3 RISK ASSESSMENT

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

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

This chapter is divided into four main parts:

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

3.1 HAZARD IDENTIFICATION

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

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

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

3.1.1 Review of Existing Mitigation Plans

The MPC previously developed a multi-jurisdiction Hazard Mitigation Plan dated 2016 and Pike County, Bowling Green, Clarksville, Curryville, Frankford, Louisiana participated in the multi-jurisdictional county-wide plan. The 2016 Hazard Mitigation Plan was consulted in development of the risk assessment and information included and updated where appropriate.

The MPC decided to include natural hazards and public health risks. The human-caused and technological hazards were eliminated from further analysis due to these hazards are not necessary for plans to meet the requirements of the Disaster Mitigation Act of 2000.

3.1.2 Review Disaster Declaration History

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

FEMA also issues emergency declarations, which are more limited in scope and do not include the long-term federal recovery programs of major disaster declarations. Determinations for declaration type are based on scale and type of damages and institutions or industrial sectors affected.

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

Disaster Number	Description	Declaration Date Incident Period	Individual Assistance (IA) Public Assistance (PA)
DR-198-MO	Severe Storm(s)	6/14/65-6/14/65 9/27/68	PA
DR-372-MO	Severe Storm(s)	4/19/73-4/19/73 5/23/77	PA
DR-439-MO	Flood	6/10/74-6/10/74 4/18/79	PA
DR-579-MO	Tornado	4/21/79-4/21/79 5/4/84	PA
DR-989-MO	Flood	4/15/93-5/29/93 2/12/98	PA
DR-995-MO	Flood	6/10/93-10/25/93 8/25/05	PA
DR-1412-MO	Severe Storm(s)	4/24/02-6/10/02 01/11/11	PA
DR-1463-MO	Severe Storm(s)	5/4/03-5/30/03 1/11/11	PA & IA
DR-1736-MO	Severe Storm(s)	12/6/07-12/15/07 8/27/14	PA
DR-1749-MO	Severe Storm(s)	3/17/08-5/9/08 5/21/15	PA
DR-1773-MO	Severe Storm(s)	6/1/08-8/13/08 7/30/14	PA & IA
DR-1934-MO	Severe Storm(s)	6/12/10-7/31/10 8/13/15	PA
DR-1961-MO	Severe Storm(s)	1/31/11-2/5/11 12/02/15	PA
EM-3017-MO	Drought	9/24/76-9/24/76 11/13/78	PA
EM-3232-MO	Hurricane	8/29/05-10/1/05 7/2/08	PA & IA
EM-3281-MO	Severe Ice Storm	12/8/07-12/15/07 3/15/11	PA
EM-3303-MO	Severe Ice Storm	1/26/09-1/28/09 11/8/11	PA
EM-3317-MO	Severe Storm(s)	1/31/11-2/5/11 1/6/12	PA
EM-3374-MO	Flood	12/22/15-1/9/16 6/1/21	PA & IA
EM-3482-MO	Biological (COVID-19)	1/20/20 6/1/21	PA
DR-4130-MO	Severe Storm(s)	5/29/13-6/10/13 2/14/18	PA
DR-4238-MO	Severe Storm(s)	5/15/15-7/27/15 7/12/21	PA
DR-4317-MO	Flood	4/28/17-5/11/17	PA & IA
DR-4435-MO	Flood	3/11/19-4/16/19	PA & IA
DR-4451-MO	Severe Storm(s)	4/29/19-7/5/19	PA
DR-4490-MO	Biological (COVID-19)	1/20/20	PA
DR-4612-MO	Severe Storm(s)	6/24/21-7/1/21	PA

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

3.1.3 Research Additional Sources

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

- Missouri Hazard Mitigation Plans (2010, 2013, and 2018)
- Previously approved planning area Hazard Mitigation Plan (2016)
- Federal Emergency Management Agency (FEMA)
- Missouri Department of Natural Resources
- National Drought Mitigation Center Drought Reporter
- US Department of Agriculture's (USDA) Risk Management Agency Crop Insurance Statistics
- National Agricultural Statistics Service (Agriculture production/losses)
- Data Collection Questionnaires completed by each jurisdiction
- State of Missouri GIS data
- Environmental Protection Agency
- Flood Insurance Administration
- Hazards US (Hazus)
- Missouri Department of Transportation
- Missouri Division of Fire Marshal Safety
- Missouri Public Service Commission
- National Fire Incident Reporting System (NFIRS)
- National Oceanic and Atmospheric Administration's (NOAA) National Centers for Environmental Information (NCEI);
- County and local Comprehensive Plans to the extent available
- County Emergency Management
- County Flood Insurance Rate Map, FEMA
- Flood Insurance Study, FEMA
- SILVIS Lab, Department of Forest Ecology and Management, University of Wisconsin
- U.S. Army Corps of Engineers
- U.S. Department of Transportation
- United States Geological Survey (USGS)
- Various articles and publications available on the internet (you should state that you will give citations to the sources in the body of the plan)

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

Table 3.2. Hazards Identified for Each Jurisdiction

Jurisdiction	Dam Failure	Drought	Earthquake	Extreme Temperatures	Flooding (River and Flash)	Land Subsidence/Sinkholes	Levee Failure	Severe Winter Weather	Thunderstorm/Lightning/Hail/ High Wind	Tornado	Wildfire	Pandemic
Pike County	X	X	X	X	X	X	X	X	X	X	X	X
Bowling Green	X	X	X	X	X	X	X	X	X	X	X	X
Louisiana	X	X	X	X	X	X	X	X	X	X	X	X
Clarksville	X	X	X	X	X	X	X	X	X	X	X	X
Paynesville	X	X	X	X	X	X	X	X	X	X	X	X
Annada	X	X	X	X	X	X	X	X	X	X	X	X
Frankford	X	X	X	X	X	X	X	X	X	X	X	X
Curryville	X	X	X	X	X	X	X	X	X	X	X	X
Schools and Special Districts												
Louisiana R-2	X	X	X	X	X	X	X	X	X	X	X	X
Bowling Green R-1	X	X	X	X	X	X	X	X	X	X	X	X
Pike County R-III	X	X	X	X	X	X	X	X	X	X	X	X
Boncl R-5	X	X	X	X	X	X	X	X	X	X	X	X
Mudlick Prairie Drainage District	X	X	X	X	X	X	X	X	X	X	X	X
Pike Grain Levee District	X	X	X	X	X	X	X	X	X	X	X	X

3.1.5 Multi-Jurisdictional Risk Assessment

This Hazard Mitigation Plan for Pike County is an update of the 2016 plan. This is a multi-jurisdictional plan that addresses the unincorporated area of Pike County, the seven communities within its boundaries and the four associated school districts.

The plan is set up to address each hazard with an individual profile to detail risks associated with the
hazard across the region and specifically for each jurisdiction participating. Each hazard profile will address hazard risk variations and describe variances.

Pike County is uniform in terms of climate, topography and building construction characteristics. Most of the town centers date back to the middle years of the last century with very little new construction.

The hazards that vary across the planning area in terms of risk include dam failure, flash flood, wildland fire, levee failure, and river flood. The details of these differences are recorded in each hazard profile under a separate heading. The unincorporated areas of the county have experienced limited damage from winter storms, tornadoes, thunderstorms, heat waves, drought, dam failure, and wildfires. The primary impact of natural hazards in the unincorporated areas of Pike County is to agriculture.

3.2 ASSETS AT RISK

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

3.2.1 Total Exposure of Population and Structures

Unincorporated County and Incorporated Cities

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

Table 3.3 shows the total population, building count, estimated value of buildings, estimated value of contents, and estimated total exposure to parcels for the unincorporated county and each incorporated city. For multi-county communities, the population and building data may include data on assets located outside the planning area. **Table 3.4** that follows provides the building value exposures for the county and each city in the planning area broken down by usage type. Finally, **Table 3.5** provides the building count total for the county and each city in the planning area broken out by building usage types (residential, commercial, industrial, and agricultural).

Table 3.3. Maximum Population and Building Exposure by Jurisdiction

Jurisdiction	2019 Annual Population Estimate	Building Count	Building Exposure ($)	Contents Exposure ($)	Total Exposure ($)
Annada	52	39	3,812	2,057	5,869
Bowling Green	5,516	1,543	220,065	130,922	350,987
Clarksville	432	256	36,060	23,214	59,275
Curryville	237	139	19,411	11,128	30,539
Eolia	421	236	35,312	18,935	54,247
Frankford	406	184	25,946	14,088	40,034
Louisiana	3,264	1,664	230,596	136,131	366,726
Paynesville	41	42	5,181	2,935	81,177
Unincorporated Pike County	18,511		576,912	316,667	893,579
Totals	28,880	4,103	1,153,295	656,077	1,882,433

Source: U.S. Bureau of the Census, Annual population estimates/ 5-Year American Community Survey 2019; Building Count and Building Exposure, Missouri GIS Database from SEMA Mitigation Management; Contents Exposure derived by applying multiplier to Building Exposure based on Hazus MH 2.1 standard contents multipliers per usage type as follows: Residential (50%), Commercial (100%), Industrial (150%), Agricultural (100%). For purposes of these calculations, government, school, and utility were calculated at the commercial contents rate.

Table 3.4. Building Values/Exposure by Usage Type

Jurisdiction	Residential	Commercial	Industrial	Agricultural	Total
Annada	3,407	354		51	3,812
Bowling Green	161,826	44,755	939	23	207,543
Clarksville	25,683	10,260		5	35,948
Curryville	14,021	3,892		33	17,946
Eolia	25,289	5,838		14	31,141
Frankford	21,227	3,361		5	24,593
Louisiana	183,316	40,863	1,879	28	226,086
Paynesville	4,455	708		19	5,182
Unincorporated Pike County	484,299	30,426	27,660	24489	566,874
Totals	923,524	140,455	30,478	24666	1,119,123

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
Annada	26	2		11	39
Bowling Green	13				13
Clarksville	18	26			44
Louisiana	66	43		2	111
Paynesville	2				2

Unincorporated Pike County	167	9	15	106	297
Totals	292	80	15	119	506

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

Even though schools and special districts' total assets are included in the tables above, additional discussion is needed, based on the data that is available from the districts' completion of the Data Collection Questionnaire and district-maintained websites. The number of enrolled students at the participating public school districts is provided in **Table 3.6** below. Additional information includes the number of buildings, building values (building exposure) and contents value (contents exposure). These numbers will represent the total enrollment and building count for the public school districts regardless of the county in which they are located.

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

Public School District	Enrollment	Building Count
Bowling Green R-I	1,410	14
Louisiana R-II	716	3
Pike County R-III	431	5

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

3.2.2 Critical and Essential Facilities and Infrastructure

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

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

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

- Mark Twain Regional Council of Governments

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
Pike County						1		1			1					1								4
Louisiana							1	1	1	1		1		1		1	1	1	1	2			1	13
Bowling Green	1		3			1	1	1	1	4		2		1	2	1	1	1	1	2			1	24
Clarksville							1	1		1							1						1	5
Paynesville								1																1
Frankford																				1				1
Curryville			1				1	1										1					1	5
Totals																								

Source: Missouri 2018 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. Pike County Bridges

County	Count	# Str Def	# Func Obs	Total Def	Area	Stru Def Area	Func Obs Area	Total Def Area
Pike	226	49	11	60	60,197	13,331	1,387	14,719

Source: www.fhwa.dot.gov/bridge/nbi/no10/county15b.cfm#mo

3.2.3 Other Assets

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

- These types of resources warrant a greater degree of protection due to their unique and irreplaceable nature and contribution to the overall economy.
- Knowing about these resources in advance allows for consideration immediately following a hazard event, which is when the potential for damages is higher.
- The rules for reconstruction, restoration, rehabilitation, and/or replacement are often different for these types of designated resources.
- The presence of natural resources can reduce the impacts of future natural hazards, such as wetlands and riparian habitats which help absorb floodwaters.

- Losses to economic assets like these (e.g., major employers or primary economic sectors) could have severe impacts on a community and its ability to recover from disaster.

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

Table 3.8. Threatened and Endangered Species in Pike County

Common Name	Scientific Name	Status
Indiana Bat	Myotis sodalist	Endangered
Gray Bat	Myotis grisecens	Endangered
Northern Long-Eared Bat	Myotis septentrionalis	Threatened
Decurrent False-Aster Fat Pocketbook	Boltonia decurrens Potamius capax	Threatened
Sheepnose Mussel	Plethobasus cyphuys	Endangered
Fat Pocketbook	Potamilus capax	Endangered

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

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

Table 3.9. Parks in and Conservation Areas in Pike County

Park / Conservation Area	Address	City
Dupont Reservation CA	Hwy 79 to Route TT	Ashburn
Prairie Slough CA	Route P	Elsberry
Ranacker CA	Route RA West	Frankford
Ted Shanks CA	Hwy 79 and Route TT	Ashburn
Ashley Access	Hwy 161	Bowling Green
Louisiana Access	Georgia Street	Louisiana
Calument Creek Access	Hwy 79 North	Clarksville
Clarence Cannon National Refuge	County Road 206	Annada
Jack Floyd Memorial Lake	County Road 282	Bowling Green
West Lake	County Road 282	Bowling Green
Clarksville Riverfront Park	One Block West of Hwy 79	Clarksville
Sunset Park	Georgia Street	Louisiana
VFW Park	Fairgrounds Road	Louisiana
Riverview Park	North Main	Louisiana
Bowling Green City Park	South Court	Bowling Green
15^{th} Street Park	15^{th} Street	Bowling Green
Visitors Center Park	Hwy 61/161	Bowling Green
Frankford City Park	Main Street	Frankford
Riverfront Park	First Street	Clarksville
City Park	Main Street	Curryville

Source: http://mdc7.mdc.mo.gov/applications/moatlas/AreaList.aspx?txtUserID=guest&txtAreaNm=s
The best source for park information is usually county and community websites.

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

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

Property	Address	City	Date Listed
Charles Bacon House	819 Kentucky St.	Louisiana	7/19/1990
Captain George & Attella Bernard House	2109 Georgia St.	Louisiana	2009
Bethel Chapel AME Church	Jct. of 6th and Tennessee Sts.	Louisiana	7/28/1995
City Market	125 S. Main St.	Louisiana	3/23/2005
James Beauchamp Clark House	204 E Champ Clark Dr.	Bowling Green	12/08/1976
Clarksville Historic District	Lewis, Front, Virginia and 3rd Sts.	Clarksville	5/09/1991
Clifford-Wirick House	105 S 2nd St.	Clarksville	7/09/1984
George Street Historic District	Georgia St. between Main and Seventh	Louisiana	5/06/1987
Goodman-Stark House	601 N 3rd St.	Louisiana	10/22/1994
Griffith-McCune Farmstead Historic District	MO WW E of jct. with MO D	Eolia	8/18/1992
Louisiana Chicago and Alton Railroad Depot	801 S Third St.	Louisiana	6/07/2006
Louisiana Public Library	121 N Third St.	Louisiana	4/12/1996
Luce-Dyer House	220 N 3rd St.	Louisiana	9/23/1982
Meloan, Cummins and Co., General Store	Jct. of Middle and Water Sts.	Paynesville	6/24/1993
North Third Street Historic District	Georgia, Noyes, North Third and North	Louisiana	8/24/2005
Northern Methodist Episcopal Church of	309 Smith St.	Clarksville	5/09/1991
Pike County Hospital	2407 West Georgia St.	Louisiana	9/19/2006
St. John's Episcopal Church (Old)	0.25 mile N of Eolia on CR D, and 0.25 mile E on CR H	Eolia	7/08/1970
Stark, Gov. Lloyd Crow, House and Carriage	1401 Georgia St.	Louisiana	12/21/1987
Turner-Pharr House	101 N 4th St.	Clarksville	5/09/1991

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

Economic Resources: Major non-government employers in the planning area (**Table 3.11**).

Table 3.11. Major Non-Government Employers in Pike County

Employer Name	Main Locations	Product or Service	Employees
True Manufacturing	Bowling Green	Refrigeration Products	370
Wal-Mart	Bowling Green	General Merchandise	200
Dyno Nobel	Louisiana	Chemical Manufacturing	50-99
All Parts	Louisiana	After-market Auto Parts	125
Daffron	Bowling Green	Computer Software	59
Stark Brothers	Bowling Green	Nursery	250
Fifth Gear	Louisiana	Outsourcing, Order	140
Trailer Man Trailers	Louisiana	Trailers	50

Calument	Louisiana	Petroleum Refining	150-250

Source: Data Collection Questionnaires; local Economic Development Commissions

Agriculture

Agriculture plays a major role in the Pike County economy and one of the major employers is a supplier to the agriculture economy. Information can be found in **Table 3.12.**

Table 3.12. Agriculture-Related Jobs in Pike County

Item		Pike
Total income from farm-related sources, gross before taxes and expenses (see text)	farms, 2012	485
	2007	372
	$1,000, 2012	18,899
	2007	4,780
Average per farm	dollars, 2012	38,967
	2007	12,848
Customwork and other agricultural services	farms, 2012	84
	2007	56
	$1,000, 2012	1,001
	2007	705
Gross cash rent or share payments (see text)	farms, 2012	179
	2007	143
	$1,000, 2012	2,318
	2007	1,708
Sales of forest products, excluding Christmas trees, short rotation woody crops, and maple products	farms, 2012	32
	2007	18
	$1,000, 2012	163
	2007	146
Agri-tourism and recreational services	farms, 2012	12
	2007	12
	$1,000, 2012	23
	2007	61
Patronage dividends and refunds from cooperatives	farms, 2012	183
	2007	176
	$1,000, 2012	453
	2007	365
Crop and livestock insurance payments	farms, 2012	173
	2007	103
	$1,000, 2012	14,493
	2007	1,639
Amount from state and local government agricultural program payments	farms, 2012	14
	2007	13
	$1,000, 2012	61
	2007	28
Average per farm	dollars, 2012	4,372
	2007	2,154
Other farm-related income sources (see text)	farms, 2012	24
	2007	21
	$1,000, 2012	385
	2007	127

3.3 LAND USE AND DEVELOPMENT

3.3.1 Development Since Previous Plan Update

Population data can sometimes be used to determine the potential for future development. An increase in population will spur a need for additional housing and attract commercial development.

Table 3.13. County Population Growth, 2000-2010

Jurisdiction	Total Population 2000	Total Population 2010	2000-2010 # Change	2000-2010 % Change
Pike County	18,516	18,314	202	1%
Louisiana	3,364	3,863	-499	-14%
Bowling Green	5,334	3,260	2,074	38%
Clarksville	442,	490	-48	-9.7%
Annada	29	48	-19	-39.5%
Paynesville	77	91	-14	-15.8%
Frankford	323	351	-28	-7.9%
Curryville	225	251	-26	-10.3%

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

Table 3.14. Change in Housing Units, 2000-2010

Jurisdiction	Housing Units 2010	Housing Units 2000	2000-2010 # Change	2000-2010 % Change
Pike County	7,875	7,493	382	4.8%
Louisiana	1,667	1,843	-176	-9.5%
Bowling Green	1,445	1,290	155	10%
Clarksville	294	278	-16	-5.7%
Annada	28	25	3	10.7%
Paynesville	28	35	-7	20%
Frankford	222	179	43	19.3%
Curryville	140	128	12	8.5%

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

Population growth or decline is generally accompanied by increases or decreases in the number of housing units. With the trend of population increase for the entire county there is reason to expect increased development.

3.3.2 Future Land Use and Development

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

School District's Future Development

The Louisiana R-II School District has recently constructed a new bus barn and does not plan to make any additional improvements. The Bowling Green R-I School District recently completed an addition to an already established structure and is planning to build a new Maintenance Building in the Spring of 2022. The Pike County R-III School District recently reconstructed a building that was lost in a fire and plans to make several improvements in the next few years including the construction of additional facilities and a greenhouse.

Special District's Future Development

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

3.4 HAZARD PROFILES, VULNERABILITY, AND PROBLEM STATEMENTS

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

Hazard Profiles

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

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

- **Hazard Description:** This section consists of a general description of the hazard and the types of impacts it may have on a community or school/special district.
- **Geographic Location:** This section describes the geographic areas in the planning area that are affected by the hazard. Where available, use maps to indicate the specific locations of the planning area that are vulnerable to the subject hazard. For some hazards, the entire planning area is at risk.
- **Strength/Magnitude/Extent:** This includes information about the strength, magnitude, and extent of a hazard. For some hazards, this is accomplished with description of a value on an established scientific scale or measurement system, such as an EF2 tornado on the Enhanced Fujita Scale. This section should also include information on the typical or expected strength/magnitude/extent of the hazard in the planning area. Strength, magnitude, and extent can also include the speed of onset and the duration of hazard events. Describing the strength/magnitude/extent of a hazard is not the same as describing its potential impacts on a community. Strength/magnitude/extent defines the characteristics of the hazard regardless of the people and property it affects.
- **Previous Occurrences:** This section includes available information on historic incidents and their impacts. Historic event records form a solid basis for probability calculations.
- **Probability of Future Occurrence:** The frequency of recorded past events is used to estimate the likelihood of future occurrences. Probability can be determined by dividing the number of recorded events by the number of years of available data and multiplying by 100. This gives the percent chance of the event happening in any given year. For events occurring more than once annually, the probability should be reported as 100% in any given year, with a statement of the average number of events annually. For hazards such as drought that may have gradual onset and extended duration, probability can be based on the number of months in drought in a given time-period and expressed as the probability for any given month to be in drought.
- **Changing Future Conditions Considerations:**

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

Vulnerability Assessments

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

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

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

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

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

Following the hazard profile for each hazard will be the vulnerability assessment. The vulnerability assessment further defines and quantifies populations, buildings, critical facilities, and other community assets at risk to damages from natural hazards. The vulnerability assessments should be based on the best available data. The vulnerability assessments can also be based on data that was collected for the 2018 State Hazard Mitigation Plan Update. With the 2018 Hazard Mitigation Plan Update, SEMA is pleased to provide online access to the risk assessment data and associated mapping for the 114 counties in the State, including the independent City of St. Louis. Through the web-based Missouri Hazard Mitigation Viewer, local planners or other interested parties can obtain all State Plan datasets. This effort removes from local mitigation planners a barrier to performing all the needed local risk assessments by providing the data developed during the 2018 State Plan Update.

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

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

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

- Other sources as cited.

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

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

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

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

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

Problem Statements

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

3.4.1 Flooding (Riverine and Flash)

Hazard Profile

Hazard Description

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

Flooding caused by dam and levee failure is discussed in Section 3.4.4 and Section 3.4.2 respectively. It will not be addressed in this section.

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

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

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

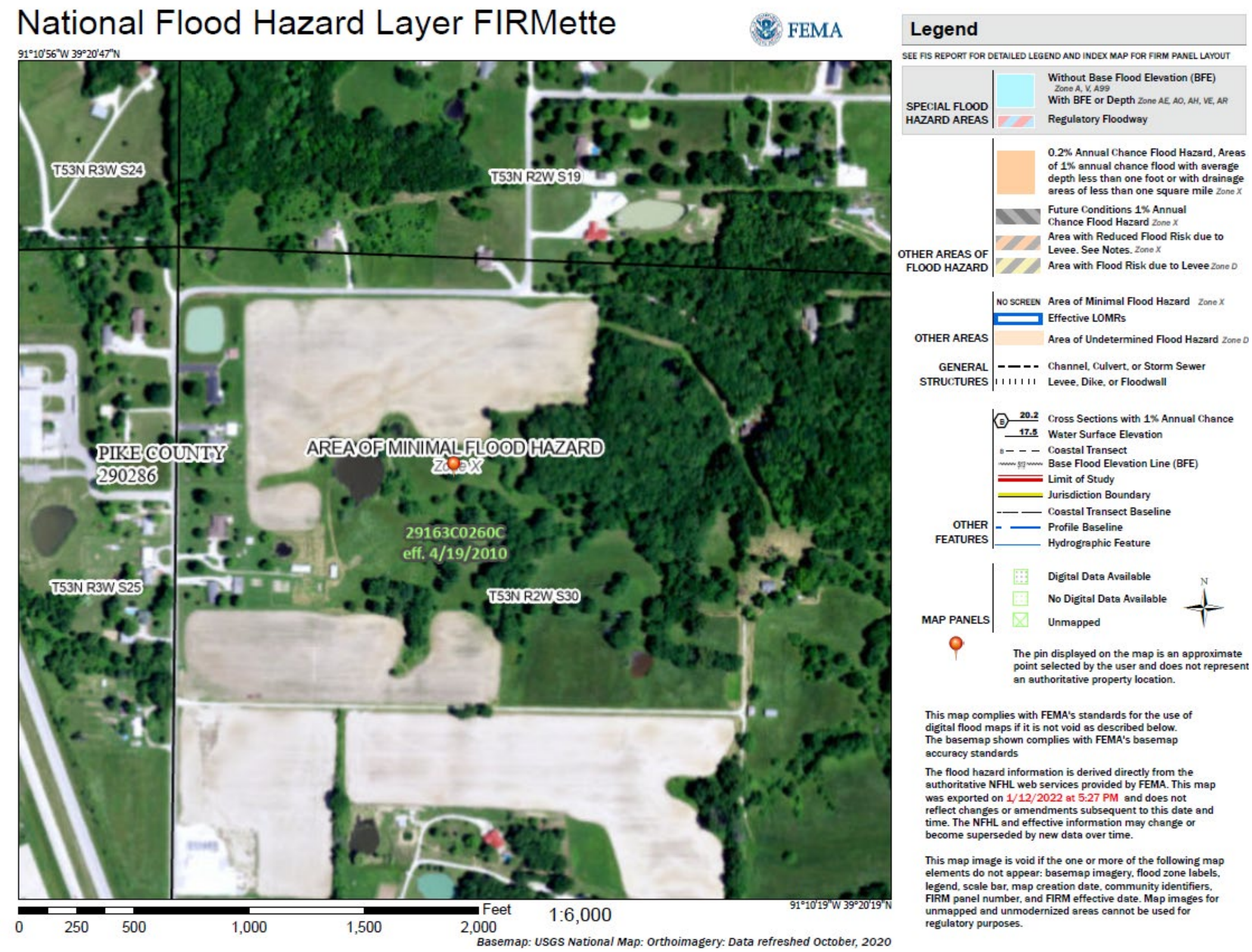
Most flash flooding is caused by slow-moving thunderstorms or thunderstorms repeatedly moving over the same area. Flash flooding is a dangerous form of flooding which can reach full peak in only a few minutes. Rapid onset allows little or no time for protective measures. Flash flood waters move at very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

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

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

Geographic Location

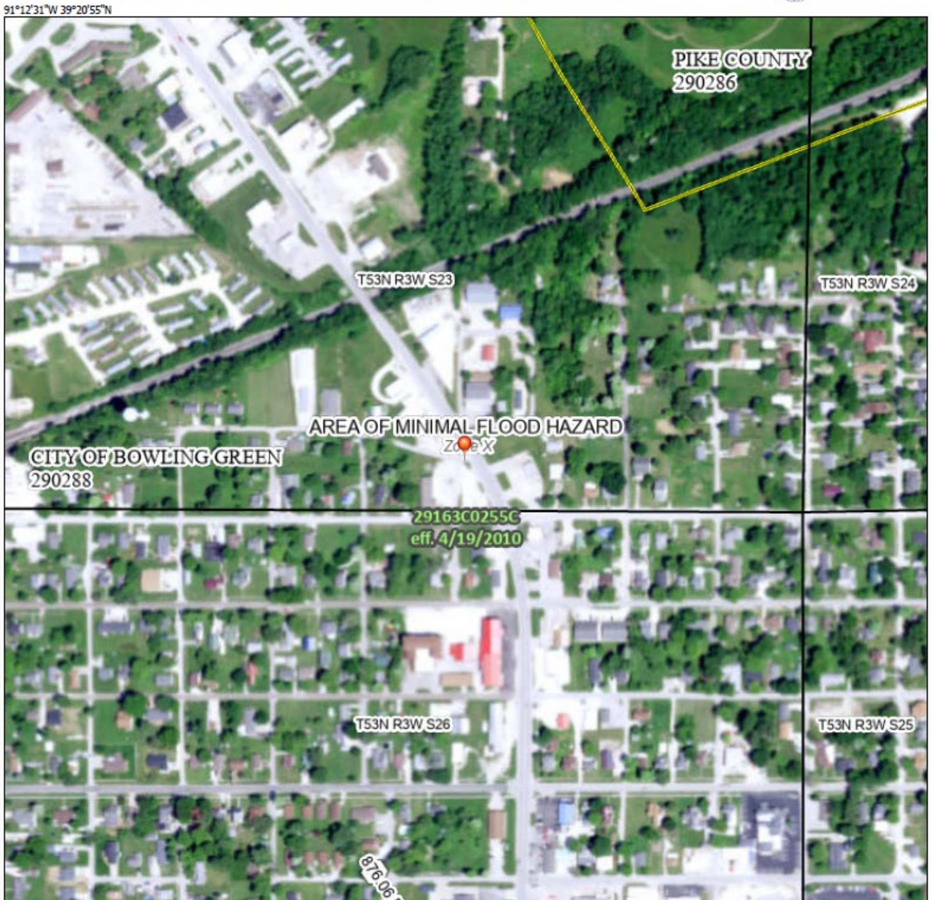
Riverine flooding is most likely to occur in SFHA's. NCEI data includes events for flooding and for flash flooding. In order to obtain information for the following tables, consult event narratives. Those events without location-specific information will be tabulated under "unspecified" locations in the table. Generally, using a 20-year time frame for previous events is adequate. However, where flooding records are scanty, as many years as needed will be used for a solid probability calculation.



National Flood Hazard Layer FIRMette

FEMA

91°12'31"W 39°20'55"N



91°11'54"W 39°20'27"N

0 250 500 1,000 1,500 2,000 Feet

1:6,000

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

Legend

SEE FIS REPORT FOR DETAILED LEGEND AND INDEX MAP FOR FIRM PANEL LAYOUT

SPECIAL FLOOD HAZARD AREAS
- Without Base Flood Elevation (BFE) *Zone A, V, A99*
- With BFE or Depth *Zone AE, AO, AH, VE, AR*
- Regulatory Floodway

OTHER AREAS OF FLOOD HAZARD
- 0.2% Annual Chance Flood Hazard, Areas of 1% annual chance flood with average depth less than one foot or with drainage areas of less than one square mile *Zone X*
- Future Conditions 1% Annual Chance Flood Hazard *Zone X*
- Area with Reduced Flood Risk due to Levee. See Notes. *Zone X*
- Area with Flood Risk due to Levee *Zone D*

OTHER AREAS
- NO SCREEN Area of Minimal Flood Hazard *Zone X*
- Effective LOMRs
- Area of Undetermined Flood Hazard *Zone D*

GENERAL STRUCTURES
- Channel, Culvert, or Storm Sewer
- Levee, Dike, or Floodwall

OTHER FEATURES
- 20.2 Cross Sections with 1% Annual Chance
- 17.5 Water Surface Elevation
- Coastal Transect
- Base Flood Elevation Line (BFE)
- Limit of Study
- Jurisdiction Boundary
- Coastal Transect Baseline
- Profile Baseline
- Hydrographic Feature

MAP PANELS
- Digital Data Available
- No Digital Data Available
- Unmapped

N

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

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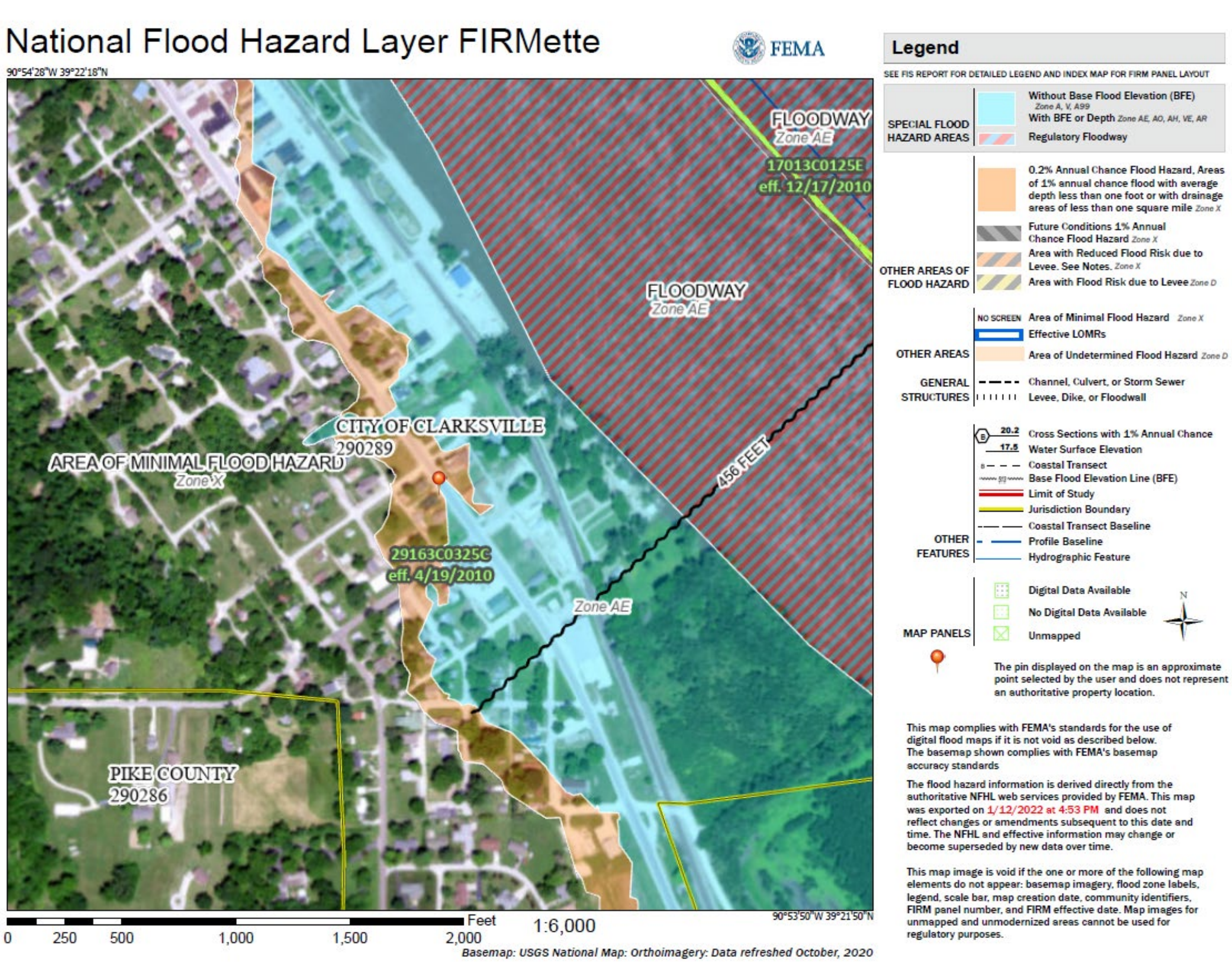
National Flood Hazard Layer FIRMette
FEMA
90°54'28"W 39°22'18"N
FLOODWAY
Zone AE
17013C0125E
eff. 12/17/2010
FLOODWAY
Zone AE
CITY OF CLARKSVILLE
290289
AREA OF MINIMAL FLOOD HAZARD
Zone X
456 FEET
29163C0325C
eff. 4/19/2010
Zone AE
PIKE COUNTY
290286
90°53'50"W 39°21'50"N
Feet
0 250 500 1,000 1,500 2,000
1:6,000
Basemap: USGS National Map: Orthoimagery: Data refreshed October, 2020
Legend
SEE FIS REPORT FOR DETAILED LEGEND AND INDEX MAP FOR FIRM PANEL LAYOUT
SPECIAL FLOOD HAZARD AREAS
Without Base Flood Elevation (BFE) Zone A, V, A99
With BFE or Depth Zone AE, AO, AH, VE, AR
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Limit of Study
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MAP PANELS
Digital Data Available
No Digital Data Available
Unmapped
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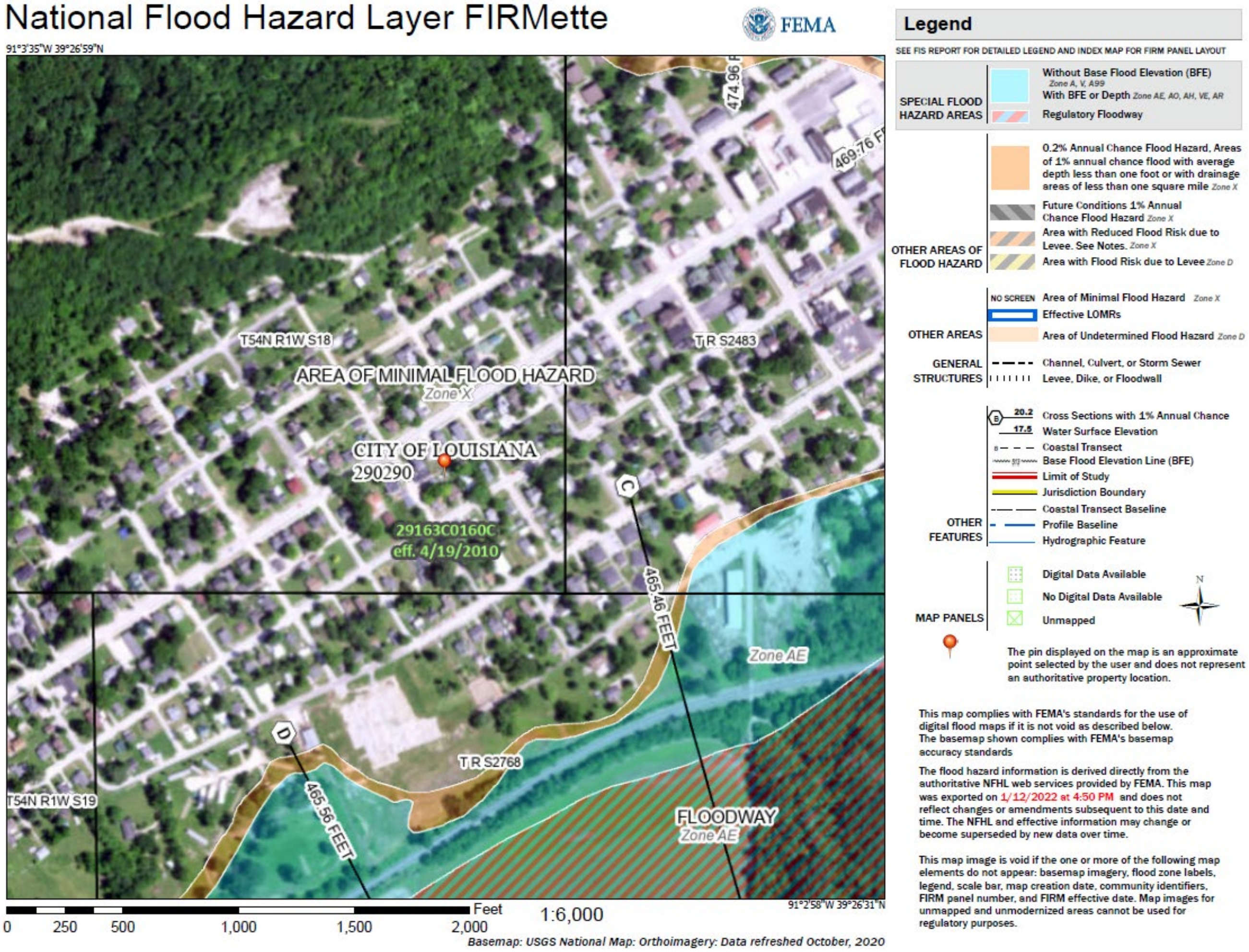
National Flood Hazard Layer FIRMette



National Flood Hazard Layer FIRMette

FEMA

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

Legend

SEE FIS REPORT FOR DETAILED LEGEND AND INDEX MAP FOR FIRM PANEL LAYOUT

SPECIAL FLOOD HAZARD AREAS
- Without Base Flood Elevation (BFE) *Zone A, V, A99*
- With BFE or Depth *Zone AE, AO, AH, VE, AR*
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- Area with Flood Risk due to Levee *Zone D*

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- Effective LOMRs
- Area of Undetermined Flood Hazard *Zone D*

GENERAL STRUCTURES
- Channel, Culvert, or Storm Sewer
- Levee, Dike, or Floodwall

OTHER FEATURES
- B 20.2 / 17.5 Cross Sections with 1% Annual Chance Water Surface Elevation
- 8 Coastal Transect
- 513 Base Flood Elevation Line (BFE)
- Limit of Study
- Jurisdiction Boundary
- Coastal Transect Baseline
- Profile Baseline
- Hydrographic Feature

MAP PANELS
- Digital Data Available
- No Digital Data Available
- Unmapped

N

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National Flood Hazard Layer FIRMette

FEMA

91°4'35"W 39°26'13"N

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

Legend

SEE FIS REPORT FOR DETAILED LEGEND AND INDEX MAP FOR FIRM PANEL LAYOUT

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MAP PANELS
- Digital Data Available
- No Digital Data Available
- Unmapped

N

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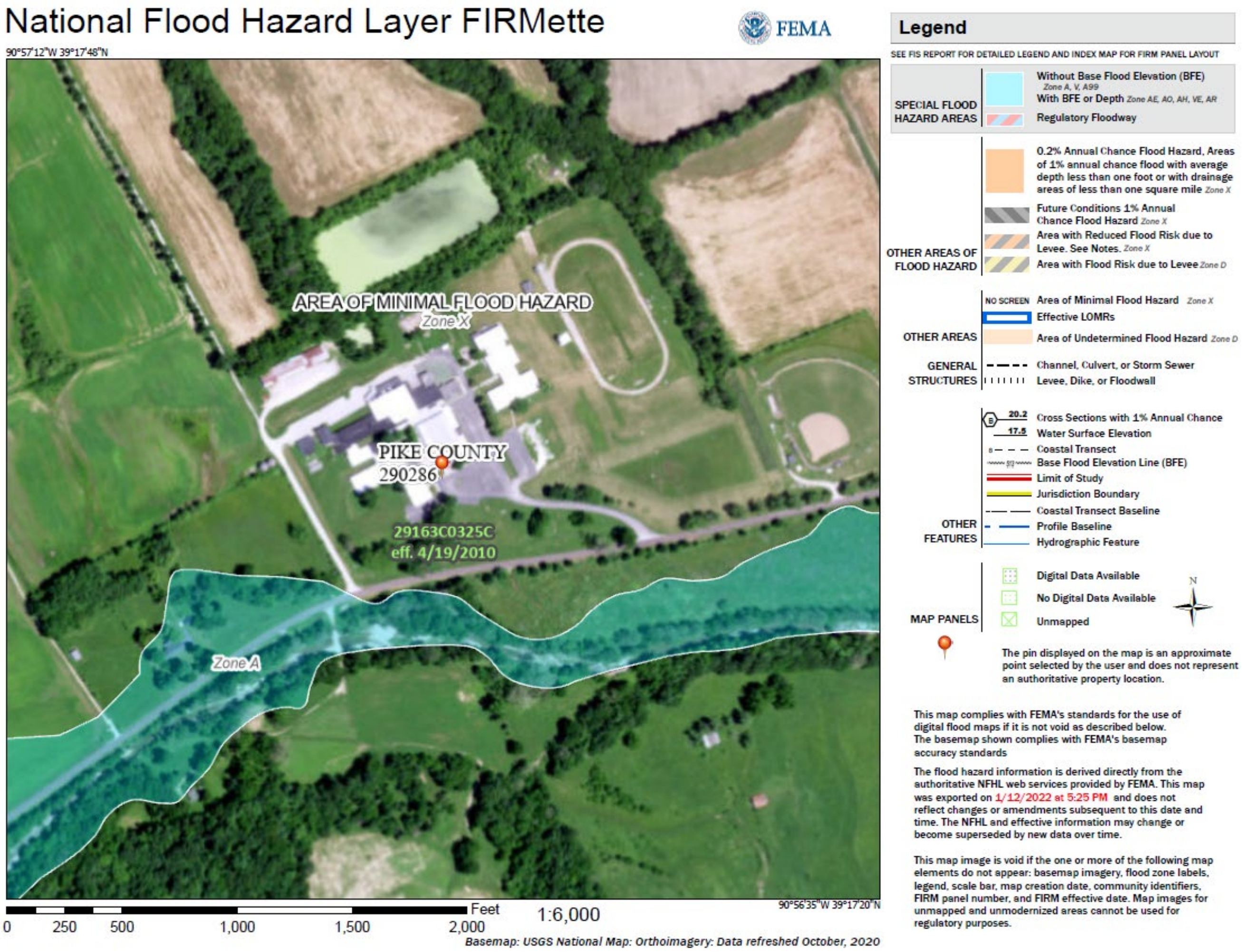


Table 3.15. Pike County NCEI Flood Events by Location, 2001-2021

Location	# of Events
Unincorporated County	9
-Unincorporated County- 2 flood events	
-Unincorporated County (Hope)- 4 flood events	
-Unincorporated County (Busch)- 3 flood events	
Clarksville	1
Louisiana	1

Source: National Centers for Environmental Information, 9/26/21

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

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

Location	# of Events
Unincorporated County	9
-Unincorporated County - 5 flood events	

-Unincorporated County (Estes)- 1 flood events	
-Unincorporated County (Spencerburg)- 1 flood events	
-Unincorporated County (Busch)- 1 flood events	
-Unincorporated County (Stark)- 1 flood events	
Annada	2
Frankford	1

Source: National Centers for Environmental Information, 9/26/21

Strength/Magnitude/Extent

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

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

National Flood Insurance Program (NFIP) Participation

Table 3.17. NFIP Participation in Pike County

Community ID #	Community Name	NFIP Participant (Y/N/Sanctioned)	Current Effective Map Date	Regular-Emergency Program Entry Date
290287	Annada	Y	4/19/10	11/19/86
290288	Bowling Green	Y	4/19/10	05/02/77
290289	Clarksville	Y	4/19/10	04/01/77
290290	Louisiana	Y	4/19/10	04/03/78
290286	County of Pike	Y	4/19/10	05/01/89
290588	Eolia	Y	4/19/10	03/26/77
290593A	Frankford	Y	4/19/10	01/07/78
290233	Paynesville	Y	4/19/10	04/19/11

Source: NFIP Community Status Book, 09/26/21; BureauNet, http://www.fema.gov/national-flood-insurance-program/national- flood-insurance-program-community-status-book; M= No elevation determined – all Zone A, C, and X: NSFHA = No Special Flood Hazard Area; E=Emergency Program

Table 3.18. NFIP Policy and Claim Statistics as of 09/26/21

Community Name	Policies in Force	Insurance in Force	Closed Losses	Total Payments
Annada	10	$474,100	56	$574,789
Bowling Green	2	$195,000	2	$3,312
Clarksville	34	$4,127,200	146	$1,311,385
Louisiana	31	$2,649,900	149	$1,877,175
County of Pike	61	$6,189,100	462	$4,348,869

Source: NFIP Community Status Book, [insert date]; BureauNet, http://bsa.nfipstat.fema.gov/reports/reports.html; *Closed Losses are those flood insurance claims that resulted in payment. Loss statistics are for the period from [date] to [date].

The City of Louisiana had the most insurance payments with those payments totaling $1,877,175.

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 86 repetitive loss properties. As of 12/7/2021, 8 properties have been mitigated, leaving 78 un-mitigated repetitive loss properties.

Table 3.19. Pike County Repetitive Loss Properties

Jurisdiction	# of Properties	Type of Property	# Mitigated	Building Payments	Content Payments	Total Payments	Average Payment	# of Losses
Clarksville	20	Residential	2	1,242,016	65,763	1,307,780	65,389	101
Pike County	50	Residential	6	3,169,211	316,687	3,485,898	69,717	311
Annada	2	Residential	0	116,315	1,455	117,770	58,885	12
Louisiana	14	Residential	0	1,222,584	288,656	1,511,241	107,945	90

Source: Flood Insurance Administration as of 12/7/2021

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

Pike County has 24 Severe Repetitive Loss properties classified as residential, business, or other properties. There are currently 275 total losses.

Previous Occurrences

<u>Presidential Flooding Disaster Declarations-</u>

June 1974- (DR-439) Federal Disaster declaration was issued for Pike County for flooding.

May 11, 1993- (DR-989) A Federal Disaster declaration was issued for Pike County for flooding from April 15, 1993 to May 29, 1993.

July 9, 1993- (DR-995) A Federal Disaster declaration was issued for Pike County for flooding from June 10, 1993 to October 25, 1993.

January 2, 2016- (DR-3374) A Federal Disaster declaration was issued for Pike County and other counties in Missouri for flooding from December 22, 2015 to January 9, 2016.

Table 3.20. NCEI Pike County Flash Flood Events Summary, 2010-2021

Year	# of Events	# of Deaths	# of Injuries	Property Damages	Crop Damages
2015	1	0	0	0.00	0.00
2017	1	0	0	0.00	0.00
2019	1	0	0	0.00	0.00

Source: NCEI, data accessed 12/7/2021

Table 3.21. NCEI Pike County Riverine Flood Events Summary, 2010-2021

Year	# of Events	# of Deaths	# of Injuries	Property Damages	Crop Damages
2013	3	0	0	25.0K	23.0K

Source: NCEI, 12/7/21

04/12/2013 - The Mississippi River rose to major flood levels along the border of Pike County. The river crested on the 22nd but remained above flood stage into May. The City of Clarksville, with the help of the Missouri National Guard and many volunteers, was able to build a sandbag wall to protect the downtown business district. Thus, damage was limited to some flooded roads, a few outbuilding in the flood plain, and agricultural lowlands.

05/01/2013 - The Mississippi River remained in flood through May along the border of Pike County. The river started at major flood levels, dropped some into the middle of the month, then rose again to major levels at the end of May. The town most affected was Clarksville. Sandbagging efforts by the National Guard and volunteers were successful in keeping the downtown area mostly dry.

06/01/2013 - The Mississippi River started June in flood and hit major flood levels cresting on the 1st. The river fell the rest of the month but remained in flood into July. Damage was mainly limited to some flooded roads and flooded farmland. Residents of Clarksville once again used the National Guard and volunteers to build a sandbag wall to keep the downtown business district dry.

Probability of Future Occurrence

With the extensive history of flooding in the planning area in the past 30 years, it is highly likely that flooding of various levels will continue to occur frequently. The probability of a flood event occurring in the planning area in any given year if 70%. Flash floods occur often in the planning area and have a 60% probability of occurring in any given year.

Changing Future Conditions Considerations

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

Vulnerability

Vulnerability Overview

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

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

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

Potential Losses to Existing Development

The existing development along the Mississippi River in Pike County includes the towns of Louisiana, Clarksville and Annada. The potential losses could include businesses, government buildings, homes. In un-incorporated Pike County, there is a potential loss of cropland, farms and homes.

Impact of Previous and Future Development

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

Hazard Summary by Jurisdiction

All of the communities can be impacted by flooding of major roads and low water crossings in the areas proximate to their corporate limits. Several incorporated areas in the county are susceptible to street flooding during periods of heavy rain as evidenced by the previous occurrences by location. The floodplain map in the geographic section shows the greatest risk to be along the Mississippi River and Salt River. The Salt River is flood controlled, but if a disaster at Clarence Cannon Dam ever happened a tragic event would take place along the Salt River with loss of life, damage to homes, businesses and cropland. The jurisdictions of Louisiana, Annada and Clarksville are at the greatest risk of damage from flooding due to their location along the Mississippi River. Businesses, government buildings and residential properties and lives would be impacted in a high flood event.

Problem Statement

Flooding or flash flooding has affected every community in Pike County which has impacted homes and business, not everyone utilizes social media or texting, Louisiana and Clarksville sits along the Mississippi river which is prone to flooding and education is deficient in what to do in the event of a flood. Possible solutions are to increase the education to residents, promote the use of social media or texting and work with officials to identify flood prone areas.

3.4.2 Levee Failure

Hazard Profile

Hazard Description

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

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

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

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

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

Geographic Location

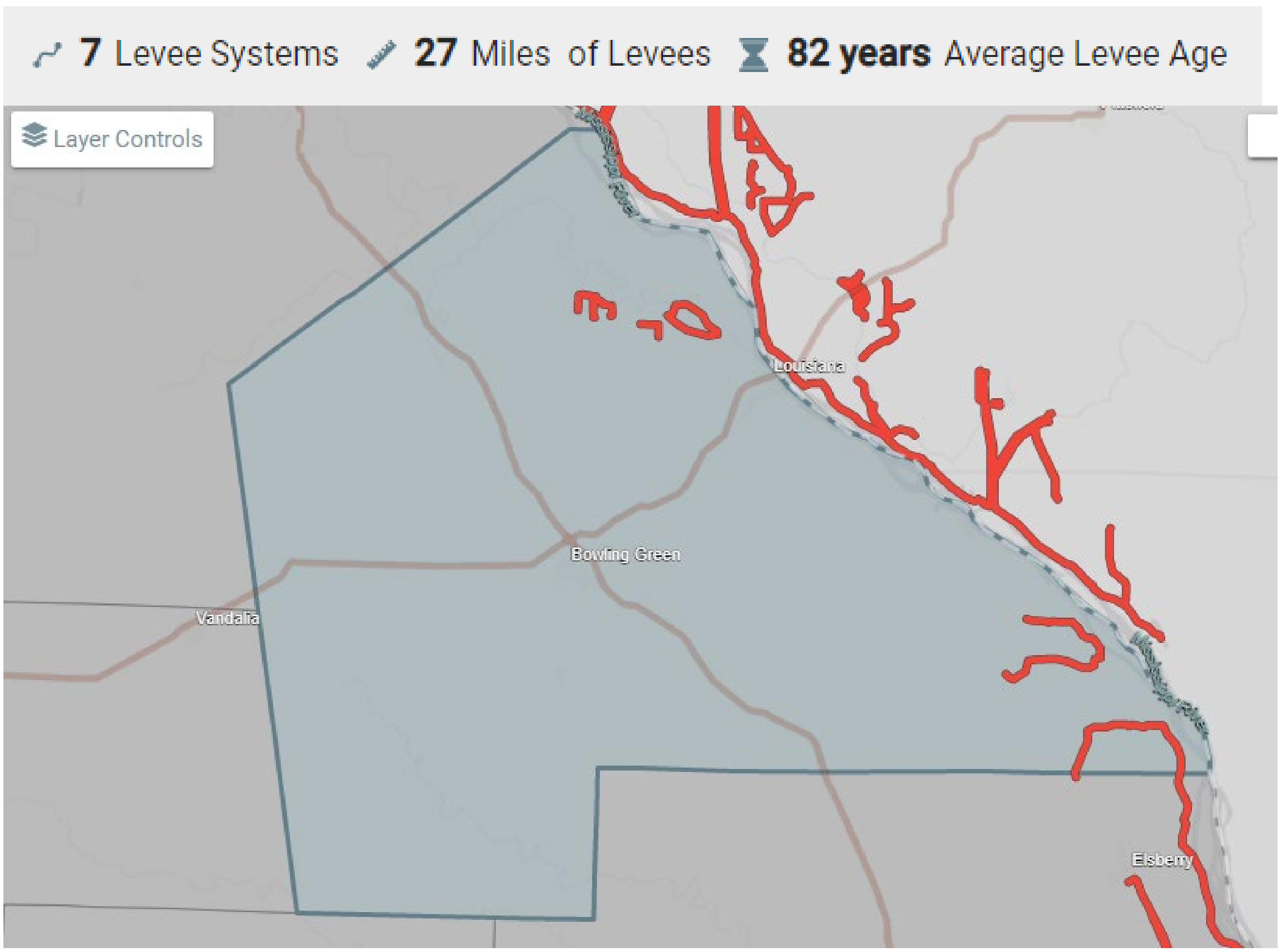
Missouri is a state with many levees. Currently, there is no single comprehensive inventory of levee systems in the state. Levees have been constructed across the state by public entities and private entities with varying levels of protection, inspection oversight, and maintenance. The lack of a comprehensive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

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

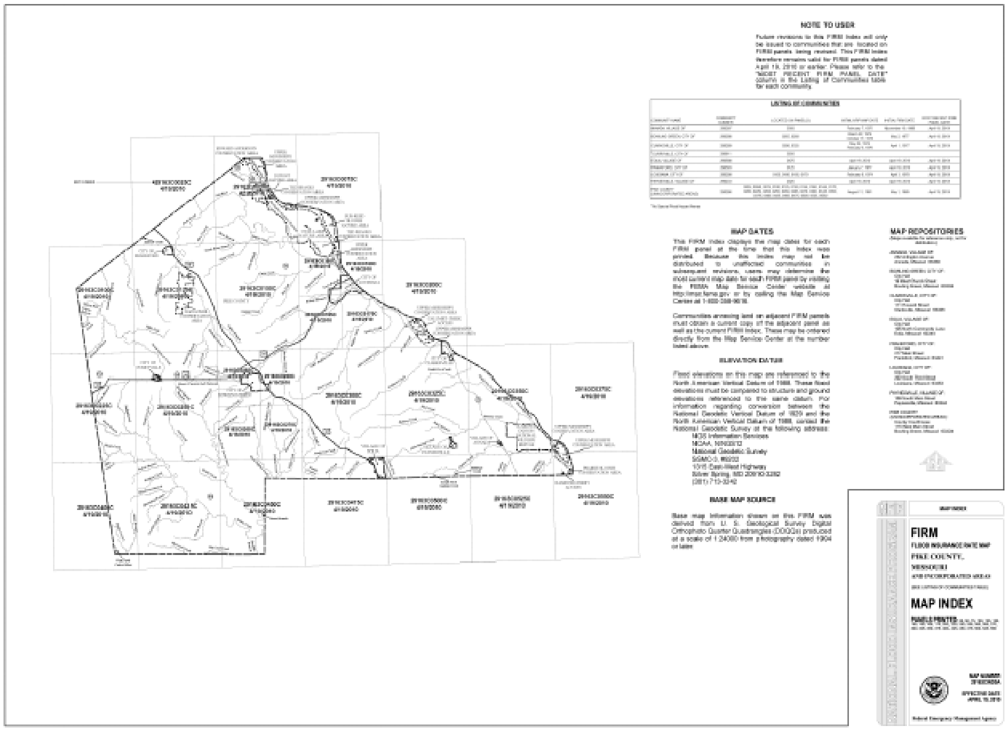
It is likely that agricultural levees and other non-regulated levees within the planning area exist that are not inventoried or inspected. These levees that are not designed to provide protection from the 1-percent annual chance flood would overtop or fail in the 1-percent annual chance flood scenario.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

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

Figure 3.2. Pike County Levees Shown on DFIRM as Providing Protection from the 1-Percent Annual Chance Flood



Source: https://levees.sec.usace.army.mil/#



Source: FEMA Flood Insurance Rate Map, 9/26/21

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

There were no breaches to U.S. Army Corps of Engineers levees operated or built in the planning area.

Probability of Future Occurrence

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

Changing Future Conditions Considerations

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

Vulnerability

Vulnerability Overview

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

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

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

Figure 3.3. 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.

The U.S. Army Corp of Engineers rated one (1) levee in Pike County as unacceptable.

Potential Losses to Existing Development

Levees have been constructed across the planning area by public entities and private entities with varying levels of protection, inspection oversight and maintenance. Levee failure would create devastating losses to existing development including businesses, government buildings, homes, and farms.

Impact of Previous and Future Development

Development upstream, in the form of additional levees, creates the greatest impact to Mississippi River flooding in Pike County due to channeling additional water into waterways. Flash floods and levee failures will continue to impact residents choosing to live in rural areas where low water crossings are required to access their homes. There is anticipated to be little or no increase in run off created by potential development; however, that could change within 15 years due to the potential development.

Hazard Summary by Jurisdiction

As stated above, the agricultural areas, along with the cities of eastern Pike County depend on levees to hold back flood waters.

Problem Statement

The risk of levee failure is usually a secondary effect of flooding or some other natural disaster. The Eastern portion of the county is directly affected by flooding of the Mississippi River and consequential levee failures. Cropland production is decreased, transportation systems effected, and the economy as a whole suffers. There is a lack of participation in hazard mitigation planning by property owners, businesses, and occupants of flood-prone areas, and outreach could be improved so they better understand the consequences of living in these areas. As well, transportation systems along Highway 79 are highly susceptible to flooding due to levee failure, and are typically closed when an event occurs. Unfortunately, there is not an effective method in place to alert residents of specifically a flash flooding issue. Levee Districts are unable to keep the existing levees in good condition and find it hard to keep up with the U.S. Corps of Engineers' regulations.

3.4.3 Dam Failure

Hazard Profile

Hazard Description

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

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

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

Table 3.22. MoDNR Dam Hazard Classification Definitions

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

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

Table 3.23. NID Dam Hazard Classification Definitions

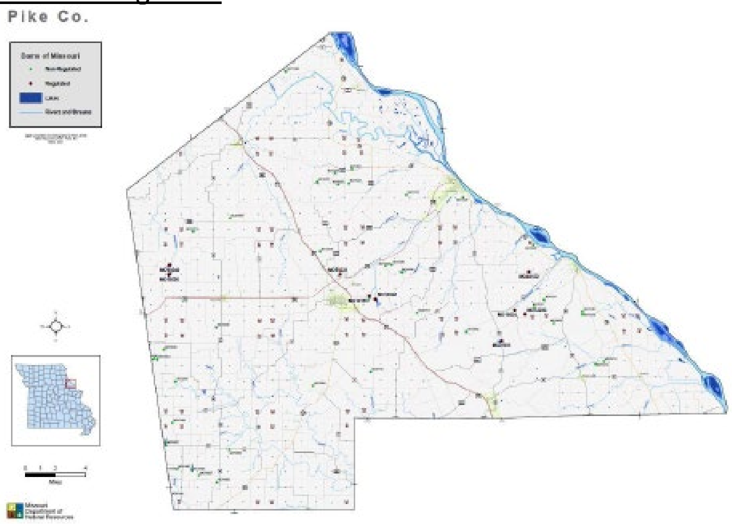
Hazard Class	Definition
Low Hazard	A dam located in an area where failure could damage only farm or other uninhabited buildings, agricultural or undeveloped land including hiking trails, or traffic on low volume roads that meet the requirements for low hazard dams.
Significant Hazard	A dam located in an area where failure could endanger a few lives, damage an isolated home, damage traffic on moderate volume roads that meet certain requirements, damage low-volume railroad tracks, interrupt the use or service of a utility serving a small number of customers, or inundate recreation facilities, including campground areas intermittently used for sleeping and serving a relatively small number of persons.

High Hazard	A dam located in an area where failure could result in any of the following: extensive loss of life, damage to more than one home, damage to industrial or commercial facilities, interruption of a public utility serving a large number of customers, damage to traffic on high-volume roads that meet the requirements for hazard class C dams or a high-volume railroad line, inundation of a frequently used recreation facility serving a relatively large number of persons, or two or more individual hazards described for significant hazard dams.

Source: National Inventory of Dams

Geographic Location

<u>Dams Located Within the Planning Area</u>



Pike County has nine state-regulated dams inside the county boundaries. Within the State of Missouri, the Department of Natural Resources maintains a Dam and Safety Program overseen by the Division of Geology and Land Survey. Chapter 236 Revised Statutes of Missouri state that a dam must be 35 feet or higher to be state regulated. The United States Army Corps of Engineers regulates the Lock and Dam #24 on the Mississippi River and the Clarence Cannon Dam located in Ralls County.

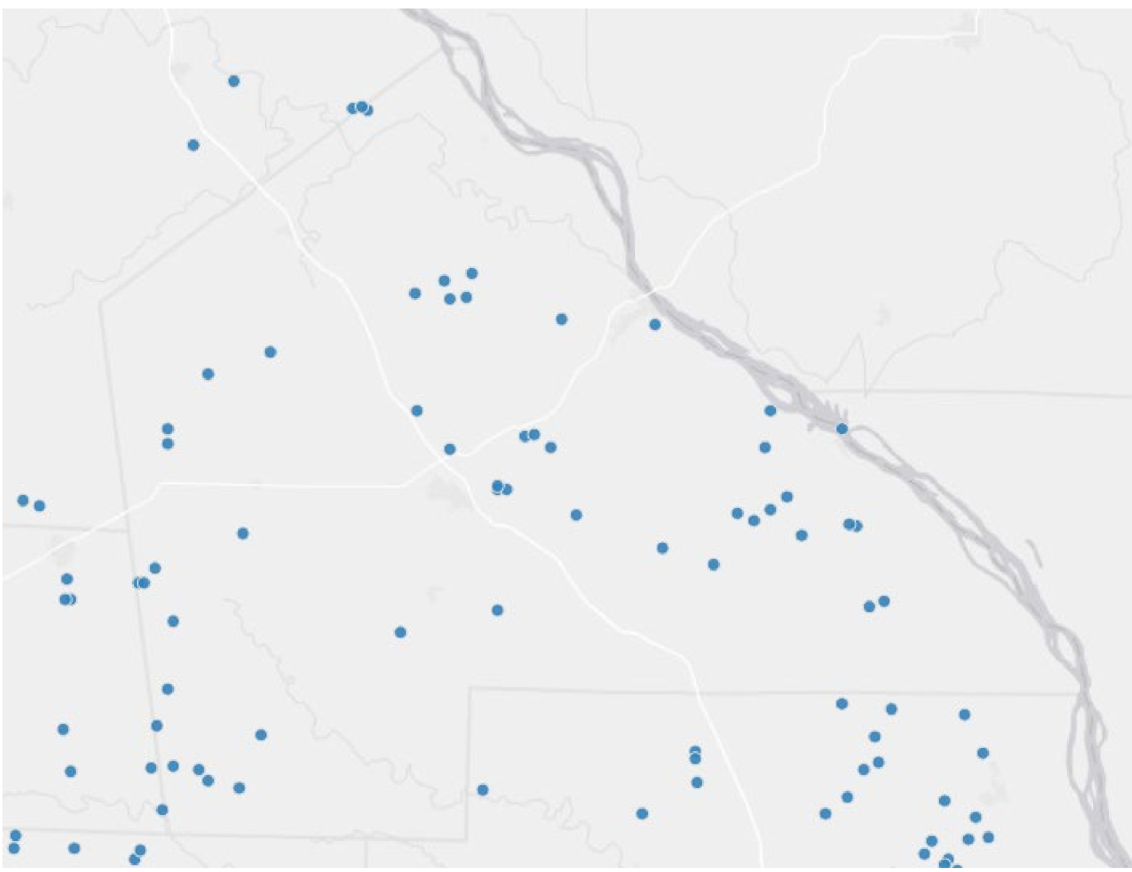
The NID Dam data for Pike County includes 41 dams: Miller Dam, Bibb Lake Dam, Station, Kohl Lake Dam-East, Charles Morris Dam, Lock and Dam #24, Bowling Green Dam #1, WL Morris Dam, Camerer Dam, Thiel Lake Dam-East, Clithero Lake Dam, Kohl Lake Dam-West, Love Lake Dam, Old Bowling Green Reservoir Dam, Morris Lake Dam, Harris Lake Dam, Bachman Lake Dam, Magee Lake Dam, Berra Lake Dam, Thiel Lake Dam-West, Lewis Lake Dam, IMR Corp-SEC 11, White Lake Dam, Vandalia Lake Dam, Ripple Lake Dam, Smith Lake Dam, Love Lake Dam, Joseph Keeven Dam, Tievoli Hills Lake #1 Dam, Vera Lake Dam, Wilhite Dam, Paul Williams Dam, Daniels Lake Dam, Pfautch Lake Dam, Clithero Lake Dam, Bowling Green Dam #2, Niemeyer Dam, Evans and Wertz's Dam, Stormwater Management Dam and Epperson Dam.

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

Dam Name	Other Dam Name	NIDID	Hazard Potential *	NID Height (Ft.)	River	Nearest City *	Distance To City (Mi.) *	County	State	Enforcement Authority
SMITH LAKE DAM	-	MO11124	High	31	TR MISSISSIPPI RIVER	LOUISIANA	1	PIKE	MO	N
VERA LAKE DAM	-	MO11300	High	25	TR-NOIX CREEK	LOUISIANA	6	PIKE	MO	N
WILLIAMS,PAUL DAM	-	MO11299	High	28	TR-NOIX CREEK	LOUISIANA	7	PIKE	MO	N
WILHITE DAM	-	MO11307	High	30	CAINS CREEK	LOUISIANA	8	PIKE	MO	N
PFAUTCH LAKE DAM	-	MO11304	High	30	TR-CAINS CREEK	LOUISIANA	7	PIKE	MO	N
BIBB LAKE DAM	-	MO10231	High	46	TRIBUTARY TO NOIX CREEK	BOWLING GREEN	1.6	PIKE	MO	Y
LOVE LAKE DAM	-	MO10276	High	30	TR-SUGAR CREEK	LOUISIANA	14	PIKE	MO	N
MORRIS W L DAM	-	MO10651	High	25	TR-SHADY CREEK	NEW HARTFORD	9	PIKE	MO	N
WHITE LAKE DAM	-	MO10551	High	25	TR-CAINS CREEK	LOUISIANA	8	PIKE	MO	N
BOWLING GREEN DAM #1	-	MO10262	High	73	TRIBUTARY TO NOIX CREEK	BOWLING GREEN	2.2	PIKE	MO	Y
OLD BOWLING GREEN RESERVOIR DAM	-	MO10263	High	23	TR-BUCKNER HOLLOW-NOIX CREEK	LOUISIANA	-	PIKE	MO	N
MAGEE LAKE DAM	LOCKHARD LAKE DAM	MO31011	High	42	MUD CREEK	EOLIA	8.7	PIKE	MO	Y
BOWLING GREEN DAM #2	-	MO12195	High	61	TR BUCKNER HOLLOW	BOWLING GREEN	1.8	PIKE	MO	Y
EVANS & WERTZ'S DAM	-	MO50414	High	27	TR-GOOSE CREEK	CLARKSVILLE	20	PIKE	MO	N

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

Figure 3.4. High Hazard Dam Locations in Pike 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

Figure 3.5. Upstream Dams Outside Pike County

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

Most of the dams upstream from Pike County are located in Pike and Pike Counties and lie in the Salt River Watershed. Any failure in those counties would affect assets located near those rivers. The Clarence Cannon Dam in Pike County flows into the Salt River in northern Pike County. Failure of the Clarence Cannon Dam would have a catastrophic impact on rural Pike County. A failure of any dams located in the Mississippi River valley could directly impact cities and rural properties located along the Mississippi River in Pike County.

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

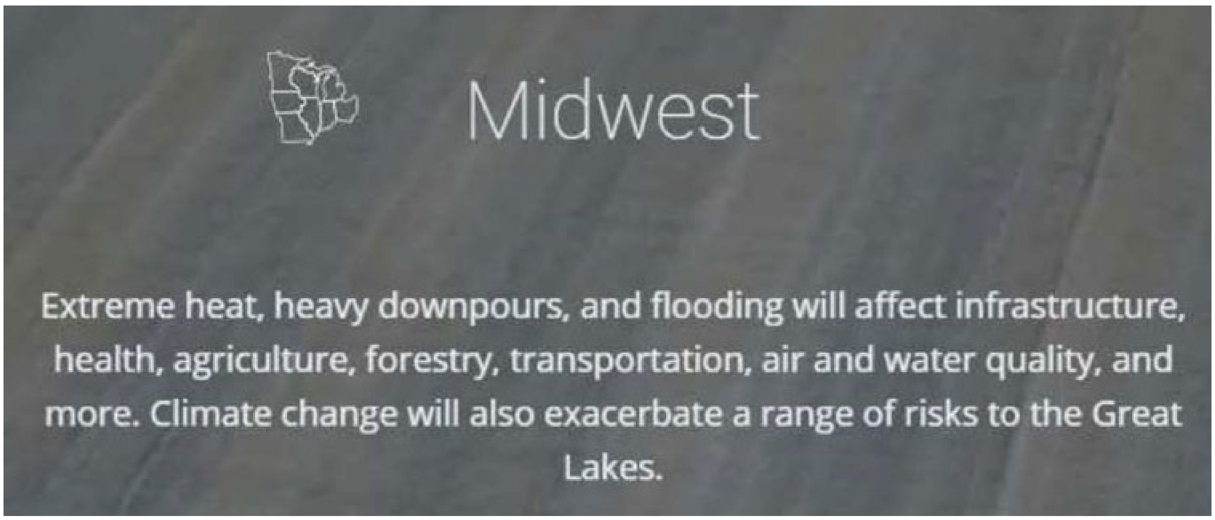
Thousands of people have been injured, many killed, and billions of dollars in property damaged by dam failures in the United States. The problem of unsafe dams in Missouri was underscored by dam failures at Lawrenceton in 1968, Washington County in 1975, Fredericktown in 1977, Taum Sauk in 2005, and a near failure in Franklin County in 1978. There have been 26 recorded dam failures in Missouri over the last 100 years. One drowning is recorded among all of these disasters. To determine previous occurrences of dam failure within the Pike County, the Pike County Missouri Natural Hazard Mitigation Plan was consulted as well as the Missouri State Hazard Mitigation Plan and the Stanford University's National Performance of Dams Program (http://npdp.stanford.edu/). One dam in Pike County previously had an incident. Bowling Green Dam #1 had an issue with seepage and piping on 6-26-1995.

Probability of Future Occurrence

Dam failure and its associated impacts is a possibility for disaster in Pike County. Pike County has fourteen high hazard dams. There is a small chance of dam failure happening based on past occurrences. However, the effects of a failure would be horrific.

Changing Future Conditions Considerations

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



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

Vulnerability

Vulnerability Overview

Most of Pike County's vulnerability in the event of a dam failure is loss of agriculture assets. Without inundation maps available it is hard to predict how far downstream the effects of a dam breech would be. Several communities have dams located upstream from them but again it is not easy to ascertain how many lives or how much property would be affected in a dam failure. Some of the dams are located close enough to major highways that it appears that a compromise in the integrity of a dam could threaten to close or damage roadways.

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

Most of Pike County's vulnerability in the event of a dam failure is loss of agriculture assets. Without inundation maps available it is hard to predict how far downstream the effects of a dam breech would be. Several communities have dams located upstream from them but again it is not easy to ascertain how many lives or how much property would be affected in a dam failure. Some of the dams are located close enough to major highways that it appears that a compromise in the integrity of a dam could threaten to close or damage roadways.

Hazard Summary by Jurisdiction

Vulnerability to dam failure is very minimal with the exception to the City of Louisiana. The remaining participating jurisdictions including school districts would be affected very minimally.

Problem Statement

Pike County residents with a dam on their property do not properly inspect the dams to ensure the safety of the dam not failing. Residents need to be informed of the proper way to inspect a dam and look for initial problems.

3.4.4 Earthquakes

Hazard Profile

Hazard Description

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

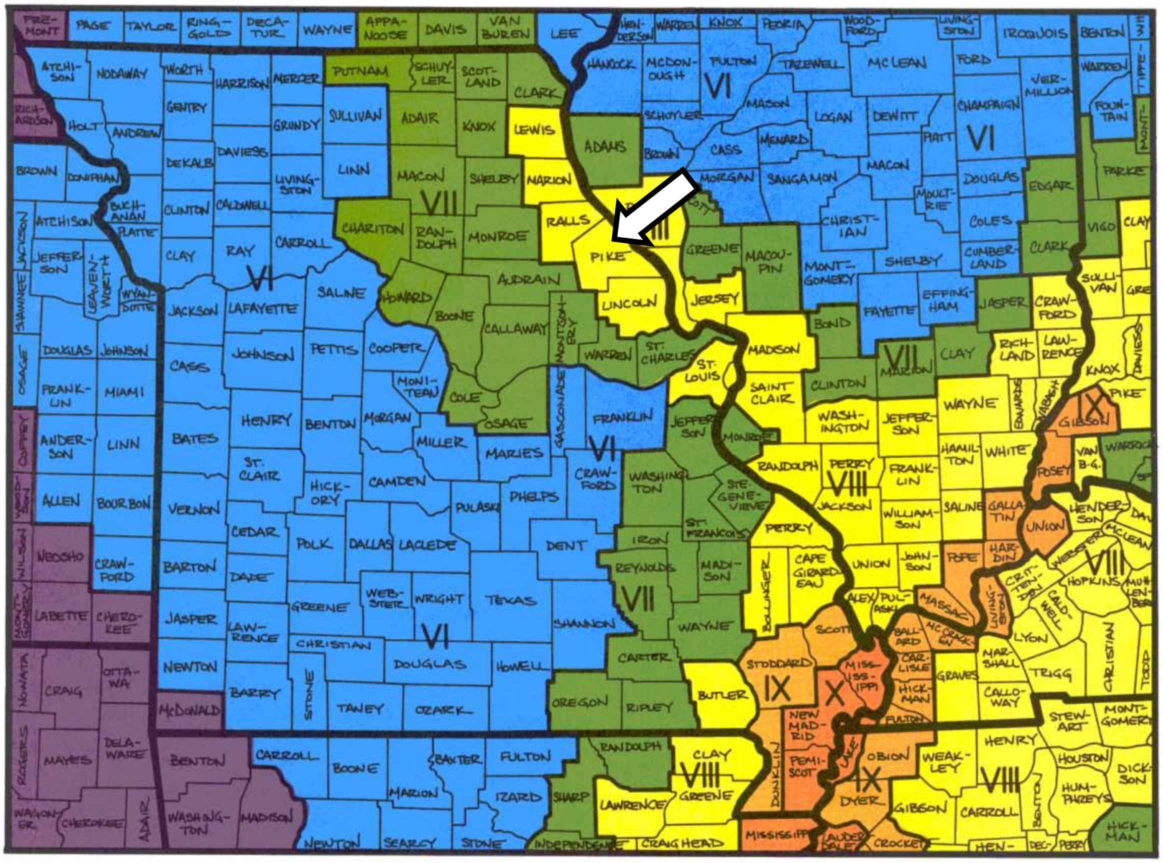
Some earthquakes occur in the middle of plates, as is the case for seismic zones in the Midwestern United States. The most seismically active area in the Midwest is the New Madrid Seismic Zone. The possibility of the occurrence of a catastrophic earthquake in the central and Eastern United States is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

Geographic Location

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

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

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

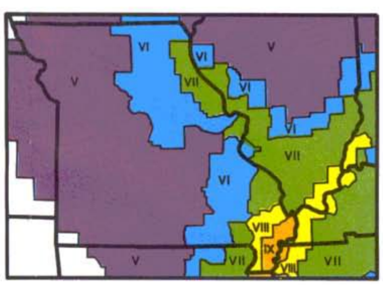


This map shows the highest projected Modified Mercalli intensities by county from a potential magnitude – 7.6 earthquake whose epicenter could be anywhere along the length of the New Madrid seismic zone.

6.7

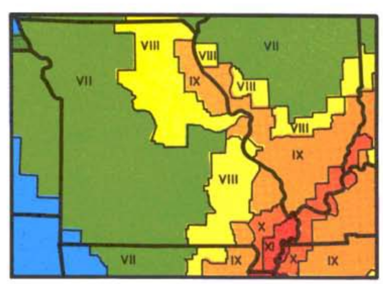
7.6

8.6



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

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



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

Figure 3.7. Projected Earthquake Intensities

MODIFIED MERCALLI INTENSITY SCALE

I People do not feel any Earth movement.

II A few people might notice movement.

III Many people indoors feel movement. Hanging objects swing.

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

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

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

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

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

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

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

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

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

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

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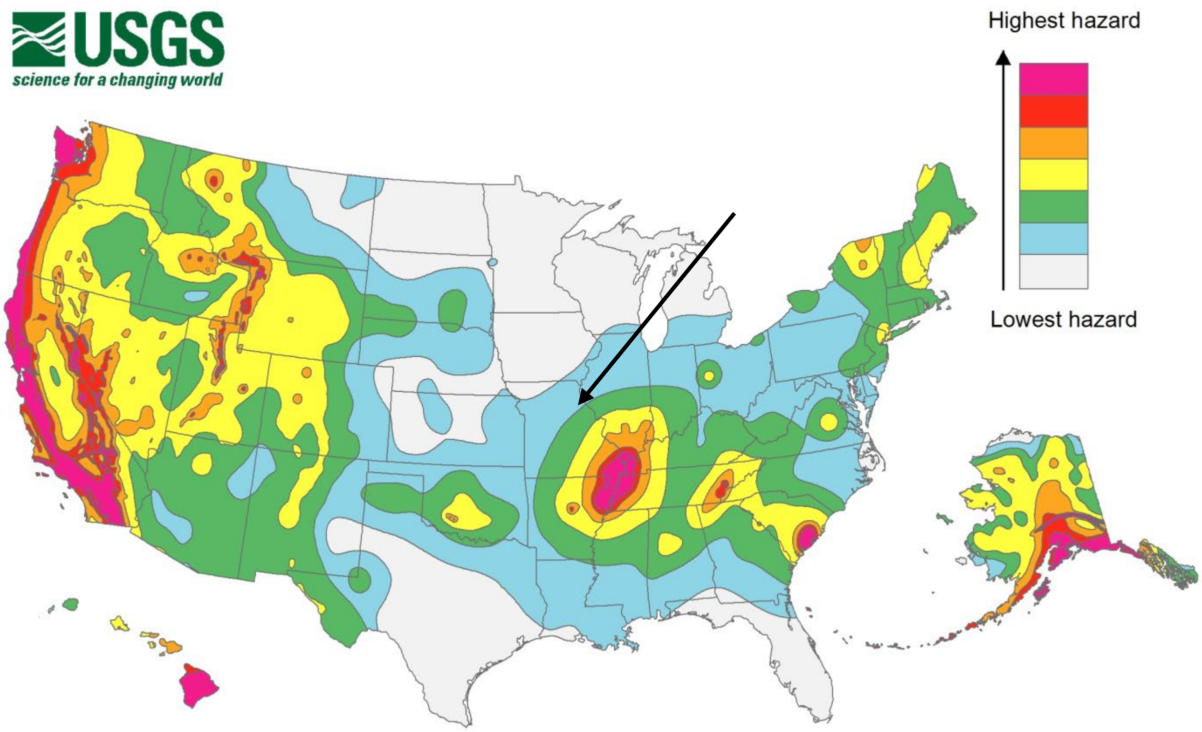
Figure 3.8. United States Seismic Hazard Map



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

Strength/Magnitude/Extent

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

Richter Magnitude Scale

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

Modified Mercalli Intensity Scale

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

Previous Occurrences

There have been 0 earthquakes recorded in Pike County since 1931.

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

Probability of Future Occurrence

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

Changing Future Conditions Considerations

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

Vulnerability

Vulnerability Overview

According to the data obtained from the 2018 State Plan, Pike County was listed as N/A for Hazard Ranking.
The State of Earthquake Coverage Report states that the average premium for earthquake coverage in Pike County in 2014 was $74.

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.

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

County	Cost Structural Damage	Cost Non-Structural Damage	Cost Contents Damage	Inventory Loss	Loss Ratio %	Relocation Loss	Capital Related Loss	Wages Losses	Rental Income Loss	Total Loss
Pike	$7,013	$17,351	$6,186	$174	1.31	$4,375	$1,150	$1,618	$1,836	$39,703

Impact of Previous and Future Development

Overall, the planning area has a low vulnerability to earthquake risk. Future development is not expected to increase the risk other than contributing to the overall exposure of what could become damaged as a result of the unlikely event.

Hazard Summary by Jurisdiction

The earthquake intensity is not likely to vary greatly throughout the planning area and all jurisdictions within the planning area will be the same throughout. However, the City of Louisiana could see a greater amount of structural damage due to having a higher percentage (35.2%) of residences built prior to 1939 than other jurisdictions in the planning area. The City of Bowling Green has a low percentage (18.5) of residences built prior to 1939 putting them at a lower risk.
See http://factfinder.census.gov/faces/nav/jsf/pages/index.xhtml

Problem Statement

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

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

3.4.5 Land Subsidence/Sinkholes

Hazard Profile

Hazard Description

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

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

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

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

Geographic Location

The Missouri Department of Natural Resources documented 134 sinkholes in the planning area. The sinkholes are throughout the county and not located in one distinct area of the county.

Source:http://www.dnr.mo.gov/geology/geosrv/envgeo/sinkholes.htm

Strength/Magnitude/Extent

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

Previous Occurrences

As noted in the 2018 State Plan, sinkholes are a regular occurrence in Missouri, but rarely are the events of any significance. The Missouri State Hazard Mitigation Plan lists seven notable sinkhole events with none of them occurring in the planning area. Although Pike County has over 134 sinkholes they have not been a problem and the likeliness of a future occurrence would be considered negligible. However, the potential for this type of hazard to occur in Pike County exists. There are portions of the county where sinkholes and underground caverns exist and can increase the likely hood of a sinkhole occurring.

Probability of Future Occurrence

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

Changing Future Conditions Considerations

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

Vulnerability

Vulnerability Overview

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

Potential Losses to Existing Development

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

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

Impact of Previous and Future Development

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

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

Hazard Summary by Jurisdiction

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

Problem Statement

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

3.4.6 Drought

Hazard Profile

Hazard Description

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

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

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

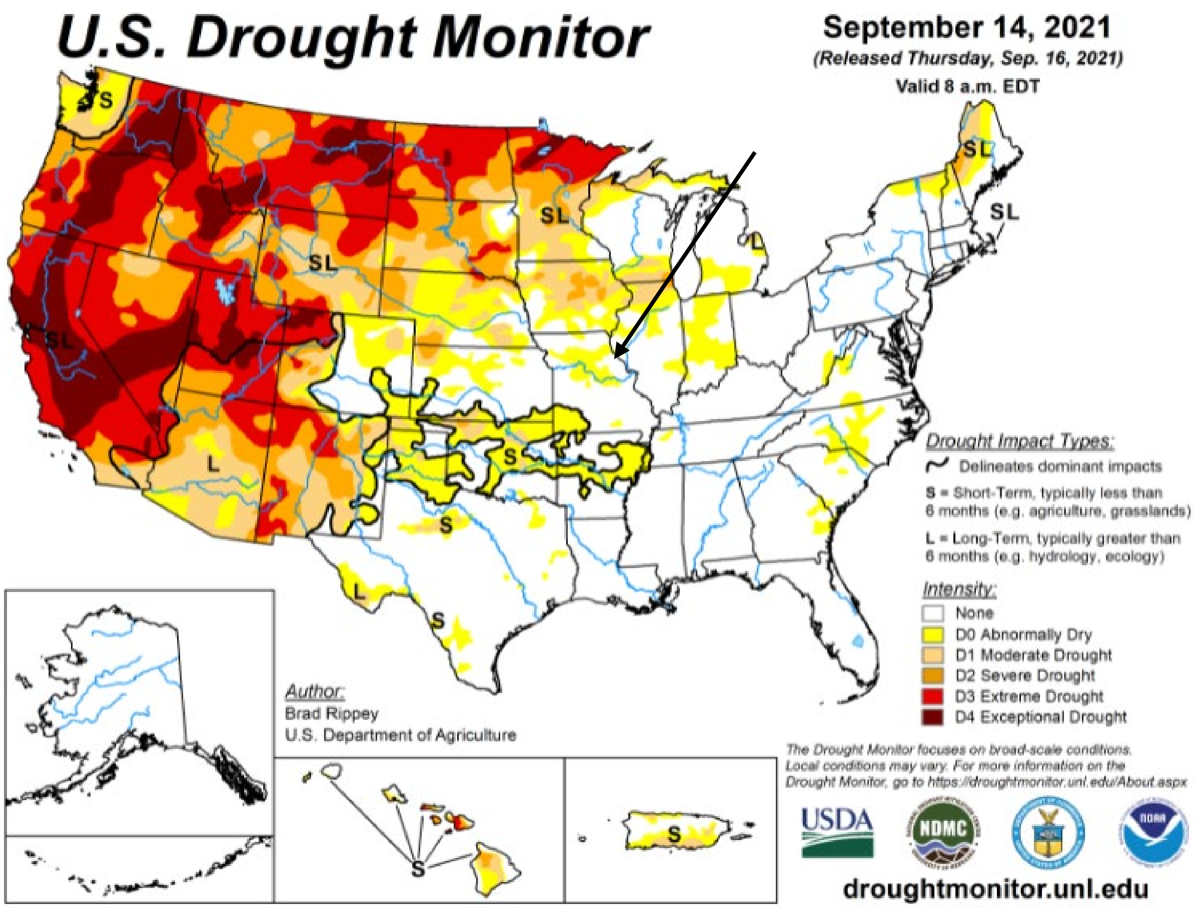
- Agricultural drought focus is on soil moisture deficiencies, differences between actual and potential evaporation, reduced ground water or reservoir levels, etc. Plant demand for water depends on prevailing weather conditions, biological characteristics of the specific plant, its stage of growth, and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

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

Geographic Location

Droughts are regional in nature. All areas of the United States are vulnerable to the risk of drought and extreme heat. Droughts can be widespread or localized events. The extent of the droughts varies both in terms of the extent of the heat and range of precipitation. The severity of a drought depends on locations, duration, and geographical extent. Additionally, drought severity depends on the water supply, usage demands made by human activities, vegetation and agricultural operations. Drought brings several different problems that must be addressed. The quality and quantity of crops, livestock, and other agricultural assets will be affected during a drought. Drought can adversely impact forested areas leading to an increased potential for extremely destructive forest and woodland fires that could threaten residential, commercial, and recreational structures.
As of 2012, 84% of Pike County consisted of land in farms which left 67,415 acres of developed land. Farming is concentrated in the north, west, south and southeast areas of the county leaving the Eastern and Central part of the county as the most developed.
Source: https://www.agcensus.usda.gov/Publications/2012/Full_Report/Volume_1,_Chapter_2_County_Level/Missouri/st29_2_008_008.pdf

Figure 3.9. U.S. Drought Monitor Map of Missouri on 9/14/21



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

Strength/Magnitude/Extent

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

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

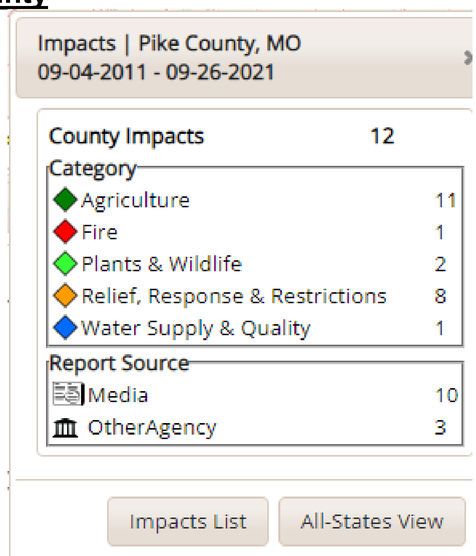
Palmer also developed a formula for standardizing drought calculations for each individual location based on the variability of precipitation and temperature at that location. The Palmer index can therefore be applied to any site for which sufficient precipitation and temperature data is available.

Previous Occurrences

Drought occurs periodically in Missouri with the most severe and costly time occurring in 2018. Although droughts are not the spectacular weather events that floods, blizzards or tornadoes can be, historically, they produce more economic damage to the State than all other weather events combined. According to NCEI's storm database, 7 drought events have occurred in Pike County between 2001 to 2021.

According to the National Drought Mitigation Center's Drought Impact Reporter, during the 10-year period from September 2011 to September 2021 Pike County had 12 drought impacts.

<u>Drought Impacts in Pike County</u>



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

Probability of Future Occurrence

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

Changing Future Conditions Considerations

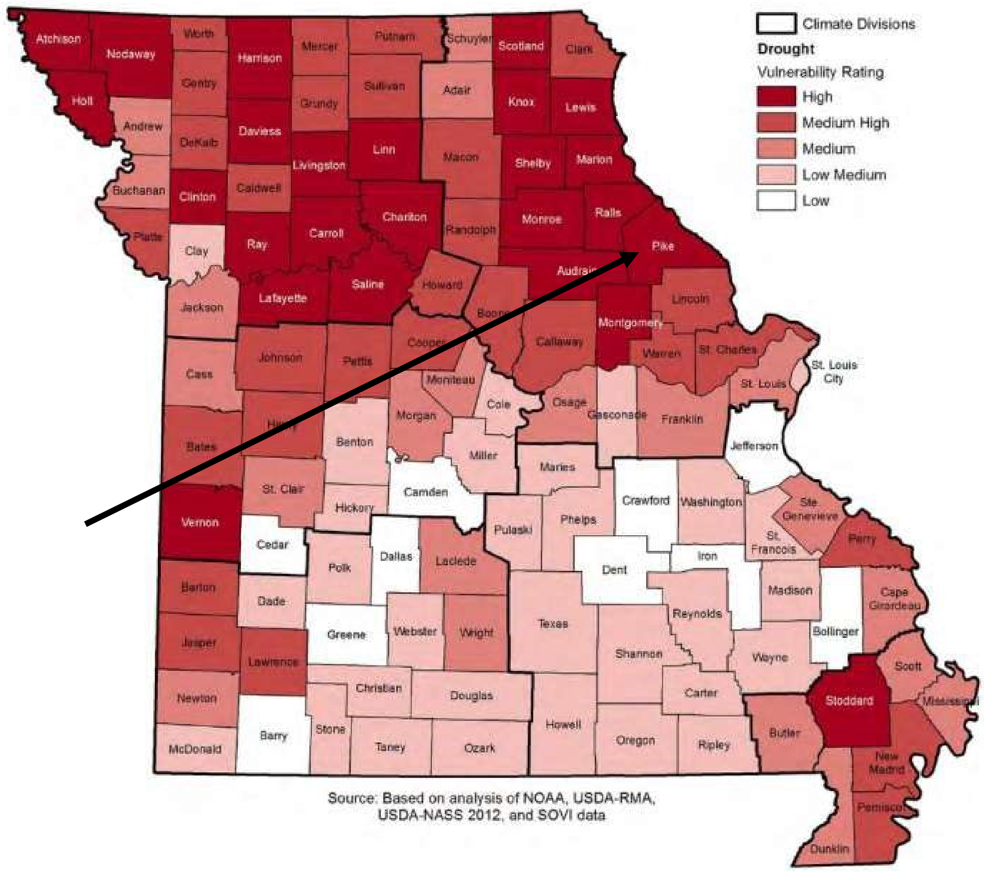
The 2018 State Plan, Severe drought, a natural part of Missouri's climate, is at risk to this agriculture dependent state. Future increases in evaporation rates due to higher temperatures may increase the intensity of naturally occurring droughts. The number of heavy rainfall events is predicted to increase,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

<u>Vulnerability</u>

Vulnerability Overview

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

Missouri Drought Vulnerability by County



Source: Based on analysis of NOAA, USDA-RMA, USDA-NASS 2012, and SOVI data

Potential Losses to Existing Development

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

Impact of Previous and Future Development

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

Changing Future Conditions Considerations

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

Hazard Summary by Jurisdiction

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

Problem Statement

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

3.4.7 Extreme Temperatures

Hazard Profile

Hazard Description

Extreme temperature events, both hot and cold, can impact human health and mortality, natural ecosystems, agriculture and other economic sectors. According to information provided by FEMA, extreme heat is defined as temperatures that hover 10 degrees or more above the average high temperature for the region and last for several weeks. Ambient air temperature is one component of heat conditions, with relative humidity being the other. The relationship of these factors creates what is known as the apparent temperature. The Heat Index chart shown in **Figure 3.10** uses both of these factors to produce a guide for the apparent temperature or relative intensity of heat conditions.

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

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

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

Geographic Location

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

Strength/Magnitude/Extent

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

Figure 3.10. Heat Index (HI) Chart

NWS Heat Index

Temperature (°F)

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

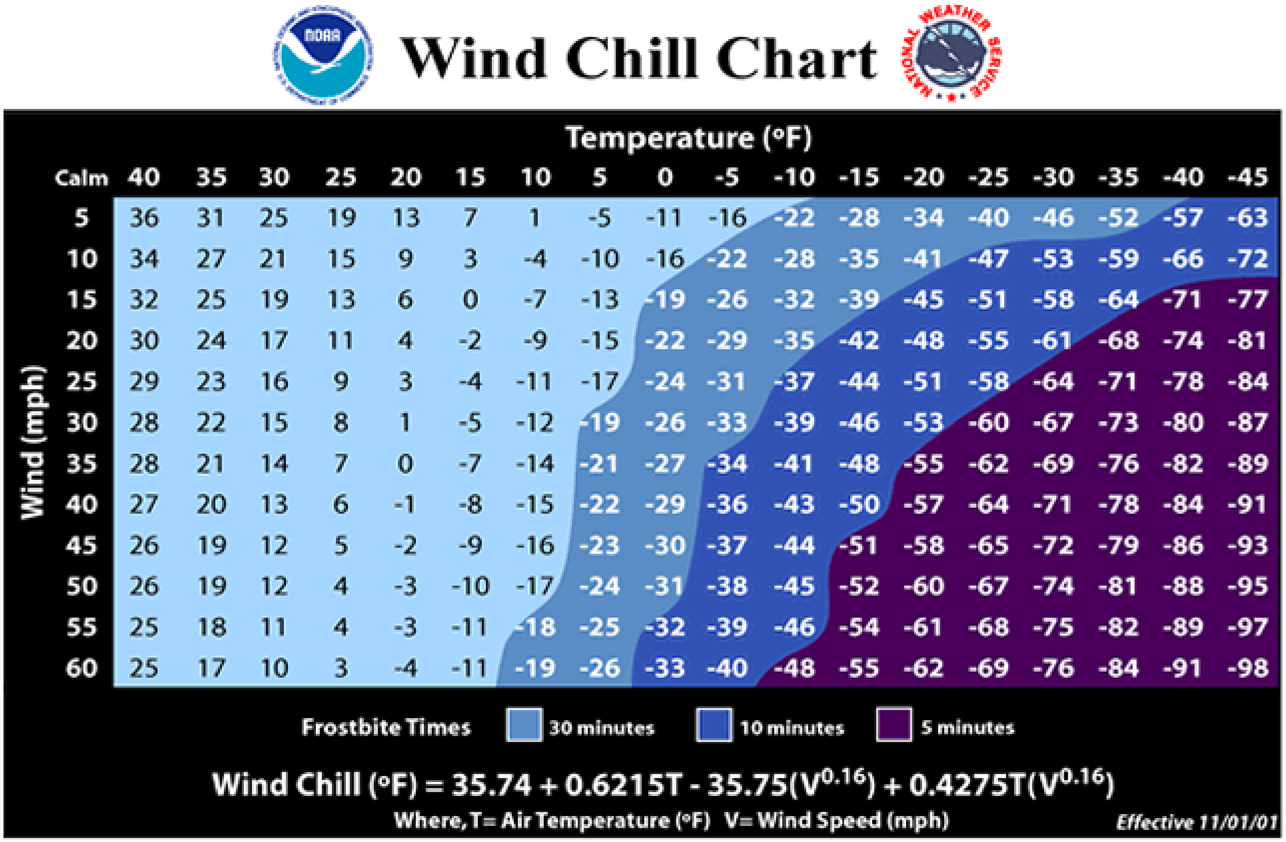
Likelihood of Heat Disorders with Prolonged Exposure or Strenuous Activity

Caution | Extreme Caution | Danger | Extreme Danger

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

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

Figure 3.11. Wind Chill Chart



Temperature (°F); Wind (mph)

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

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

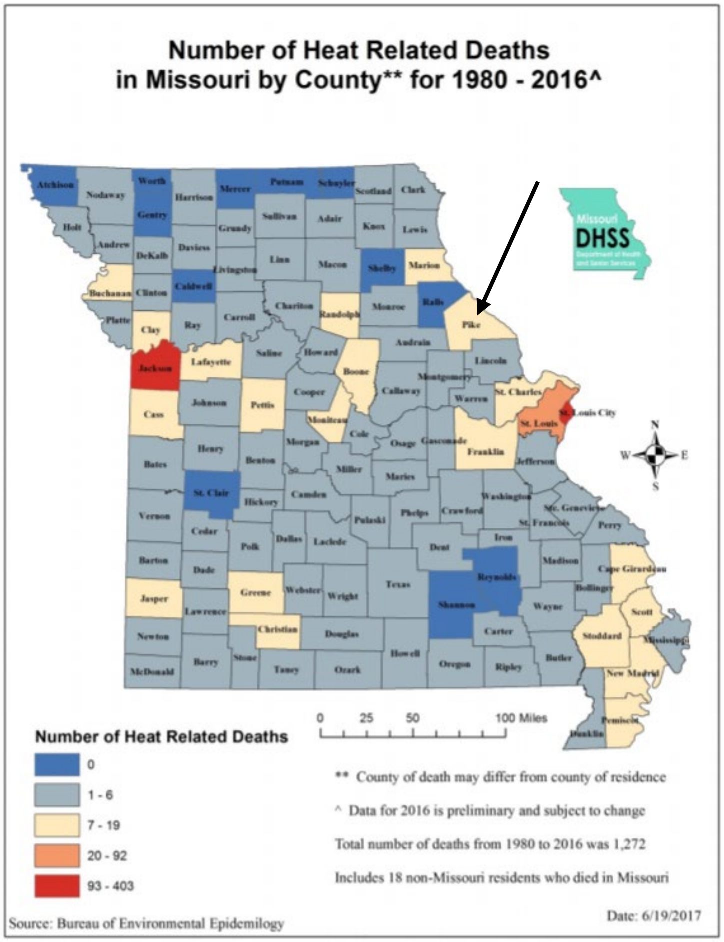
Where, T= Air Temperature (°F) V= Wind Speed (mph)

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 21 recorded events of excessive heat in the 20-year period of 2001-2021. There was 0 deaths or injuries associated with these events. The NCEI database shows 0 recorded events of extreme cold/wind chill. Figure 3.34 illustrates between 7-19 heat related deaths in Pike County between the time of 1980-2016, no supporting documentation could be found to include in this plan.

Figure 3.12. Heat Related Deaths in Missouri 1980 - 2016



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

Extreme heat can cause stress to crops and animals. Losses to insurable crops during the 10-year time period were unable to be obtained. Extreme heat can also strain electricity delivery infrastructure overloaded during peak use of air conditioning during extreme heat events. Another type of infrastructure damage from extreme heat is road damage. When asphalt is exposed to prolonged extreme heat, it can cause buckling of asphalt-paved roads, driveways, and parking lots.

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

Probability of Future Occurrence

NOAA dating back to 2011 indicates 6 years with extreme heat events (2011, 2012, 2014, 2015, 2016, 2017). Based on this historical data, the calculated probability of an extreme heat event in any given year is 60%.

Changing Future Conditions Considerations

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

Vulnerability

Vulnerability Overview

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

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

Table 3.25. Typical Health Impacts of Extreme Heat

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

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

Figure 3.118. Average Annual Occurrence for Extreme Heat

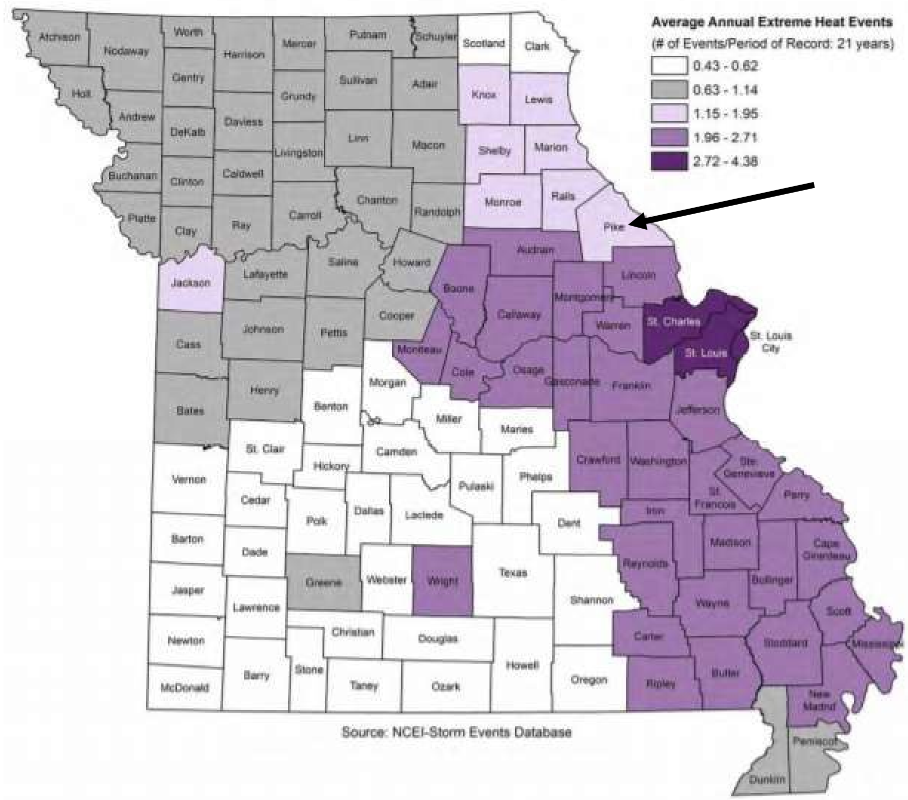


Figure 3.119. Vulnerability Summary for Extreme Heat

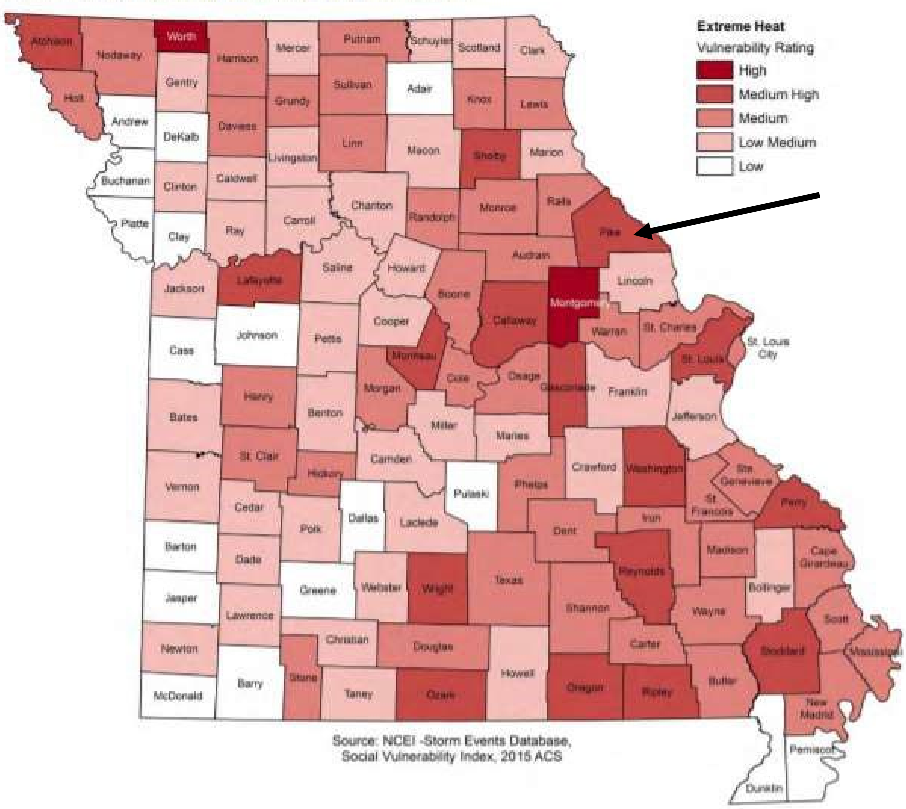
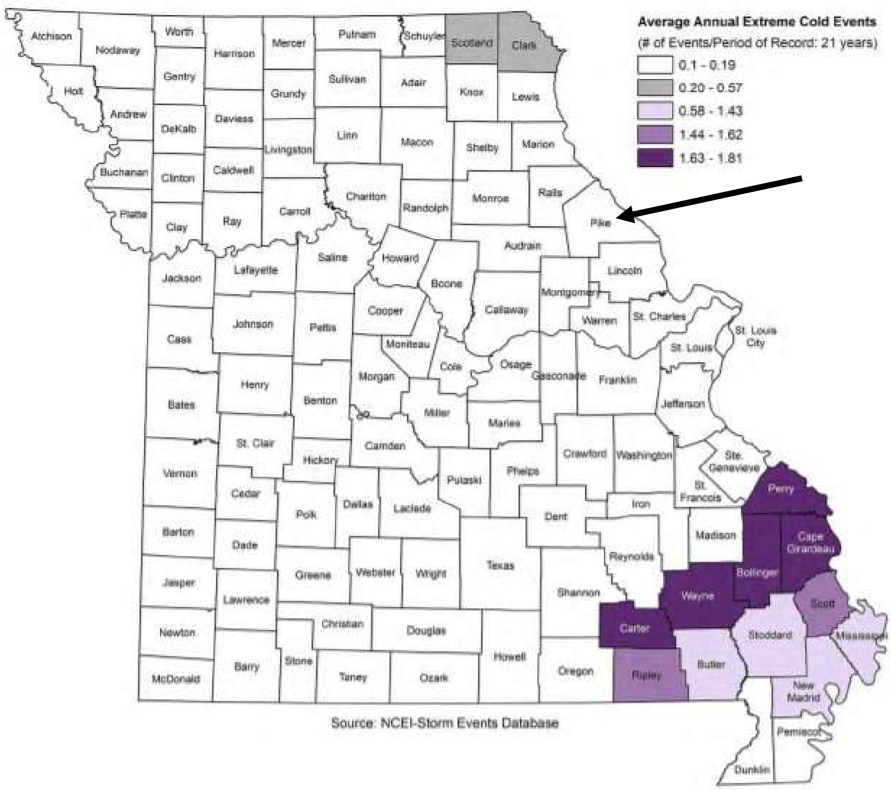
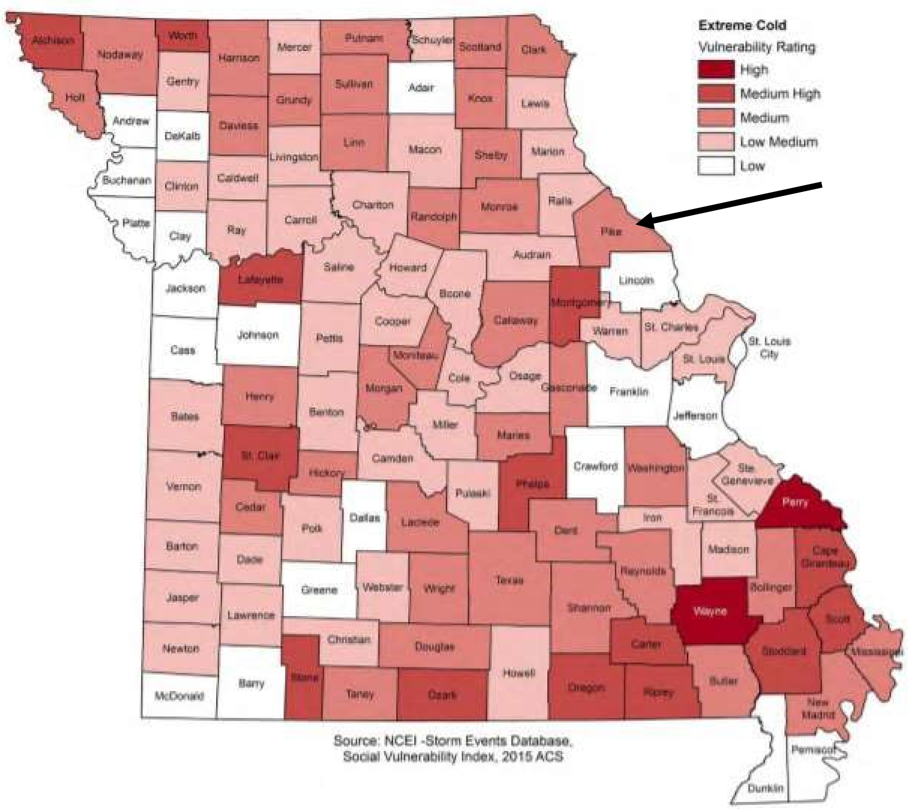


Figure 3.120. Average Annual Occurrence for Extreme Cold



Source: NCEI-Storm Events Database

Figure 3.121. Vulnerability Summary for Extreme Cold



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

Potential Losses to Existing Development

Pike County is considered to be one of the highest counties in insurance payments for extreme heat. Illness and loss of life are the most concern with extreme heat however there has not been any injury or deaths related extreme heat reported in the 10-year period reviewed.

Impact of Previous and Future Development

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

Hazard Summary by Jurisdiction

Those at greatest risk for heat-related illness and deaths include children up to five years of age, people 65 years of age and older, people who are overweight, and people who are ill or on certain medications. To determine jurisdictions within the planning area with populations more vulnerable to extreme heat, demographic data was obtained from the 2010 census on population percentages in each jurisdiction comprised of those under age 5 and over age 65. Data was not available for overweight individuals and those on medications vulnerable to extreme heat. **Table 3.33** below summarizes vulnerable populations in the participating jurisdictions. Note that school and special districts are not included in the table because students and those working for the special districts are not customarily in these age groups.

Table 3.26. Pike County Population Under Age 5 and Over Age 65, 2010 Census Data

Jurisdiction	Population Under 5 yrs	Population 65 yrs and over
*Pike County	1,131	2,883
Louisiana	226	170
Clarksville	29	93
Paynesville	10	15
Annada	0	3
Bowling Green	290	590
Frankford	18	50

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

All of the schools in Pike County have air conditioning which does not put school age children at risk during extreme temperatures due to this the schools do not have a policy in affect to close if there are extreme heat occurrences.

Problem Statement

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

3.4.8 Severe Thunderstorms
Including High Winds, Hail, and Lightning

Hazard Profile

Hazard Description

Thunderstorms

A thunderstorm is defined as a storm that contains lightning and thunder which is caused by unstable atmospheric conditions. When cold upper air sinks and warm moist air rises, storm clouds or 'thunderheads' develop resulting in thunderstorms. This can occur singularly, as well as in clusters or lines. The National Weather Service defines a thunderstorm as "severe" if it includes hail that is one inch or more, or wind gusts that are at 58 miles per hour or higher. At any given moment across the world, there are about 1,800 thunderstorms occurring. Severe thunderstorms most often occur in Missouri in the spring and summer, during the afternoon and evenings, but can occur at any time. Other hazards associated with thunderstorms are heavy rains resulting in flooding (discussed separately in **Section 3.4.1**) and tornadoes (discussed separately in **Section 3.4.10**).

High Winds

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

Lightning

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

Hail

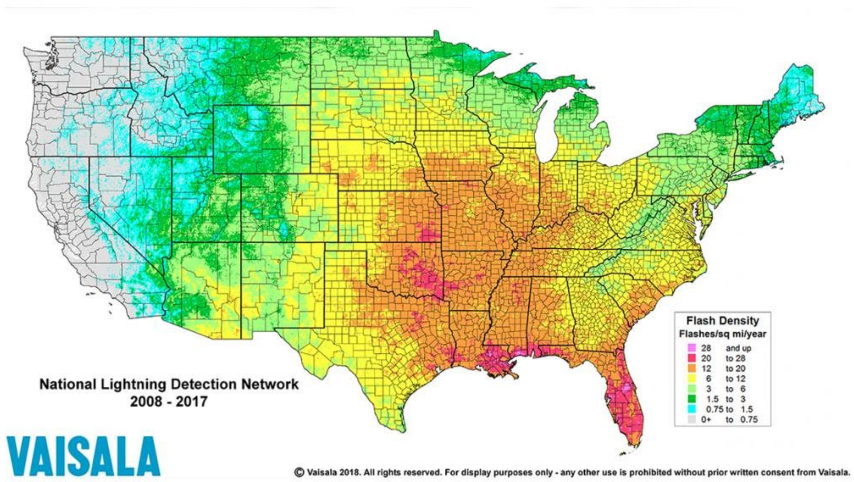
According to the National Oceanic and Atmospheric Administration (NOAA), hail is precipitation that is formed when thunderstorm updrafts carry raindrops upward into extremely cold atmosphere causing them to freeze. The raindrops form into small frozen droplets. They continue to grow as they come into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

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

Geographic Location

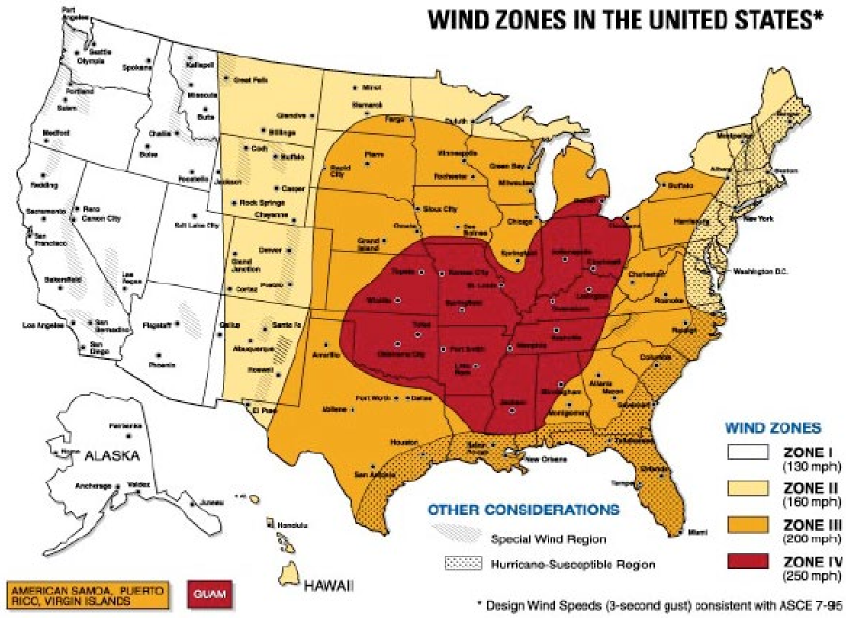
All of Pike County is susceptible to thunderstorms/high winds/hail and lighting events. Although these events occur similarly throughout the planning area, they are more frequently reported in more urbanized areas. In addition, damages are more likely to occur in more densely developed urban areas.

Figure 3.13. Location and Frequency of Lightning in Missouri



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

Figure 3.14. 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 3.34** below describes typical damage impacts of the various sizes of hail.

Table 3.27. Tornado and Storm Research Organization Hailstorm Intensity Scale

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

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

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

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

Previous Occurrences

Limitations to the use of NCEI reported lightning events include the fact that only lightning events that result in fatality, injury and/or property and crop damage are in the NCEI.

The tables below (**Table 3.35 through Table 3.38**) summarize past crop damages as indicated by crop insurance claims. The tables illustrate the magnitude of the impact on the planning area's agricultural economy.

Table 3.28. Crop Insurance Claims Paid in Pike County from Thunderstorms, 01/2016-01/2021.

There were no claims reported.

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

Table 3.29. Crop Insurance Claims Paid in Pike County from High Winds, 01/2016-01/2021.

Crop Year	Crop Name	Cause of Loss Description	Insurance Paid
2016	Corn	Wind/Excess Moisture	$1,766
2019	Soybeans	Wind/Excess Moisture	$661
2020	Wheat	Wind/Excess Moisture	$480
Total			$2,907

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

Table 3.30. Crop Insurance Claims Paid in Pike County from Lightning, 01/2016-01/2021.

There were no claims reported.

Table 3.31. Crop Insurance Claims Paid in Pike County from Hail, 01/2011-01/2021.

Crop Year	Crop Name	Cause of Loss Description	Insurance Paid
2019	Wheat	Hail	906
2019	Wheat	Hail	906
2019	Soybeans	Hail	2723

Total			4536

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

Probability of Future Occurrence

Thunderstorms

Based on this data, there have been 22 events in a 10-year period, producing an average of 2.2 high wind events each year in Pike County. Based on history, the probability of a high wind event in any given year is 100 percent. Thus, making the probability as likely in any given year.

High Winds

Based on this data, there have been 1 event in a 10-year period, producing an average of 0.1 high wind events each year in Pike County. Based on history, the probability of a high wind event in any given year is 100 percent. Thus, making the probability as likely in any given year.

Lightning

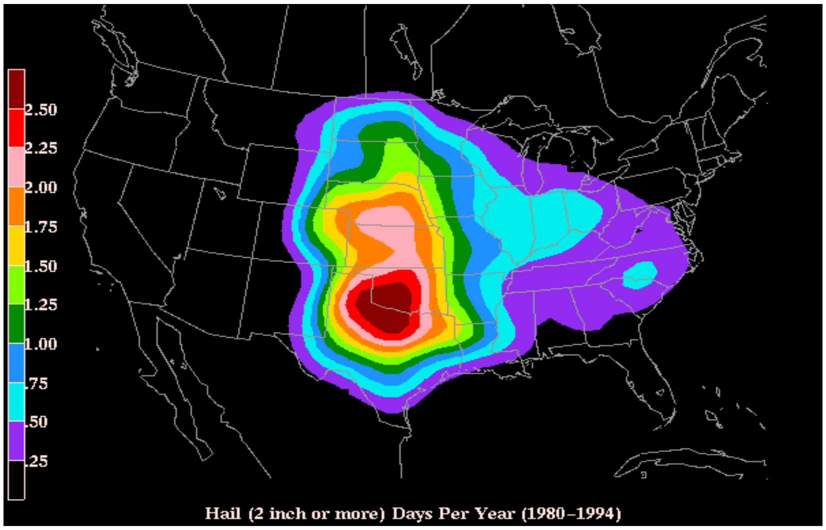
Due to no reports, adequate calculations cannot be configured at this time.

Hail

Based on this data, there have been 11 events in a 10-year period, producing an average of 1.1 hail events each year in Pike 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 3.15 is based on hailstorm data from 1980 -1994. The figure shows the probability of hailstorm occurrence (2” diameter or larger) based on number of days per year. Pike County is located in the region to receive between .75 and 1 hailstorms annually. Include probability calculations for thunderstorms, high winds, hail, and lightning.

Figure 3.15. Annual Hailstorm Probability (2" diameter or larger), U 1980- 1994



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

Changing Future Conditions Considerations

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

Vulnerability

Vulnerability Overview

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

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

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

Potential Losses to Existing Development

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

Previous and Future Development

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

Hazard Summary by Jurisdiction

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

Problem Statement

Thunderstorms can damage power lines with the high winds or fallen debris such as tree limbs. Not everyone in the county utilizes social media, texting or have access to a weather radio, smaller communities do not have warning sirens, rural areas do not have warning sirens.

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

3.4.9 Severe Winter Weather

Hazard Profile

Hazard Description

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

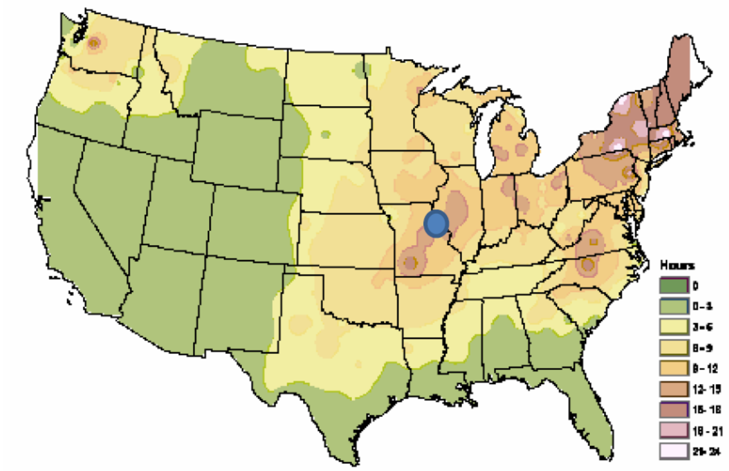
- **Blizzard**—Winds of 35 miles per hour or more with snow and blowing snow reducing visibility to less than ¼ mile for at least three hours.
- **Blowing Snow**—Wind-driven snow that reduces visibility. Blowing snow may be falling snow and/or snow on the ground picked up by the wind.
- **Snow Squalls**—Brief,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

Geographic Location

The entire Pike County is vulnerable to heavy snow, extreme temperatures and freezing rain. The snow season normally extends from late November through mid-March, but significant snows have fallen as early as November 24, 2004 to as late as April 10, 1997.

Figure 3.16 shows the entire planning area (approximated within the blue circle) is in the orange-shaded area that receives 9-12 hours of freezing rain a year.

Figure 3.16. NWS Statewide Average Number of Hours per Year with Freezing Rain



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

Strength/Magnitude/Extent

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

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

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

Previous Occurrences

Table 3.32. NCEI Ralls County Winter Weather Events Summary, [2011-2021].

Type of Event	Inclusive Dates	Magnitude	# of Injuries	Property Damages	Crop Damages
Winter Storm	02/21/13		0	0	0
Heavy Snow	03/24/13		0	0	0
Winter Storm	12/21/13		0	0	0
Winter Storm	01/05/14		0	0	0
Cold/Wind Chill	01/06/14		0	0	0
Winter Storm	02/04/14		0	0	0
Heavy Snow	02/15/15		0	0	0
Heavy Snow	02/20/15		0	0	0
Heavy Snow	11/15/18		0	0	0
Blizzard	11/25/18		0	0	0
Heavy Snow	01/11/19		0	0	0
Winter Storm	12/15/19		0	0	0
Winter Storm	01/01/21		0	0	0

Source: NCEI, data accessed [11/08/21]

February 21, 2013 - A major winter storm hit Northeast Missouri. After a brief period of freezing rain and sleet, the precipitation became all snow and fell heavy at times. Final amounts across the area ranged from 9 to 12 inches.

March 24, 2013 - 6 to 11 inches of snow fell across Central, Northeast and East Central Missouri. Thunder snow was reported in many areas with the snow falling at a rate of 2 inches per hour. Since the snow fell from late Saturday night and Sunday, overall impacts were minimal. Most area schools were closed Monday. However, since temperatures warmed into the 30s Monday, area roads were in good shape by Monday afternoon.

December 21, 2013 - A winter storm produced freezing rain, sleet and snow across Northeast Missouri. Ice accumulations averaged 1/4 inch with about 1/2 inch of sleet and then up to 2 - 3 inches of snow. There were scattered power outages and travel problems.

January 05, 2014 - A very strong winter storm dropped 6 - 9 inches of snow across Central and parts of Eastern Missouri. Strong northerly winds produced snow drifts of 2 to 5 feet. All schools and most businesses were closed on the 5th and 6th, with many schools remaining closed for several days due to very cold temperatures and wind chills.

January 06, 2014 - The winter storm that brought heavy snow to much of the area followed that up with the coldest temperatures in 20 years. Some of the temperatures include Rosebud -26, Washington -21, Farmington -15, Hannibal -14, Jefferson City -14, Canton -13, St. Charles -13, Auxvasse -12, Fredericktown -12, Warrenton -12, Clarksville -11, Columbia -11, Chesterfield -11, Potosi -10, Lambert St. Louis International Airport -8. Wind Chill values the morning of the 6th ranged from -25 to -33.

February 04, 2014 - An early February winter storm dropped from 6 to 13 inches of snow across Central and Northeast Missouri. Travel was very difficult and most schools in rural areas were closed the rest of the week.

February 15, 2015 - A mid-February snowstorm dropped up to 7 inches of snow across parts of East Central and Southeast Missouri.

February 02, 2015 - A winter storm brought a mix of winter weather to the region. Northeast Missouri received mainly snow, while further to the south a mix of snow, sleet and a little freezing combined to create hazardous winter storm conditions.

November 15, 2018 - A strong system lifted northeast across the bootheel of Missouri into the Ohio

Valley. North of the system, a strong deformation zone set up with a swath of heavier snowfall from east central Missouri into southwestern Illinois. By the time the snow came to an end during the afternoon hours of November 15th, up to 9 inches of snow fell with the highest amounts over portions of Warren and St. Charles counties in Missouri.

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

January 01, 2019 - A strong storm system moved through the region with snow developing by the evening hours of January 11th. The area received several waves of heavy snowfall through the morning hours of January 13th. The heaviest snowfall, which exceeded a foot in some locations, occurred over portions of central/northeast Missouri and west central Illinois, although over 6 inches of snow fell across the majority of eastern Missouri and western Illinois.

December 15, 2019 - A winter storm moved into the region on Sunday, December 15th with snow moving into central Missouri by mid-morning. The snow spread west to east through the day and into the evening hours before tapering off. Snowfall rates during this period were between 1 to 2 inches an hour in some locations, especially along the I-70 corridor. Then most of the area saw some light freezing drizzle through Monday morning, December 16th before a second round of snow developed by mid-morning and persisted through Monday evening. The snow came to an end by midnight. Overall, a widespread 4 to 6 inches of snow fell during this event with an axis of higher amounts between Columbia, MO and Belleview, IL and another axis of heavy snowfall from Steelville, MO to Carlyle, IL.

January 01, 2021 - A surface low occluded prior to it reaching the forecast area with a new surface low developing and tracking further east. This led to cooler surface temperatures and a cooler warm nose aloft, which impacted precipitation accumulations and types for portions of the forecast area. Wintry mix at the onset of precipitation changed over to freezing rain. The impacts of the cooler surface temperatures kept the precipitation type as freezing rain a bit longer and this lead to higher ice accumulation amounts across the forecast area. This was particularly notable in portions of central and northeastern Missouri, where up to four tenths of an inch of icing occurred. As the system exited region, the precipitation transitioned to some sleet and snow before ending.

Winter storms, cold, frost and freeze take a toll on crop production in the planning area. According to the USDA's Risk Management Agency, payments for insured crop losses in the planning area as a result of winter storm and cold conditions from 2005 to 2015 totaled $284,133.

Table 3.33. Crop Insurance Claims Paid in Pike County as a Result of Cold Conditions and Snow [2011-2020].

Crop Year	Crop Name	Cause of Loss Description	Insurance Paid ($)
2011	Wheat, Corn, Soybeans	Cold Winter	$38,327
2012	Corn	Cold Wet Weather	$40,918
2013	Wheat, Soybeans	Cold Wet Weather	$16,964
2014	Wheat, Corn, Soybeans	Cold Winter, Freeze	$93,199
2015	Wheat, Corn, Soybeans	Cold Wet Weather	$20,732
2016	Wheat, Soybeans	Cold Wet Weather	$17,806
2017	Corn, Soybeans	Cold Wet Weather	$19,431

2018	Wheat, Soybeans	Cold Wet Weather	$1,117
2019	Wheat, Corn, Soybeans	Cold Winter, Freeze	$28,233
2020	Corn, Soybeans	Cold Wet Weather	$7,406
Total			$284,133

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

Probability of Future Occurrence

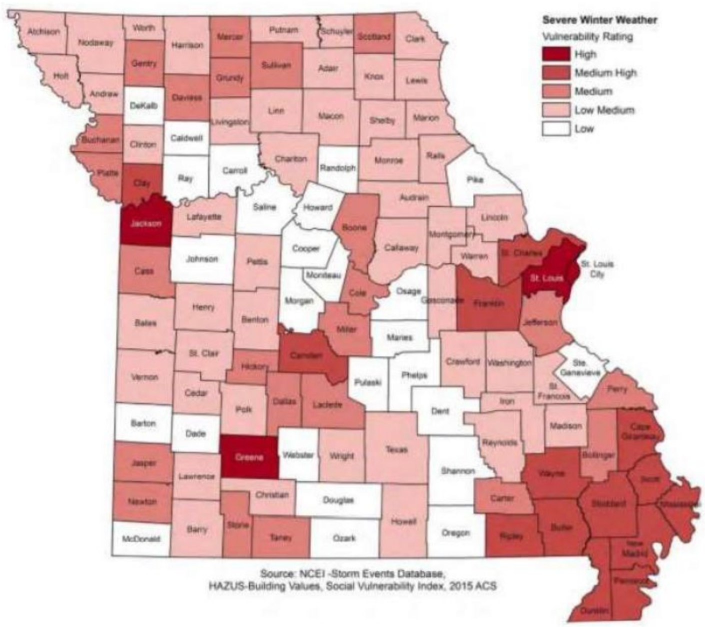
According to NCEI, during the 10 – year period from 2011 to 2021, the planning area experienced thirteen winter weather events. This translates to an annual probability of approximately 1.3 per year winter weather event will occurring.

Changing Future Conditions Considerations

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

Vulnerability

Vulnerability Overview



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

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

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

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

Potential Losses to Existing Development

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

Previous and Future Development

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

Hazard Summary by Jurisdiction

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

Problem Statement

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

3.4.10 Tornado

Hazard Profile

Hazard Description

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

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

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

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

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

Geographic Location

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

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 3.43**) 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 3.34. 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 3.44**. 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 3.35. Enhanced Fujita Scale with Potential Damage

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

EF5	>200	<0.1%	Explosive. Strong frame houses levelled off foundations and swept away; automobile-sized missiles fly through the air in excess of 300 ft.; steel reinforced concrete structure badly damaged; high rise buildings have significant structural deformation; incredible phenomena will occur.

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

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

Previous Occurrences

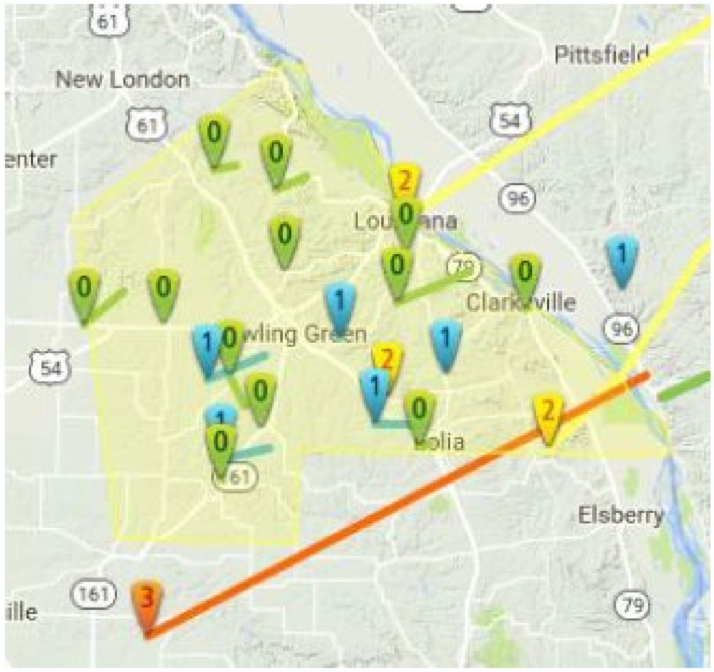
There are limitations to the use of NCEI tornado data that must be noted. For example, one tornado may contain multiple segments as it moves geographically. A tornado that crosses a county line or state line is considered a separate segment for the purposes of reporting to the NCEI. Also, a tornado that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

Table 3.36. Recorded Tornadoes in Pike County, 1993 – Present

Date	Beginning Location	Ending Location	Length (miles)	Width (yards)	F/EF Rating	Death	Injury	Property Damage	Crop Damages
05/25/96	Bowling Green	Bowling Green	3	50	F0	0	0	0	0
06/14/98	Curryville	Curryville	0.2	50	F0	0	0	0	0
02/11/99	Annada	Annada	6.4	100	F0	0	0	0	0
04/08/99	Louisiana	Louisiana	0.5	75	F2	0	0	$200,000	0
02/29/00	Curryville	Curryville	10	50	F0	0	0	0	0
03/12/06	New Hartford	Ashley	6	175	F1	0	0	0	0
03/13/06	Annada	Annada	8	100	F0	0	0	0	0
06/22/06	Ashley	Ashley	0.3	50	F0	0	0	0	0
01/07/11	Stark	Clarksville	4.98	40	EF0	0	0	0	0
02/27/11	Frankford	Frankford	3.69	80	EF0	0	0	0	0
04/15/11	Vera	Booth	3.01	20	EF1	0	0	0	0
04/19/11	Clarksville	Clarksville	4.16	200	EF1	0	0	0	0
06/28/15	Edgewood	Eolia	3.13	90	EF1	0	0	0	0
	Total		53.37	1,080		0	0	$200,000	0

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

Figure 3.17. Pike County Map of Historic Tornado Events



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

During the previous 10 years of data from the USDA Risk Management Agency Pike County has not received any insurance payments for crop damages as a result of tornadoes.

Probability of Future Occurrence

The National Climatic Data Center reported 22 tornadoes in Pike County in a 65-year time period, which calculates to a 34 percent chance of a tornado in any given year. Therefore it is a low probability that some portion of Pike County will experience tornado activity in any given year.

Changing Future Conditions Considerations

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

Vulnerability

Vulnerability Overview

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

Figure 3.18. Tornado Alley in the U.S.

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

Potential Losses to Existing Development

In Pike County, the NCEI estimate for past damages from 1950 to 2021 is $477,530 and the annualized property damage is $6,821.86 over the 70 years.

To estimate vulnerability to tornadoes, the MPC decided to consider the impacts of an F0 tornado due to this being the most common in the period reviewed tornado with wind speed of approximately 65-85 mph and a length of 3.16 miles and width of 65.29 yards in Pike County. The location chosen is based on medium housing and commercial structure density to show the variance of potential damages. Based on information from the NOAA Storm Prediction Center, a F0/EF0 tornado of this magnitude would create some damage to chimneys; branches broken off trees; shallow-rooted trees pushed over; sign boards damaged. Several factors impact the severity of damage, including wind speed, time on the ground, length/width of the cell, population density, building density, age and construction of buildings and time of day.

Previous and Future Development

Due to the decrease in population in Pike County, vulnerability to tornadoes is anticipated to remain the same. Future development for public buildings such as schools, government offices, as well as buildings with high occupancy and campgrounds should consider including a tornado saferoom to protect occupants in the event of a tornado.

Hazard Summary by Jurisdiction

Tornadoes can occur in the entire planning area however due to the age of housing, age of commercial structures and a high concentration of mobile homes throughout the county some of the jurisdictions would suffer heavier damages.

Problem Statement

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

Possible solutions could be awareness made of existing tornado shelters, education on what to do in the event of a tornado, construction of safe rooms, and smaller communities could install warning sirens. A strong emphasis could be made for everyone in the county to own a weather radio.

3.4.11 Wildfire

Hazard Profile

Hazard Description

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

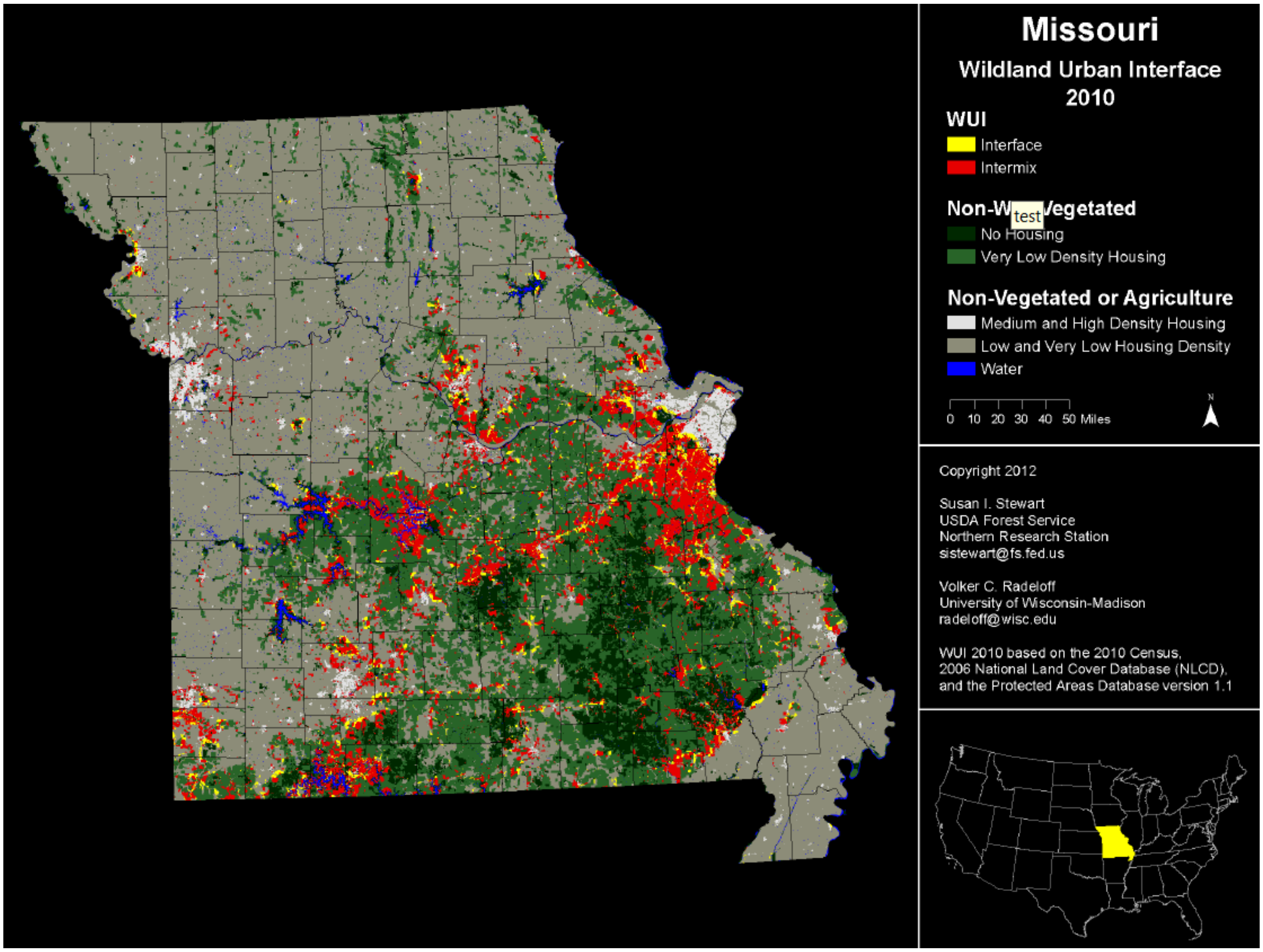
The Forestry Division of the Missouri Department of Conservation (MDC) is responsible for protecting privately owned and state-owned forests and grasslands from wildfires. To accomplish this task, eight forestry regions have been established in Missouri for fire suppression. The Forestry Division works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

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

Geographic Location

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

The map below shows the Wildland-Urban Interface for the State of Missouri. The entire Northeast Region is comparable to Pike County with very low risk for damages to any of the cities in the area. Wildfires are included in the plan because like most other natural hazards there is always a possibility. When there are periods of extreme heat and drought the risk of wildfire increases.



Strength/Magnitude/Extent

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

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

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

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

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

Previous Occurrences

According to information obtained from the Missouri Division of Fire Safety (MDFS) Website as well as the Missouri Department of Conversation Wildfire Data Search there were 191 reported wildland or grass fires in Pike County from 2005 to 2020. In total, these 191 fires burned 2,386.81 acres and no injuries were reported. Forty-one of the fires had an unknown cause for starting and burning 690.2 acres and 35 were started by a debris. These 76 fires burned 1,320.21 acres during the fifteen-year reporting period.

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

Probability of Future Occurrence

When analyzing the wildland fires, there has been an average of 11.9375 fires burning 159.12 acres per year. However, it was reported these fires did not result in major damages. The probability score to be likely in any given year that a wildfire could occur in the planning area.

Changing Future Conditions Considerations

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

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

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

Vulnerability

Vulnerability Overview

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

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

Potential Losses to Existing Development

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

Impact of Previous and Future Development

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

Hazard Summary by Jurisdiction

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

Problem Statement

Pike County cannot issue a burn ban until it is reviewed by the State Fire Marshall. Due to the length of review, there is often many opportunities for wildfire which could be avoided by the timely release of a burn ban. Residents do not comply with burn bans, education is not available for the levels of burn bans, many residents lack education in fire safety and not all residents utilize social media and texting.

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

3.4.12 Pandemic

Hazard Profile

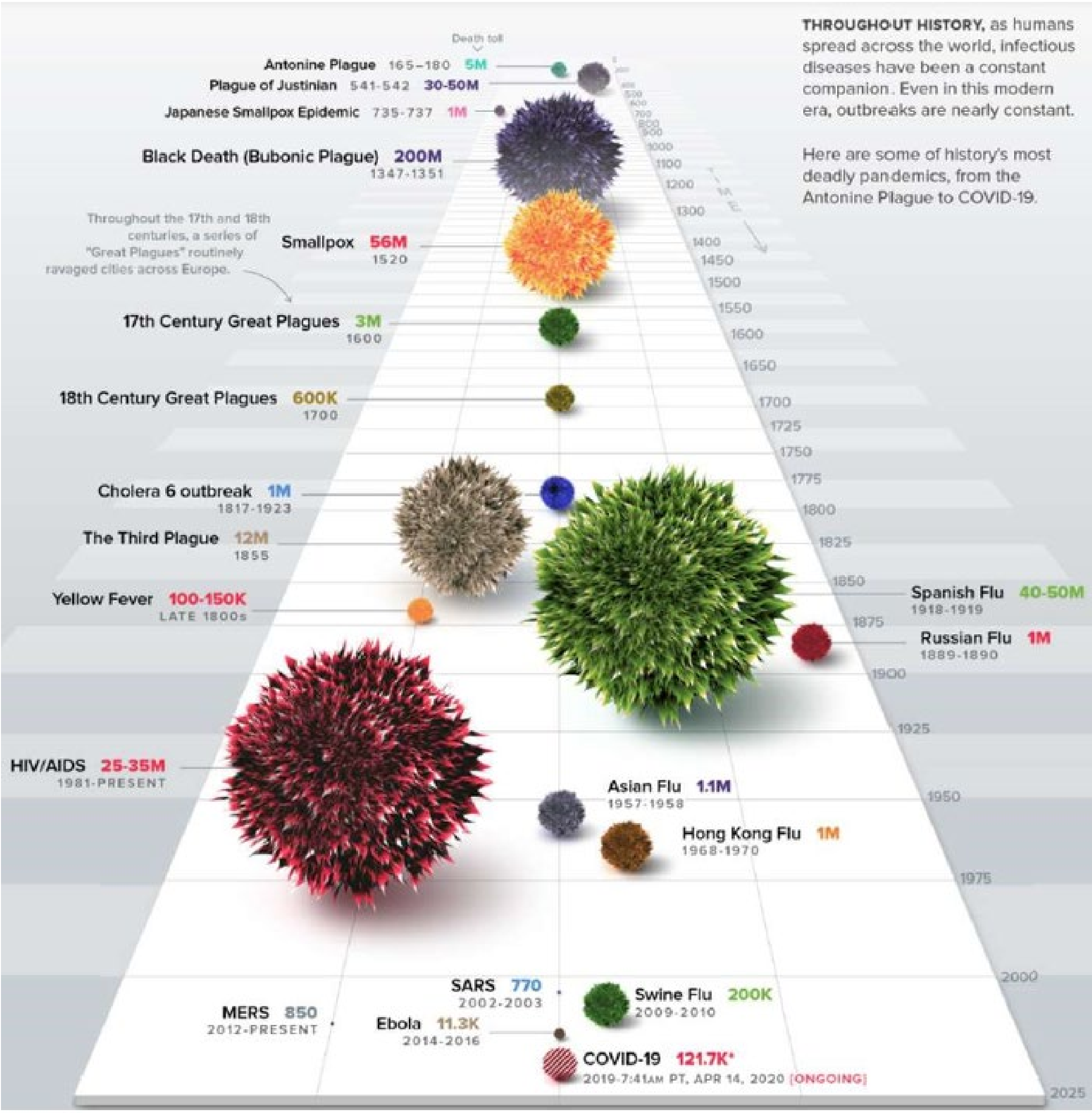
Hazard Description
According to the Center for Disease Control, a pandemic is a global outbreak of disease. Pandemics happen when a new virus emerges to infect people and can spread between people sustainably. Because there is little to no pre-existing immunity against the new virus, it spreads worldwide.

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

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

Previous Occurrences
The planning area, in addition to others across the globe, is currently in the midst of a pandemic. The virus that causes COVID-19 is infecting people and spreading easily from person-to-person. On March 11, 2020 the COVID-19 outbreak was characterized as a pandemic by the World Health Organization. According to the Center for Disease Control, this is the first pandemic known to be caused by a new coronavirus. In the past century, there have been four pandemics caused by the emergence of new influenza viruses. As a result, most research and guidance around pandemics is specific to influenza, but the same premises can be applied to the current COVID-19 pandemic. Pandemics of respiratory disease follow a certain progression outlined in a “Pandemic Intervals Framework.” Pandemics begin with an investigation phase, followed by recognition, initiation, and acceleration phases. The peak of illnesses occurs at the end of the acceleration phase, which is followed by a deceleration phase, during which there is a decrease in illnesses. Different countries can be in different phases of the pandemic at any point in time and different parts of the same country can also be in different phases of a pandemic.
As humans have spread across the world, so have infectious diseases. Even in this modern era, outbreaks are nearly constant, though not every outbreak reaches pandemic level. Figure 3.43 below outlines the history of pandemics dating back to 165.

Figure 3.43. History of Pandemics



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

Probability of Future Occurrence

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

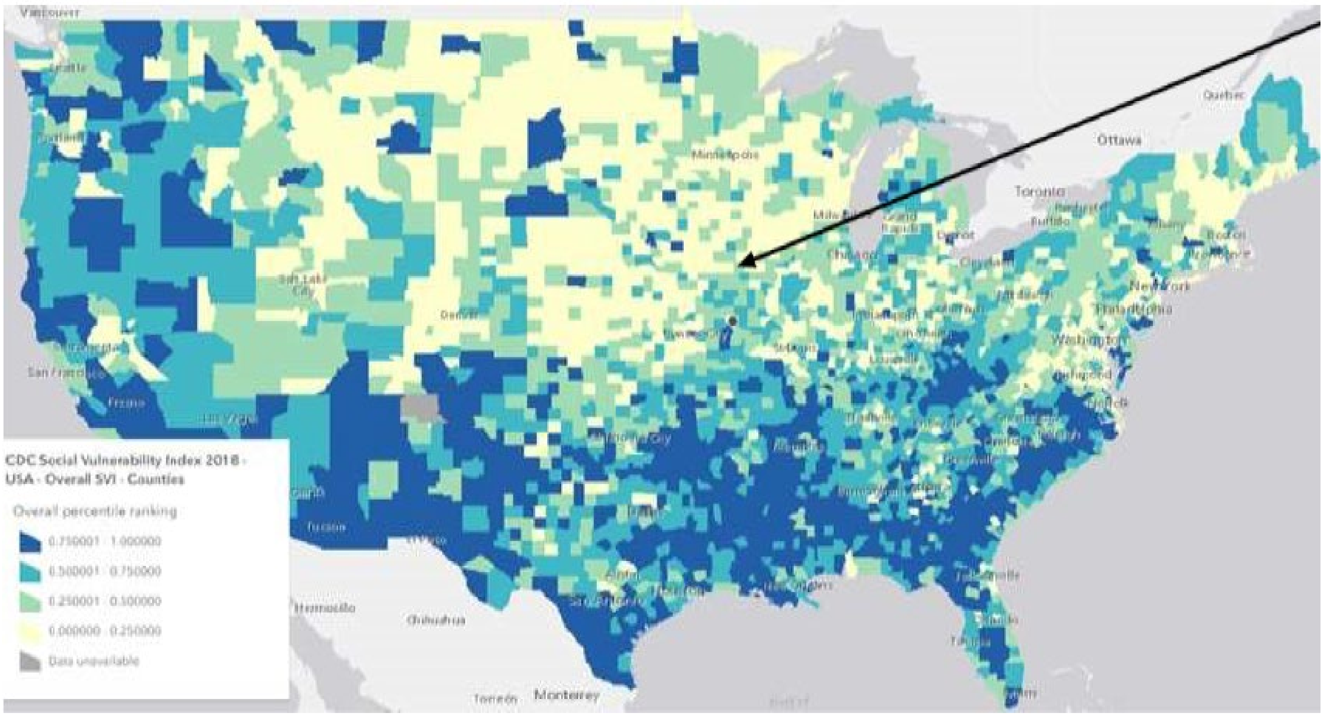
Changing Future Conditions Considerations

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

Vulnerability

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

Figure 3.44. Social Vulnerability Rating in the United States



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

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

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

Hazard Summary by Jurisdiction

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

Problem Statement

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