length of the New Madrid seismic zone.

7.6

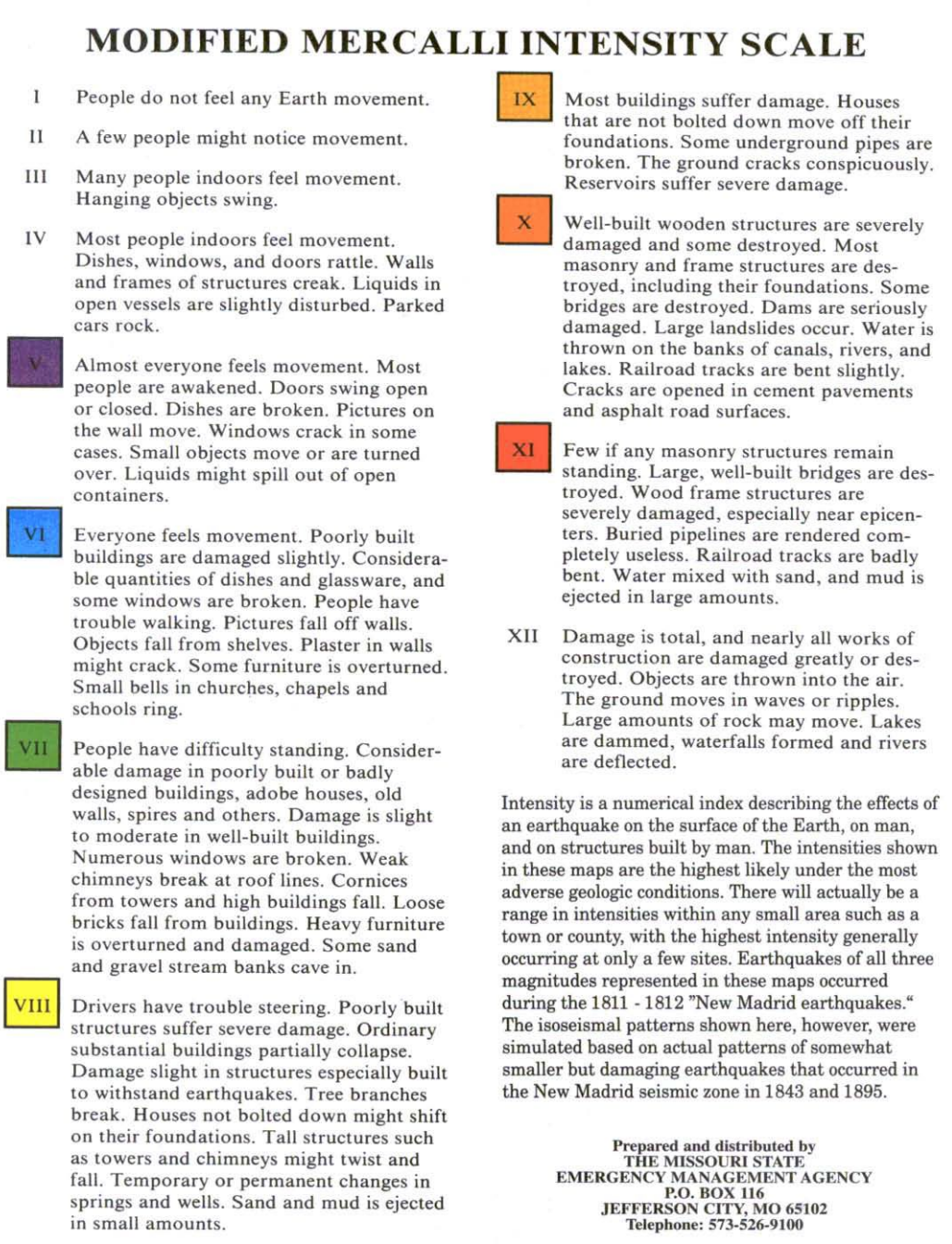
This map shows the highest projected Modified Mercalli intensities by county from a potential magnitude – 8.6 earthquake whose epicenter could be anywhere along the length of the New Madrid seismic zone.

8.6



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

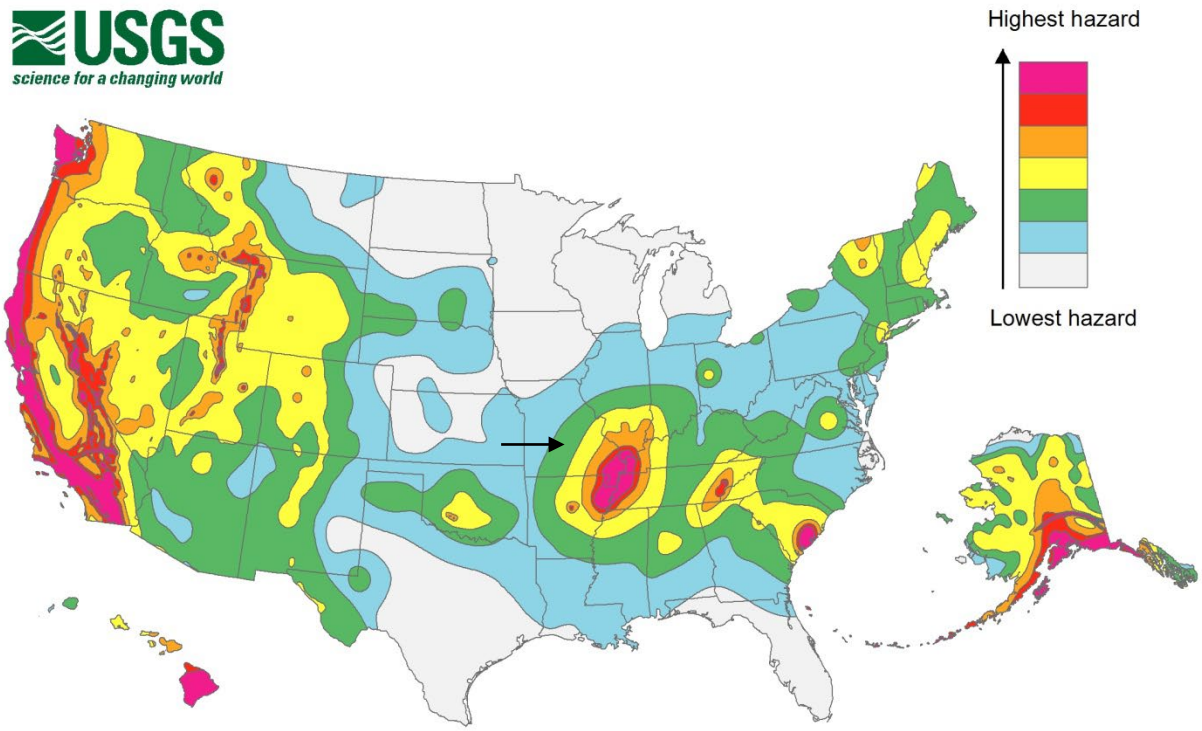
Figure 3.13. Projected Earthquake Intensities



The United States Geological Survey updated maps in 2014 to represent an assessment of the best available science in earthquake hazards and incorporate new findings on earthquake ground shaking, faults, seismicity, and geodesy. The USGS National Seismic Hazard Mapping Project developed the maps by using information from interaction in science and engineering workshops involving hundreds of participants, review by several science organizations, and State surveys, and advice from expert panels and a Steering Committee.

Figure 3.14 shows the updated map illustrating seismicity across the United States. The black arrow showing the location of Laclede County has been added.

Figure 3.14. 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 only been two earthquakes in Laclede County since 1931. The largest earthquake event within 30 miles of Laclede County occurred in 1988 when a 3.3 magnitude earthquake was recorded. On April 29, 2018, a 2.5 magnitude earthquake registered about ten miles south to southeast of Lebanon. Little or no damage was reported since the magnitude of both earthquakes was small. In 2021 shakes from a magnitude 4 earthquake that originated in the Missouri bootheel were felt in Laclede County, but no damage was reported.

Probability of Future Occurrence

Since there have been three earthquakes felt in Laclede County since 1931, the probability of a future earthquake event occurring in Laclede County is 3.2% (3 earthquakes/ 93 years = 3.2% probability in a given year). The USGS database shows that there is a 0.49% chance of a major earthquake within 50km of Laclede County, MO within the next 50 years. Although these calculated probabilities are low, it is still important to consider the unpredictability of earthquakes and the proximity to the New Madrid Seismic Zone. According to a fact sheet prepared by SEMA in 2003, the probability of a magnitude 6.0 to 7.5 or greater earthquake along the New Madrid Fault is 25 to 40 percent over the next 50 years. Overall, the probability of an earthquake occurring along the New Madrid Fault and affecting Laclede County is greater than an earthquake occurring within the county itself.

Changing Future Conditions Considerations and the Impact of Climate Change

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

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

Vulnerability

Vulnerability Overview

Overall, the vulnerability for Laclede County is low since the probability of damaging earthquake in the county is low. As previously mentioned, the greatest earthquake risk to Laclede County is the New Madrid Fault in Southeast Missouri. As stated by SEMA, the probability for a magnitude 6.0 to 7.5 or greater earthquake along the New Madrid Fault is 25 to 40 percent over the next 50 years. A magnitude 6.7 earthquake at the New Madrid Fault would cause minor physical movement and little damage. A 7.6 magnitude earthquake would cause more violent movement and damage in poorly constructed buildings and an 8.6 magnitude earthquake would cause considerable damage in poorly built, badly designed or older structures, broken windows, the falling of loose bricks from buildings, and other structural damage. This could lead to some injuries, but fatalities are unlikely.

Potential Losses to Existing Development

The Hazus building inventory counts are based on the 2010 census data adjusted to 2014 numbers using the Dun & Bradstreet Business Population Report. Inventory values reflect 2014 valuations, based on RSMeans (a supplier of construction cost information) replacement costs. Population counts are 2010 estimates from the U.S. Census Bureau. Data included below for the planning area from the 2023 State Plan Table A.10.

County	Total Losses (in $ Thousands)	Loss Per Capita (in $ Thousands)	Annualized Loss Ratio (in $ per Million)
Laclede	$182	$0.0051	$57

Impact of Previous and Future Development

Future development, which would most likely occur within Lebanon, will only be at greater risk to earthquakes if construction does not adhere to building codes. Future development overall is not expected to increase the risk other than contributing to the overall exposure of what could become damaged as a result of an event.

EMAP Consequence Analysis

Table 3.28. EMAP Impact Analysis: Earthquakes

Subject	Detrimental Impacts
Public	Adverse impact expected to be severe for unprotected personnel and moderate to light for protected personnel.
Responders	Adverse impact expected to be severe for unprotected personnel and moderate to light for protected personnel.
Continuity of Operations	Damage to facilities/personnel in the area of the incident may require relocation of operations and lines of succession execution. Disruption of lines of communication and destruction of facilities may extensively postpone delivery of

	services.
Property, Facilities, and Infrastructure	Damage to facilities and infrastructure in the area of the incident may be extensive for facilities, people, infrastructure, and HazMat.
Environment	May cause extensive damage, creating denial or delays in the use of some areas. Remediation needed.
Economic Condition of Jurisdiction	Local economy and finances adversely affected, possibly for an extended period of time.
Public Confidence in the Jurisdiction's Governance	Ability to respond and recover may be questioned and challenged if planning, response, and recovery not timely and effective.

Hazard Summary by Jurisdiction

Earthquake intensity is not likely to vary greatly throughout the county; the risk of occurrence is the same throughout. However, damages will differ in some jurisdictions based on the age of the structures, if one community has older buildings than another community, that community is likely to experience more damage. **Table 3.1** shows the number of housing units built in 1939 or earlier for each jurisdiction.

Table 3.1. Number and Percent of Units Built in 1939 or Earlier

Jurisdiction	# Units Built 1939 or Earlier	% Units Built 1939 or Earlier
Unincorporated Laclede County	1448	9.8%
City of Conway	84	24.8%
City of Lebanon	754	10.9%
City of Richland	51	5.6%
City of Stoutland	35	38.5%
Village of Phillipsburg	25	30.5%

Source: U.S. Census Bureau; 2016 American Community Survey 5-Year Estimates

Problem Statement

The history of earthquake events within Laclede County is scarce, with only two minor events on record. The risk for damage from earthquakes is possible, the New Madrid Seismic Zone is the most active area that could threaten Laclede County. If a higher magnitude earthquake within the New Madrid Seismic Zone occurred, the City of Stoutland and the Village of Phillipsburg could experience severe damage due to the high percentage of older buildings. Potential damage to future infrastructure can be mitigated by utilizing and enforcing proper building codes. Earthquake education and preparedness should also be practiced by school districts as well as within the communities since earthquakes are unpredictable and can happen at any time.

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 collapses. 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.

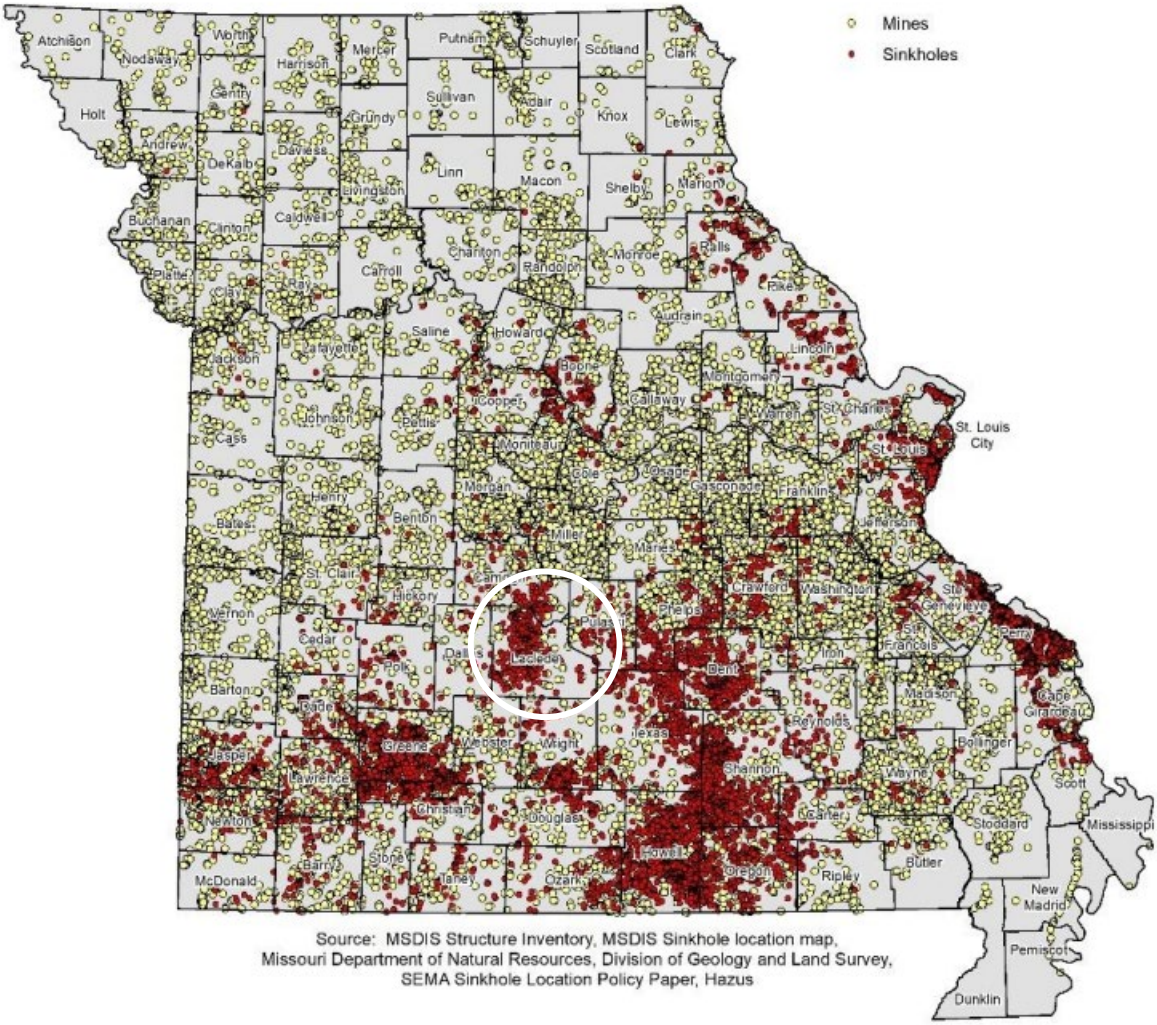
According to the U.S. Geological Survey (USGS), the most damage from sinkholes tends to occur in Florida, Texas, Alabama, Missouri, Kentucky, Tennessee, and Pennsylvania. Fifty-nine percent of Missouri is underlain by thick, carbonate rock that makes Missouri vulnerable to sinkholes. Sinkholes occur 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.

Mineral deposits in Laclede County include lead, iron, and zinc deposits. According to the 2023 Missouri State Hazard Mitigation Plan, there are approximately 157-363 current sink holes and 2-152 mineral mines in the planning area, these could impact hazard vulnerability. (page 3.173-3.174 MO Hazard Mitigation Plan 2023-2028)

Geographic Location

There are sinkholes present throughout Laclede County, however, there is a large concentration of sinkholes extending through the entire county in the central and western regions. **Figure 3.15** below shows the location of all known sinkholes and mines according to the Missouri Department of Natural Resources.

Figure 3.15. Sinkholes and Mines in Laclede County



Strength/Magnitude/Extent

Sinkholes vary in size and location, and these variances will determine the impact of the hazard. A sinkhole could result in the loss of a personal vehicle, a building collapse, or damage to infrastructure such as roads, water, or sewer lines. Groundwater contamination is also possible from a sinkhole. Because of the relationship of sinkholes to groundwater, pollutants captured or dumped in sinkholes could affect a community's groundwater system. The 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

Sinkholes are a regular occurrence in Missouri, but rarely are events of any significance. Sinkhole incidents are not officially recorded, and no occurrences of sinkholes or land subsidence have been recorded in recent local news.

Probability of Future Occurrence

Since there are no records of previous event dates in the planning area, probabilities cannot be calculated. However, with the karst topography present in Laclede County, it is likely that there will be an event at some point in the future.

Changing Future Conditions Considerations and the Impact of Climate Change

According to the 2023 Missouri State Hazard Mitigation Plan, direct effects from changing climate conditions such as an increase in droughts 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 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 Missouri are a common feature where limestone and dolomite outcrop. Dolomite is a rock similar to limestone with magnesium as an additional element, along with the calcium normally present in the minerals that form the rocks. Sinkholes can be considered a slow changing nuisance; sudden, catastrophic collapse can destroy property, delay construction projects, contaminate ground water resources, and damage underground utilities. Laclede County mostly consists of sandstone and dolomite.

Potential Losses to Existing Development

The City of Lebanon is situated on a large concentration of sinkholes. The large population and concentration of infrastructure in Lebanon means that a sinkhole event in this area would lead to large losses. Sinkholes lie under the entire city, so a catastrophic event, although unlikely, could lead to damage to residences, schools, roads, power lines, gas lines, and critical facilities.

Impact of Previous and Future Development

Future development over abandoned mines and in areas of known risk to sinkhole formation in Laclede County will increase vulnerability to this hazard. Population and development in these areas will increase exposure to sinkhole occurrence. There are currently no regulations prohibiting construction over or near known sinkholes. It is possible that future development will affect storm water runoff patterns and lead to expansion or formation of sinkholes.

EMAP Consequence Analysis

Table 3.2. EMAP Impact Analysis: Land Subsidence/Sinkholes

Subject	Detrimental Impacts
Public	Localized impact expected to be moderate to light for incident areas and light for other adversely affected areas.
Responders	Localized impact expected to limit damage to personnel in

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

Hazard Summary by Jurisdiction

The risk of sinkhole damage for individual communities and school districts is limited to the amount of exposure of buildings and infrastructure. Phillipsburg and Lebanon sit on the region of concentrated sinkholes, so they are both at risk. However, the risk of damage is much greater in Lebanon than Phillipsburg because of the higher population and infrastructure. Gasconade C-4, Laclede County C-5, and Lebanon R-III School Districts are all at risk of being impacted by sinkholes, as they are located in the central-western region of the county with the high concentration of sinkholes. The unincorporated areas in Laclede County are also vulnerable to sinkholes. In the unincorporated areas of the county there are farms and large tracts of land that are not publicly owned, and sinkholes are not often reported, but it is known to have sinkholes. There is a large sink hole called the Goodwin Hollow Sink Hole that has been a large trash dump for many years and there is a local group that is trying to clean it up to protect the sink hole and the water that flows to Ha Ha Tonka Spring. Richland has indicated they are not aware of any sinkholes within the city limits.

Problem Statement

It is likely that the number of sinkholes will increase as development increases within the county. This makes an already at-risk Lebanon even more likely to be at risk of sinkholes and their impacts. The potential damage from a sinkhole event in the area could be disastrous; however, this situation is unlikely. In the event of a sinkhole, remediation is possible with fill material. Building on top of sinkhole sites can be prohibited, however, this is highly unlikely since Lebanon is the county's largest city and has already experienced the most development with no plans of slowing.

It is important to keep the knowledge and mapping of the areas prone to sinkholes up to date, certain regulations can be made for properties that lie on sinkholes. Information about identifying potential sinkhole formation and promoting Missouri FAIR plan sinkhole insurance can be included in public outreach and hazard awareness programs. Undeveloped land that is in a sinkhole prone area can be used for park space or other recreational purposes.

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 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.

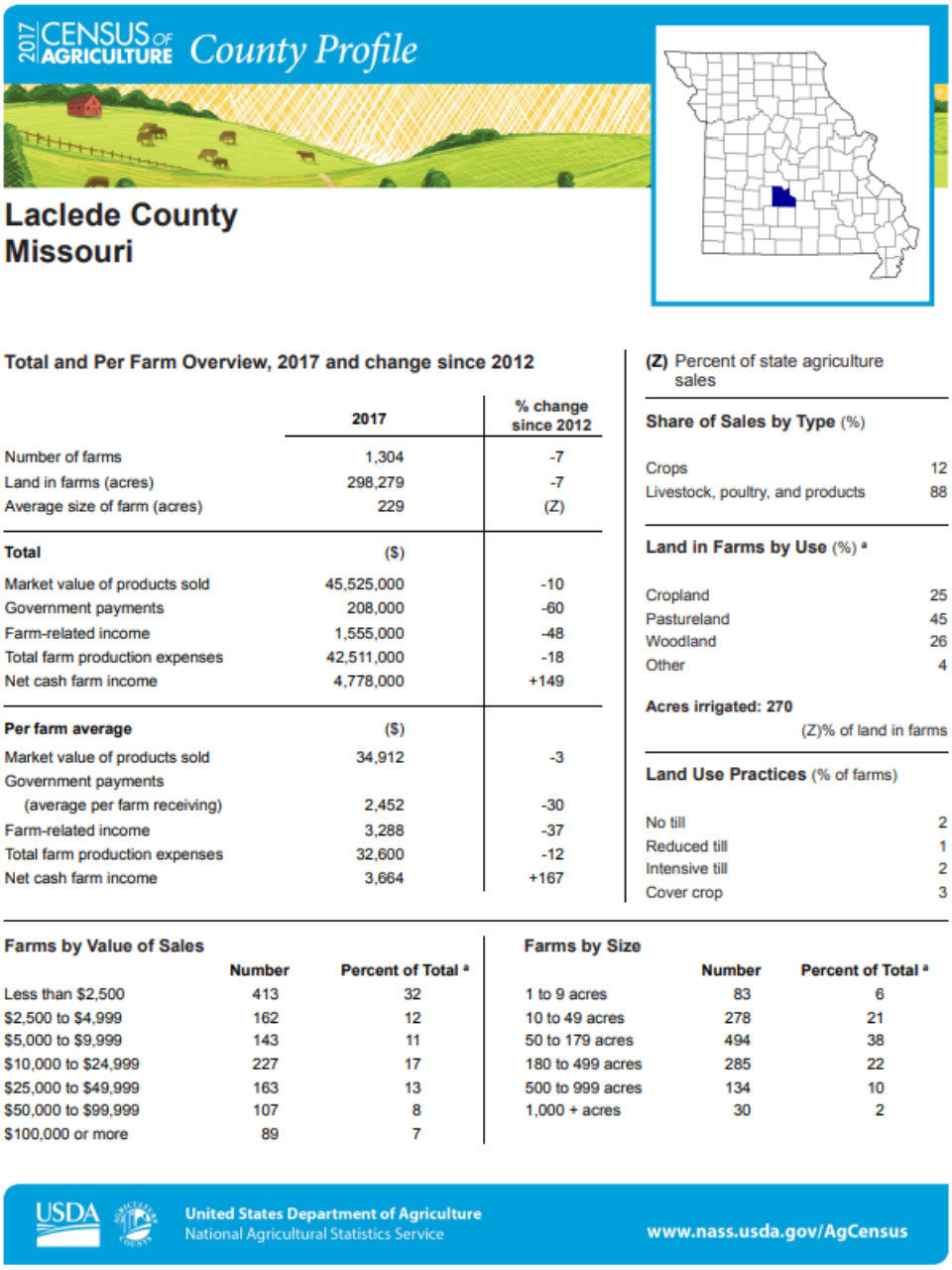
- Agricultural drought focuses on soil moisture deficiencies, differences between actual and potential evaporation, reduced ground water or reservoir levels, etc. Plant demand for water depends on prevailing weather conditions, biological characteristics of the specific plant, its stage of growth, and 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, Laclede County consists of 298,279 acres of farmland. Crop and livestock sales in Laclede County generate 12% and 88%, respectively, of state agriculture sales. A drought would directly impact crop and livestock production, and the agriculture economy in Laclede County and state.

Figure 3.16. Census of Agriculture, Laclede County



2017 CENSUS OF AGRICULTURE *County Profile*

Laclede County
Missouri

Total and Per Farm Overview, 2017 and change since 2012

	2017	% change since 2012
Number of farms	1,304	-7
Land in farms (acres)	298,279	-7
Average size of farm (acres)	229	(Z)
Total	($)	
Market value of products sold	45,525,000	-10
Government payments	208,000	-60
Farm-related income	1,555,000	-48
Total farm production expenses	42,511,000	-18
Net cash farm income	4,778,000	+149
Per farm average	($)	
Market value of products sold	34,912	-3
Government payments (average per farm receiving)	2,452	-30
Farm-related income	3,288	-37
Total farm production expenses	32,600	-12
Net cash farm income	3,664	+167

(Z) Percent of state agriculture sales

Share of Sales by Type (%)

Crops	12
Livestock, poultry, and products	88

Land in Farms by Use (%) [a]

Cropland	25
Pastureland	45
Woodland	26
Other	4

Acres irrigated: 270
(Z)% of land in farms

Land Use Practices (% of farms)

No till	2
Reduced till	1
Intensive till	2
Cover crop	3

Farms by Value of Sales

	Number	Percent of Total [a]
Less than $2,500	413	32
$2,500 to $4,999	162	12
$5,000 to $9,999	143	11
$10,000 to $24,999	227	17
$25,000 to $49,999	163	13
$50,000 to $99,999	107	8
$100,000 or more	89	7

Farms by Size

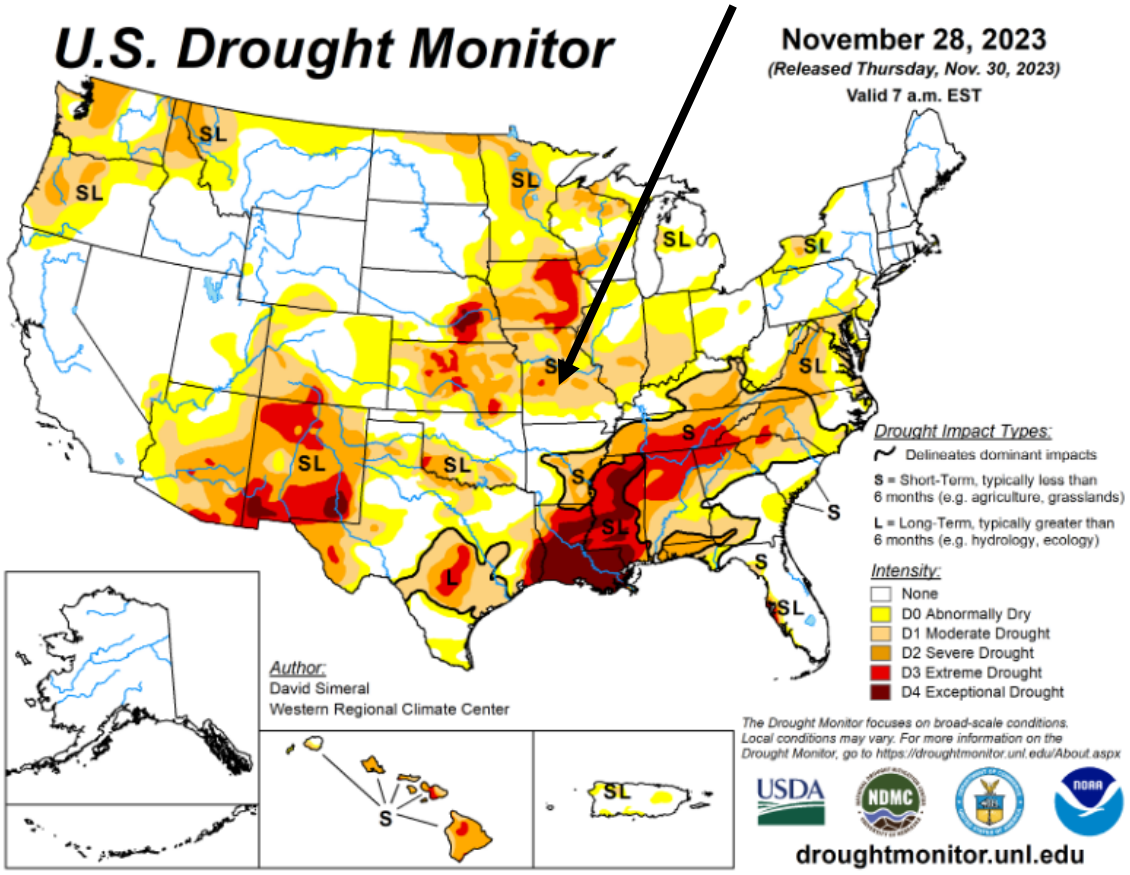
	Number	Percent of Total [a]
1 to 9 acres	83	6
10 to 49 acres	278	21
50 to 179 acres	494	38
180 to 499 acres	285	22
500 to 999 acres	134	10
1,000 + acres	30	2

USDA United States Department of Agriculture
National Agricultural Statistics Service
www.nass.usda.gov/AgCensus

Source:
https://www.nass.usda.gov/Publications/AgCensus/2017/Online_Resources/County_Profiles/Missouri/cp29105.pdf

A recent map from the U.S. Drought Monitor is below and serves as an example of the geographic area that could be in drought at any given moment in time. This is only a snapshot of the conditions at the specified time. The arrow indicates the planning area.

Figure 3.17. U.S. Drought Monitor Map of Missouri on Date



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

Strength/Magnitude/Extent

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

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

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

Previous Occurrences

Drought conditions over the last five years in Laclede County have led to crop indemnities. The year with the highest losses was 2023, when a prolonged drought caused a total of $143,430 (so far) in crop indemnities. The crop that has been most vulnerable to these drought conditions is corn. **Table 3.1** shows the amount of drought losses for each of the past five years.

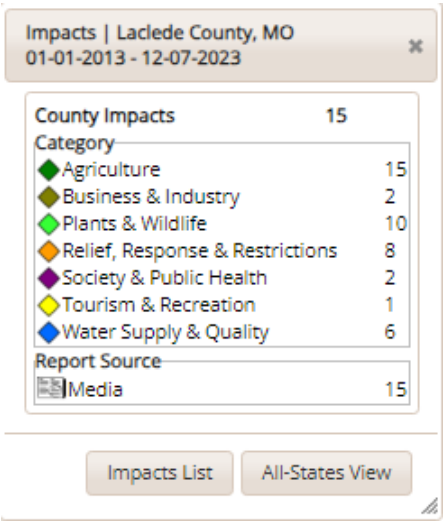
Table 3.1. USDA Indemnity Payments for Losses due to Drought 2019-2023

Year	Crop	Losses
2019	Wheat	$3,365.00
2019	Corn	$23,108.00
2019	Soybeans	$8,178.39
2019	Pasture	$9,605.00
2020	Corn	$64,545.00
2020	Soybeans	$26,417.00
2020	Pasture	$51,081.00
2021	Wheat	$2,714.00
2021	Corn	$6,144.00
2021	Soybeans	$9,676.00
2021	Pasture	$39,218.00
2022	Wheat	$781.00
2022	Corn	$80,093.00
2022	Soybeans	$2,215.00
2022	Pasture	$21,948.00
2023	Corn	$124,647.00
2023	Pasture	$18,783.00
Total		**$483,009.39**

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

According to the National Center for Environmental Information, during the 20-year period from 2003 to 2023 (so far), Laclede County had 15 reported drought impacts. The following are the categories:

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



Source: https://droughtreporter.unl.edu/map/

Probability of Future Occurrence

According to the 2023 State Plan, Laclede County has a low total rating for droughts and is very likely to experience droughts in the future, with a 5.87% chance likelihood of a severe drought.

Changing Future Conditions Considerations and the Impact of Climate Change

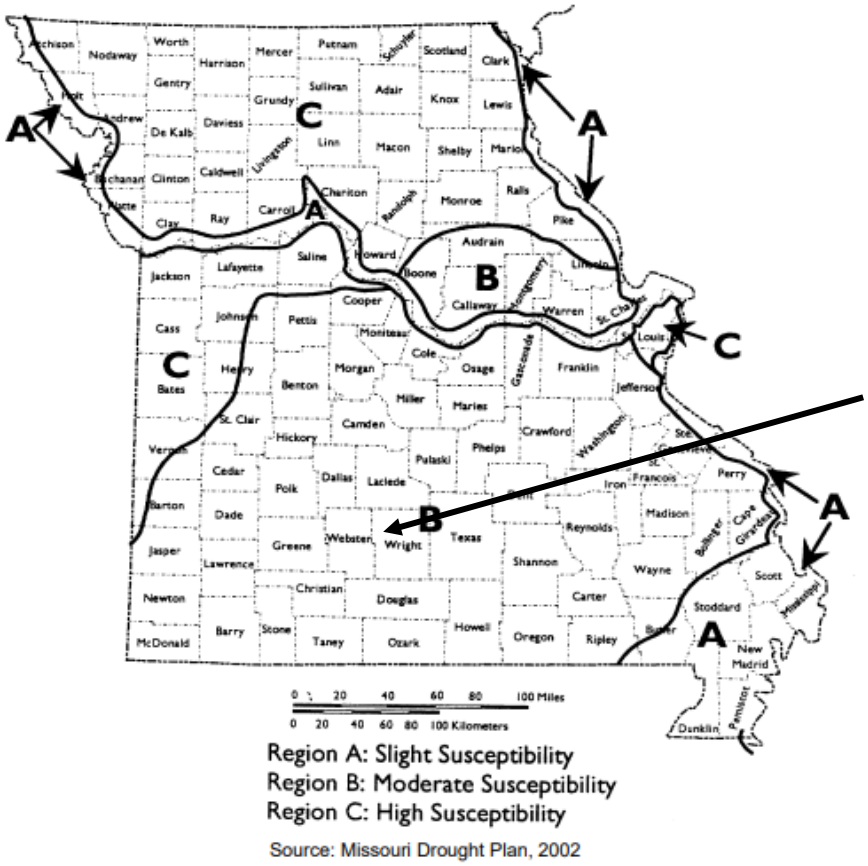
The 2023 Missouri State Hazard Mitigation Plan states that severe drought, a natural part of Missouri's climate, is a risk to this agriculture dependent state. Future increases in evaporation rates due to higher temperatures may increase the intensity of naturally occurring droughts. The number of heavy rainfall events is predicted to increase, yet researchers currently expect little change in total rainfall amounts, indicating the periods between heavy rainfalls will be marked by an increasing number of dry days. Higher temperatures and increased evapotranspiration increase the likelihood of a drought. This could lead to agricultural drought and suppressed crop yields.

Vulnerability

Vulnerability Overview

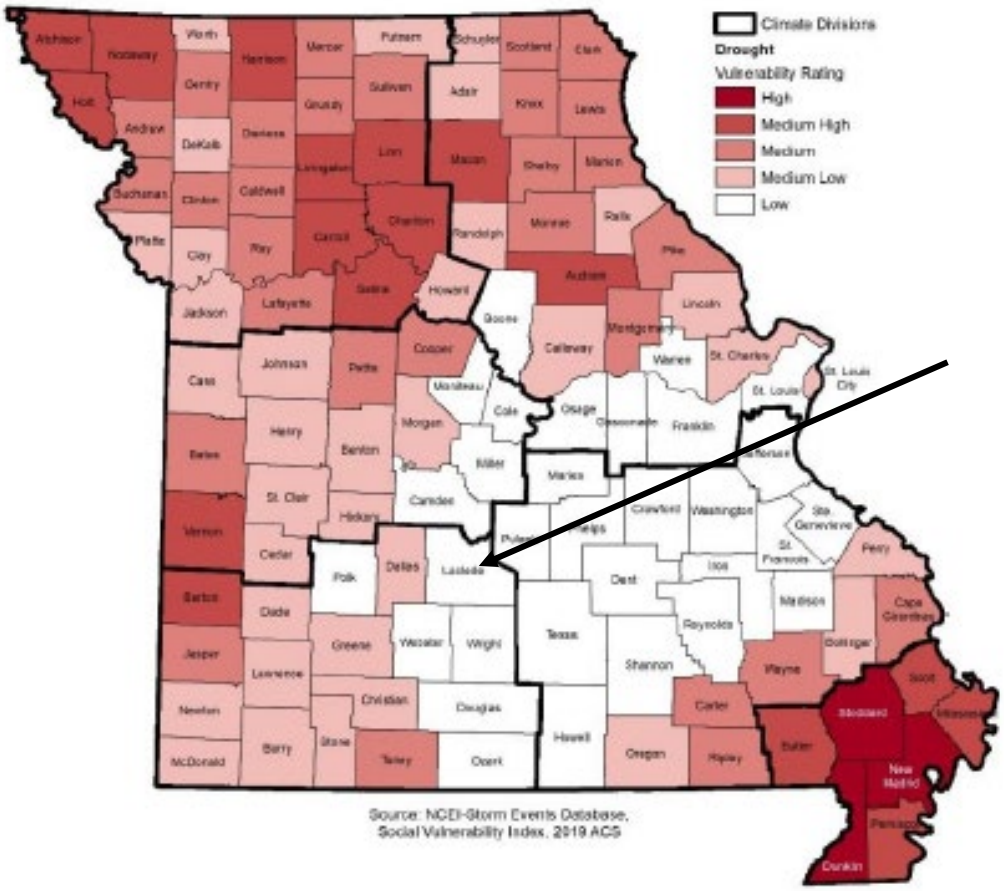
According to the analysis from the 2023 State Plan, Laclede County is located in Region B with a Moderate Susceptibility for droughts (Figure 3.18), and a low vulnerability for droughts (Figure 3.19).

Figure 3.18. Missouri Drought Susceptibility



Source: 2023 Missouri State Hazard Mitigation Plan *Planning area indicated by arrow

Figure 3.19. Missouri Drought Vulnerability by County



Source: 2023 Missouri State Hazard Mitigation Plan *Planning area indicated by arrow

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.

To determine the anticipated potential losses the historical losses were annualized to determine potential future losses for Laclede County to be $96,601.88 in any given year.

Impact of Previous and Future Development

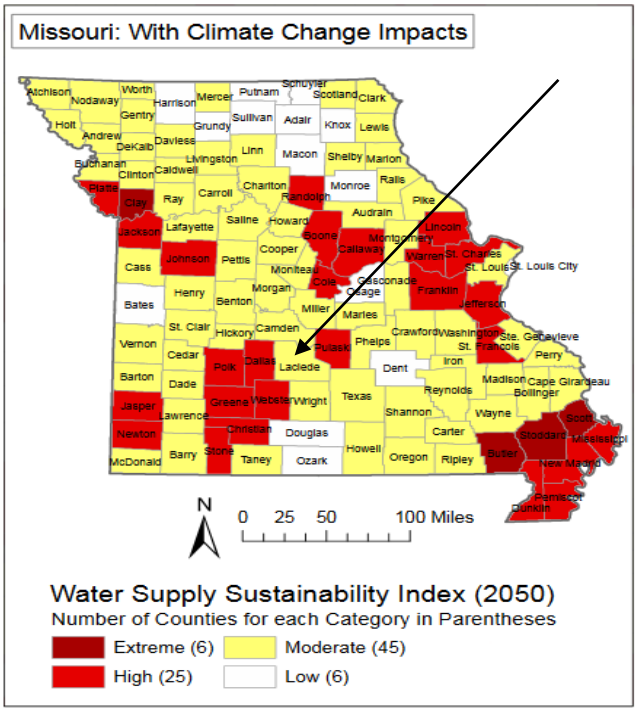
Future development will remain vulnerable to drought. Typically, some urban and rural areas are more susceptible than others. For example, urban areas are subject to water shortages during periods of drought. Excessive demands of the populated area place a limit on water resources. In rural areas, crops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

Changing Future Conditions Considerations and the Impact of Climate Change

A new analysis, performed for the Natural Resources Defense Council, examined the effects of climate change on water supply and demand in the contiguous United States. The study found that more than 1,100 counties will face higher risks of water shortages by mid-century as a result of climate change. Two of the principal reasons for the projected water constraints are shifts in precipitation and potential evapotranspiration (PET). Climate models project decreases in precipitation in many regions of the U.S., including areas that may currently be described as experiencing water shortages of some degree.

Figure 3.20 below shows Laclede County ranked as Moderate on the Water Supply Sustainability Index.

Figure 3.20. Climate Change Impacts on Water Supply in Missouri



Source: https://www.nrdc.org/issues/climate-adaptation#overview

EMAP Consequence Analysis

Table 3.2. EMAP Impact Analysis: Drought

Subject	Detrimental Impacts
Public	Most damage expected to be agricultural in nature. However, water supply disruptions may adversely affect people.
Responders	Nature of hazard expected to minimize any serious damage to properly equipped and trained personnel.
Continuity of Operations	Unlikely to necessitate execution of the Continuity of Operations Plan. Nature of hazard expected to minimize serious damage to services, except for moderate impact on water utilities.
Property, Facilities, and Infrastructure	Nature of hazard expected to minimize any serious damage to facilities.
Environment	May cause disruptions in wildlife habitat, increasing interface with people, and reducing numbers of animals.
Economic Condition of Jurisdiction	Local economy and finances dependent on abundant water supply adversely affected for duration of drought.
Public Confidence in the Jurisdiction's Governance	Ability to respond and recover may be questioned and challenged if planning, response, and recovery not timely and effective.

Hazard Summary by Jurisdiction

The probability of drought is the same for the entire county, and the drought conditions experienced in the cities would be the same as those experienced in rural areas. There are three public water districts that cover the county, and those that receive water from these sources are less likely to feel the impact of drought compared to those who rely on private wells. Laclede County PWSD #1, #2, and #3 serve the Cities of Lebanon and Stoutland. The unincorporated areas of Laclede County rely on private wells for water. Smaller communities do not have public water and also rely on private wells for water. Agricultural croplands and pastures of the area are the most vulnerable when it comes to drought and water shortages.

Problem Statement

Drought is a moderate risk overall to Laclede County, mostly within the agricultural sector. Drought damage has occurred in the past and is most likely going to occur in the future, especially when impacts from climate change are taken into consideration. Currently, crop insurance is the best way to provide protection from crop losses in times of drought. Planting drought-resistant hybrid crops and utilizing moisture-preserving farming methods could help conserve the water supply and reduce crop loss for farms. Potential actions to mitigate the impacts of drought within the county could include public information campaigns regarding how and when to save water, and restricting use of public water for non-essential usage.

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 3.21** 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 of 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.

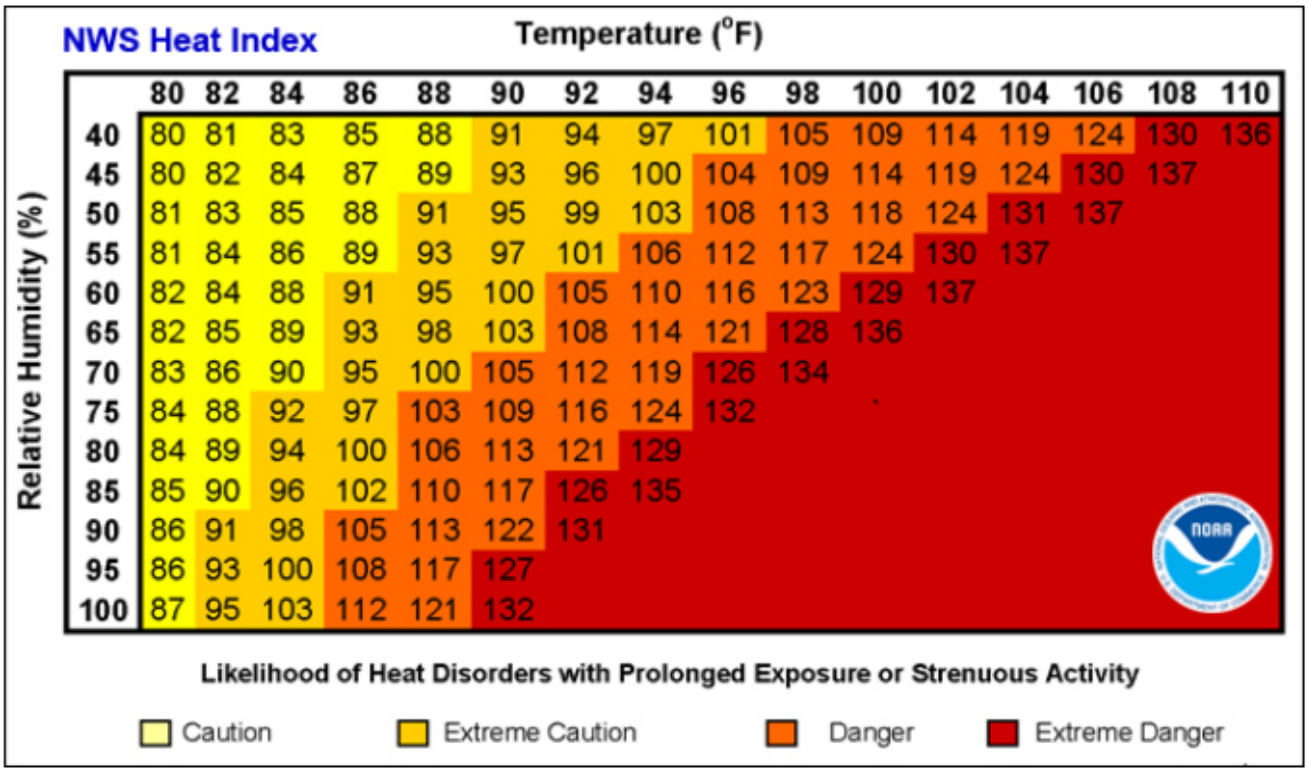
Geographic Location

The entire planning area is subject to extreme heat, and there is no variation amongst the participating jurisdictions.

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 nighttime 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.

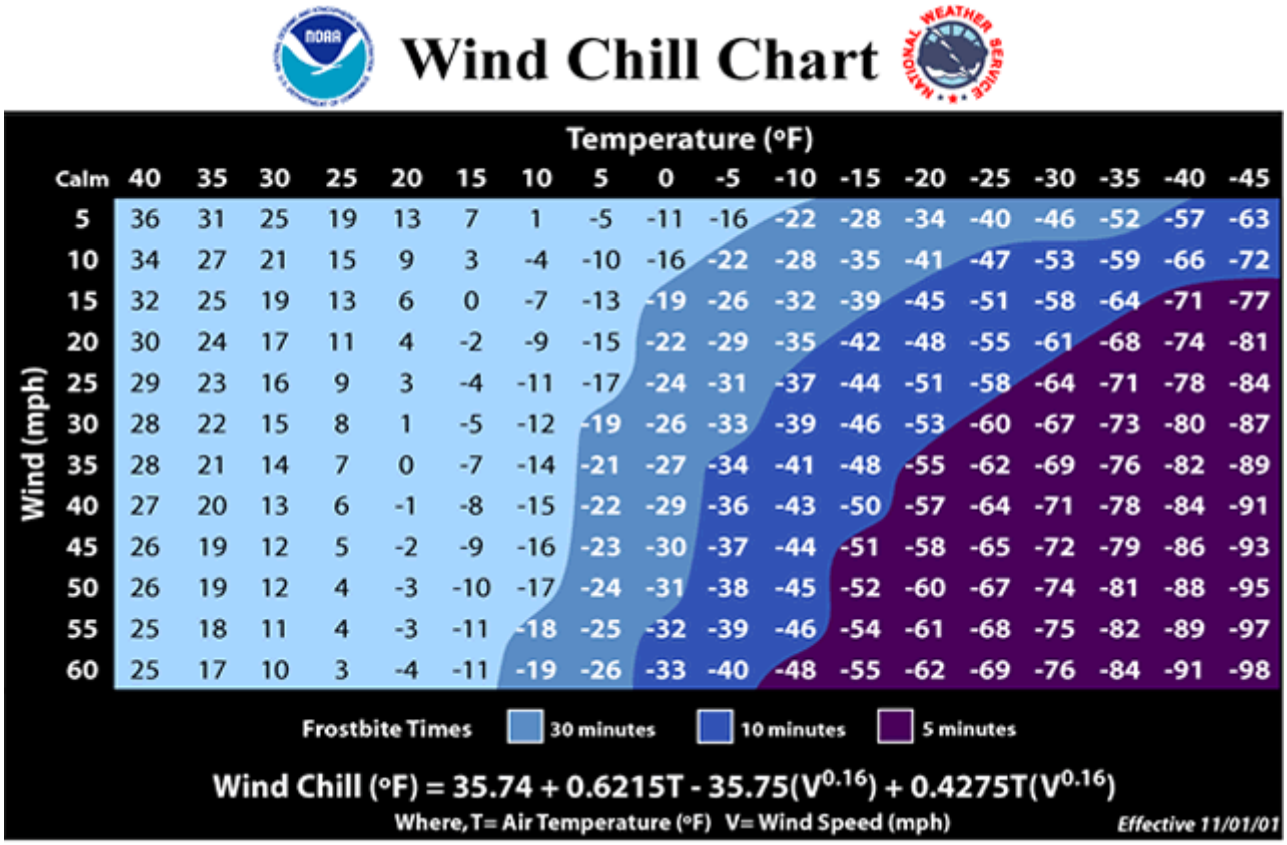
Figure 3.21. Heat Index (HI) Chart



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

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

Figure 3.22. Wind Chill Chart



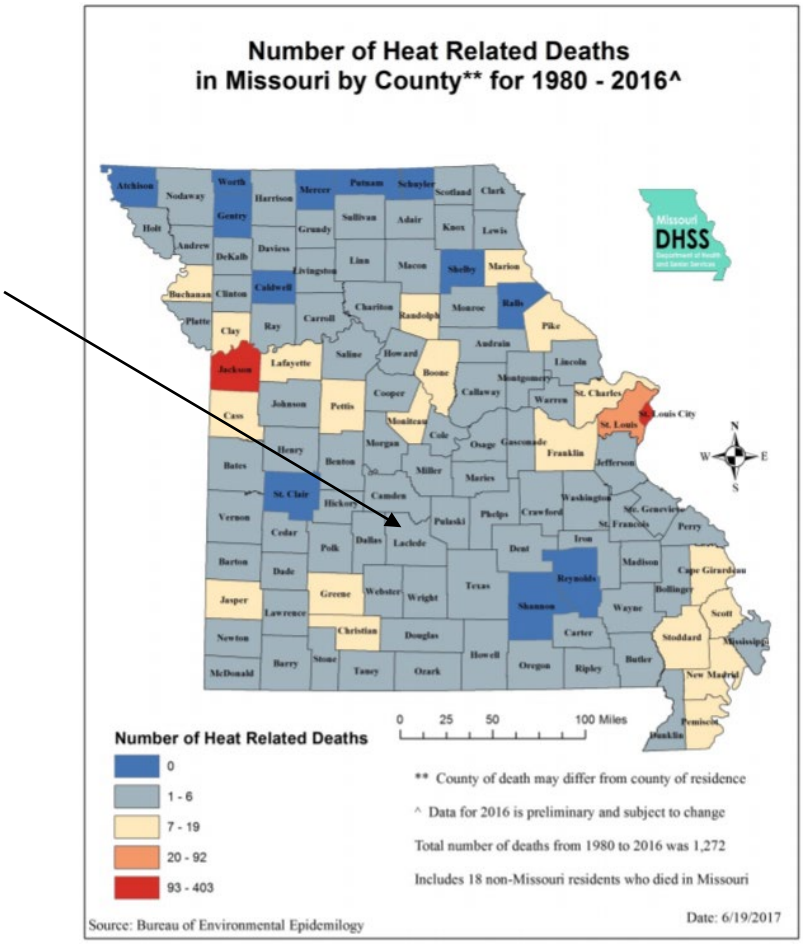
Source: https://www.weather.gov/safety/cold-wind-chill-chart

Previous Occurrences

The recorded events in the National Centers for Environmental Information (NCEI) database state there have been 0 recorded events of excessive heat in the 20-year period of 2003 to 2023. There were 0 deaths or injuries associated with these events. The NCEI database shows 2 recorded events of extreme cold/wind chill. There were 0 deaths or injuries associated with these events.

Figure 3.2323 illustrates 1-6 heat related deaths in Laclede County between the time of 1980 to 2016, however, no supporting documentation could be found to include in this plan.

Figure 3.23. Heat Related Deaths in Missouri 1980 - 2016



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

Extreme heat can cause stress to crops and animals. According to USDA Risk Management Agency, losses to insurable crops during the 5-year time period from 2019 to 2023 were $764. Extreme heat can also strain electricity delivery infrastructure overloaded during peak use of air conditioning during extreme heat events. Another type of infrastructure damage from extreme heat is road damage. When asphalt is exposed to prolonged extreme heat, it can cause buckling of asphalt-paved roads, driveways, and parking lots.

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

Probability of Future Occurrence

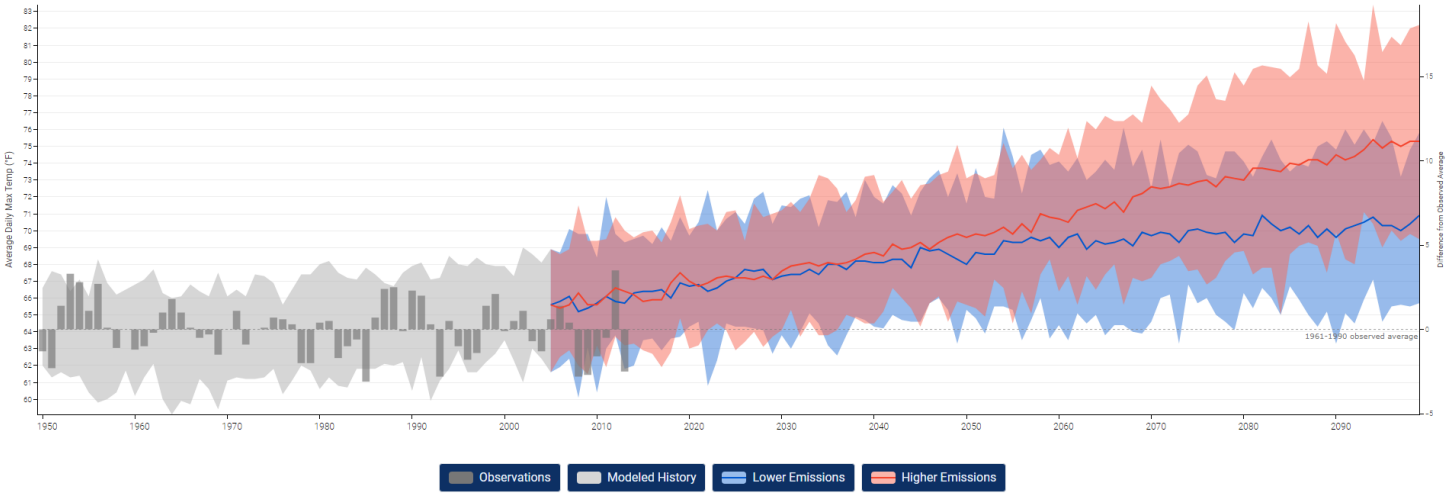
Due to lack of data provided by NOAA's Storm Events Database, an accurate probability could not be calculated, but due to the location of the planning area, it can be concluded that an extreme temperature event will occur in the future.

Changing Future Conditions Considerations and the Impact of Climate Change

According to the 2023 Missouri State Hazard Mitigation 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 tends to have higher concentrations of vulnerable populations. Higher demand for electricity as people try to keep cool amplifies stress on power systems and may lead to an increase in the number of power outages. Atmospheric concentrations of ozone occur at higher air temperatures, resulting in poorer air quality, while harmful algal blooms flourish in warmer water temperatures, resulting in poorer water quality.

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

Figure 3.24. Extreme Temperatures and Emissions in the Midwest, 21st Century



Source: https://nca2014.globalchange.gov/report/regions/midwest

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

Table 3.3. Typical Health Impacts of Extreme Heat

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

105-130° F (HI)	Heatstroke/sunstroke highly likely with continued exposure

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

Potential Losses to Existing Development

Since 2019, Laclede County has experienced $764 in crop losses, with one event in 2021. Future extreme heat events could potentially lead to more crop losses.

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. Overall, the vulnerable populations have slightly increased in numbers since the 2010 Census which will potentially increase future impacts.

EMAP Consequence Analysis

Table 3.4. EMAP Impact Analysis: Extreme Temperatures

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

Hazard Summary by Jurisdiction

Those at greatest risk for heat-related illness and deaths include children up to five years of age, people 65 years of age and older, people who are overweight, and people who are ill or on certain medications. To determine jurisdictions within the planning area with populations more vulnerable to extreme heat, demographic data was obtained from the 2010 census on population percentages in each jurisdiction comprised of those under age 5 and over age 65. Data was not available for overweight individuals and those on medications vulnerable to extreme heat. **Table 3.55** 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 3.5. Laclede County Population Under Age 5 and Over Age 65, 2020 Census Data

Jurisdiction	Population Under 5 yrs	Population 65 yrs and over
*Laclede County	2,449	6,397
Conway	80	121
Lebanon	972	2,394
Richland	304	282
Stoutland	19	37
Phillipsburg	9	23

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

All schools in Laclede 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 effect to close if there are extreme temperatures.

Problem Statement

All jurisdictions within the Laclede County are equally susceptible to damage caused by extreme heat since these events occur regionally. However, the populations that are particularly at risk include children under the age of five, the elderly over the age of 65, those living below the poverty line, and those that work outside.

Laclede County does include mitigation strategies for extreme heat including the opening of cooling stations for those who may not have air-conditioning. The county should continue to spread awareness of these cooling stations to ensure all who need to use them know where to go. A notification system for citizens could also help spread awareness of potential extreme heat events and provide citizens with more time to find cooling stations or shelter.

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

Hail

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

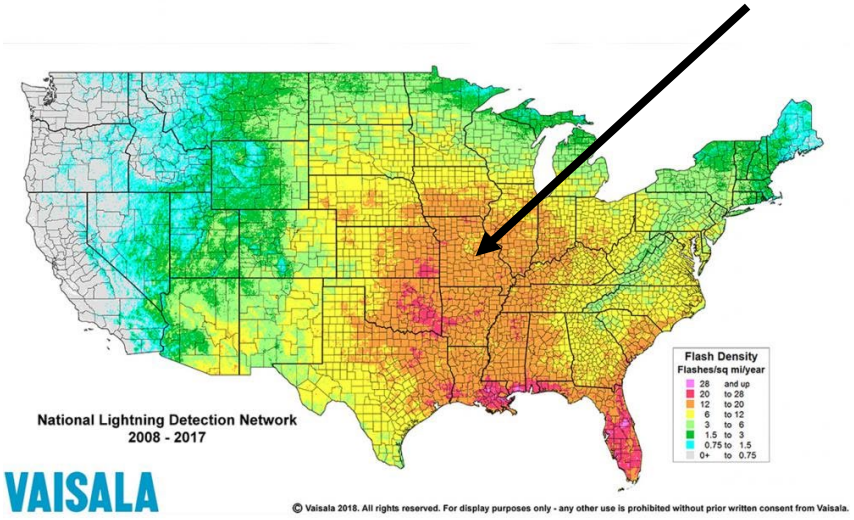
At the time when the updraft can no longer support the hailstone, it will fall down to the earth. For example, a ¼" diameter or pea sized hail requires updrafts of 24 miles per hour, while a 2 ¾" diameter or baseball sized hail requires an updraft of 81 miles per hour. According to the NOAA, the largest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

Geographic Location

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

Figure 3.2525 shows lightning frequency in the United States. Laclede County is shown with a black arrow and appears to lie on the region that could fall under an average flash density of 4 to 5 or 5 to 6.

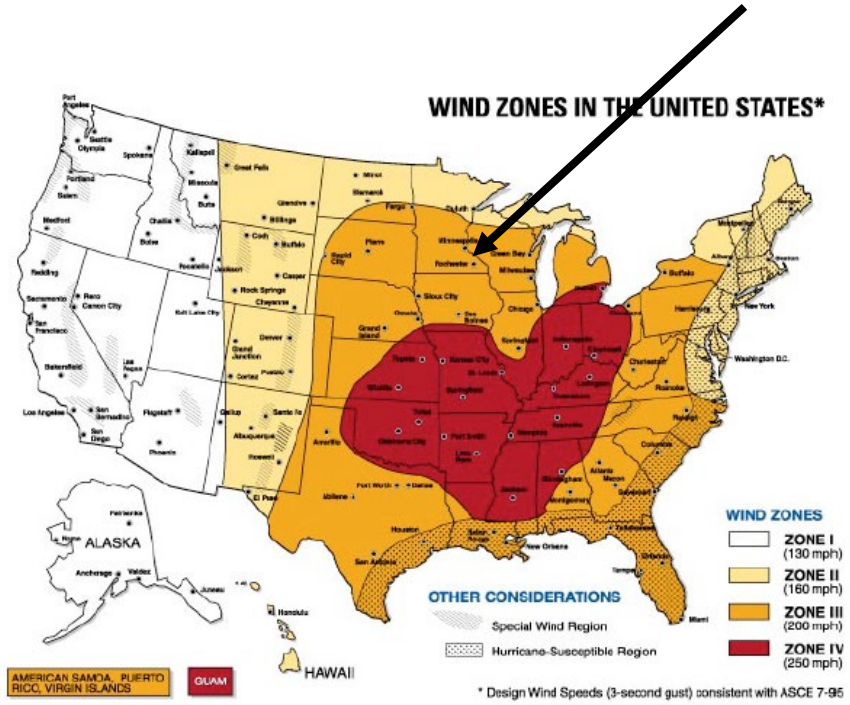
Figure 3.25. Location and Frequency of Lightning in Missouri



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

Figure 3.2626 shows wind zones in the United States. Laclede County is shown with a black arrow and lies in Zone IV, the zone with the highest possible wind speeds in the country.

Figure 3.26. Wind Zones in the United States



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

Strength/Magnitude/Extent

Based on information provided by the Tornado and Storm Research Organization (TORRO), **Table 3.66** below describes typical damage impacts of the various sizes of hail.

Table 3.6. 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	Severe damage to aircraft bodywork

Intensity Category	Diameter (mm)	Diameter (inches)	Size Description	Typical Damage Impacts
			> Soft ball	
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

Source for Tables 3.7 through 3.10: NOAA NCEI Storm Data

Table 3.7. Reported Events/Damages in Laclede County from Thunderstorms 2013-2023

Wind Magnitude	Number of Events	Property Damages	Crop Damages
50 kts	5	20.00K	0.00K
52 kts	41	392.00K	0
61 kts	3	10.00K	0
65 kts	1	250.00K	0
77 kts	1	0	0

May 2020 (77 kts)- This was the second of two severe storms to strike the Lebanon area this day. The Lebanon Airport AWOS KLBO measured an 89 MPH wind gust before going offline. Planes were flipped and hangers damaged. A church steeple was torn off. Multiple trucks were overturned on Interstate 44 between mile markers 125 and 127. Several road signs were damaged, and a boat was reported in the median of the highway.

Table 3.8. Reported Events/Damages in Laclede County from High Winds 2013-2023

No data available.

Table 3.9. Reported Events/Damages in Laclede County from Hail 2013-2023

Hail Size (Inches)	Number of Events	Property Damages	Crop Damages
.75	8	0	0
.88	11	0	0
1.00	30	1.00K	0
1.25	2	0	0

1.75	7	525.00K	0

Table 3.10. Reported Events/Damages in Laclede County from Lightning 2013-2023

Number of Events	Property Damages	Crop Damages
1	5.00K	0.00K

August 2019 - A lightning strike downed a tree on power lines near the Nature Center in Bennett Springs State Park.

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.

According to USDA Risk Management Agency Insurance Claim data, there were not any crop insurance claims between 2019 and 2023 for Thunderstorms, High Winds, Lightning, and Hail. While the planning area has a significant agricultural economy, reasons for claims may not be all inclusive, and therefore the lack of crop insurance claims should not be a concluding factor.

Probability of Future Occurrence

Thunderstorms

Thunderstorm wind events 50 knots or greater have a probability of occurring 5 times per year in the planning area in any given year. These rates are expected to continue in the future.

High Winds

High wind events with 52 knots or greater are expected to occur infrequently over a 10-year period.

Lightning

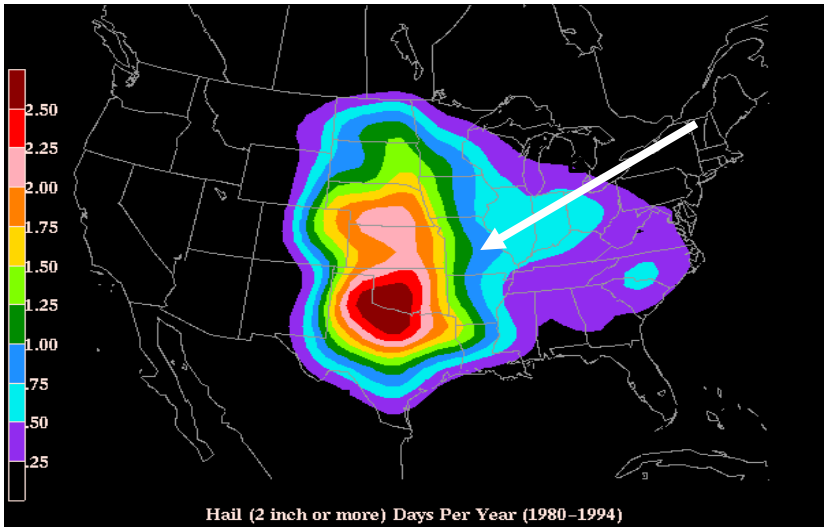
Lightning events are expected to occur infrequently over a 10-year period.

Hail

Based on this data, there have been 58 events in a 10-year period, producing an average of 5.8 hail events each year in Laclede County. Based on history, the probability of a hail event in any given year is 100 percent. Thus, making the probability as likely in any given year.

Figure 3.2727 is based on hailstorm data from 1980-1994. It shows the probability of hailstorm occurrence (2” diameter or larger) based on number of days per year. Laclede County is located in the region to receive between .75 and 1 hailstorm annually.

Figure 3.27. Annual Hailstorm Probability (2" diameter or larger), U 1980- 1994



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

Changing Future Conditions Considerations and the Impact of Climate Change

According to the 2023 Missouri State Hazard Mitigation 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 damage. 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 damage occurs 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 damage 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 damage occurs 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 have not been any fatalities or injuries due to lightning in Laclede County during the 10-year period reviewed. No property or crop damage was reported in relation to the specified major weather events during the 10-year reporting period.

Hail

There was $526,000 worth of property insurance claims for a 10-year period over 58 events. Hail has historically been a damaging event depending on the size of the hail, so all existing development is at risk due to the probability of future events.

High Winds

Due to the likelihood of several events (thunderstorm, lightning, hail, and high winds) occurring at once, the insurance claims do not depict each hazard that caused property damage, thus making it difficult to predict future impacts. High winds are typically involved in thunderstorm activity, so property and crops are at risk for damage caused by high winds despite the lack of previous data.

Previous and Future Development

Growth in Laclede County is occurring at a slow rate, with Lebanon seeing the most growth in terms of population, business, and housing. Additional development in these areas results in the exposure of more households and structures vulnerable to damages from high winds, hail, and lightning.

EMAP Consequence Analysis

Table 3.11. EMAP Impact Analysis: Severe Thunderstorms

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

Subject	Detrimental Impacts
	HazMat spills.
Economic Condition of Jurisdiction	Losses to private structures covered, for the most part, by private insurance.
Public Confidence in the Jurisdiction's Governance	Ability to respond and recover may be questioned and challenged if planning, response, and recovery not timely and effective.

Hazard Summary by Jurisdiction

Although thunderstorms/high winds/lightning/hail events are area-wide, communities with a greater percentage of structures built prior to 1939 are considered to be more vulnerable to the impact of high wind and hail damage. Laclede County has four jurisdictions with structures built before 1939 accounting for at least 10% of all structures, Conway, Lebanon, Stoutland, and Phillipsburg. New construction and population growth as seen in Lebanon would increase the exposure and risk to this hazard; however, the new construction following building code requirements will assist in mitigating the effects of strong storms.

School district facilities are at risk of the damages of thunderstorms, high winds, hail, and lightning as well. However, the risk to student populations has been decreased in both Laclede County R-I Schools and the Joel E. Barber School (Laclede County C-5) due to construction of storm shelters.

Problem Statement

Poorly built and older structures are more vulnerable to the impacts of high winds during thunderstorms. High winds and lightning can lead to problems with electrical utilities and can cause power outages. Both high winds and hail can damage roofs; and hail can damage crops and vehicles. People are also at risk of injury or death from high wind, hail, and lightning events.

The risk of property damage, injury, and death from thunderstorms, high winds, lightning, and hail in Laclede County can be mitigated by identifying safe refuge areas in public buildings, nursing homes, and other facilities that house vulnerable populations. The purchasing and installation of NOAA weather radios in schools, government buildings, and public areas may assist in providing early warning to allow for the public to seek shelter during these events. A text notification system may also benefit the public and vulnerable populations and reduce the risk of injury and death. Education and hazard awareness programs in public schools would help increase public safety in the event of severe thunderstorm events.

3.4.9 Severe Winter Weather

Hazard Profile

Hazard Description

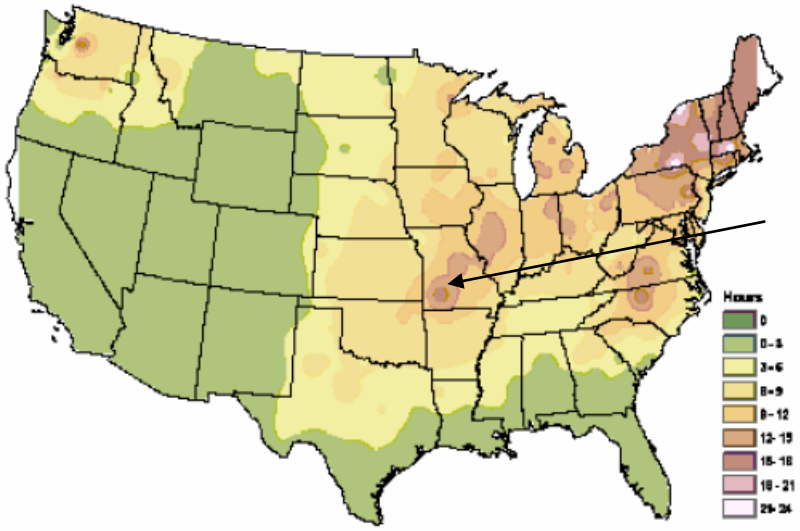
A major winter storm can last for several days and be accompanied by high winds, freezing rain or sleet, heavy snowfall, and cold temperatures. The National Weather Service describes different types of winter storm events as follows.

- **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 county is vulnerable to heavy snow, ice, extreme cold temperatures and freezing rain. **Figure 3.2828** shows the average number of hours per year that freezing rain occurs. Laclede County is in a zone that can expect 12-15 hours of freezing rain per year.

Figure 3.28. 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

There were 19 winter weather events in Laclede County between 2013 and 2023. The events included blizzards, cold/wind chill, heavy cold/wind chill, heavy snow, ice storm, winter storm, and winter weather. **Table 3.1212** lists the events in chronological order.

Table 3.12. NCEI Laclede County Winter Weather Events Summary, [2013-2023]

Date	Type of Event	# of Deaths	# of Injuries	Property Damages	Crop Damages
02/21/2013	Winter Storm	0	0	0	0
12/05/2013	Winter Storm	0	0	0	0
01/05/2014	Winter Storm	0	0	0	0
03/02/2014	Winter Storm	0	0	0	0
02/20/2015	Winter Storm	0	0	0	0
02/28/2015	Winter Storm	0	0	0	0
12/16/2016	Winter Weather	0	0	100.00K	0
01/13/2017	Ice Storm	0	0	0	0
01/01/2018	Cold/Wind Chill	1	0	0	0
02/04/2018	Winter Weather	0	0	0	0
04/06/2018	Frost/Freeze	0	0	0	0
02/15/2019	Winter Weather	0	0	0	0
01/27/2021	Winter Weather	0	0	0	0
02/14/2021	Winter Weather	0	0	0	0
02/17/2021	Winter Weather	0	0	0	0
04/20/2021	Frost/Freeze	0	0	0	0
12/22/2022	Winter Weather	0	0	0	0
01/12/2023	Winter Weather	0	0	0	0
01/29/2023	Winter Weather	0	0	0	0
Total		**1**	**0**	**100.00K**	**$0**

Source: NCEI, data accessed [12/9/2023]

Winter Weather (12/16/2016)
Freezing drizzle conditions caused numerous car accidents in Laclede County. There was one indirect fatality near Phillipsburg. Missouri Highway Patrol reported another accident involving several cars on I-44 near Conway. This accident caused major traffic problems on I-44 and closure of the eastbound lane for over 2 hours.

Cold/Wind Chill (01/01/2018)
Extreme cold temperatures were responsible for the death of a 52-year-old woman walking home in Lebanon.

Probability of Future Occurrence

According to NCEI, during the 10-year period from 2013 to 2023, the planning area experienced 22 winter weather events. This translates to an annual probability of approximately 2.2 per year a winter weather event will occur.

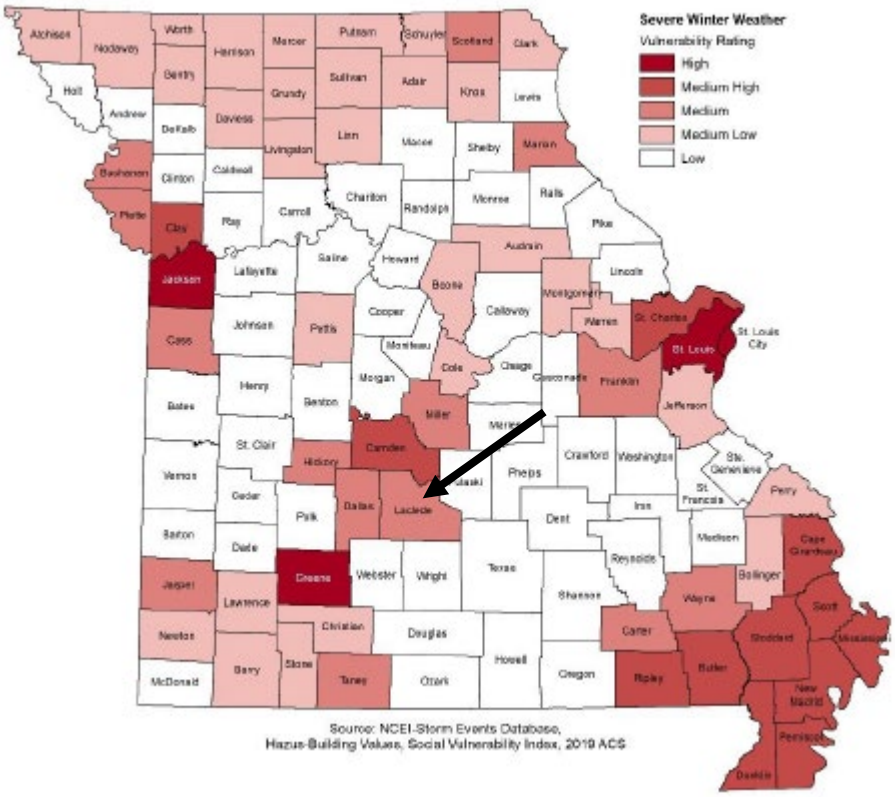
Changing Future Conditions Considerations and the Impact of Climate Change

According to the 2023 Missouri State Hazard Mitigation 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, plants, 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

Figure 3.29. Severe Winter Weather Vulnerability by County



Source: 2023 Missouri State Hazard Mitigation Plan *Planning area indicated by arrow

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 damage 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. Damage also occurs to lines and equipment from falling trees and tree limbs weighted down by ice. Potential losses could include the 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

Laclede County has many building throughout that were constructed prior to 1939 that suffer from harsh winter weather. The loss of income is experienced by existing businesses due to power outages. In general, heavy winter storms increase wear and tear on roadways through the cost of such damages is difficult to determine.

Previous and Future Development

Increased development and any resulting increase in population will increase exposure to damage from severe winter weather. As mentioned previously, Lebanon is the only jurisdiction experiencing significant growth and currently plans to expand in the future. Future construction of facilities that will serve vulnerable populations will need to be prepared for extreme weather conditions. New roads will require increased snow removal and salt trucks to ensure the safety of the public. Any increases in agriculture crop production will subsequently increase the risk of exposure.

Table 3.13. EMAP Impact Analysis: Severe Winter Weather

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

Hazard Summary by Jurisdiction

The jurisdictions that are most at risk to severe winter weather include those living below the poverty line, those aged 65 years or older, and those living in mobile homes. Those living below the poverty line are more vulnerable to winter weather because heat may not be available or affordable. Those aged 65 years or older are more vulnerable to winter weather because of potential health problems or lack of ability to endure the cold. Richland is the most vulnerable jurisdiction based on poverty and elderly population, with the highest values in both categories. Lebanon is also vulnerable based on these criteria with the third highest poverty percent and second highest elderly percent.

Problem Statement

Severe winter weather can include blizzards, heavy snow, ice storms, sleet, and extreme cold/wind chill that can be devastating to communities. Traffic accidents, damaged utility lines, structural collapse, and extremely low temperatures put the public and infrastructure at risk. People over 65 years old and those living in poverty or in areas with insufficient heat are especially at risk to hypothermia and frostbite.

Organizing outreach to at-risk populations, including establishing and promoting heating centers can help reduce risk of exposure to severe winter weather. Having an alert system in place can also allow the public time to avoid driving or other dangerous scenarios. Communities should also be sure to have sufficient slow removal and salt trucks prepared as the winter months arrive.

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 3.1414**) 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 3.14. 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 3.1515**. 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 3.15. 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

Table 3.1616 below includes NCEI reported tornado events and damages since 1993 in the planning area. Prior to that date, only really destructive tornadoes were recorded.

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.

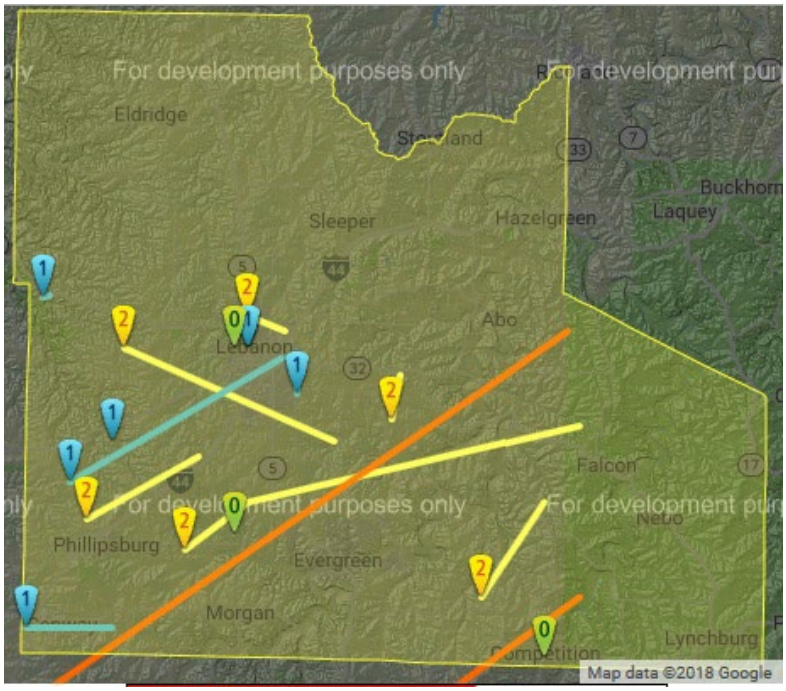
Table 3.16. Recorded Tornadoes in Laclede County, 1993 – Present

Date	Beginning Location	Ending Location	Length (miles)	Width (yards)	F/EF Rating	Death	Injury	Property Damage	Crop Damages
04/24/1993	Competition	Competition	0.50	45	F0	0	2	$500,000	$0
04/26/1994	Lebanon	Lebanon	2.50	50	F1	0	0	$50,000	$0
11/10/1995	Lebanon	Lebanon	10.00	200	F2	0	0	$3,000,000	$0
05/05/1996	Conway	Conway	4.00	100	F1	0	1	$500,000	$0
05/06/2003	Lebanon	Lebanon	0.20	20	F0	0	0	$0	$0
05/30/2004	Lebanon	Lebanon	1.00	200	F1	0	0	$10,000	-
03/12/2006	Competition	Competition	3.00	35	F0	0	0	$80,000	-
10/17/2007	Morgan	Morgan	0.10	35	EF0	0	0	$10,000	$0
01/07/2008	Conway	Abo	24.68	300	EF3	0	12	$8,000,000	$0
01/07/2008	Phillipsburg	Brush Creek	5.44	300	EF2	0	0	$100,000	$0
03/31/2008	Lebanon	Lebanon	1.79	75	EF2	0	0	$500,000	$0
05/08/2009	Jones Lebanon	Jones Lebanon	2.00	440	EF2	0	0	$500,000	$0
02/29/2012	Phillipsburg	Lebanon	11.00	150	EF1	0	5	$750,000	$0
02/29/2012	Bennett Springs	Bennett Springs	0.25	75	EF1	0	0	$500,000	$0
05/27/2017	Brush Creek	Russ	9.00	100	EF1	0	0	$100,000	$0
05/27/2017	Nebo	Winnipeg	4.97	400	EF1	0	0	$100,000	$0
05/27/2017	Dryknob	Dryknob	2.07	100	EF1	0	0	$0	$0
05/27/2017	Winnipeg	Winnipeg	0.01	100	EF1	0	0	$0	$0
05/23/2019	Abo	Abo	1.26	440	EF1	0	0	$0	$0
	Total					**0**	**20**	**$14,700,000**	**$0**

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

Figure 3.3030 shows historic tornado paths in Laclede County

Figure 3.30. Laclede County Map of Historic Tornado Events



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

There are no records in the USDA Risk Management Agency Database that refer to crop damages as a result of tornado events since 1993.

Probability of Future Occurrence

Since 1993, or the past 25 years, there have been 19 tornado events in Laclede County recorded by the NCEI. This means that during any given year, there is a 63% probability of a tornado event occurring. Out of the 19 events, 12 led to property damage, meaning the annual probability of a damaging tornado event is 63% in any given year.

Changing Future Conditions Considerations and the Impact of Climate Change

According to the 2023 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 has 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 38.5 tornadoes a year, such research is closely followed by meteorologists in the state.

Vulnerability

Vulnerability Overview

Laclede County, along with the rest of Missouri, is located in a region of the U.S. with high frequency of dangerous and destructive tornadoes referred to as "Tornado Alley **Figure 3.3131** illustrates areas where dangerous tornadoes historically have occurred.

Figure 3.31. Tornado Alley in the U.S.

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

Potential Losses to Existing Development

As stated previously, Laclede County has experienced 19 tornado events over the last 30 years causing a total of $14,700,000 in property damage. This means that over 30 years, the average annual loss from tornado damage is $490,000. Out of the 19 tornado events recorded, 15 events were ranked as at least an EF1 tornado. With probability of a tornado event during a given year being 63%, it is logical to assume that a tornado event would most likely be ranked at least an EF1, which could cause an average of $233,333 in damage.

Previous and Future Development

Development across the Laclede County and within incorporated jurisdictions increases the potential for losses. The average annual loss over the 30 year period to date is $490,000, which would stay the same if there was no additional development. Future development and population increase will increase exposure to damage.

EMAP Consequence Analysis

Table 3.17. EMAP Impact Analysis: Tornadoes

Subject	Detrimental Impacts
Public	Localized impact expected to be severe for incident areas and moderate to light for other adversely affected areas.
Responders	Localized impact expected to limit damage to personnel in the areas at the time of the incident.

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

Hazard Summary by Jurisdiction

A tornado event could occur anywhere in Laclede County, but some jurisdictions would suffer heavier damages because of the age of the housing or the high concentration of mobile homes. Lebanon is a jurisdiction at risk because it is already the most populated city with the largest amount of infrastructure. With future development plans, they face more risk to tornado events. Jurisdictions with high percentages of mobile homes will also be more at risk. Communities with structures built before 1939 are also more vulnerable to tornadoes because of high winds.

Problem Statement

Tornadoes are the most violent of all atmospheric storms and can happen quickly within any part of the county. Wind speeds can exceed 250 miles per hour and tornado paths can be miles long, causing complete destruction of anything within the path. Tornado events in Laclede County have caused 20 injuries and over $14,000,000 in damages since 1993.

The risk of injury, death, and property damage can be mitigated by the construction of FEMA safe rooms in new schools, daycares, and nursing homes. Joel E. Barber (Laclede County C-5) and Laclede County R-I School District have already constructed FEMA safe rooms to help protect the community. Any safe rooms that are open to the public will also help protect the populations living in mobile homes. Additionally, NOAA weather radios, alert applications, and public education can provide early warnings and prepare the public for what to do in case of a tornado.

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.

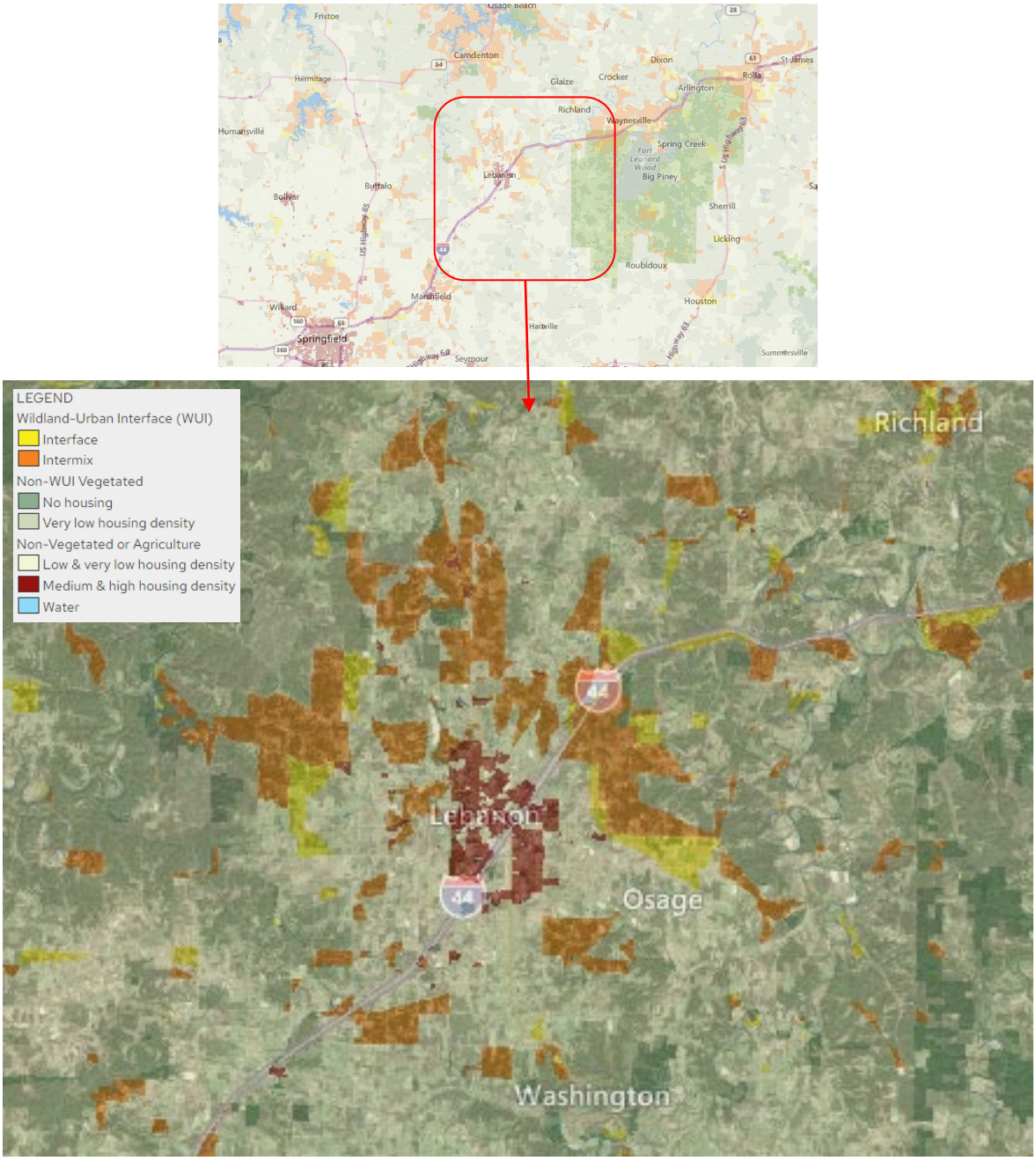
Most of Missouri fires occur during the spring season between February and May. The length and severity of wildland fires depend largely on weather conditions. Spring in Missouri is usually characterized by low humidity and high winds. These conditions result in higher fire danger. In addition, due to 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.

Figure 3.32 below shows the Wildland-Urban Interface for Laclede County. The jurisdictions that are most at risk to damage from wildfires are Lebanon and Richland. Lebanon has medium to high housing density, and is surrounded by both interface and intermix zones. Richland does not have as much housing density but also has interface and intermix zones surrounding the area. Stoutland and Phillipsburg have intermix zones near their communities as well, but smaller portions and not as much infrastructure or housing is at risk.

Figure 3.32. Wildland-Urban Interface for Laclede County, 2020



Source: https://silvis.forest.wisc.edu/data/wui-change/

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 MDC Wildfire Data, there have been 233 wildfires reported in Laclede County from 2013 to 2023. Arson and debris are two of the most common causes of the fires. Only four fires were reported as being caused by lightning. The remaining causes were classified as equipment, smoking, campfire, miscellaneous, not reported or unknown. **Table 3.1** shows the number of wildfires reported per year.

Table 3.1. Laclede County Wildfires Per Year, 2013-2023

Year	Number of Wildfires
2013	15
2014	48
2015	43
2016	36
2017	32
2018	8
2019	7
2020	4
2021	14
2022	12
2023	14

Source: Missouri Department of Conservation, https://mdc12.mdc.mo.gov/Applications/MDCFireReporting/

No schools or special districts in Laclede County reported any fire incidents that impacted their facilities.

Probability of Future Occurrence

There were a total of 233 wildfires over 11 years, meaning there is a 100% probability of future wildfire events in any given year in Laclede County. The average number of wildfire events per year is 21.2.

Changing Future Conditions Considerations and the Impact of Climate Change

According to the 2023 Missouri State Hazard Mitigation Plan, higher temperatures and changes in rainfall are unlikely to substantially reduce forest cover in Missouri, although the composition of trees

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

Additionally, stated in the 2023 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.

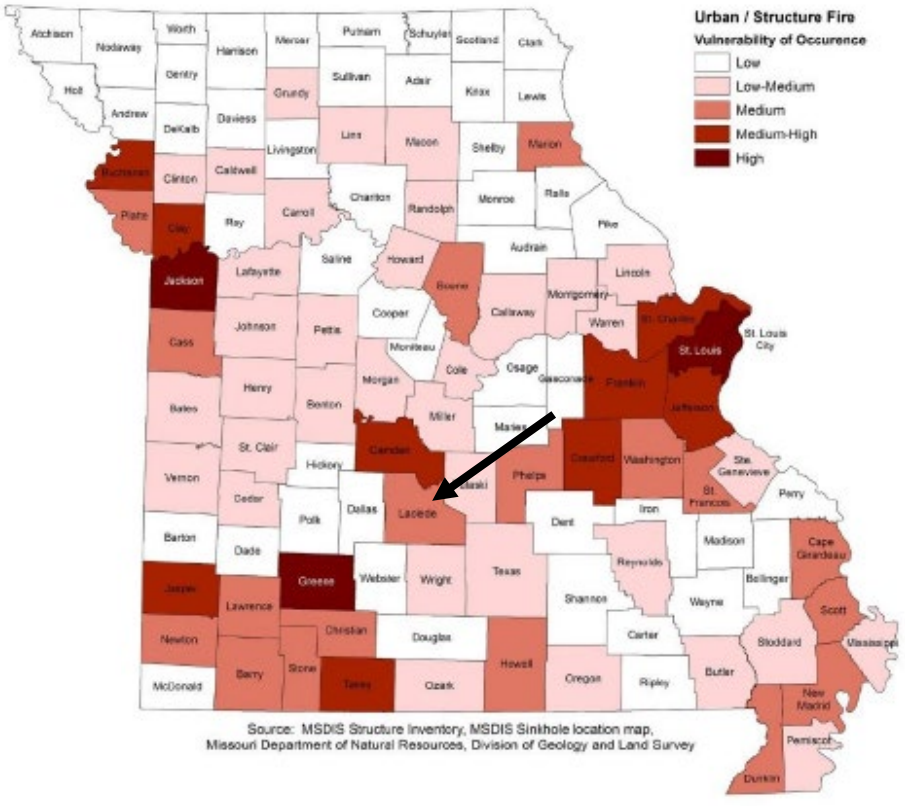
Vulnerability

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 developed land. In years of significant drought or excessive heat, the potential for a wildfire in planning area increases.

As outlined in the 2023 Missouri State Hazard Mitigation Plan, Laclede County was given a medium vulnerability rating being based on housing density, building exposure, social vulnerability, likelihood of occurrence, annual property loss, and number of deaths/injuries. The data for wildfires are insufficient due to only 60% of fire departments in Missouri reporting to the National Fire Incident Reporting System. The majority of the fire departments in the planning area are comprised of volunteers and are limited in the time spent to report information.

Figure 3.33. Vulnerability to Structural and Urban Fire



Source: 2023 Missouri State Hazard Mitigation Plan *Planning area indicated by arrow

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 has 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

It is anticipated that the City of Lebanon will be the jurisdiction hosting the most growth in the near future. The future land use plan shows residential areas spreading outside of city limits and further into the interface and intermix zones. It is expected that any WUI developments in this area will follow all necessary regulations and hopefully reduce the risk to wildfire hazards.

EMAP Consequence Analysis

Table 3.2. EMAP Impact Analysis: Wildfire

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

Hazard Summary by Jurisdiction

As discussed previously, the jurisdiction that is most likely going to grow the most in the near future is Lebanon. The city is located almost in the middle of a large region of intermix area, with interface area included as well. Further development in Lebanon will increase the exposure to wildfires, thus increase the risks associated with wildfires. Since the interface and intermix regions around Lebanon are widespread, all school districts near Lebanon are at higher risk of wildfire impacts as well. Richland is another jurisdiction that is surrounded by both interface and intermix zones. However, the greater area of interface and intermix zones surrounding Lebanon compared to Richland makes them more vulnerable, especially since this increases the chances of a fire spreading once it has been started.

Problem Statement

Wildfire events occur frequently in Laclede County and have caused significant damage in the past. Populations and structures in WUI areas of the county have an increased risk of wildfires due to the higher amount of material present. Because Lebanon sits in large interface and intermix zones, and contains the most development within the county, they are most vulnerable to wildfire hazards.

County officials and local fire departments can promote fire resistant construction materials and landscape design techniques to help mitigate the risk to wildfire in development that will most likely occur in the near future. Information about these materials and techniques are included in the MDC publication, *Living with Wildfire*. Education, outreach, and communication between government officials, emergency services, school districts, and residents can also help reduce the risks associated with wildfires.