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.

Following is a community-wide risk assessment for Wayne County, Missouri. The data used to compile this assessment can be found throughout the body of this document, primarily in the profile of each hazard and capabilities of each jurisdiction. The natural hazards discussed throughout this document were examined using available data relevant and necessary for determining the frequency and strength of natural hazards, areas vulnerable to those hazards, potential impacts, and the probability that each hazard will occur.

The goal of the risk assessment is to identify and profile hazards relevant to the county and its communities. For each identified hazard, the potential loss in the planning area, including loss of life, personal injury, property damage, and economic loss, is estimated as resulting from such an 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.

The Wayne County Hazard Mitigation Planning Committee has determined that this updated plan, as with past county plans, will address only natural hazards. Natural hazard has been defined by I. Burton, R. Kates, and G. White in *The Environment as Hazard*, as "those elements of the physical environment, harmful to man and caused by forces extraneous to him." Consistent with this definition, war, chemical contamination, and other manmade phenomena are excluded from classification as natural hazards. Natural hazards can take many forms (e.g. tornado, wildfire, flood, landslide, and earthquake). Happenings such as those listed above, which occur in a populated area, are, according to the Organization of American States, referred to as hazardous events. It is not until significant property damage and loss of life result from a natural hazard that the phenomena can legitimately be classified as a natural disaster.

3.1.1 Review of Existing Mitigation Plans

The planning committee reviewed the hazards identified in the *2018 Wayne County Hazard Mitigation Plan, 2018.* In the 2018 county-wide plan, ten natural hazards were identified:

- Flooding
- Dam Failure
- Earthquakes
- Sinkholes
- Drought
- Extreme Temperatures
- Severe Thunderstorm, High Winds, Lightning, Hail
- Severe Winter Weather
- Tornadoes
- Wildfire

Furthermore, the planning committee examined those hazards identified as applicable to the State of Missouri per the *Missouri State Hazard Mitigation Plan, 2023.* Those hazards listed above, as well as levee failure were identified. The planning committee reviewed all eleven natural hazards and compared them to the known historical hazards that have impacted jurisdictions within Wayne County. After this review, the committee determined the above list of ten natural hazards to be appropriate for the planning area, thereby requiring no modification.

The updated plan will review and analyze the natural hazards as listed above. Each of the above listed phenomena has either occurred within Wayne County at some point in time or could occur given the geography and other environmental conditions which exist within the county. Some of the above hazards are more likely to occur in this area, while some are less likely.

In the pages that follow, each hazard will be described, its history of occurrence within the planning area, and its probability of recurrence assessed.

Due to the location and geography of Wayne County, the occurrence of certain natural hazards, which may take place elsewhere in the world, is virtually impossible. The following list contains natural hazards, which have been determined to be insignificant threats within Wayne County:

- avalanche;
- coastal erosion;

- coastal storms;
- expansive soils;
- landslide/rockfall;
- hurricane and other tropical storm-related phenomena;
- tsunami;
- volcano and other volcanic-related phenomena; and,
- arid and semi-arid-related phenomena.

No identified avalanche risk areas exist within the planning area and there exists no history of occurrence. There are no coastal areas in the state or in the planning area. Per the Missouri Department of Natural Resources, no areas at risk of expansive soils have been identified as located within the county or the state. Landslides and/or rockfalls are considered to be a widespread hazard of concern in neither the planning area, nor the state, per the Missouri Department of Transportation (MoDOT). Any such risk areas, as well as consequential mitigation, fall under the jurisdiction of MoDOT. Per the state plan, "It was determined that additional analysis of these limited areas would duplicate effort." Hurricanes, tropical storms, and tsunamis do not occur in or near Wayne County due to its central location within North America. The geologic and soil structure found in Wayne County does not encourage volcanic activity. Because of this, there are no volcanoes within or near the county. Finally, arid and semi-arid-related phenomena do not occur in Wayne County due to its climate and geology. As with the previous plan, levee failure will not be reviewed in this plan. Per the Wayne County Commission, no levees exist within Wayne County. Furthermore, there are no mapped levees nor associated levee protected areas within or immediately upstream of Wayne County.

In Missouri, local plans customarily include only natural hazards The planning committee discussed including man-made hazards in the Wayne County Hazard Mitigation Plan. However, as only natural hazards are required by FEMA regulations, the committee decided to only include natural hazards.

3.1.2 Review Disaster Declaration History

The federal government may, at times, issue disaster declarations. 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.

The Stafford Act provides for two types of disaster declarations: emergency declarations and major disaster declarations. Declarations discussed within this plan include both types. The emergency declarations authorize the President to provide supplemental disaster assistance. Major disaster declarations provide for a wide range of federal assistance programs for individuals and public entities for both emergency and permanent repairs.

Individual assistance includes assistance to individuals and households for things such as crisis counseling, case management, unemployment assistance, legal services and 3.6 supplemental nutrition assistance program. Public assistance provides monetary resources to states, tribes, and local governments for things such as debris removal, emergency protective measures, roads and bridges, water control facilities, buildings and equipment, utilities, and park, recreational and other facilities.

As noted above, 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.

The following table (**Table 3.1**) lists the federal FEMA disaster declarations that included the planning area from 1965 to present. The table lists twenty-five disasters inlcuding the disaster number, a short description, the date of declaration, the period of incident, and the amounts of Individual Assistance (IA) and Public Assistance (PA) distributed.

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

Disaster Number	Description	Declaration Date Incident Period	Individual Assistance (IA) Public Assistance (PA)
DR-4741	Severe Storm	9/21/2023 7/29/2023-8/14/2023	PA Only
DR-4636	Severe Storm	1/10/2022 12/10/2021-12/10/2021	PA Only
DR-4552	Severe Storm	7/9/2020 5/3/2020-5/4/2020	PA Only
DR-4490	Biological	3/26/2020 1/20/2020-5/11/2023	PA Only
EM-3482	Severe Storm	3/13/2020 1/20/2020-5/11/2023	PA Only
DR-4551	Flood	7/9/2019 4/29/2019-7/5/2019	PA Only
DR-4317	Flood	6/2/2017 4/28/2017-5/11/2017	PA Only
EM-3374	Flood	01/02/2016 12/22/2015-1/9/2016	PA Only
EM-3317	Severe Storm	2/3/2011 1/31/2011-2/5/2011	PA Only
EM-3303	Severe Ice Storm	1/30/2009 1/26/2009-1/28/2009	PA Only
EM-3281	Severe Ice Storm	12/12/2007 12/8/2007-12/15/2007	PA Only
EM-3232	Hurricane	9/10/2005 8/29/2005-10/1/2005	PA Only
EM-3017	Drought	9/24/1976 9/24/1976-9/24/1976	PA Only
DR-1980	Severe Storm	5/9/2011 4/19/2011-6/6/2011	PA Only
DR-1847	Severe Storm	6/19/2009 5/8/2009-5/16/2009	PA Only
DR-1822	Severe Storm	2/17/2009 1/26/2009-1/28/2009	PA Only
DR-1809	Severe Storm	11/13/2008 9/11/2008-9/24/2008	PA Only
DR-1749	Severe Storm	3/19/2008 3/17/2008-5/9/2008	IA & PA
DR-1748	Severe Ice Storm	3/12/2008 2/10/2008-2/14/2008	PA Only
DR-1412	Severe Storm	5/6/2002 4/24/2002-6/10/2002	PA & IA
DR-1006	Severe Storm	12/1/1993 11/13/1993 - 11/19/1993	IA & PA
DR-995	Flood	7/9/1993 6/10/1993-10/25/1993	IA Only

DR-672	Flood	12/10/1982 12/10/1982	IA & PA
DR-516	Flood	7/21/1976 7/21/1976	IA & PA
DR-372	Severe Storm	4/19/1973 4/19/1973-4/19/1973	IA & PA

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

3.1.3 Research Additional Sources

Multiple sources of data were consulted during the assessment of hazard risk to each participating jurisdiction and included the following:

- Missouri Hazard Mitigation Plan, 2023
- Wayne County Hazard Mitigation Plan (2018)
- Federal Emergency Management Agency (FEMA)
- Missouri Department of Natural Resources
- National Drought Mitigation Center Drought Reporter
- US Department of Agriculture's (USDA) Risk Management Agency Crop Insurance Statistics
- National Agricultural Statistics Service (Agriculture production/losses)
- Data Collection Questionnaires completed by each jurisdiction
- State of Missouri GIS data
- 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);
- Wayne County Emergency Management Agency
- Wayne 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 with citations provided within 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. 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. 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 are broad estimates. 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.

Injuries and deaths caused by a storm event are reported by the NOAA on an area-wide basis. Any death or injury listed in connection with a hazard event may or may not have occurred within the participating jurisdiction.

3.1.4 Hazards Identified

Not all of the hazards included in this plan impact the entire planning area in the same manner; yet, some hazards do have the potential to impact the entire planning area. For example, winter weather will impact the entire planning area as the county, all cities and school districts will be impacted to some degree when severe winter weather strikes the county. The table below lists each jurisdiction and each hazard significantly impacting that jurisdiction in alphabetical order. An "x" indicates that the hazard has the potential to impact a jurisdiction and has been chosen for further analysis, whereas, an "-" indicates the hazard is not applicable to the jurisdiction.

Table 3.2. Hazards Identified for Each Jurisdiction

Jurisdiction	Dam Failure	Drought	Earthquake	Extreme Temperatures	Flooding (River and Flash)	Land Subsidence/Sinkholes	Levee Failure	Severe Winter Weather	Thunderstorm/Lightning/Hail/ High Wind	Tornado	Wildfire
Wayne County	x	x	x	x	x	x	-	x	x	x	x
City of Greenville	x	-	x	x	-	x	-	x	-	x	x
City of Piedmont	x	-	x	x	x	x	-	x	-	x	x
City of Williamsville	-	-	x	x	-	x	-	x	x	x	x
Clearwater R-I School District	x	-	x	x	-	-	-	x	x	x	x
Greenville R-II School District	-	-	x	x	-	-	-	x	x	x	x

3.1.5 Multi-Jurisdictional Risk Assessment

Following is a multi-jurisdictional hazard profile for Wayne County, Missouri and all the jurisdictions within the boundaries of Wayne County. The data used to compile this assessment can be found throughout the body of Section 3 as well as the tables included in this section.

This plan is an update of the *Wayne County Natural Hazard Mitigation Plan* approved in 2019. The data and information included reflect changes and updates in the five years since the 2019 plan approval.

Each of the hazards has a profile that includes an assessment of the risks to the local participating jurisdictions. Some hazards, such as flooding, vary in risk across the planning area. These variations in risk are discussed within the profile of each hazard.

Wayne County is located in the northeastern portion of the Ozark Foothills Region. The climate in Wayne County is consistent throughout the year; temperatures and precipitation are fairly uniform. There are some variations of topography throughout the county. These topographical differences and the relative impact of hazards will be discussed in more detail throughout the hazard profiles. A variety of recreational areas, including Clearwater Lake, Wappapello Lake, Sam A. Baker State Park, Markham Springs, Old Greenville U.S. Historic Site, Mark Twain National Forest, Coldwater State Forest, Black River, and the Saint Francis River are located in the county. There are no urbanized areas within the county.

In addition to topographical differences there are other variations across the county that will be discussed in greater detail throughout the hazard profiles. Some of these differences include the locations of dams that can impact certain areas, flooding along rivers that will impact different areas of the county to various extents, sinkholes, and concentrations of agricultural lands and forests. Such differences throughout the planning area will be discussed in greater detail in the vulnerability sections of each hazard under a separate heading.

3.2 ASSETS AT RISK

This section assesses the planning area population, structures, critical facilities and infrastructure, and other important assets that may be at risk of damage from natural hazards. There have been limited changes to the planning areas since the approval of the 2019 *Wayne County Hazard Mitigation Plan.*

The best data available for the planning area was used to describe all assets at risk. Regarding the Flood Risk Datasets, data falls within the following categories which may or may not be available for the planning area:

- Good: If a digital FIRM (DFIRM) is not available for the flood risk analysis, use the census block exposure data out of Hazus or available as a Tiger/Line (note links above). If this method is chosen, apply corporate boundaries of jurisdictions in the plan to the GIS data available to parse out assets at risk for each jurisdiction. If this method is chosen, use this exposure data for all hazards so that the analysis is consistent.
- Better: If a DFIRM is available for the flood risk assessment AND parcel data is available in GIS format w/ associated building values—but not in a format that can be imported into Hazus, analysis can be done to show parcels and associated values in the planning area

compared against the actual regulatory floodplain. The limitation with this is that your potential loss estimates will not be based on a depth/damage function as they are in Hazus. But, this is still a much more accurate picture of what is vulnerable to flooding than using the Hazus estimated floodplain and census block. If you use this method for the flood risk assessment, it is best to use the parcel data for the total exposure for all hazards so that the analysis is consistent. Contents values are not usually included w/ parcel data structure values. However, using the formulas that Hazus uses, they can be calculated. Residential (50%), Commercial (100%), Industrial (150%), Agricultural (100%).

- Best: If DFIRM with depth grids are available, as produced during the Risk MAP process, AND parcel data is available in GIS format AND parcel data is in a format compatible w/ Hazus' user-defined data, this gives the best analysis. This provides the actual parcels and associated values in the planning area against the actual regulatory floodplain and will also take into account the depth-damage function in Hazus.

3.2.1 Total Exposure of Population and Structures

Unincorporated County and Incorporated Cities

In the following three tables, population numbers are based on data collected during the 2020 Decennial Census. 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 at https://drive.google.com/drive/folders/0Bzg99s866kWocFB5Y3hCRlRuWWM . 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 within the source documentation for **Table 3.3** below.

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. **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	2020 Decennial Census	Building Count	Building Exposure ($)	Contents Exposure ($)	Total Exposure ($)
City of Greenville	443	164	30,199,000	17,636,000	47,835,000
City of Piedmont	1,897	792	114,264,000	64,126,000	178,390,000

City of Williamsville	279	134	15,067,000	7,894,000	22,961,000
Village of Mill Spring	159	79	8,133,000	4,057,000	12,190,000
Unincorporated Wayne	8,196	7,850	624,276,000	342,514,000	966,790,000
Total	10,974	9,019	791,939,000	436,227	1,228,166,000

Source: U.S. Bureau of the Census, Decennial Census, 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%). G overnment, school, and utility were calculated at the commercial contents rate.

Table 3.4. Building Values/Exposure by Usage Type

Jurisdiction	Residential ($)	Commercial ($)	Educational ($)	Governmental ($)	Industrial ($)	Agricultural ($)	Total ($)
City of Greenville	24,727,000	17,155,000	4,315,000	1,633,000	0	5,000	30,199,000
City of Piedmont	135,421,000	32,072,000	5,394,000	3,266,000	2,195,000	43,000	114,264,000
City of Williamsville	21,443,000	1,492,000	0	0	0	26,000	15,067,000
Village of Mill Spring	12,170,000	0	0	0	0	20,000	8,133,000
Unincorporated	863,138,000	44,752000	539,000	52,682,000	52,682,000	4,046,000	624,276,000
Total	1,057,093,000	95,470,000	10,248,000	6,532,000	54,877,000	4,139,000	791,939,000

Source: Missouri GIS Database, SEMA Mitigation Management Section

Table 3.5. Building Counts by Usage Type

Jurisdiction	Residential Counts	Commercial Counts	Educational Counts	Governmental Counts	Industrial Counts	Agricultural Counts	Total
City of Greenville	128	23	8	1	0	4	164
City of Piedmont	701	43	10	2	1	35	792
City of Williamsville	111	2	0	0	0	21	134
Village of Mill Spring	63	0	0	0	0	16	79
Unincorporated Wayne	4,468	60	1	1	24	3,296	7,850
Totals	5,471	128	19	4	25	3,372	9,019

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	Building Exposure ($)	Contents Exposure ($)	Total Exposure ($)
Clearwater R-I School District	911	9	38,924,537	5,274,239	44,208,776
Greenville R-II School District	701	No Response	No Response	No Response	No Response

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

3.2.2 Critical and Essential Facilities and Infrastructure

This section will include information from the Data Collection Questionnaires 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 Questionnaires provided by each participating jurisdiction as well as the following sources:

Facilities housing chemicals (fueling stations, etc.) are categorized by the Environmental Protection Agency (EPA) as either Tier I or Tier II facilities. Any EPA-regulated facility in the U.S. that stores or handles more than 10,000 pounds of hazardous chemicals are subject to annual Tier II inventory reporting requirements. Although few in number relative to other counties in the state, such facilities do exist within Wayne County. A listing of Tier II Facilities located within the planning area is provided below and was sourced from the SEMO Regional Local Emergency Planning District (LEPD)--the multi-county LEPD serving the county.

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**
City of Greenville	0	0	1	1	1	0	1	1	0	0	1	0	0	0	1	1	1	0	1	3	0	2	1	14
City of Piedmont	1	1	1	1	1	0	1	1	0	0	1	1	0	0	1	1	1	1	1	2	0	49	1	17
City of Williamsville	0	0	0	1	1	0	1	2	0	0	0	0	0	0	0	0	1	1	1	0	0	12	1	9
Village of Mill Spring	0	0	0	1	1	0	1	2	0	0	0	0	0	0	0	0	1	1	1	0	0	0	0	8
Wayne County -	0	0	0	2	1	0	5	2	0	0	1	0	0	0	1	1	1	1	0	2	0	13	0	17
Totals	1	1	2	6	5	0	9	8	0	0	3	1	0	0	3	3	5	4	4	7	0	76	3	65

Source: *Missouri State Hazard Mitigation Plan, 2023* and Hazard Mitigation Viewer; Data Collection Questionnaires; Hazus, SEMO Regional LEPD

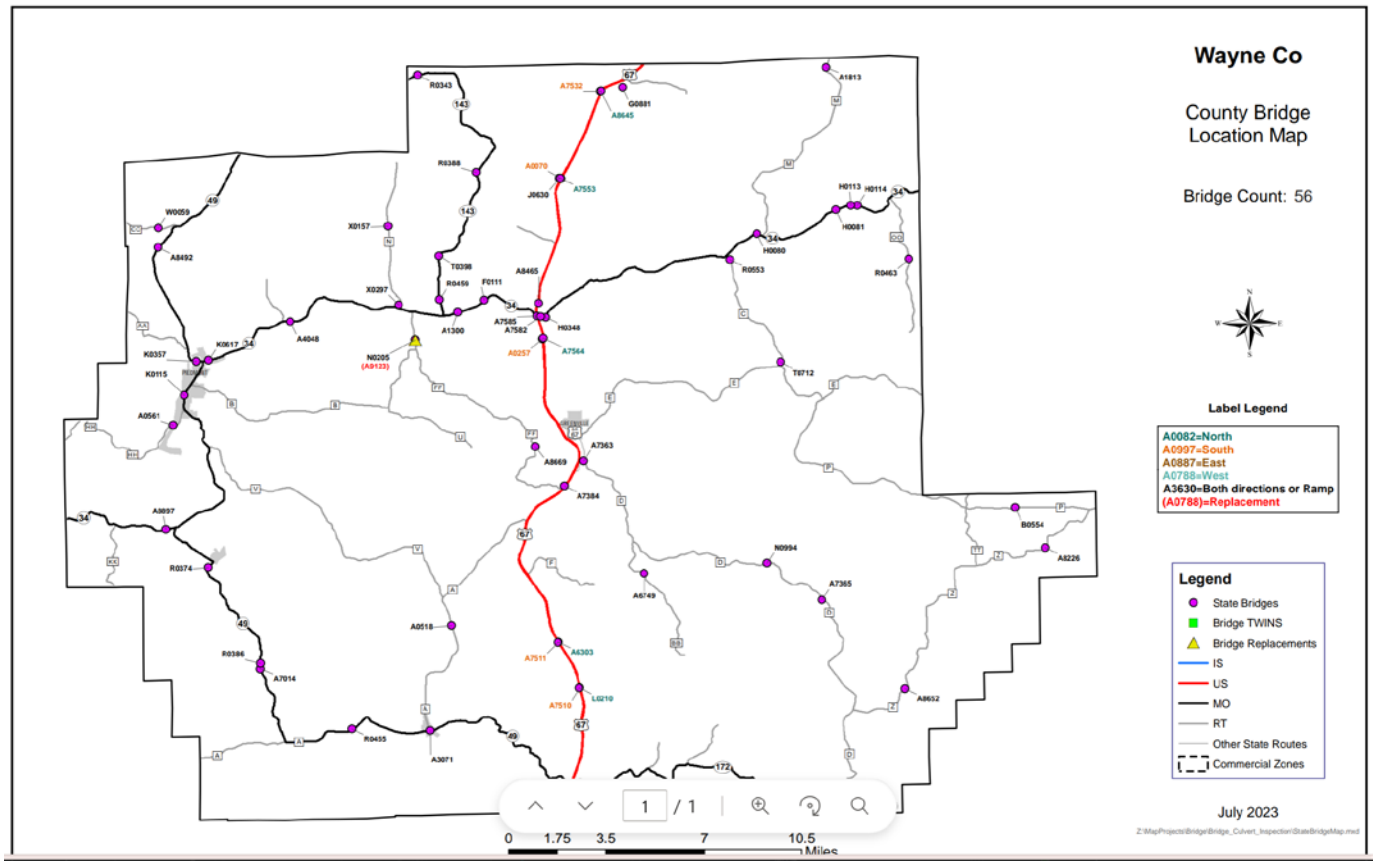
According to the National Bridge Inventory found at http://www.fhwa.dot.gov/bridge/nbi/no10/county.cfm, there are 198 bridges located within Wayne County and its incorporated jurisdictions. The condition of 71 of bridges located within the planning area are rated as "Good," 118 rated as "Fair," and 9 rated as being in "Poor" condition. Four of the county's 198 bridges are federally owned and maintained—all are in "Good" condition. Federally maintained bridges in Wayne County comprise less than1% of total bridge square footage in the county. The remaining 194 bridges are owned and maintained by either the county, municipalities, or private landowners.

There are four maps included within Figure 3.1. The first two maps show the location of all bridges in Wayne County. The first map shows state-owned/maintained bridges, while the second map shows non-state-owned structures including both bridges and culverts. The third map shows the location of bridges and culverts within the county's largest municipality (the City of Piedmont).

The final map in Figure 3.1 identifies the bridges that are "scour critical." This term refers to one of the database elements in the National Bridge Inventory and is quantified using a "scour index." The "scour index" 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.

A scour critical bridge is susceptible to scouring or the removal of sediments, such as sand and rocks from around the bridge abutments or piers by swiftly moving water. The Missouri Department of Transportation uses a classification system of A-D to indicate the potential for scour on the bridges it maintains. Those bridges in the "A" class are those that are most vulnerable and those in the "D" class are the least vulnerable to scour. As can be seen upon the final map in Figure 3.1, six bridges within the planning area are rated as scour critical—four state-owned bridges and two non-state bridges. The four state-owned scour critical bridges are rated C and D. Fortunately, no scour critical bridges are located within the limits of municipal jurisdictions within the county.

Figure 3.1. Wayne County Bridges




NON STATE STRUCTURES
PIEDMONT
Bridge
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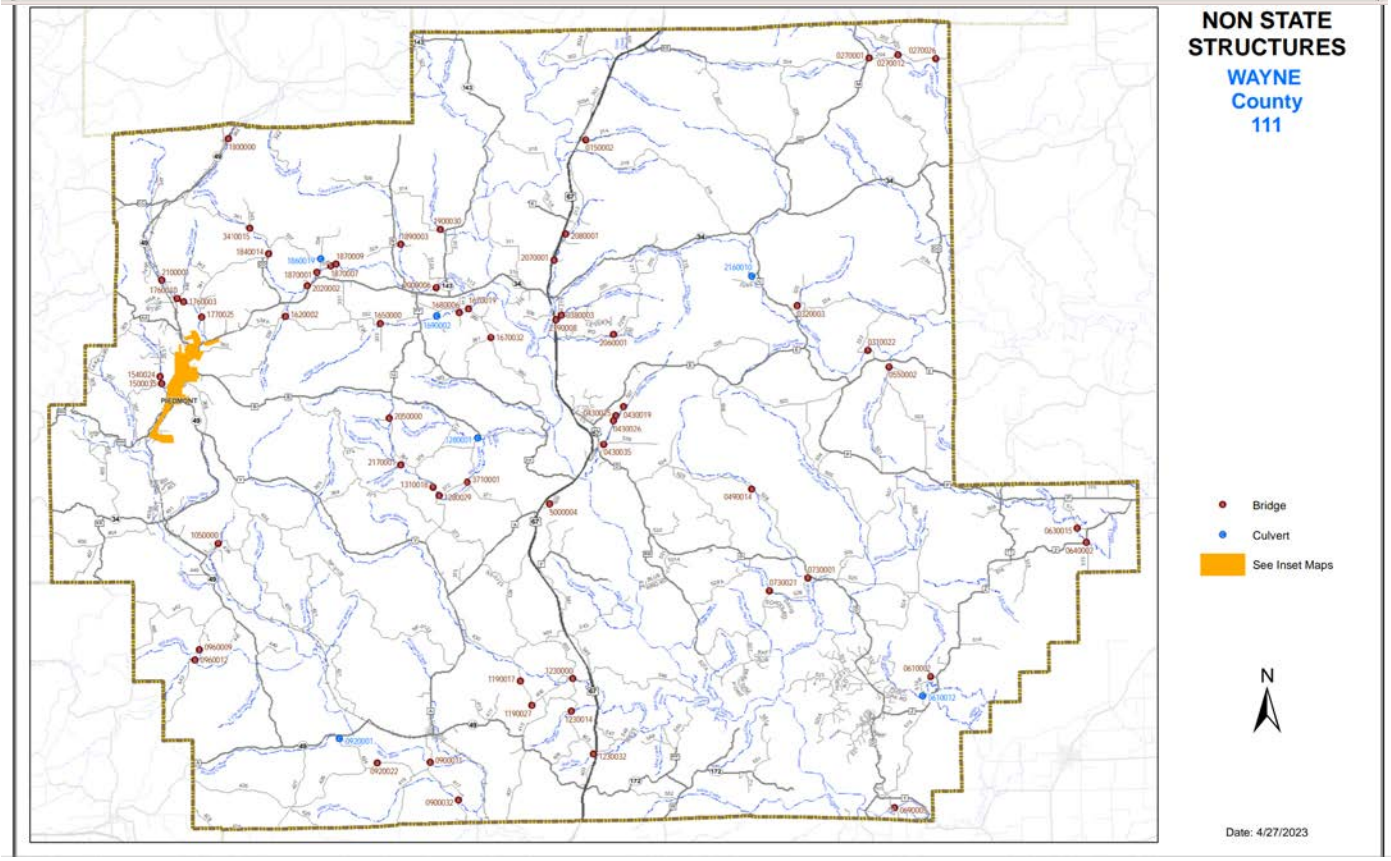
NON STATE STRUCTURES
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County
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Bridge
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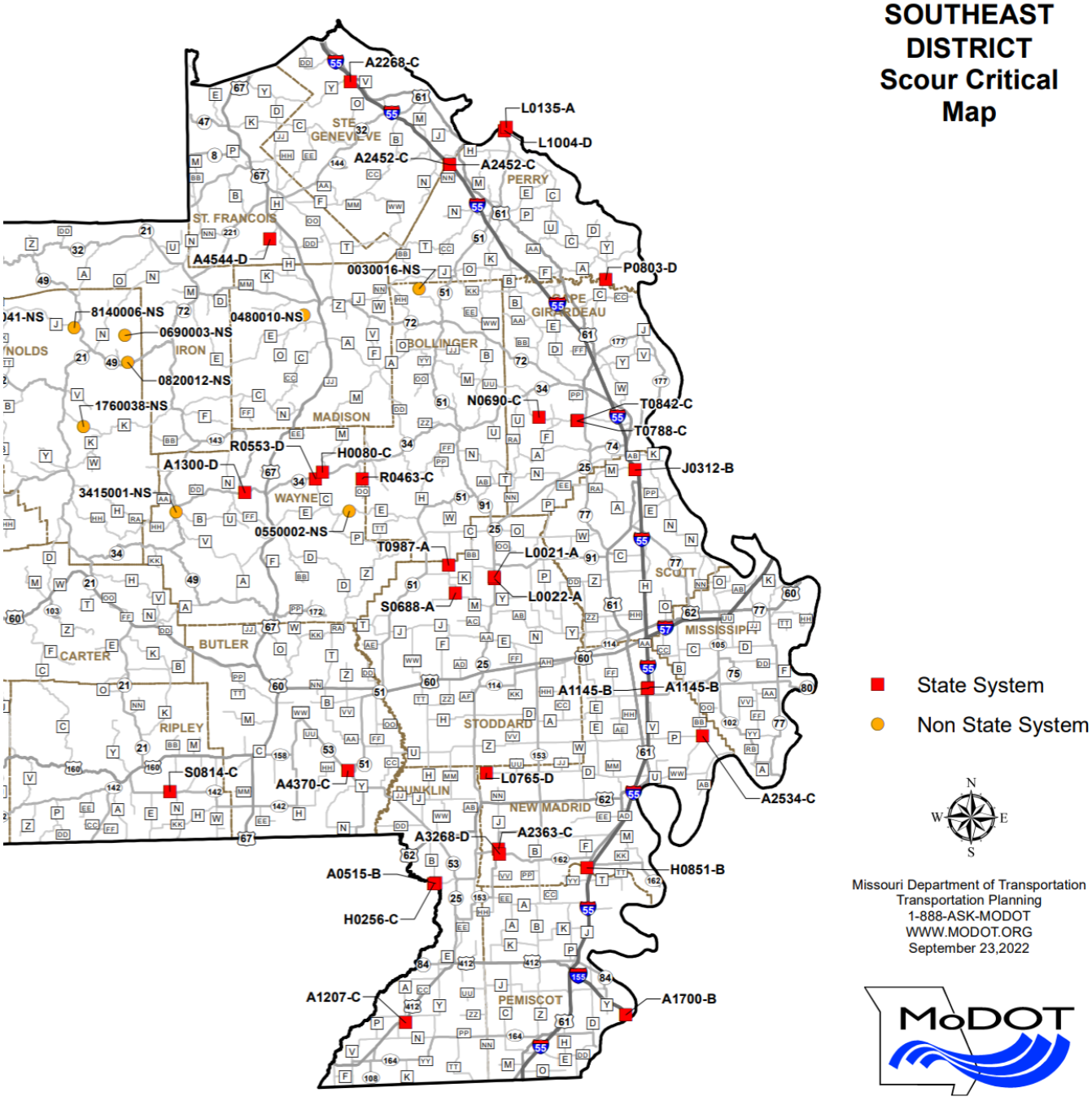


An interactive website developed by Transportation for America purportedly allows users to locate and map structurally deficient bridges in their area. Transportation for America is an alliance of elected, business, and civic leaders from communities across the country, united to encourage states

and the federal government to invest in smart, homegrown, locally-driven transportation solutions. Unfortunately, the mapping tool found http://t4america.org/maps-tools/bridges/ is unusable.

3.2.3 Other Assets[5(d)]

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

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

(**Table 3.8**) below shows Federally Threatened, Endangered, Proposed and Candidate Species in the planning area.

Table 3.8. Threatened and Endangered Species in Wayne County

Common Name	Scientific Name	Status
Gray Bat	Myotis grisescens	Endangered
Indiana Bat	Myotis sodalis	Endangered
Northern Long-eared Bat	Myotis septentrionalis	Endangered
Tricolored Bat	Perimyotis subflavus	Proposed Endangered
Alligator Snapping Turtle	Macrochelys temminckii	Proposed Threatened
Curtis Pearlymussel	Epioblasma florentina curtisii	Endangered
Pink Mucket	Lampsilis abrupta	Endangered
Rabbitsfoot	Quadrula cylindrica cylindrica	Threatened
Snuffbox Mussel	Epioblasma triquetra	Endangered
Western Fanshell	Cyprogenia aberti	Threatened
Hine's Emerald Dragonfly	Somatochlora hineana	Endangered
Monarch Butterfly	Danaus plexippus	Candidate
Big Creek Crayfish	Faxonius peruncus	Threatened
St. Francis River Crayfish	Faxonius quadruncus	Threatened
Mead's Milkweed	Asclepias meadii	Threatened

Source: U.S. Fish and Wildlife Service, https://ecos.fws.gov/ipac/

The Missouri Department of Conservation (MDC) provides a database of lands the MDC owns, leases, or manages for public use. **Table 3.9** provides the names and locations of parks and conservation areas in the county.

Table 3.9. Parks in Wayne County

Park / Conservation Area	Address/Location/Driving Directions	City
Sam A. Baker State Park	MO Highway 143, Des Arc, MO 63636	Unincorporated Portion of

Lake Wappapello State Park	MO Highway 172, Williamsville, MO 63967	Unincorporated Portion of
Rotary Park	300 Pittsburg Street	Piedmont
Handy Park	200 East Elm	Piedmont
Chapman Park	N 2nd & W Green Streets	Piedmont
Ash Park	210 Ash Street	Piedmont
Clearwater Lake Management Lands	7914map.eps (mo.gov)	Unincorporated Portion of Wayne County
Riverside Conservation Area	4643map.eps (mo.gov)	Unincorporated Portion of Wayne County
Lon Sanders Canyon Conservation Area	8827map.pdf (mo.gov)	Unincorporated Portion of Wayne County
Clearwater District Headquarters	5309map.eps (mo.gov)	Unincorporated Portion of Wayne County
Graves Mountain Conservation Area	4621map.eps (mo.gov)	Unincorporated Portion of Wayne County
Coldwater Access	9239map.eps (mo.gov)	Unincorporated Portion of Wayne County
Flatwoods Conservation Area	Flatwoods Conservation Area Map (mo.gov)	Unincorporated Portion of Wayne County
Coldwater Conservation Area	4634map (mo.gov)	Unincorporated Portion of Wayne County
Wappapello Lake, Greenville Recreation Area	Wappapello Lake, Greenville Recreation Area (U.S. Army Corps of Engineers) | Missouri Department of Conservation (mo.gov)	Unincorporated Portion of Wayne County
Bradley A. Hammer Memorial Conservation Area	9629map.eps (mo.gov)	Unincorporated Portion of Wayne County
Iron Bridge Access	9227map.eps (mo.gov)	Unincorporated Portion of Wayne County
Wappapello Lake Management Lands	6627map.eps (mo.gov)	Unincorporated Portion of Wayne County
Wappapello Lake, Chaonia Landing Recreation Area	From the junction of Highways 67 and 172, take Highway 172 east, then north on Route W to the lake.	Unincorporated Portion of Wayne County
Yokum School Conservation Area	6530map.eps (mo.gov)	Unincorporated Portion of Wayne County
University Forest Conservation Area	8850map.eps (mo.gov)	Unincorporated Portion of Wayne County
Wappapello Lake, Spillway Recreation Area	From the junction of Highway 51 and Route T south of Puxico, take Route T west to the spillway.	Unincorporated Portion of Wayne County
Duck Creek Conservation Area	Duck Creek Conservation Area (mo.gov)	Unincorporated Portion of Wayne County

Source: Data Collection Questionnaires; Missouri Department of Natural Resources, Park and Site Status Viewer (arcgis.com); Missouri Department of Conservation (Find Places To Go | Missouri Department of Conservation (mo.gov))

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.

According to Andrew Rumbach—a professor of planning at the University of Colorado, Denver, "Many historic resources were built before modern flood regulations and modern building codes, so they're located in areas that are prone to these kind of disasters." In some communities, historic structures may be integral to the area's local economy via the tourism industry. In others, such structures may provide a sense of identity and heritage to a community's residents. Two programs—the National Park Service's Certified Local Government Program and the National Main Street Program can assist local governments in identifying ways to mitigate damage to historic resources

The National Main Street Program helps member communities outline a clear deliberate path to revitalize and strengthen their downtown or commercial districts. The program is implemented by the National Mainstreet Center—a subsidiary of the National Trust for Historic Preservation. Through the program, communities develop a revitalization plan based upon market data and organized around economic vitality, design, promotion, and organization. There are no Main Street communities within the planning area.

The Certified Local Government Program is a partnership between national, state, and local governments developed to help communities save the irreplaceable historic character of places. Local communities must become certified as a CLG through a process overseen by the National Park Service, communities make a local commitment to historic preservation. Communities that have these programs typically have infrastructure designed to protect historic sites. There are no Certified Local Governments within Wayne County.

The properties listed in the below table are located within the planning area and are on the National Register of Historic Places (**Table 3.10).**

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

Property	Address	City	Date Listed
Fort Benton	3.5 miles south of US 67 and MO 34	Patterson	10/21/2002
Old Greenville	Address Restricted	Greenville	2/17/1990
Sam A. Baker State Park Historic District	St. Francis Mountains bounded roughly	Patterson	2/27/1985

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

Economic Resources: **Table 3.11** shows major non-governmental employers in the planning area.

Table 3.11. Major Non-Government Employers in Wayne County

Employer Name	Main Locations	Product or Service	Employees
McAllister Software	Piedmont	Technology	180
Clearwater School	Piedmont	Education	170
Greenville R-II School District	Greenville	Education	118
Fine Laboratories, Inc.	Piedmont	Aircraft Component Fabrication	100
Z Manufacturing Inc.	Piedmont	Sewing Products & Screen	

Source: Data Collection Questionnaires; Piedmont Area Chamber of Commerce; East Wayne Chamber of Commerce

Agriculture: Agriculture plays a somewhat important role in Wayne County and consists primarily of livestock farming. According to the United States Department of Agriculture 2012 Census of Agriculture, there were 411 farms in Wayne County and 116,617 acres of land in farms. The market value of agricultural products sold that were produced within Wayne County in 2012 was $7,788,000. Twenty percent of this total was crop sales at $1,555,000; while, 80% was livestock sales at $6,233,000. Per USDA's Missouri Cattle County Estimates (May 2023), 11,500 head of cattle were farmed in Wayne County—a figure relatively low when compared to other Missouri counties, the highest of which is Lawrence County with 115,000 head. **Table 3.12** provides a summary of the agriculture-related jobs in Wayne County.

Table 3.12. Agriculture-Related Jobs in Wayne County

Agricultural Identifier	Number/Amount
Farms with Workers	62
Total Farm Workers	128
Total Annual Payroll	$761,000
Farms with Unpaid Workers	147
Unpaid Farm Workers	326

Source: USDA, Census of Agriculture, 2017

3.3 LAND USE AND DEVELOPMENT

3.3.1 Development Since Previous Plan Update[5(e)]

There have been few developmental changes in the planning area since the previously approved plan was adopted. Consequently, there has been little change to hazard risk within the planning area. Building permit data from the U.S. Census Bureau (found at https://www.census.gov/construction/bps/) is not available by county or place. Wayne County does not issue building permits.

Table 3.13 provides the population growth statistics for all cities in Wayne County as well as the county as a whole. Due to the size of the cities within the county, the most accurate and recent data available is that collected during the 2020 Decennial Census.

Table 3.13. County Population Change, 2010-2020

Jurisdiction	Total Population 2010	Total Population 2020	2010-2020 # Change	2000-2020 % Change
Wayne County	13,521	10,974	-2,547	-18.8
City of Greenville	511	443	-68	-13.3
City of Piedmont	1,977	1,897	-80	-4.0
City of Williamsville	342	279	-63	-18.4
Village of Mill Spring	189	159	-30	-15.9

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

Population growth or decline is generally accompanied by increases or decreases in the number of housing units. **Table 3.14** provides the change in numbers of housing units in the planning area from 2010 to 2020.

Table 3.14. Change in Housing Units, 2010-2020

Jurisdiction	Housing Units 2010	Housing Units 2020	2010-2020 # Change	2000-2020 % Change
Wayne County	8,083	6,109	-1,974	-24.4
City of Greenville	234	194	-40	-17.1
City of Piedmont	993	926	-67	-6.8
City of Williamsville	188	143	-45	-23.9
Village of Mill Spring	106	93	-13	-12.3

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

There have been little changes in development within the planning area since the last plan update. Given this, "changes in development" have not impacted the community's vulnerability to hazards overall. Within each hazard section that follows, there is a heading entitled "Previous and Future Development." Further discussion of how changes in development have impacted the community's vulnerability to a specific hazard, as applicable, is described at these locations.

3.3.2 Future Land Use and Development[5(e)]

No plans are currently in existence for future development within Wayne County, the City of Greenville, City of Piedmont, City of Williamsville, or Village of Mill Spring. Future land use within

the participating jurisdictions is anticipated to remain unchanged.

School District's Future Development

Little future development is expected in each school district. The population of students within each of the two school districts is expected to stay the same or show only a slight increase. The facilities and classrooms currently in use will be sufficient for the planned future student population. Neither school district reports proposed construction, bonds, renovation, student growth/decline, employment growth/decline, nor facilities improvement plans.

Special District's Future Development

No special district's participated in the update of this hazard mitigation plan.

3.4 HAZARD PROFILES, VULNERABILITY, AND PROBLEM STATEMENTS

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

Hazard Profiles

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

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

- **Hazard Description:** This section consists of a general description of the hazard and the types of impacts it may have on a community or school/special district.
- **Geographic Location:** This section describes the geographic areas in the planning area that are affected by the hazard. Where available, use maps to indicate the specific locations of the planning area that are vulnerable to the subject hazard. For some hazards, the entire planning area is at risk.
- **Strength/Magnitude/Extent:** This includes information about the strength, magnitude, and extent of a hazard. For some hazards, this is accomplished with description of a value on an established scientific scale or measurement system, such as an EF2 tornado on the Enhanced Fujita Scale. This section should also include information on the typical or expected strength/magnitude/extent of the hazard in the planning area. Strength, magnitude, and extent can also include the speed of onset and the duration of hazard events. Describing the strength/magnitude/extent of a hazard is not the same as describing its potential impacts on a community. Strength/magnitude/extent defines the characteristics of the hazard regardless of the people and property it affects.
- **Previous Occurrences:** This section includes available information on historic incidents and their impacts. Historic event records form a solid basis for probability calculations. Events for the previous 20 years are provided when hazards are random in occurrence, such as tornadoes. Data of occurrence for the previous 10 years is provided when the hazard event occurs more often such as severe thunderstorms. In some cases, searches will be limited by criteria such as magnitude. Regardless, previous events occurring since the last plan update will be included for each hazard.
- **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 are also considered, including the effects of long-term changes in weather patterns and climate on the identified hazards. A data tool provided by the National Oceanic & Atmospheric Administration (NOAA) and found at https://toolkit.climate.gov/tools/climate-explorerproved useful for this purpose.

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 2023 State Hazard Mitigation Plan Update. With the 2023 Hazard Mitigation Plan Update, SEMA is pleased to provide online access to the risk assessment data and associated mapping for the 114 counties in the State, including the independent City of St. Louis. Through the web-based Missouri Hazard Mitigation Viewer, local planners or other interested parties can obtain all State Plan datasets. This effort removes from local mitigation planners a barrier to performing all the needed local risk assessments by providing the data developed during the 2023 State Plan Update.

The Missouri Hazard Mitigation Viewer includes a Map Viewer with a legend of clearly labeled features, a north arrow, a base map that is either aerial imagery or a street map, risk assessment data symbolized the same as in the 2023 State Plan for easy reference, search and query capabilities, ability to zoom to county level data and capability to download PDF format maps. The Missouri Hazard Mitigation Viewer can be found at this link: http://bit.ly/MoHazardMitigationPlanViewer2018.

The vulnerability assessments in the County A 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:**

The plan will provide an overall summary of each jurisdiction's vulnerability to the identified hazards. The overall summary of vulnerability will identify structures, systems, populations or other community assets as defined by the community that are susceptible to damage and loss from hazard events.

- **Potential Losses to Existing Development:**

For each participating jurisdiction, the plan will describe the potential impacts of the hazard. Impact means the consequences of effect of the hazard on the jurisdiction and its assets. Assets were determined by the community and include, for example, people, structures, facilities, systems, capabilities, and/or activities that have value to the community.

- **Previous and Future Development:**

This section will include information on how changes in development have impacted the community's vulnerability to the hazard being evaluated. Changes in vulnerability resulting from development in known hazard prone areas since the prior plan update will be discussed. In addition, anticipated future development in the county, if any, and its effect upon hazard risk will be discussed.

- **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. Jurisdiction-specific information in those cases where the risk varies across the planning area will be provided. The focus of the problem statements sub-section is to synthesize the "problems" revealed through the risk assessment and then through the process of updating the mitigation strategy, develop mitigation actions that are aimed at "solving" the identified problems. Problem statements will relate to specific jurisdictions as well as specific assets or areas of the planning area that are problematic.

3.4.1 Flooding (Riverine and Flash)

Hazard Profile

Hazard Description [4(a)(2)]

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 levee and dam failure is discussed in Section 3.4.2 and Section 3.4.3, 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 [4(a)(1)]

Riverine flooding is most likely to occur in SFHAs. Historically there are three frequent sources of

common flooding within W ayne County: Mckenzie Creek near Piedmont, the Black River, and the St. Francis River. The areas surrounding Wappapello Lake are also subject to flooding. The riverine flooding history below was gathered from the National Climatic Data Center (NCDC) for a twenty-year period spanning January 1, 2003 to December 31, 2022. Riverine flooding is most likely to occur in SFHAs. It should be noted that Wayne County's existing FIRM is dated 2011. The county is currently in the "Developing of Hydraulics" status of map update & development. Floodplain maps showing the special flood hazard areas (SFHA's) for each jurisdiction can be located within Appendix A. School district assets located in SFHA's are noted where applicable.[4(a)(1)]

Table 3.15 shows the flood event history for Wayne County between 2003 and 2022. There were 71 flood events occurring within the planning area during this twenty-year period.

Table 3.15. Wayne County NCEI Flood Events by Location, 2003-2022

Location	# of Events
Unincorporated County	56
-unspecified – 5 flood events	
-Patterson - 5 flood events	
-Leeper – 1 flood event	
-Silva – 36 flood events	
-Lodi – 3 flood events	
-Wappapello – 2 flood events	
-Hiram – 1 flood event	
-Taskee Station – 1 flood event	
-Shook – 1 flood event	
-Old Greenville – 1 flood event	
City of Greenville	10
City of Piedmont	4
City of Williamsville	1
Village of Mill Spring	0

Source: National Centers for Environmental Information, 2003-2022

Flash flooding occurs in SFHAs and those locations in the planning area that are low-lying. It can also occur in areas without adequate drainage to carry away the amount of water that falls during intense rainfall events. **Table 3.16** shows the number of flash flood events (14) by location as recorded in NCEI for the 20-year period between January 1, 2003 and December 31, 2022.

Table 3.16. Wayne County NCEI Flash Flood Events by Location, 2003-2022

Location	# of Events
Unincorporated County	9
-unspecified - 4 flood events	
-Cascade – 1 flash flood event	
-Lake Wappapello – 1 flash flood event	
-Old Greenville – 1 flash flood event	
-Wappapello – 1 flash flood event	
City of Greenville	1
City of Piedmont	2
City of Williamsville	1
Village of Mill Spring	1

Source: National Centers for Environmental Information, 2003-2022

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[5(c)]

Table 3.17 shows NFIP participation status for the communities in the planning area. **Table 3.18** shows the number of flood insurance policies in force, the amount of insurance in force, the number of closed losses, and the total payments for each jurisdiction, where applicable. The data presented covers the period between 1983 and 2019.

Sanctioned communities are those communities that are not currently participating in the NFIP and where a Flood Hazard Boundary Map or Flood Insurance Rate Map has been issued. As of the compilation of this plan update, there were no sanctioned communities within the planning area.

Table 3.17. NFIP Participation in Wayne County

Community ID #	Community Name	NFIP Participant (Y/N/Sanctioned)	Current Effective Map Date	Regular-Emergency Program Entry Date
290449	Wayne County	Yes	6/16/2011	2/1/1987
290450	City of Greenville	Yes	6/16/2011	8/1/1986
290451	City of Piedmont	Yes	6/16/2011	9/30/1988
290452	City of Williamsville	Yes	6/16/2011	8/1/1986
290499	Village of Mill Spring	Yes	6/16/2011	6/16/2011

Source: NFIP Community Status Book, 2023; Community Status Book | FEMA.gov

Table 3.18. NFIP Policy and Claim Statistics as of November 30, 2023

Community Name	Policies in Force	Insurance in Force	Closed Losses	Total Payments
Wayne County	57	7,889,000	16	369,425.59
City of Greenville	0	0	2	51,852.73
City of Piedmont	37	4,066,000	32	1,151,380.98
City of Williamsville	6	338,000	4	85,000
Village of Mill Spring	1	11,000	1	75,000

Source: National Flood Insurance Program, 11/30/2023; PIVOT, 1983 to 2019

The City of Piedmont had the most closed losses with thirty-two total claims and payouts totaling $1,151,380.98. Closed losses are those flood insurance claims resulting in payment.

Repetitive Loss/Severe Repetitive Loss Properties[5(c)]

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 fourteen repetitive loss properties. As of October 2023, two properties have been mitigated, leaving twelve un-mitigated repetitive loss properties.

Table 3.19 provides a summary of the repetitive loss properties in the planning area.

Table 3.19. Wayne County Repetitive Loss Properties

Jurisdiction	# of Properties	Type of Property	# Mitigated	Building Payments	Content Payments	Total Payments	Average Payment/Loss	# of Losses
Piedmont, City of	5	residentia	1	$287,456.46	$307,552.52	$595,008.98	$45,769.92	13
Wayne, County of	9	residentia	1	$434,118.49	$307,552.52	$741,671.01	$32,246.57	23

Source: Flood Insurance Administration as of October 2023

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

Of the repetitive loss properties within Wayne County and its four participating municipalities, there is one validated residential SRL structure. The SRL property is located within the city of Piedmont and has not been mitigated. As of October 2023, $142,993.42 has been paid in claims for this property by the NFIP across seven losses, resulting in an average loss of $20,428..

Previous Occurrences[4(a)(3)]

There have been five Presidential disaster declarations including the planning area that involved flood. They are listed below.

- DR-4551-MO, Flood, 7/9/2019, 4/29/2019-7/5/2019, PA Only
- DR-4317, Flood, 6/2/2017, 4/28/2017-5/11/2017, PA Only
- EM-3374, Flood, 01/02/2016, 12/22/2015-1/9/2016, PA Only
- DR-995, Flood, 7/9/1993, 6/10/1993-10/25/1993, IA Only
- DR-672, Flood, 12/10/1982, 12/10/1982, IA & PA
- DR-516, Flood, 7/21/1976, 7/21/1976, IA & PA

None of the above-listed events coincide with a flood event as recorded within the NCEI storm event database. Per this data source reconciliation, any impacts resulting from the events would not have been attributed to flooding.

Table 3.20 and **Table 3.21** summarize NCEI information for the last 20 years for flash and riverine flooding in the planning area, respectively.

Table 3.20. NCEI Wayne County Flash Flood Events Summary, 2003 to 2022

Year	# of Events	# of Deaths	# of Injuries	Property Damages ($)	Crop Damages ($)
2003	1	0	0	0	0
2004	1	0	0	5,000	0

2005	2	0	0	500,000	0
2006	1	0	0	0	0
2007	1	0	0	0	0
2008	1	0	0	0	0
2009	1	0	0	0	0
2010	1	0	0	0	0
2011	1	0	0	20,000,000	0
2013	1	0	0	10,000	0
2015	1	0	0	0	0
2017	1	0	0	0	0
2020	1	0	0	0	0

Source: NCEI, July 2023

Per the FEMA Data Visualization Tool found at https://www.fema.gov/data-visualization-floods-data-visualization, there have been ____ instances of Public Assistance provided to various jurisdictions in the planning area. Trends in PA distributions indicate repetitive damage sites as listed below. These sites may be those which should be considered for mitigation.

Table 3.21. NCEI Wayne County Riverine Flood Events Summary, 2003 to 2022

Year	# of Events	# of Deaths	# of Injuries	Property Damages ($)	Crop Damages
2003	1	0	0	0	0
2004	1	0	0	0	0
2005	3	0	0	0	0
2006	2	0	0	0	0
2007	4	0	0	0	0
2008	6	0	0	9,275,000	0
2009	10	0	0	0	0
2011	4	0	0	203,000	0
2013	6	0	0	0	0
2015	7	0	0	7,000	0
2016	5	0	0	0	0
2017	4	0	0	1,400,000	0
2018	5	0	0	0	0
2019	6	0	0	0	0
2020	2	0	0	0	0
2021	2	0	0	0	0
2022	3	0	0	0	0

Source: NCEI, July 2023

Probability of Future Occurrence

There have been fourteen flash flood events in the 20-year period between 2003-2022. This equates to .7 events per year. Given this, it is reasonable to assume that one flash flood event will occur every seventeen months somewhere within the planning area.

There have been 71 riverine flood events in the 20-year period between 2003-2022. This equates to 3.55 riverine flood events per year.

Changing Future Conditions Considerations[4(c)]

If increased precipitation intensity continues, frequency of floods in Missouri is likely to increase as well. Over the last half century, average annual precipitation in most of the Midwest has increased by 5 to 10 percent. But rainfall during the four wettest days of the year has increased about 35 percent,

and the amount of water flowing in most streams during the worst flood of the year has increased by more than 20 percent. It is likely (66-100% probability) that the frequency of heavy precipitation or the proportion of total rainfall from heavy falls will increase in the 21st century across the globe. More specifically, it is “very likely” (90-100% probability) that most areas of the United States will exhibit an increase of at least 5% in the maximum 5-day precipitation by the late 21st century. As the number of heavy rain events increases, more flooding and pooling water can be expected.

Flooding occasionally threatens navigation and riverfront communities; greater river flows could increase these threats. In April and May 2011, a combination of heavy rainfall and melting snow caused a flood that closed the Mississippi River to navigation, threatened Caruthersville, and prompted evacuation of Cairo, Illinois, due to concerns that its flood protection levees might fail. The expected increases in rainfall frequency and intensity are likely to put additional stress on natural hydrological systems and community stormwater systems.

Heavier snowfalls in the winter will lead to intensified spring flooding, and groundwater levels will remain high even in non-floodplain areas. Such changes in climate patterns can lead to the development of compounding events that interact to create extreme conditions. Flooding caused by high groundwater levels typically recedes more slowly than riverine flooding, slowing the response and recovery process. Groundwater-fed rivers and streams are also likely to experience heightened flooding when groundwater levels are high.

Jurisdictions updating or installing stormwater management systems should consider potentially larger future discharge amounts when sizing culverts and drainage ways; storage capacity can also be increased by building retention basins to hold excess stormwater. Communities already prone to flooding should be prepared for a potential increase in facility closures and/or damages, as well as an increase in public demand for flood response and assistance.

Natural features that experience repeated flooding may manifest changes in the form of stream bank instability and changing shoreline, floodplain, and wetland boundaries. Communities may wish to plan for the potential loss of cropland and damage to both private property and public infrastructure such as bridges.

The environmental impacts of flooding include erosion, surface and groundwater contamination, and reduced water quality. The threat of more frequent flood events may thus be a concern particularly for communities who depend on lakes and rivers for tourism. Too, rural communities may experience increases in well contamination and road washouts, while more populated and developed areas may be particularly vulnerable to flash flooding as heavy rain events quickly overwhelm the ability of a more impermeable environment to absorb excess stormwater.

Vulnerability[5(b); 5(d)]

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.

The vulnerability overview for Wayne County comes primarily from HAZUS data included in the *2023 Missouri State Hazard Mitigation Plan*. HAZUS uses GIS technology to estimate the impacts of disasters. HAZUS-MH produces a flood polygon and flood depth grid that represents the base flood. Data for Wayne County utilized HAZUS flood data. The 2023 state plan includes flood analysis for all 114 Missouri counties. This data is coupled with DFIRM depth grids and enhanced building inventory.

DFIRM data is not available for Wayne County, and impact estimates in counties where DFIRM data was integrated typically increases the losses when compared to counties such as Wayne County where only HAZUS-generated flood data was utilized. The damage building counts generated by HAZUS are susceptible to rounding errors and are likely the weakest output of the model due to the use of HAZUS census blocks for analysis

Potential Losses to Existing Development

Within the *2023 Missouri State Hazard Mitigation Plan*, the state describes its usage of a consistent methodology to estimate property and economic losses resulting from a 100-year flood event. The analysis used the best available data specific to each county—digital effective FIRM data and LiDAR-derived building footprints. With computer modeling, state planners were able to quantify risk along known flood-hazard areas. The analysis provided estimates of the number of buildings impacted, building repair costs, and associated contents and inventory losses. For the purposes of estimating losses in Wayne County, the state used depth grids derived from the National Flood Hazard Layer (NFHL) XS plus BFA's.

For the purposes of its analyses, the state classified property by function as either agricultural, commercial, educational, governmental, industrial, religious, or residential. Damage to a structure was assumed to be directly related to the depth of water during a 100-year flood event. At a depth of two feet, 20% of the property is considered damaged per FEMA's depth-damage function; therefore, 20% of the property's value was assigned as a "direct loss."

Tables 3.26 A and 3.26 B within the state planning document display the direct building and income loss estimates for each county within the State of Missouri in the event of a 100-year flood. Per the data presented within Table 3.26 A, Wayne County has the second highest estimated direct building loss ratio of all 114 counties behind McDonald County. The analysis compares the value of the county's overall building inventory (estimated at $1,527,737,022) to the value of anticipated flood-induced direct property damage during a 100-year flood event. In Wayne County, the state estimated $114,537,420 in direct structural damage resulting from such an event. The flood loss ratio can be viewed as an indicator of impact severity upon a community's sustainability.

Additionally, the data analyses resulted in the following estimates as resulting from a 100-year flood event:

- 614 damaged structures
- 367 Substantially damaged structures
- 2,927 displaced persons
- 1,397 persons in need of shelter.

The HAZUS analysis conducted by the state estimated classified structure damage by property type. Per Table 3.26 B, 576 residential, 461 agricultural, 33 commercial, and 9 educational properties would be damaged as a result of a county-wide 100-year flood event. The total loss resulting from such an event was estimated at $255,240,158. It should also be noted that there are six scour critical bridges located in Wayne County as shown in Figure 3.1.

In reviewing available data and discussing with school districts, there are no school district assets located in floodplains, and no prior damage reports from the schools resulting from flooding. In discussion with county personnel and local residents, there has been no damage to any critical facilities in the county that resulted from flooding.

The City of Greenville—as the county seat—would be the community with the highest risk of loss due to the infrastructure located there. Of the four participating municipal jurisdictions, only portions of Piedmont and Mill Spring are at slight risk of flooding. The City of Piedmont has implemented numerous mitigation projects (primarily voluntary residential flood buyouts) to lessen the impact of flooding upon its jurisdiction. Piedmont has no populations or critical facilities at risk of flooding.

Vulnerability of the Village of Mill Spring is minimal as few structures exist near the flood source—a tributary to the Black River. The village, with less than six residential structures at risk of flooding, has no critical facilities at risk of flooding. The Cities of Williamsville and Greenville have no structures, populations, or critical facilities at risk of a flooding event.

Risk Mapping, Assessment, and Planning (RiskMAP) is a new FEMA program that provides communities with flood information and tools they can use to enhance their mitigation plans and better protect citizens. Through more accurate flood maps, risk assessment tools, and outreach RiskMap builds on Map Modernization and strengthens local ability to make informed decisions about reducing risk. There exist two RiskMap products including information pertinent to Wayne County: a Flood Risk Report—Lower St. Francis River, Arkansas (December 2017) and its associated Flood Risk Map—Lower St. Francis Watershed, 08020203. Per the map, the southeastern-most corner of the county is at “low” and very low” risk of flooding. A small section (approximately one square mile) of land due west of Puxico, Missouri near the Mingo Wildlife Reserve was identified as at “medium” risk of flooding. The map can be found at FRM_08020203_20171229.pdf (fema.gov).

Impact of Previous and Future Development[4(c); 5(f)]

As there is little future development anticipated within Wayne County or any of the jurisdictions within the planning area, the impact of flooding is not anticipated to increase in the county or any of the incorporated cities.

Hazard Summary by Jurisdiction

Vulnerability to flooding varies greatly across the county. Areas near Lake Wappapello, Clearwater Lake, and along the Black River are the those most prone to flooding. Tables 3.15 and 3.16 above show the riverine and flash flood events by location within the planning area. Per the historic event data, Silva and Patterson—both unincorporated areas of Wayne County—and the City of Greenville experience more frequent riverine flood events than do other portions of the county. The floodplain maps located within Appendix A show the portions of the planning area most susceptible to riverine flooding.

Wayne County– The majority of areas vulnerable to flooding are located within the balance of the county. It should be noted that the county has participated in two residential flood buyouts within the Black River Retreat community, thereby lessening potential property losses due to flooding along the Black River. Per the Missouri Mitigation Viewer, twelve residential properties have been mitigated

within the unincorporated portion of Wayne County. The portion of the county most frequently cited within Table 3.15 as subject to riverine flooding is the community of Silva. As shown in the table, thirty-six of fifty-six incidents have occurred in this location. To better depict the area's risk, detailed floodplain maps of the community comprise the last two pages of Appendix A.

City of Greenville – Riverine and flash flooding are not primary concerns within the City of Greenville. Per the Missouri Hazard Mitigation Viewer, there have been no flood buyouts within the jurisdiction.

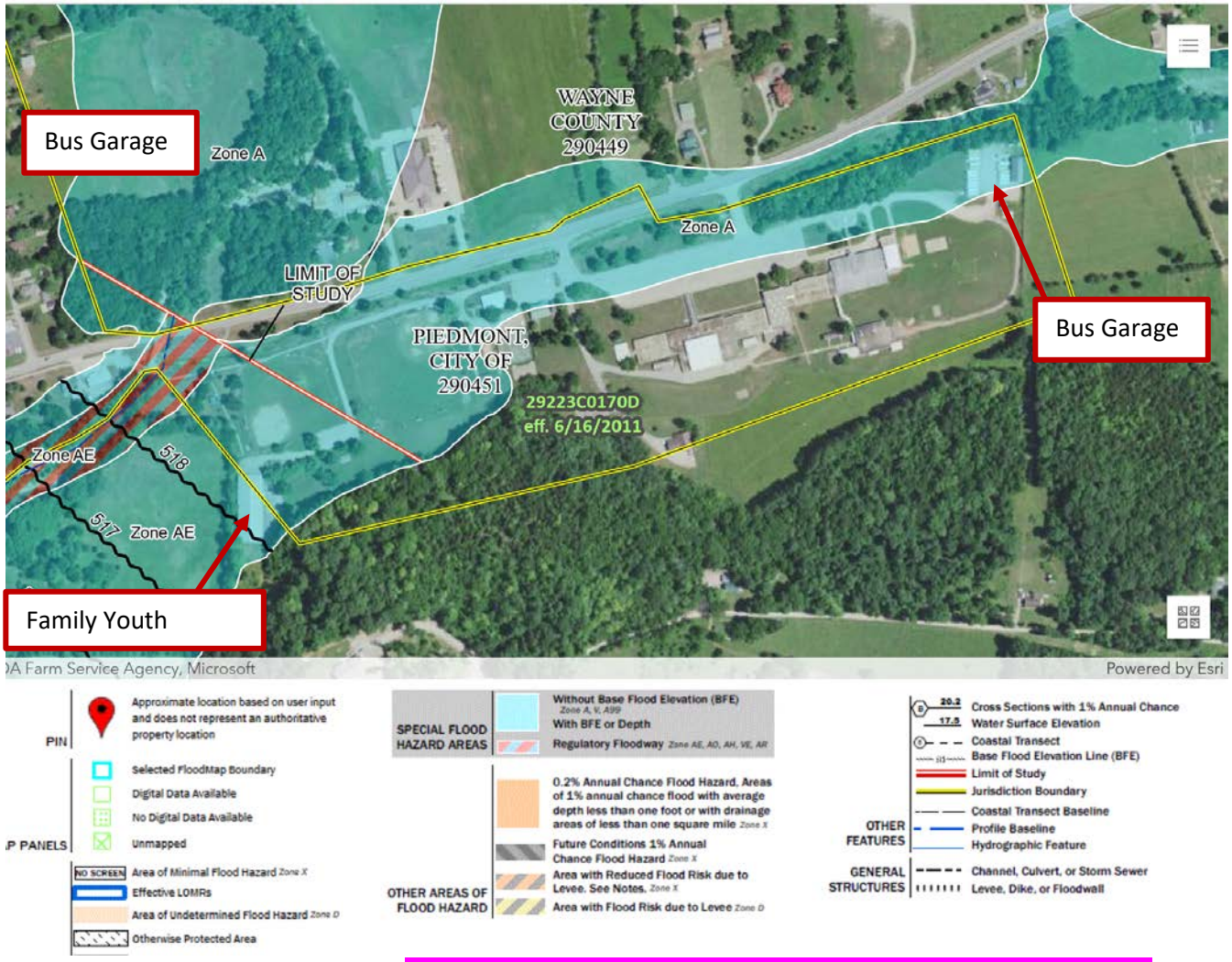
City of Piedmont -- The City of Piedmont utilized mitigation grant funding and local resources to acquire and demolish many residential properties susceptible to flooding. Because of this, the city is at lessened risk of damage from riverine and flash flooding. Per the Missouri Hazard Mitigation Viewer, approximately 66 residential properties have been mitigated by the city. Despite this, however, additional properties remain located in the floodplain, some of which have experienced repetitive losses.

City of Williamsville -- Riverine and flash flooding are not primary concerns within the City of Williamsville, although the city does participate within the National Flood Insurance Program. Per the Missouri Hazard Mitigation Viewer, there have been no flood buyouts within the jurisdiction.

Village of Milll Spring -- The Village of Mill Springs is somewhat susceptible to flooding with five city streets (a total length of less than one mile) and a few residential structures at risk of minimal flooding. Per the Missouri Hazard Mitigation Viewer, there have been no flood buyouts within the jurisdiction.

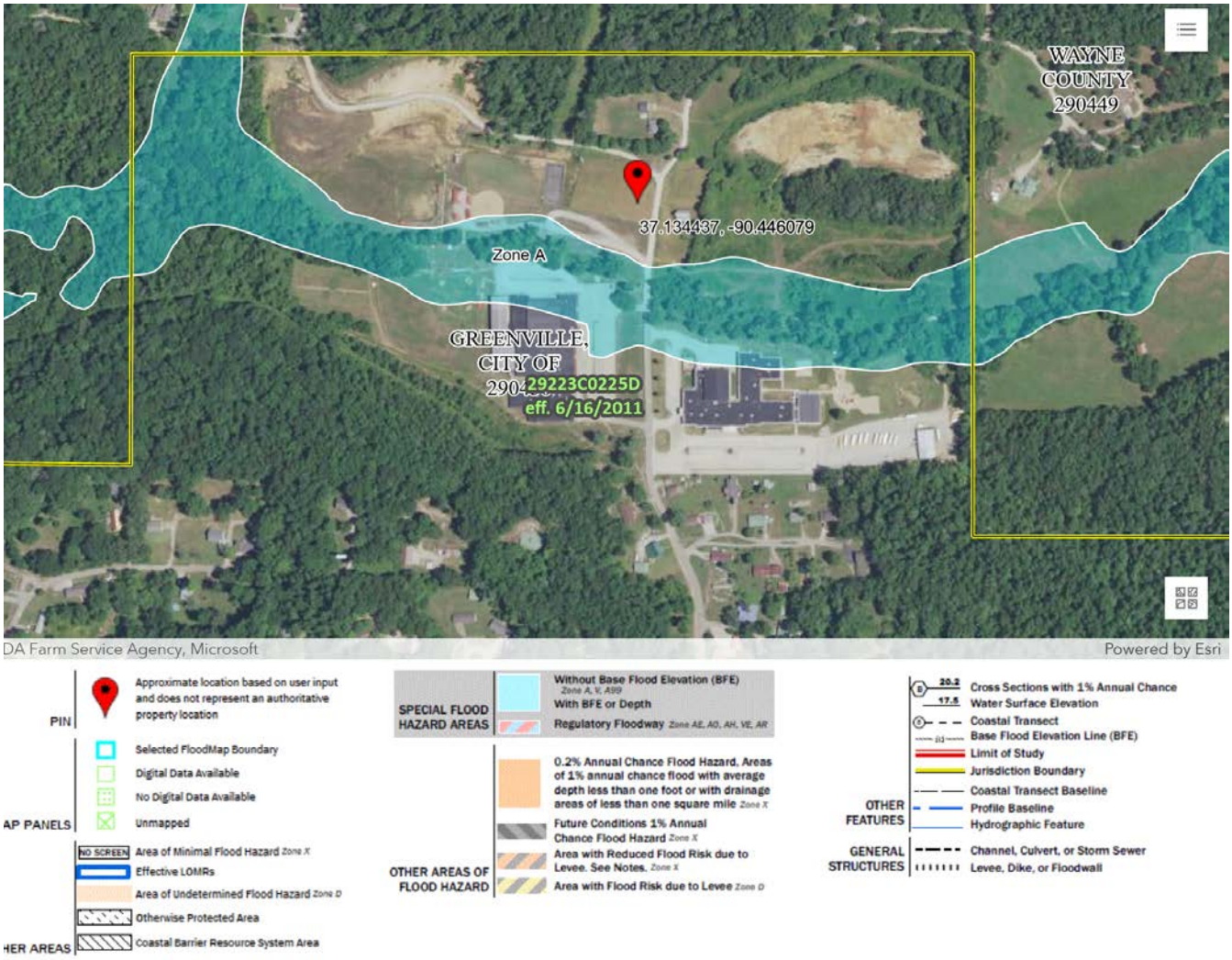
Clearwater R-I School District – During the 2022-2023 school year, the district's elementary school sustained damage due to flooding. Administrative officials were unaware of any other damage incidents resulting from flood events. The district has one primary facility located within the 100-year floodplain—its bus garage. As shown on the map in Figure 3.2 below, outbuildings, parking areas, transportation routes, and recreational facilities are subject to flooding during a 100-year flood event. In addition, the primary highway accessing the district campus (MO Highway 34) lies within the floodplain. This would significantly hinder—if not prevent—access to the school during such an event. Furthermore, some students may not be able to access the school campus during flash flood events due to flooded low water crossings located in the balance of the county.

Figure 3.2. Clearwater R-I School District Assets Located within the 100-Year Floodplain



Greenville R-II School District-- School facilities have incurred damage due to riverine flooding within the past twenty years as no district assets are located within the boundaries of the 100-year floodplain. In addition, some students residing in the balance of the county may not be able to access the school campus during flash flood events. District assets located within the 100-year floodplain are shown within Figure 3.3 below.

Figure 3.3. Greenville R-II School District Assets Located within the 100-Year Floodplain



Problem Statement

Both Wayne County and the City of Piedmont have un-mitigated repetitive loss properties located within their jurisdictional boundaries. In addition, both school districts headquartered in the county have facilities located within the 100-year floodplain.

- The unincorporated area of Wayne County near the community of Silva experiences more riverine flood events than any other community in the planning area. Possible solutions include the purchase and demolition of residential properties located within the floodplain.

- The City of Piedmont has multiple repetitive loss properties located within its jurisdictional boundaries. The purchase and demolition of such properties would mitigate future damages resulting from flood events.

- The Clearwater R-I School District is surrounded by 100-year floodplain along the northern and western boundaries of its campus. Access to the district campus is from MO mitigation Highway 34 located adjacent to the campus at the north. Per the graphic in Figure 3.2, the

district campus will be inaccessible during a 100-year flood event. The identification of ingress and egress routes located outside of the floodplain would prove useful during 100-year flood events.

- A portion of the Greenville R-II School District's primary campus is located within the 100-year floodplain. To prevent flooding of the district's facilities, the city and school district could partner to explore the installation of earthen structures which could divert floodwaters away from school facilities.

3.4.2 Dam Failure[4(b)(1)b; 4(b)(2,3)]

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.

Both the Missouri Department of Natural Resources (MoDNR) and the U.S. Army Corps of Engineers maintain inventories of dams. The National Inventory of Dams (NID) is maintained by the U.S. Army Corps of Engineers (USACE). The MoDNR database contains information for dams located within the State of Missouri.

In Missouri, dams less than 25 feet are generally not inventoried and are unregulated by the Missouri Department of Natural Resources. Dams taller than 25 feet but less than 35 feet are inventoried by the department with some dam data (e.g. height, etc.) provided to the National Inventory of Dams. Dams within this size category, however, remain unregulated in the State of Missouri. Dams 35 feet or more in height are regulated by the department. Construction and operation of such dams require a permit.

Table 3.22 below, outlines the classification system—defined by inundations areas—Missouri uses to describe dams.

Table 3.23. outlines the classification system used by the U.S. Army Corps of Engineers within its National Inventory of Dams, which defines dams by size and potential loss of life assuming failure.

Table 3.22. MoDNR Dam Hazard Classification Definitions

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

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	Loss of one human life is possible if the dam fails.

Significant Hazard	Possible loss of human life and likely significant property or environmental destruction.
High Hazard	Equals or exceeds 25 feet in height and which exceeds 15 acre -feet storage, or equals or exceeds 50 acre -feet of storage and exceeds 6 feet in

Source: U S A C E , National Inventory of Dams

Geographic Location

Dams Located Within the Planning Area

The U.S. Army Corps of Engineers' (USACE) National Inventory of Dams (NID) lists 41 dams in Wayne County, 24 of which are considered "High Hazard" dams by the USACE classification structure. Of the remaining 17 dams, four are classified as "Significant Hazard" while 13 are considered "Low Hazard." Eight of the dams are federally regulated—the Clearwater Dam in the northwestern portion of the county, the Wappapello Dam in the southeastern portion of the county, and three additional saddle-dike dams located in the vicinity of Wappapello Lake. Two additional dams—the Puxico Quad No. 1 Dam and the Fox Pond Dam are regulated by the U.S. Fish & Wildlife Service, while the Markham Springs Dam is regulated by the U.S. Department of Agriculture, Forest Service.

Per the *2023 Missouri State Hazard Mitigation Plan*, there are six dams located within the planning area and regulated by the State of Missouri. Three of those six regulated dams are considered Class I dams, while two are Class II and one is Class III.

Per the *2023 Missouri State Hazard Mitigation Plan*, there are 26 unregulated dams located within the planning area—17 of which are considered "High Hazard" dams by the NID

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

Dam Name	Owner	EAP ?	Dam Height (ft)	Normal Storage (acre-ft)	Last Inspection Date	River/ Stream	Nearest Downstream City	Distance to Nearest City (m)
Clearwater Dam	USACE	Yes	155	413,000	4/24/23	Black River	Leeper / Mill Spring	6.8 / 8.6
Wappapello Dam	USACE	Yes	114	1,134,600	4/28/22	St. Francis River	Wappapello	1
Lake Lynn Dam	Private	Yes	59	662	9/21/21	Tr-Lick Creek	McGee	6
Eagle Sky Lake Dam	Eagle Sky Foun-dation	Yes	57	3,300	8/19/21	Camp Creek	Patterson	5
Seven Lakes #1 Dam	Private	Yes	55	1,360	4/19/22	Goose Creek	Des Arc	1
Seven Lakes Dam	Private	Yes	45	1,300	4/19/22	Goose Creek	Des Arc	2

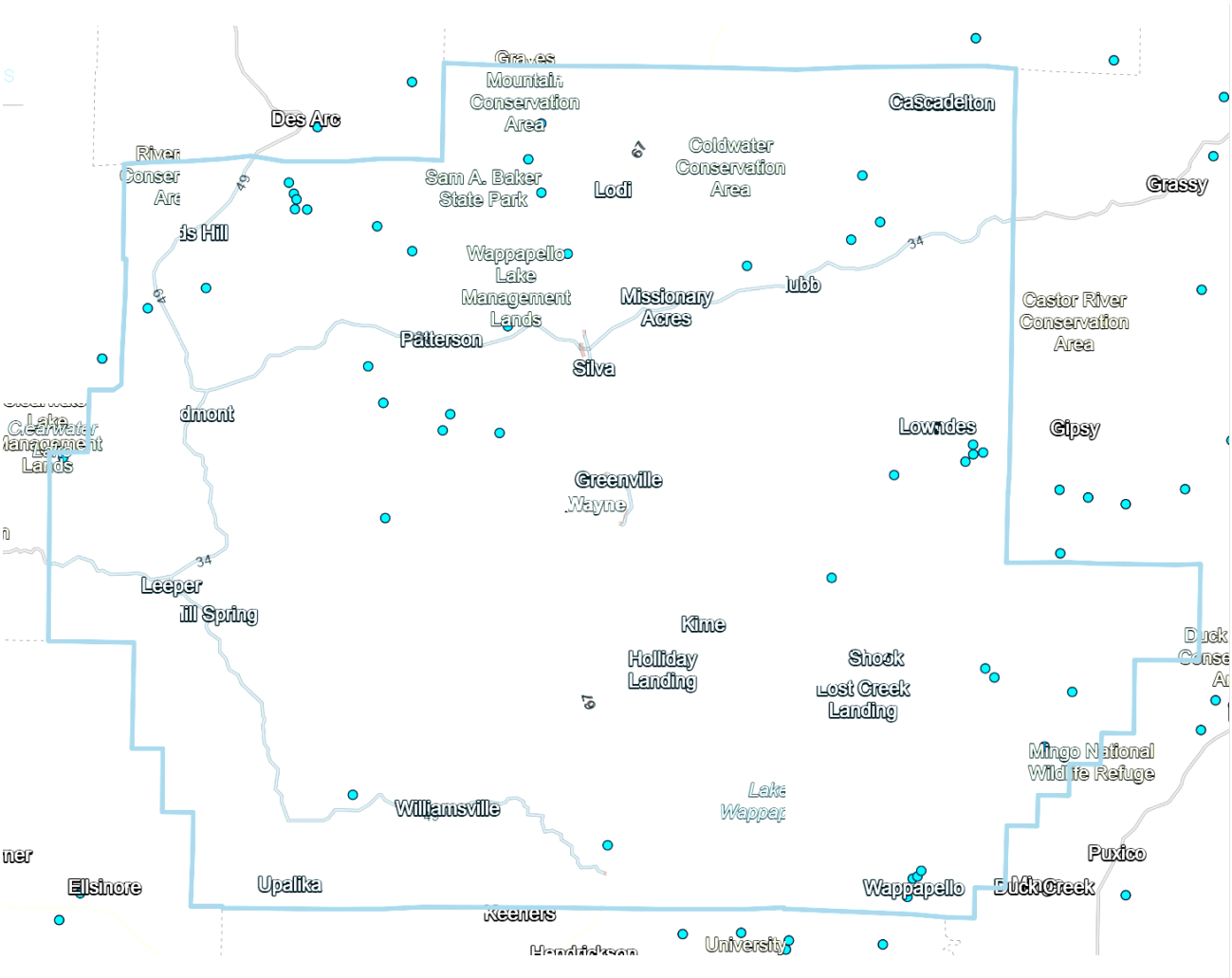
#3								
Lake of the Pines Dam	Bobby Turner	No	44	963	1/24/90	Tr-Barnes Creek	Lowndes	2
Lake Ray Dam	Private	Yes	41	733	9/21/21	Tr- Lick Creek	N/A	N/A
Horseshoe Ridge Leerjack	Leerjack, Inc.	No	40.3	0	N/A	St. Francis	Lode	3
Turners Dream Lake Dam	Dick Twitty	No	35	988	5/16/79	Tr-Barnes Creek	Lowndes	2
Lottes Dam	Dr. J Otto Lottes	No	34	364	5/17/79	Tr- West Fork Lost Creek	Shook	N/A
Lake Julia Dam	Leisure Lands, Inc.	No	34	382	5/16/79	Tr-Barnes Creek	Lowndes	2
Lake Janna Dam	Leisure Lands, Inc.	No	32	51	5/16/79	Tr-Barnes Creek	Lowndes	2
Rothwell Ranch Lake Dam	Dan Rothwell	No	31	50	N/A	Tr-McKen-zie Creek	Piedmont	N/A
Seven Lakes #2	Paul Shy, Jr.	No	28	138	4/4/78	Goose Creek	Des Arc	2
A.O. Shearrer Lake Dam	A.O. Shearrer	No	28	150	10/7/80	Little Lake Creek	Patterson	2
Lake Potashnik Dam	SE MO Council Boy Scouts	No	26	97	10/7/80	Tr-St. Francis River	Greenville	12
Collins Lake Dam Section 31	Bill & Penny Collins	No	25	67	N/A	Little Lake Creek	Wappapello	22
Sunrise Lake Dam	Mt Lk Hunt-Fish League	No	24	116	7/12/78	Tr-Rings Creek	Patterson	3
Mountain Lake Dam	Mt Lk Hunt-Fish	No	24	244	7/11/78	Tr-Rings Creek	Greenville	11

	League							
Lake Jeano Dam	C.A. Ricketts	No	23	172	8/23/79	Greasy Creek	Piedmont	4
Porter Dam	R. Porter c/o Janet Clark	No	23	234	N/A	Tr-Wet Fork Otter Creek	Wappapello	14
Collins Lake Dam–Section 16	James Collins	No	20	128	N/A	Tr-Big Creek	Greenville	13
Williams Lake-Section 31 Dam	Charles A. Williams		20	86	N/A	Tr-Bear Creek	Clubb	3

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

Figure 3.5 below provides the locations of high hazard dams located in the planning area. Inundation maps and emergency action plans can be found in Appendix B.

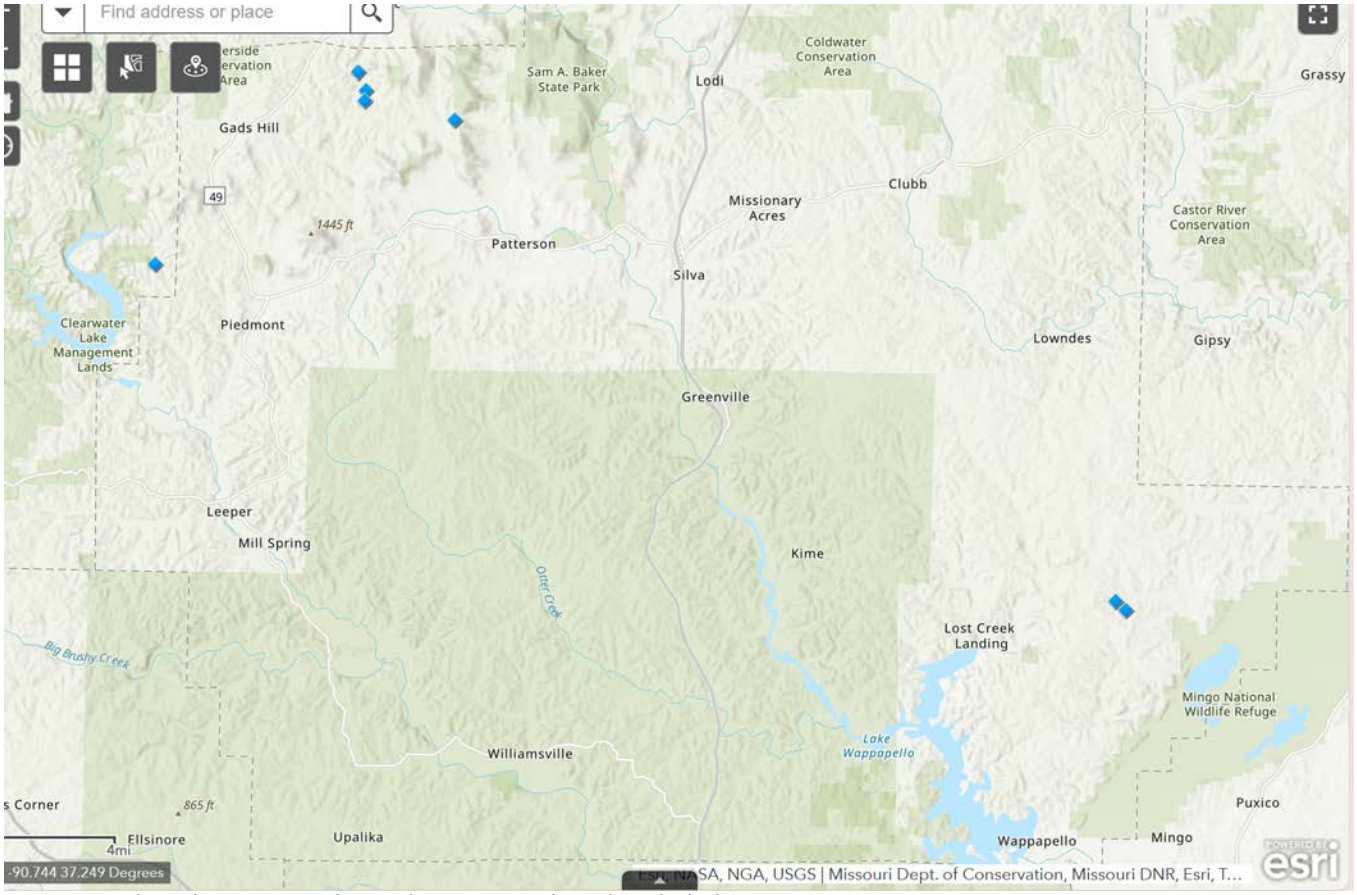
Figure 3.4. High Hazard Dam Locations in Wayne County



Source: U.S. Army Corps of Engineers, National Dam Inventory

Figure 3.5 below provides the locations of state-regulated dams located in the planning area.

Figure 3.5. State Regulated Dams in Wayne County



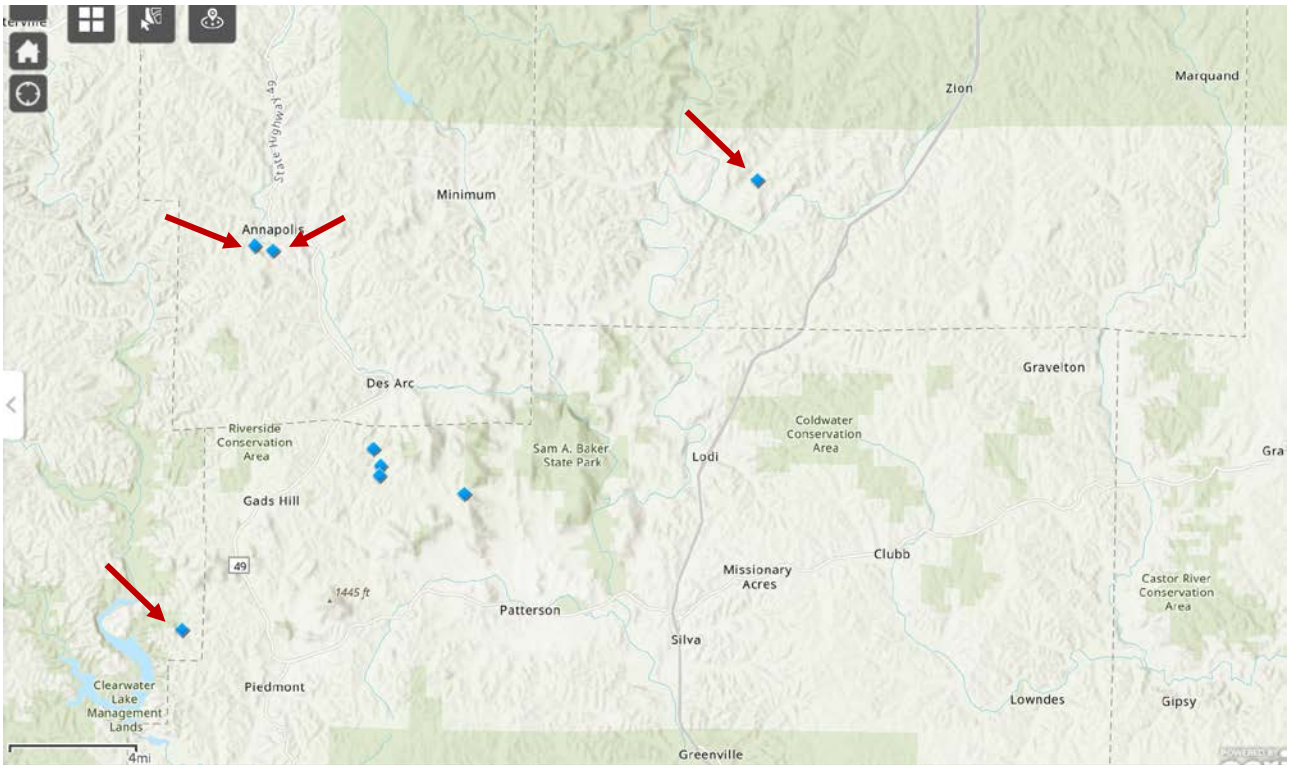
Source: Missouri Department of Natural Resources, Missouri Geological Survey, GeoSTRAT

It is important to note that when identifying areas at risk of dam failure, the geographic location affected is not the location of the dam, but rather the area(s) that would be inundated in the event of dam failure. Dam breach inundation area maps and available Emergency Action Plans can be found in Appendix B of this plan. The vulnerability assessment, below, includes information regarding assets likely impacted in the event of a dam failure in the planning area.

Upstream Dams Outside the Planning Area

The map provided in (**Figure 3.6**) below shows four state-regulated dams located upstream of the planning area: the Little Clearwater Lake Dam in Reynolds County, the West Peak Quarry Dam #1 in Iron County, the Primary Spoils Dam in Iron County, and the Hinkle Lake Dam in Madison County. After reviewing the available inundation maps for these "upstream" dams, it was determined that no assets other than farmland would be negatively impacted in the event of failure.

Figure 3.6. Upstream Dams Outside Wayne County



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

Strength/Magnitude/Extent

The probable severity of a future dam failure event in Wayne County depends primarily upon two variables – the size and location of the dam in question. As previously stated, there are 26 unregulated dams located in the planning area--all of varying capacities. Should any one of these structures fail, resulting damage could range from negligible to critical depending upon both the dam's location and size.

The strength/magnitude of dam failure would be similar in some cases to a flood event (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. For this reason, dam failures could flood areas outside of mapped flood hazards such as Special Flood Hazard Areas and the 100-Year Floodplain.

For example, many dams in the county are smaller impoundments, located on private property. Should any one of these structures fail, damages to property would most likely be negligible. Yet, the Wappapello Lake Dam and the Clearwater Lake Dam, both located in Wayne County, would inundate sections of both Wayne County and Butler County to the south if either were to fail.

Of the 41 dams located in Wayne County, the National Dam Inventory shows 9 as holding more than 500 acre-feet of water, while 2 (Clearwater Lake Dam and Wappapello Lake Dam) hold 413,000 and 1,134,600 acre-feet, respectively. The remaining 32 dams hold less than 400 acre-feet of water. One acre-foot is equal to the inundation of one acre of water at a depth of one foot. Based solely upon this data with consideration of threats resulting from the Wappapello Lake and Clearwater Lake dams, severity classifications ranging from limited to catastrophic can be assigned to future incidents. A worst-case dam failure scenario within the planning area would be the structural compromise of the

Clearwater Dam.

According to the *2023 Missouri State Hazard Mitigation Plan*, there are five state-regulated and two federally-regulated dams for which inundation data is available. Per Figures 3.55 & 3.57 within the plan, 40 structures in the county were identified as vulnerable to failure of a state-regulated dam and 40 structures in the county were identified as vulnerable to failure of a federally-regulated dam. State planners identified the inundation zones of each dam and counted structures within the zones using HAZUS GIS data. A value was then assigned to potential losses resulting from dam failure assuming a flood depth of two feet or damage to 20% of the structures' values. The resulting combined value of potential loss for the planning area was $3,684,264, while the combined population at-risk was estimated at 82 persons as shown within Table A.8 of the plan.

Dam failures most often occur in isolation, rather than simultaneously. The above-estimates provide a county-wide view of dam failure. The resulting values should be analyzed and considered as an unlikely worse-case scenario. Inundation area maps relative to the planning area and associated Emergency Action Plans can be found within Appendix B of this plan.

Both state and federally-regulated dams are inspected by either U.S. Army Corps of Engineers (USACE) or the Missouri Department of Natural Resources (MDNR) with the frequency of inspection based on dam hazard class. Inspection reports from the MDNR for all high hazard dams regulated by the State were requested when conducting the current plan update. The MDNR denied release of the reports without a Sunshine Request. Furthermore, a chief engineer with the Department expressed concern regarding the age of any findings within the reports citing that findings likely would have been corrected or resolved within months of the report. Consequently, inspection reports were not reviewed.

Previous Occurrences

According to Stanford University's National Performance of Dams Program, there have been 33 dam failure incidents in Missouri. Fortunately, no such incidents have been reported since 2016, and none of those events have resulted in fatalities. Per the same source, two other "dam incidents" have occurred within the planning area. During the summer of 1994, concrete cracking was identified at Seven Lakes #1 Dam. Two years earlier, an incident was reported at Wappapello Lake Dam, but no detail regarding the event was known to the source.

On May 2, 2011, following spring flooding in the planning area, overtopping occurred at Wappapello Lake Dam emergency spillway resulting in the destruction of an approximate 300-meter portion of T Highway in Wayne County. Fortunately, there were no injuries or loss of life. The dam's emergency spillway functioned as designed. The flood event prompting the event proved significant and widespread resulting in a Presidential Disaster Declaration (DR-1980).

Probability of Future Occurrence

The state-regulated and inspected dams located within Wayne County and their state classifications are listed below.

- Lake Lynn Dam, Class II
- Lake Ray Dam, Class II
- Eagle Sky Lake Dam, Class I
- Seven Lakes Dam #4, Class III
- Seven Lakes Dam #3, Class I
- Seven Lakes Dam #1, Class I

All but Seven Lakes Dam #4 are considered high hazard dams by the U.S. Army Corps of Engineers. The "High Hazard" non-federal dams located within the planning area, but not regulated by the State of Missouri are listed below.

1. Lake of the Pines Dam
2. Horseshoe Ridge Leerjack
3. Turners Dream Lake Dam
4. Lottes Dam
5. Lake Julia Dam
6. Lake Janna Dam
7. Rothwell Ranch Lake Dam
8. Seven Lakes #2
9. A.O. Shearrer Lake Dam
10. Lake Potashnik Dam
11. Collins Lake Dam Section 31
12. Sunrise Lake Dam
13. Mountain Lake Dam
14. Lake Jeano Dam
15. Porter Dam
16. Collins Lake Dam–Section 16
17. Williams Lake-Section 31 Dam

Per Table 3.24, there are seventeen high hazard dams not currently regulated by the State of Missouri. The normal storage capacity of these dams ranges from 50 to 988 acre-feet. This could result in property damage and/or loss of life as the dams are not regularly inspected. The lack of regular inspections may increase the probability of failure as structural damage may go unnoticed and, therefore, not corrected. Regular inspection and maintenance serve to lessen the probability of dam failure.

Fortunately, there has been only one spillway overtopping event (Wappapello Lake Dam—2011) and no dam failures within the planning area. Consequently, no data exists on which to calculate the probability of a dam failure event.

Changing Future Conditions Considerations

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

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

Vulnerability

Vulnerability Overview

Through the NID dam hazard classification system, the USACE classifies dams according to what impacts could occur within downstream inundation areas. Per the *2023 Missouri State Hazard Mitigation Plan*, "the downstream hazard classification system utilized by the National Inventory of Dams provides the Hazard Classification system as a means to determine overall vulnerability in the event of dam failure." As described above, the NID reports 41 dams in the planning area. Of those 41 dams, 24 (58.5%) are "High Hazard," 4 (9.8%) are "Significant Hazard," and 13 (31.7%) are "Low Hazard." If any of the 24 "High Hazard" dams in the county were to fail, loss of human life is likely. If any of the four "Significant Hazard" dams were to fail, loss of human life is possible. Failure of any of the thirteen "Low Hazard" dams can result in loss of property, but loss of life is unlikely. However, this system does not indicate the structural integrity of the dam or likelihood of failure. For regulated dams, there are two main processes in place to advance dam safety: 1) Inspection and 2) Emergency Action Planning.

Persons at risk of dam breach may include not only residents downstream, but also farm workers, hunters, anglers, hikers, campers and other recreationists. Figure 3.59 within the *2023 Missouri State Hazard Mitigation Plan* provides the estimated population at risk to dam failure based on the average household size and the number of residential structures located within the dam inundation area. Per the state calculation, 1-104 persons residing in Wayne County are at risk of injury or death resulting from the failure of a state-regulated dam. At the same time, 1-2,913 persons are at risk of injury or death resulting from the failure of the Clearwater or Wappapello Dams. The inundation areas for these two large impoundments spans the service areas of both school districts headquartered within the planning area.

The two largest dams in the planning—the Clearwater Lake Dam (along the Black Rivere) and the Wappapello Lake Dam (along the St. Francis River) are maintained and regulated by the U.S. Army Corps of Engineers (USACE). Per risk data found within the Corp's National Inventory of Dams, a high pool breach at the Clearwater Dam would occur at 609 feet with the number of daytime people at risk of injury or death estimated at 15,562. A high pool breach during the daytime at the Wappapello Dam would occur at 414 feet with 3,848 people at risk.

Potential Losses to Existing Development:

As reported in Table 3.44 in the *2023 Missouri State hazard Mitigation Plan*, the state estimated loss amounts resulting from dam failure for each county in the state. The analysis included both state-regulated and USACE-owned dams. For Wayne County, the state estimated potential loss as a result of dam failure at $3,684,264. To determine the potential loss, a damage estimation of 20% percent of the total structure value in dam inundation areas was used. This damage amount was based on FIA depth-damage curves for a one-story structure with no basement flooded at two feet.

The four dams located in neighboring Iron and Madison Counties pose negligible threat to assets, life, and resources within the planning area. The potential inundation areas for the dams include rural sparsely populated land area located within the far north and northwestern portion of the planning area. No inundation maps were available for any dams located upstream of Wayne County.

The Missouri Department of Natural Resources (MDNR) provided Emergency Action Plans (EAP's) for the 5 state regulated dams located within the planning area. Per data found within the

documents, the number of residential and/or commercial structures located within the dam breach inundation areas of the 5 dams is as follows:

- Eagle Sky Dam, Class I, High Hazard, 24 structures within the unincorporated portion of Wayne County
- Lake Lynn Dam, Class II, High Hazard, 3 structures within the unincorporated portion of Wayne County, one wildlife refuge
- Lake Ray Dam, Class II, High Hazard, same as Lake Lynn Dam (above)
- Seven Lakes #1 Dam, Both Class I, Both High Hazard, 8 structures located outside planning area in Iron County to the north
- Seven Lakes Dam #3, Class I, High Hazard, same as Seven Lakes #1 Dam (above)

Per the USACE-provided inundation map found in Appendix B (for Clearwater Lake), there are two wastewater treatment facilities, one police station, one fire station, one airport, and one school, a lengthy stretch of the Union Pacific Railroad, and a smaller federal dam (Markham Spring) Furthermore, there are two wastewater treatment facilities located within the Wappapello Lake inundation area.

Inspection reports for state-regulated dams were requested of the Missouri Department of Natural Resources. Department representatives were not readily willing to provide dam inspection reports due to their inclusion of private information. Furthermore, they expressed concerns regarding the age and applicability of data noted by the inspectors. Inundation maps were provided by both the state and USACE. Following request by the planner for this update, the USACE was unwiling to provide Emergency Action Plans (EAP's) for the federally-regulated dams within the planning area but did offer to consider EAP data release directly to the State Emergency Management Agency (SEMA).

Impact of Previous and Future Development

Wayne County is very rural and sparsely populated. There is little to no development anticipated within the inundation areas of any of the dams located in the county. The county does not issue building permits.

Hazard Summary by Jurisdiction

Wayne County – portions of the unincorporated parts of the county are located within multiple inundation zones—for both High Hazard and Class I dams. The number of persons at-risk of injury or death due to dam failure—particularly resulting from breach at the Clearwater Lake or Wappapello Lake Dams—are significant.

City of Greenville – The city is not located within the inundation area of any dam for which inundation areas are currently mapped.

City of Piedmont – The southern portion of the city is located within the Clearwater Dam inundation area. Both the city's airport and wastewater treatment facility are located within the area to be flooded anywhere from six to fifteen feet should the dam fail in its entirety. This is depicted within the inundation maps found within Appendix B.

City of Williamsville – A large portion of the city is located within the 2-6 feet inundation zone of the Clearwater Dam. Should this massive structure fail, the city's wastewater treatment facility, its police station, city hall, fire station, elementary school, and wastewater treatment facility are all

anticipated to flood.

Village of Mill Spring - The southwestern portion of the village is located within the Clearwater Dam inundation area. While no critical facilities are shown to be located on the map, transportation routes accessing the village and the Union Pacific Railroad would be significantly flooded should the dam fail.

Clearwater R-I School District – the district has no assets in a known inundation area.

Greenville R-II School District – the districts' Williamsville Elementary School campus is located within the Clearwater Dam inundation area and could be flooded up to six feet should the dam fail.

Problem Statement

Variations in risk between geographic areas exist for dam failure. Many critical facilities and a school campus are located within the inundation areas of two USACE dams. The Cities of Piedmont and Williamsville, as well as the Village of Mill Spring will be heavily impacted by failure of the Clearwater Dam. Furthermore, given the number of unregulated "high hazard" dams located within the planning area (17), the unincorporated portion of the county is also subject to significant, yet ill-defined vulnerability from dam failure.

Emergency Actions Plans (EAP's) for the 5 state-regulated dams were reviewed by the planner in the course of this plan update. It was noted that the inspections did not include the new 911 addresses for the structures located within the dam breach inundation areas. The old rural route addresses can be easily replaced and would significantly expedite emergency response in the event of a dam failure event.

- The City of Piedmont, the City of Williamsville, and the Village of Mill Spring will all be heavily impacted by the failure of the Clearwater Dam. Leaders of the municipalities should obtain and familiarize themselves with the dam's Emergency Action Plan (EAP) and develop local communication plans to be implemented should such an event occur.
- A lack of regular inspection/maintenance of un-regulated high hazard dams was noted by the Mitigation Planning Committee. Possible solutions include the development of a regular maintenance schedule, identification of qualified staff and/or consultant to assist, and maintenance report submittal requirements.
- Wayne County should consult with the Missouri Department of Natural Resources to revise the addresses of structures located downstream of the 5 state-regulated dams for which dam breach inundation maps are available.
- Wayne County should seek funding to identify dam-breach inundation areas of NID-identified "high hazard" dams not regulated by the state and conduct a vulnerability analysis.
- Wayne County should consider a partnership with neighboring Butler County (to the south) and Stoddard County (to the southeast) to educate and familiarize the public with the Emergency Action Plans (EAP's) for both the Clearwater and Wappapello Dams, repsectively.

3.4.3 Earthquakes

Hazard Profile

Hazard Description

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

As explained by the Federal Emergency Management Agency, major earthquakes and their accompanying foreshocks and aftershocks can be measured in two different ways. In 1935, the Richter Scale was developed by Charles F. Richter to measure the amount of energy released by an earthquake. The Modified Mercalli Intensity Scale was also developed as a tool to measure the severity of a quake using damage observations. The Mercalli Scale uses Roman numerals I to XII to rate an earthquake's intensity. A description of Modified Mercalli Scale is offered below in Figure 3.8.

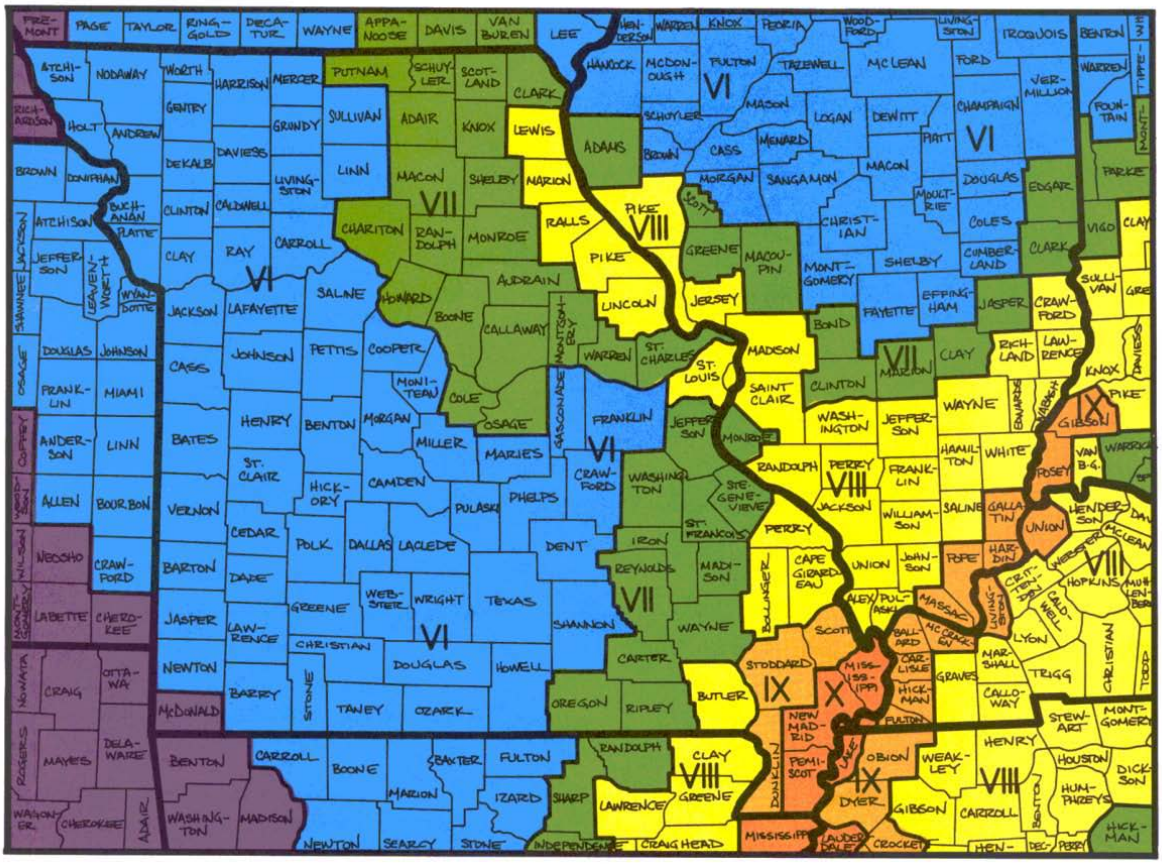
Historically, in Missouri, the most severe earthquakes occurred in the New Madrid Seismic Zone (NMSZ) from December 16, 1811, through March 12, 1812. The two most severe occurred on December 16, 1811, and February 7,1812. These quakes rank seventh and ninth respectively among the largest earthquakes ever recorded in the United States.

Geographic Location

The planning area—located in Southeast Missouri—is subject to earthquakes originating from the New Madrid Seismic Zone. The zone is made up of several thrust faults that stretch throughout Southeast Missouri. The effects of a large earthquake will impact the entire county indiscriminately. All jurisdictions are expected to experience the same intensity across the planning area. Wayne County, like its neighboring counties, is at risk for strong ground movements. The immediate vicinity of the Ozarks is also at risk from earthquakes in the Mew Madrid Seismic Zone because subsurface conditions of the Mississippi and Missouri River Valleys can amplify ground shaking.

The map below shows the highest projected Modified Mercalli intensities by county from a potential magnitude 7.6 earthquake whose epicenter could be anywhere along the length of the New Madrid Seismic Zone. The secondary maps in Figure 3.7 show the same regional intensities for a 6.7 and an 8.6 earthquake. In the below graphic, Wayne County is the only green county in Missouri that directly abuts an orange county (Stoddard).

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

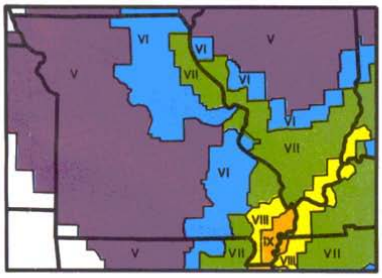


This map shows the highest projected Modified Mercalli intensities by county from a potential magnitude – 7.6 earthquake whose epicenter could be anywhere along the length of the New Madrid seismic zone.

6.7

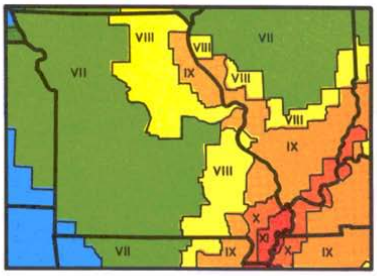
7.6

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 3.8. Projected Earthquake Intensities

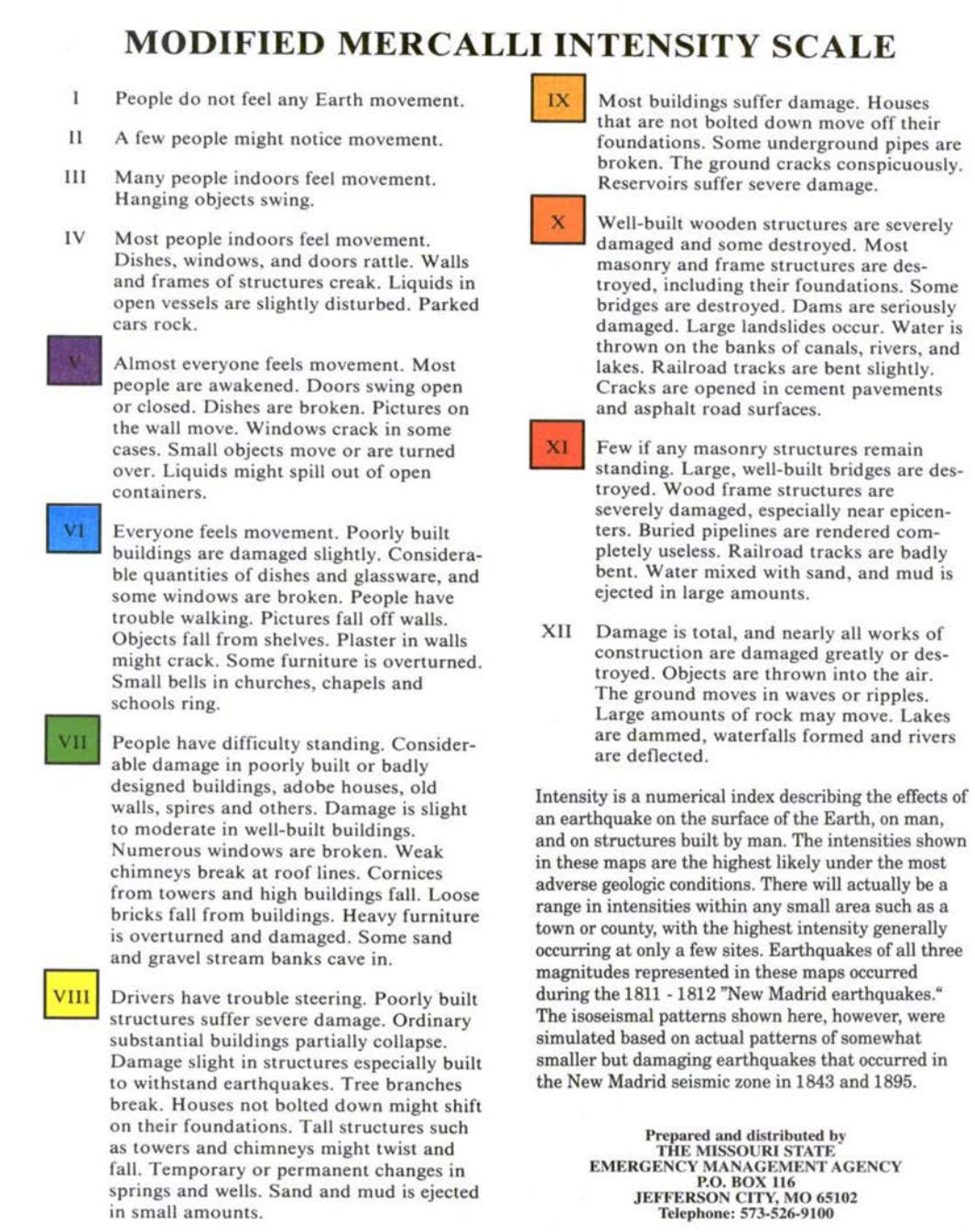
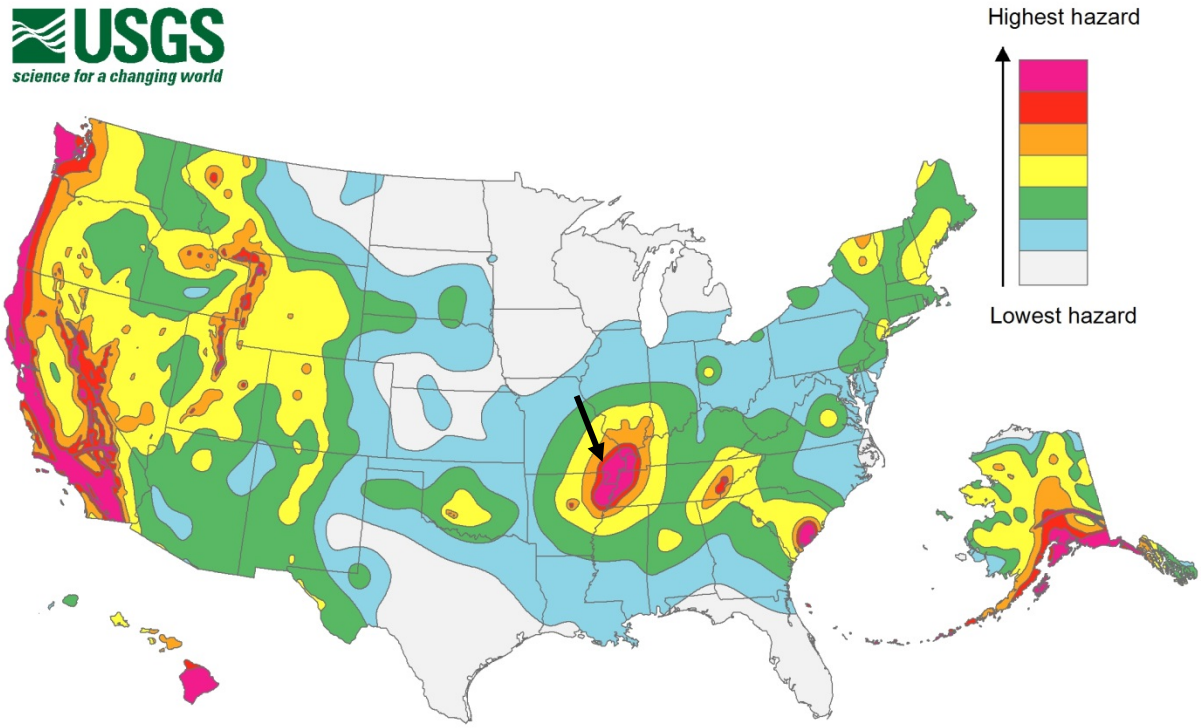


Figure 3.9 illustrates seismicity in the United States. The planning area lies along the boundary of the bright pink and orange area and is indicated by the black arrow.

Figure 3.9. United States Seismic Hazard Map



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

Strength/Magnitude/Extent

As referenced above, 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

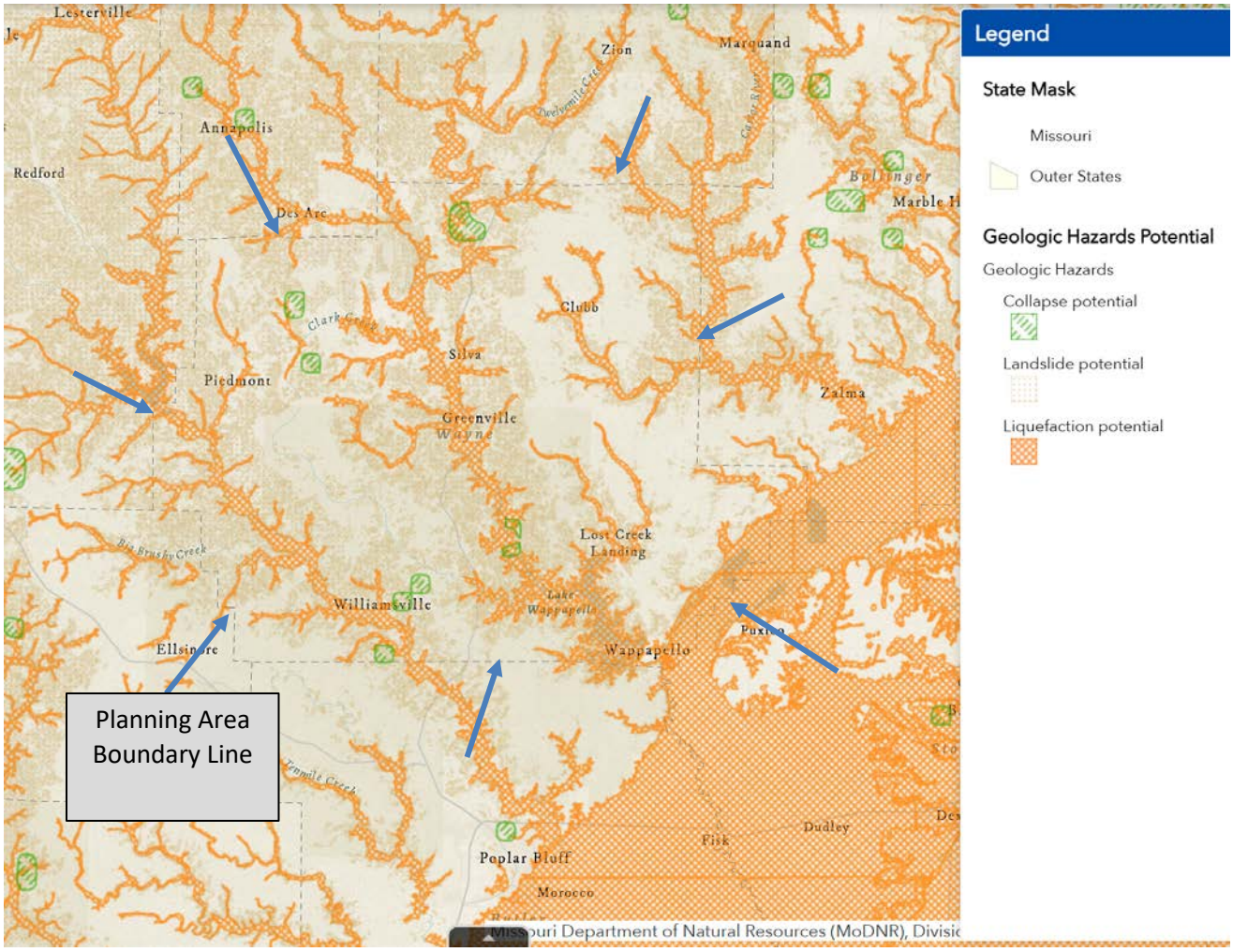
The Richter Magnitude Scale was developed in 1935 as a device to compare the size of earthquakes. The magnitude of an earthquake is measured using a logarithm of the maximum extent of waves recorded by seismographs. Adjustments are made to reflect the variation in the distance between the various seismographs 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.

Using the Missouri Department of Natural Resources, GeoSTRAT tool, a better understanding of earthquake impact upon certain parts of the planning area can be ascertained. In Figure 3.10 below, it can be seen that areas along streams and bodies of water are subject to liquefaction (the orange cross-hatching in the graphic below), while seemingly smaller select portions of the planning area are subject to collapse (see the green hash-marked areas). Landslide potential, though difficult to see in the graphic, is prevalent in the county, particularly outside of the "potential liquefaction" areas. Within the below map, the county boundary is indicated by the light gray dashed line highlighted by the blue arrows.

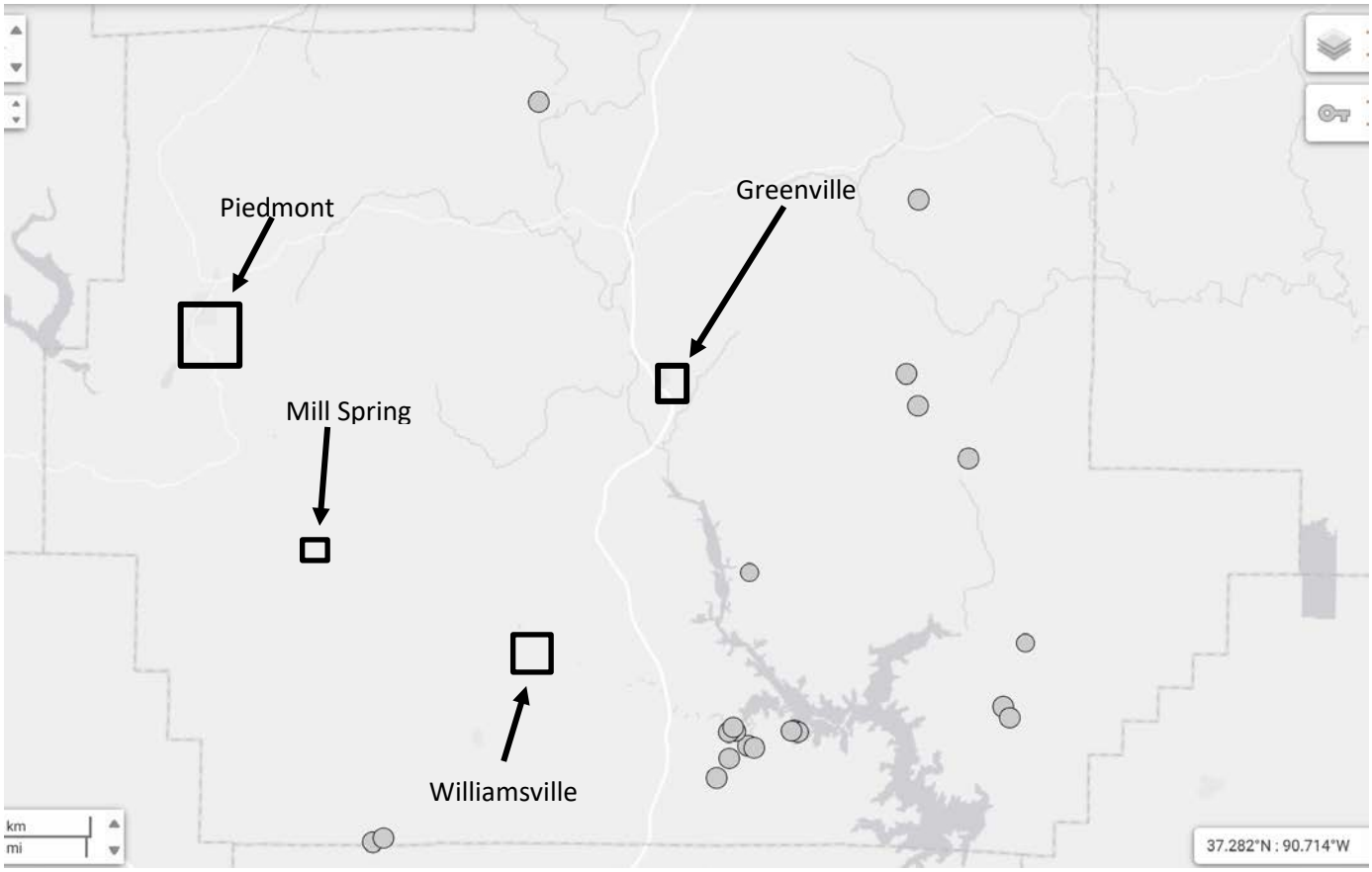
Figure 3.10. Geologic Hazards Potential Within Wayne County, Missouri



Previous Occurrences

Per www.homefacts.com, Greenville—the county seat of the planning area—has a moderate risk of earthquakes. According to the U.S. Geologic Survey (USGS) there have been 7,769 earthquakes Magnitude 0.1 and Magnitude 4.7 within 250 km (156 miles) of Greenville, MO within the past 20 years. In reviewing the specific incidents during that time period, the strongest earthquake (magnitude 4.7) occurred near Greenbriar, AR. Twenty of the 7,760 earthquakes had an epicenter in Wayne County and ranged from magnitude 1.4 to 4.0 on the Richter Scale. The county saw its magnitude 4.0 quake on November 18, 2021.

Figure 3.11. Geologic Hazards Potential Within Wayne County, Missouri



Per the Center for Earthquake Research and Information at the University of Memphis, the most recent earthquake with an epicenter in the planning area occurred on July 28, 2023. The quake measured 2.2 on the Richter Scale and was centered in the southern portion of the county just west of Wappapello.

The largest earthquakes ever felt in the United States occurred along the New Madrid fault line during the winter of 1811-1812. During the course of three months, three earthquakes registering above 8.0 on the Richter Scale were felt by nearly the entire eastern half of the United States. According to the United States Geological Survey, church bells in Boston, Massachusetts rang as a result of the tremendous shaking. In fact, the New Madrid quakes were two to three times stronger than the 1964 Alaska earthquake and ten times more powerful than the 1906 San Francisco Quake.

Probability of Future Occurrence

There are multiple ways to assess the probability of an earthquake occurring within the planning area in any given year. Three such methods are described below.

Per Table A.11 on page 69 of the *2023 Missouri State Hazard Mitigation Plan*, "FEMA's National Risk Index has calculated the annualized frequency of earthquake events. Annualized frequency is defined as the expected frequency or probability of a hazard occurrence per year. This value represents the probability of earthquake occurrences, in events, (at least minor-damage shaking) impacting a location in any given year." Per this calculation, the earthquake annualized frequency for Wayne County is 0.002760, or 2.76 events per year.

Using the earthquake occurrence data provided by the USGS over the past 20 years, the probability of an earthquake in the planning area can be calculated. Using 20 reported earthquakes with epicenters located in Wayne County between 2004 and 2023 (20 years), the probability of an earthquake occurring in the planning area in any given year is 100%.

The U.S. Geological Survey estimates the probability of a magnitude 7.5 or greater earthquake occurring somewhere along the New Madrid Zone at 7% to 10% within the next 50 years. The probability of an earthquake exceeding magnitude 6.0 occurring within the same time period is estimated by the USGS at 25% to 40%.

Changing Future Conditions Considerations

According to the *2023 Missouri State Hazard Mitigation Plan*, 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 that are caused by changing future conditions.

Vulnerability

Vulnerability Overview

A statement pulled from the 2019 report, *Where Was the 31 October 1895 Charleston, Missouri Earthquake?* claims that "faults associated with the western edge of the Reelfoot Rift appear favorably oriented for failure in the current stress regime." The report examines what is thought to be the most recent 6.0 or grater earthquake in the U.S. and emphasizes that an elevated seismic hazard extends westerly from the New Madrid Seismic zone into Southeast Missouri. Assuming the validity of the report's hypothesis, the planning area and its surrounding counties could be at greater risk of more significant earthquakes than traditionally thought.

Per the Missouri Department of Commerce and Insurance, "Missouri is the third largest market for earthquake insurance among the states, exceeded only by California and Washington." According to the department's *2022 Residential Earthquake Coverage in Missouri* published in April 2023, the number of insurance policies with earthquake endorsements in the New Madrid Seismic Zone has decreased by 49.3%, from 60.2% in 2000 to 10.9% in 2022. This is due primarily to increases in cost of coverage. Per the report, the average cost of earthquake coverage was $57 per year in 2000 and $565 per year in 2022. According to the report, 13.5% of property owners hold earthquake insurance within the planning area with an average annual premium of $191.

The data used for this vulnerability overview and potential loss estimation were gathered from the *2023 Missouri State Hazard Mitigation Plan* and are described in more detail within the following section. County level data from Chapter 3 of the state plan provided the best and most recent data available.

Potential Losses to Existing Development

The *2023 Missouri State Hazard Mitigation Plan* describes the analysis of earthquake hazard vulnerability using HAZUS software and assuming two different scenarios—an *annualized loss scenario* and a *probabilistic loss scenario*. The two scenarios and relative assumptions are described below.

Annualized Loss Scenario – Annualized loss is defined as the expected value of loss in any one year. A FEMA loss study (*FEMA P-366 HAZUS Estimate Annualized Earthquake Losses for the United States, April 2017*) was combined with analyses using FEMA's loss estimation software (HAZUS 6.1) to produce an "apples to apples" county comparison of earthquake risk statewide. The HAZUS analyses used a Level 1 building inventory database comprised of demographic data from the 2010 census.

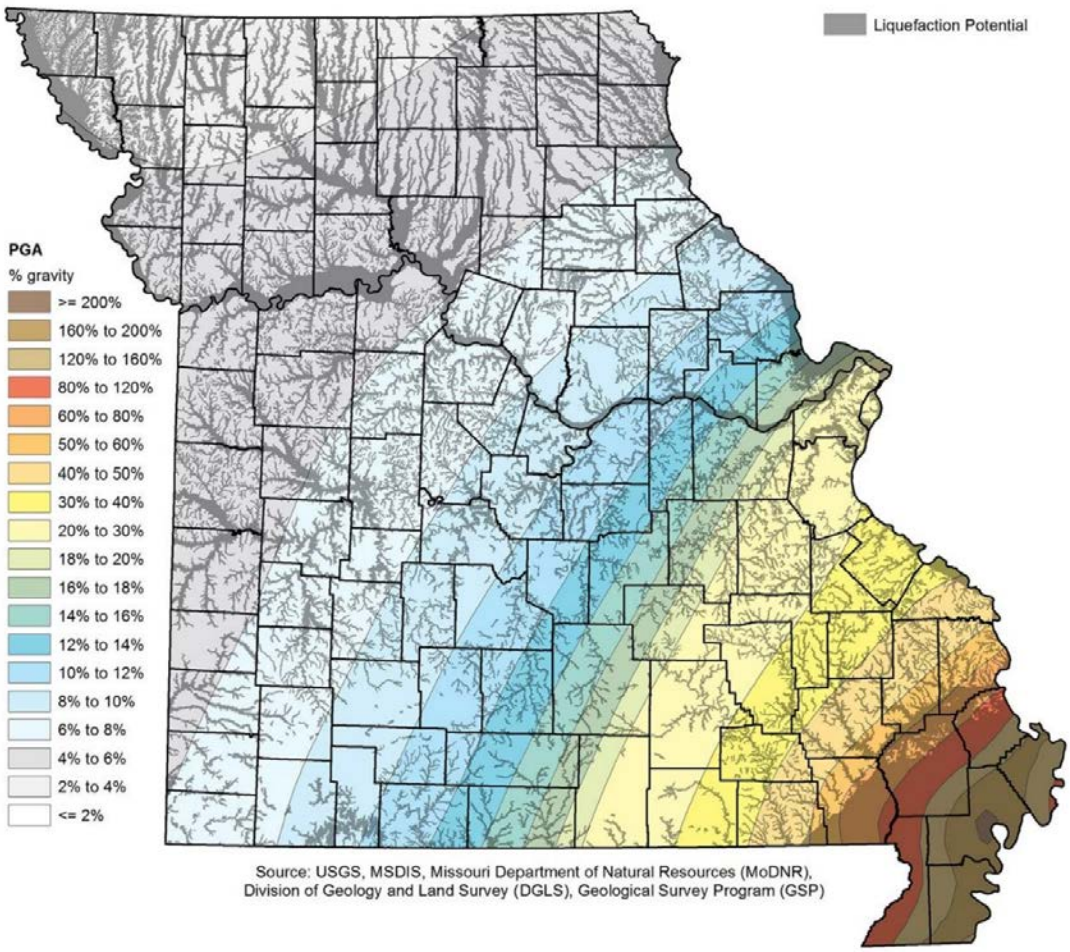
Using this method of loss estimation, economic losses to buildings were annualized over eight earthquake return periods (100; 200; 500; 1,500; 2,000; and, 2,500 years). The software computes annualized loss estimates by aggregating the losses and their exceedance probabilities from the eight "return periods." Annualized loss is the maximum potential annual dollar loss resulting from the various return periods averaged on a 'per year' basis, specifically, the summation of all HAZUS-supplied return periods multiplied by the return period probability (as a weighted calculation).

As reported in Table A.10 in the *2023 Missouri State Hazard Mitigation Plan,* total losses—using the annualized loss scenario—total losses due to earthquake are estimated at $361,000,000 with a loss per capita of $26.70 and resulting in an annualized loss ratio of $288 per million. Per the state plan, "the annualized loss ratio represents the ratio of the average annualized losses divided by the entire building inventory by county as calculated by Hazus. The loss ratio is an indication of the economic impacts an earthquake could have, and how difficult it could be for a particular community to recover from an event."

Probabilistic Loss Scenario – assumes a worst-case earthquake event along the New Madrid Seismic Zone modeled by "an event with a 2% probability of exceedance in 50 years and using ground shaking levels recognized in earthquake resistant design. For the purposes of the analysis, site classification and soil liquefaction characteristics—provided by the National Earthquake Hazards Reduction Program of the Central United States Earthquake Consortium—were used to enhance the accuracy of the hazard modeling.

Using this loss scenario, structural and non-structural damage estimated for Wayne County were $57,036,000 and $188,917,000, respectively. The total loss for the planning area—including structural building components, non-structural building components, contents, inventory, relocation, capital-related, wages, and rental income—was estimated at $372,871,000. The loss ratio for the county using this method of analysis was 19.57%. Loss ratios for all Missouri counties ranged from .17% in Worth County to 64.73% in New Madrid County. Figure 3.11, below, provides a visual depiction of ground shaking and liquefaction potential during the modeled event.

Figure 3.12. HAZUS Earthquake 2% Probability of Exceedance in 50 Years —Ground Shaking and Liquefaction Potential



FEMA's National Risk Index provides one other categorization of risk by combining estimated annual losses with a measure of social vulnerability and community resilience. FEMA categorizes an evaluated geography into one of five categories: Relatively High, Relatively Moderate, Relatively Low, Very Low, Undetermined. The social vulnerability measure comes from the University of South Carolina's Social Vulnerability Index, while the community resilience measure comes from the university's Hazards and Vulnerability Reasearch Institute. Considering the aforementioned measures, FEMA determined not only Wayne County's annualized loss rating, but also its earthquake risk rating to be "Relatively Low."

Impact of Previous and Future Development

Future development is not expected to increase the risk other than contributing to the overall exposure of what could become damaged as a result of an event. Fortunately, no future development is anticipated within the planning area.

Hazard Summary by Jurisdiction

The earthquake intensity is not likely to vary greatly throughout the planning area; therefore, the

risk will not be significantly different throughout the county. Given the propensity for epicenter variation, no specific area of Wayne County, however, is more susceptible to earthquakes than another area.

It should be noted, however, that damages could differ if there are structural variations in the planning area's built-environment. For example, aged housing units are likely to suffer more damage than later built units. When occupied, these older units can contribute to injury and even death. Furthermore, because the planning area is located within the New Madrid Seismic Zone, the potential for ground shaking and liquefaction lessens from the southeastern portion of the planning area to the northwestern portion as shown in Figure 3.12 above. Geologic variations throughout the planning area can contribute to the type of destruction caused by an earthquake (e.g. collapse, liquefaction, or landslide). Figure 3.10 depicts the likelihood of each effect throughout the planning area.

Wayne County – Potential for damage due to earthquakes may vary somewhat throughout the county due to the epicenter location of an earthquake event, as well as variations in soil type and geology throughout the planning area. The historic county courthouse and other older masonry-type buildings are more vulnerable to damages from earthquake due to their age. For those 20 earthquakes that have originated in planning area in the past 20 years, the majority of epicenters have been in the southeastern portion of the county around Lake Wappapello.

City of Greenville – Compared to other municipalities in the county, Greenville has lowest proportion of older homes (10.2%) within its jurisdiction. For this reason, the city may be less susceptible to damage from earthquake than other jurisdictions in the planning area.

City of Piedmont – The city has the second highest proportion (19.1%) of older occupied housing units (those built before 1939) of all jurisdictions in the county. This could result in a higher rate of structural damage, injuries, and residential displacement due to earthquake.

City of Williamsville – The city has a high rate of occupied housing units built before 1939 (18.8%), is located within the 40%-50% gravity Peak Ground Acceleration area within Figure 3.12, and is subject to ground shaking as shown within Figure 3.10. In addition, earthquakes in Wayne County tend to have epicenters located in the portion of the planning area nearer to Williamsville as shown in Figure 3.11. For these reasons, the city may experience more destruction during an earthquake event

Village of Mill Spring - The village has the highest proportion of older occupied housing units (those built before 1939) at 25.5% than any other jurisdiction in the planning area.

Clearwater R-I School District – The district has one building constructed before 1939—its old gymnasium. Its service area spans the northwestern portion of the planning area.

Greenville R-II School District – The district has no building constructed before 1939. Its service area spans the central and southeastern portion of the planning area.

Problem Statement

Risk of and vulnerability to earthquake does not vary greatly throughout the region. Certain areas do have older housing stock. The Village of Mill Spring has a high proportion of aged housing stock, yet the City of Williamsville has both a high percentage of aged housing stock and is located near an area more susceptible to ground shaking. It should be noted that per Figure 3.11, the majority of

earthquakes with epicenters in Wayne County occur in the southeastern portion of the planning area. The Wayne County Courthouse is a multi-story structure built between 1941 and 1943. Should a strong earthquake occur along the NMSZ, the facility is likely to incur damage, thereby, interrupting county government operations.

- The Wayne County Courthouse, due to its age and multi-story design is susceptible to damage from earthquakes. To minimize interruptions to government operations following an earthquake event, the county could pre-identify an alternative operation base and solidify plans for the relocation of physical operations.

- Housing stock within the Village of Mill Spring is significantly older than other residential structures in the planning area and could be at higher risk. Possible solutions include review by a structural engineer of occupied housing units constructed before 1939 for potential retrofits.

- Housing stock within the City of Williamsville is aged and more subject to ground shaking. The city council may wish to partner with the Village of Mill Spring for engineering reviews of occupied housing units and/or review local ordinances and establish building codes to address seismic provisions.

3.4.4 Land Subsidence/Sinkholes[4(b)(1)c; 4(b)(2,3)]

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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.

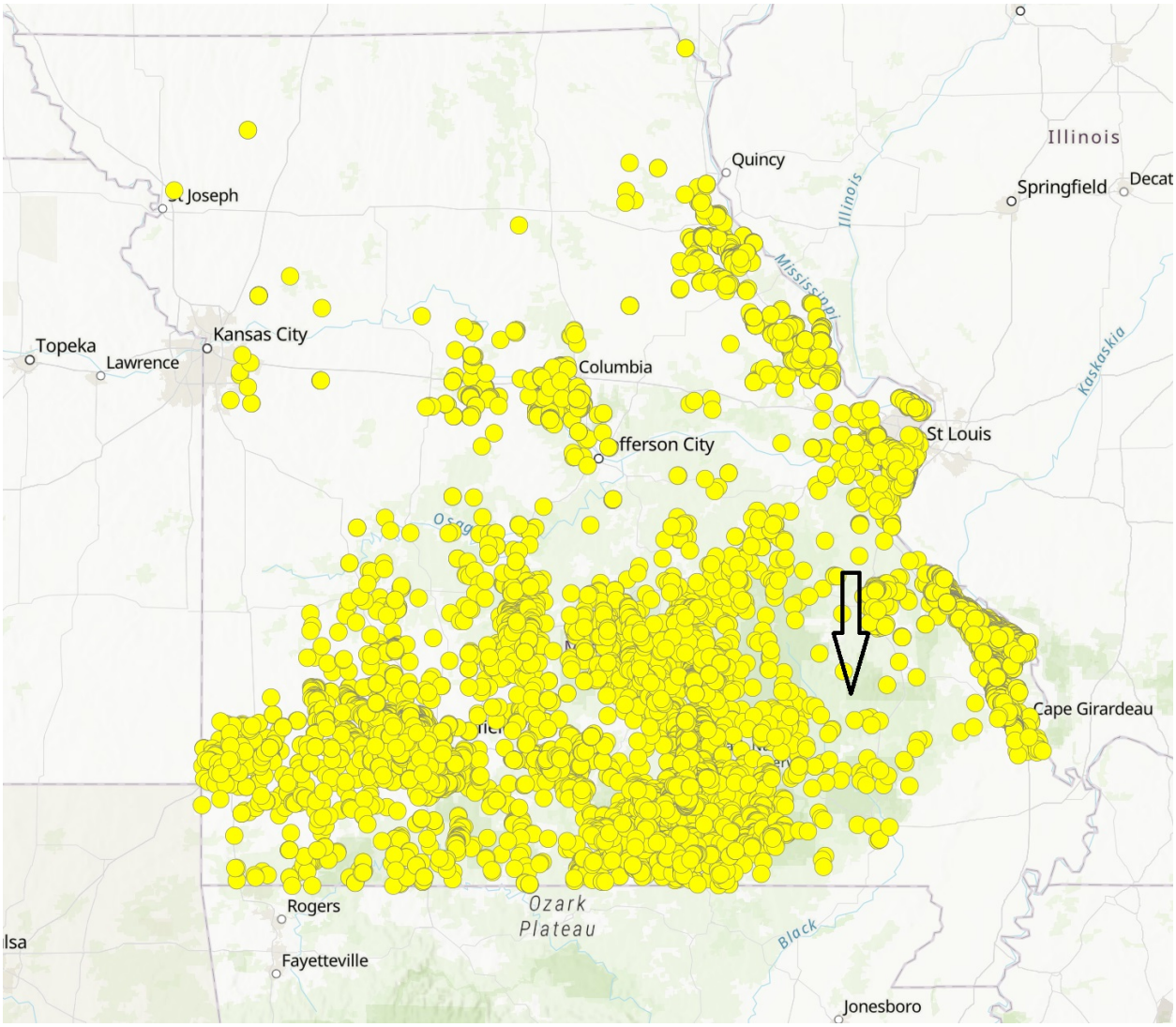
According to the U.S. Geological Survey (USGS), the most damage from sinkholes tends to occur in Florida, Texas, Alabama, Missouri, Kentucky, Tennessee, and Pennsylvania. Fifty-nine percent of Missouri is underlain by thick, carbonate rock that makes Missouri vulnerable to sinkholes. Sinkholes occur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

There were no mining activities known to the planning committee at the time of this plan update.

Geographic Location

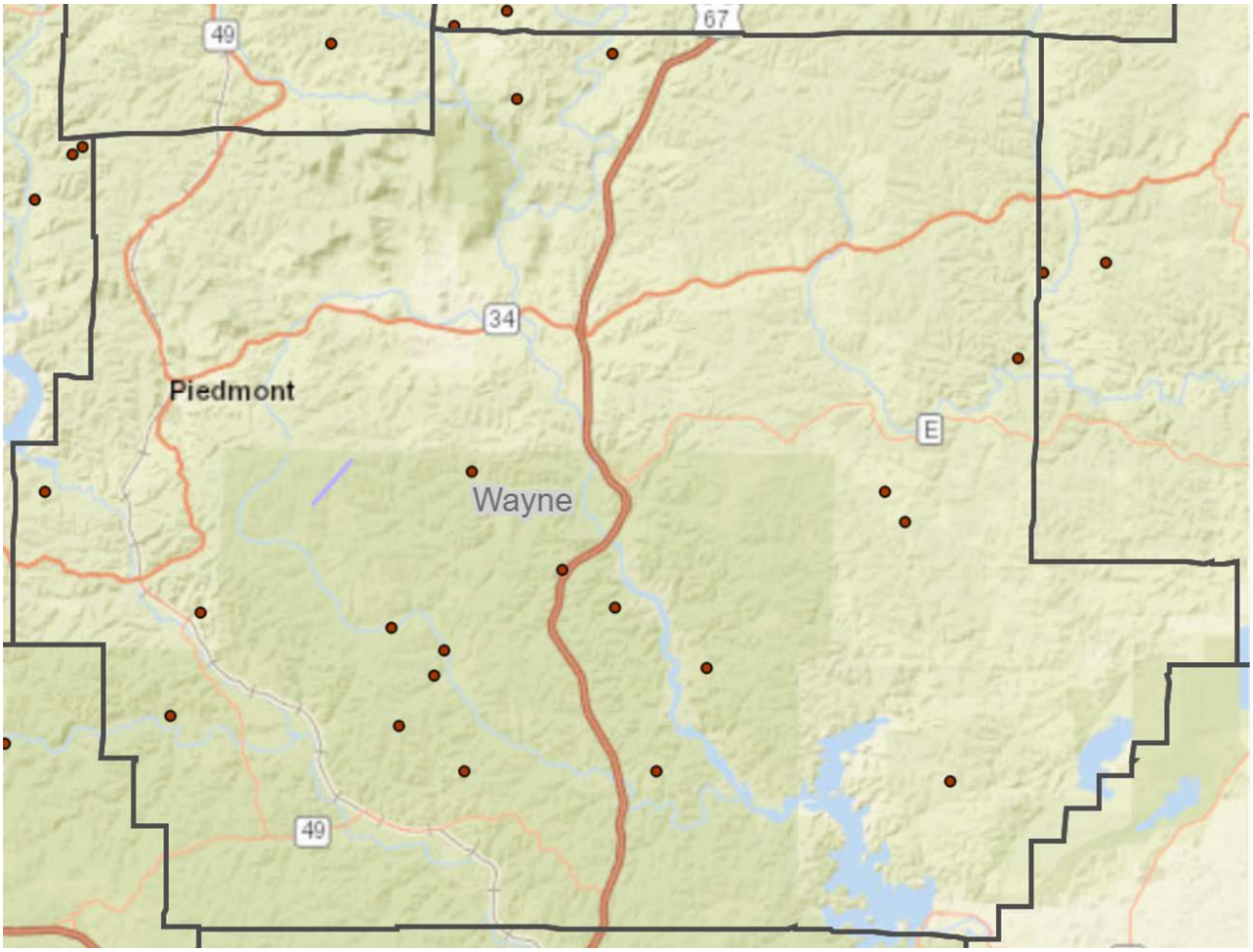
The maps below shows the distribution of sinkholes across the state as well as the location of 19 sinkholes in the planning area. Relative to the remainder of the state (particularly south-central Missouri), Wayne County has few sinkholes. For those that have been identified within the county, most are near Williamsville in the southwestern portion of the county.

Figure 3.13. Sinkhole Locations in the State of Missouri



Source: Missouri Hazard Mitigation Viewer

Figure 3.14. Sinkhole Locations in the State of Missouri



Source: Missouri Hazard Mitigation Viewer

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

Sinkholes are a regular occurrence in Missouri, but rarely are they of any significance. Fortunately, per the USGS and local authorities there is no record of sinkhole collapse in Wayne County.

Probability of Future Occurrence

It should be noted that there exists no centralized database for sinkhole collapses in the state. There is no

record of previous sinkhole collapse events in the county; consequently, probabilities could not be calculated.

Changing Future Conditions Considerations

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

Vulnerability

Vulnerability Overview

County level data from the *2023 Missouri State Hazard Mitigation Plan*, was consulted as the best and most recent data available for the purposes of assessing vulnerability of jurisdictions in the planning area to sinkhole collapse.

Potential Losses to Existing Development

There is no known existing development in the planning area at risk of damage due to sinkhole collapse. Furthermore, no previous events have been recorded so as to provide a record of historical losses.

Impact of Previous and Future Development

Fortunately, no future development is anticipated within the planning area. Consequently, future development is not expected to increase the risk of damage due to sinkholes.

Hazard Summary by Jurisdiction

The majority of, if not all, known sinkholes in the planning area are located in the unincorporated portions of the county. Twelve of the 19 known sinkhole locations, or 63.2%, are located in the southwestern portion of Wayne County. Outside of this fact, there is no difference in incidence or risk between communities or districts. For this reason, risk is considered uniform throughout the planning area. Due to data limitations regarding prior events and a lack of local involvement in sinkhole location identification methods, an analysis specific enough to indicate risk to existing structures in the planning area—including those owned and maintained by school and special districts—is impossible.

Wayne County – Most, if not all, of known sinkholes as mapped by the Missouri Department of Natural Resources are located within the balance of the county. Because of this risk of sinkhole collapse is most applicable to the county than to other jurisdictions within the planning area.

City of Greenville – There are no known sinkholes within the jurisdictional boundaries of the city.

City of Piedmont - There are no known sinkholes within the jurisdictional boundaries of the city.

City of Williamsville - There are no known sinkholes within the jurisdictional boundaries of the city.

Village of Mill Spring - There are no known sinkholes within the jurisdictional boundaries of the city.

Clearwater R-I School District – There are no school district assets located on or near known sinkholes.

Greenville R-II School District - There are no school district assets located on or near known sinkholes.

Problem Statement

Vulnerability of the planning area to damages resulting from sinkhole collapse is limited; yet, full analysis of existing sinkholes (precise location, size, and existing development) is difficult.

- Local authorities have limited knowledge of how state officials create sinkhole identification maps. A local understanding of the methods employed to locate and map sinkholes would help jurisdictional representatives better evaluate the danger sinkholes pose to existing and future development within their jurisdictions.

3.4.5 Drought

Hazard Profile

Hazard Description

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

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

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

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

plant, its stage of growth, and the physical and biological properties of the soil.

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

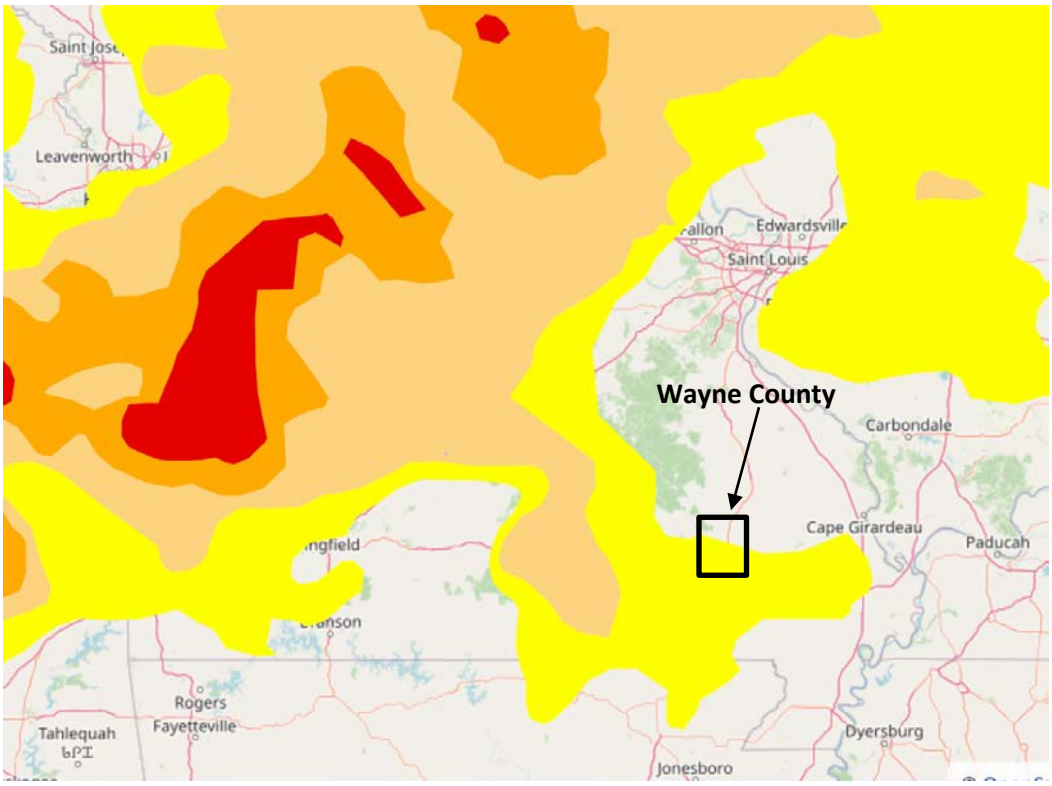
Geographic Location

The entire planning area is at risk to drought; however, drought most directly impacts the agricultural sector. The percentage of surface land used for agricultural purposes in Wayne County is .

Farming in Wayne County is concentrated in the balance of the county outside of municipality boundaries. There is currently no conversion of farmland to development occurring in the planning area. Consequently, negative impacts of drought in the county are expected to lessen baring unpredictable changes in climate. Per agricultural census data provided by the U.S. Department of Agriculture, the number of farms and harvested acres in the county declined substantially from 2012 to 2017. For example, in 2012, 230 farms harvested 28,002 acres of crops, livestock, etc.; later, in 2017, only 190 farms harvested 14,146 acres in the county. This amounts to a 17.4% reduction in number of farms and a 49.5% reduction in harvested acres. Given this information, it can reasonably be assumed that droughts in the planning area in 2017 had less negative impacts on the local industry than in 2012. Should this trend continue, drought is likely to become less impactful to the county as a whole.

The map in Figure 3.15 below is from the U.S. Drought Monitor and provides an example of the geographic area that could be in drought at any given moment in time. Remember that it is only a snapshot of conditions at a given moment in time. An arrow and rectangle indicate the location of the planning area on the map. On the date indicated, the northern portion of the planning area was in no drought, while the southern portion was in moderate drought (yellow).

Figure 3.15. U.S. Drought Monitor Map of Missouri on August 15, 2023



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

The Drought Impact Reporter of the University of Nebraska's National Drought Mitigation Center is a source of county-level data for types o f impacts resulting from previous drought events. In a 20-year period from 2004 to 2023, the monitor located 27 instances of drought impact involving Wayne County. The types of impact ranged from hay shortages and increases in cost of hay, water hauling to livestock, toxicity detected in silage for livestock, drought declarations and emergency provisions from public sources, increased wildfire incidence, fire bans, early leaf drop, implementation of grazing variances, increased cattle sales, the use of corn refuse for silage, and increased cost per acre for growing crops.

According to the NOAA's National Center for Environmental Information, from September 1, 2004, through August 31, 2023, there were seven drought events impacting Wayne County. The events ranged in length from .25 months to 7.75 months. Due to the nature of drought in general, events spanning longer periods result in more severe impacts. Narrative describing the two most severe events follows:

08/01/2010-1/31/2011 - (7 months in drought) Moderate drought conditions persisted over much of southeast Missouri. After a very dry June, some areas received beneficial rain in July and August. Rainfall for the months of July and August was variable, consisting of isolated to widely scattered showers and thunderstorms. Many locations were one to over three inches below normal for the month of August. Hot conditions increased evaporation rates and crop stress. Unirrigated corn yields were expected to be a total failure in some places. Livestock producers in Ripley and Carter Counties were feeding hay due to pastures that were burned up by not having significant rainfall for six weeks. Livestock water was also becoming a concern for some producers. Year-to-date rainfall deficits were 4 to 8 inches. By month's end, 32 percent of the Missouri cotton harvest was rated poor or very poor. Eighty-seven percent of pastureland in the extreme southeast corner of the state was rated as poor or very poor, which impacted hay crops. Unirrigated corn yields were expected to be a total failure in some places.

Outdoor fire danger became very high at times. By month's end, 85 percent of pastureland was rated poor or very poor. Ninety-two percent of topsoil was rated short or very short on moisture. A federal

disaster declaration was granted for most of southeast Missouri due to anticipated crop losses. Drought conditions improved during November with heavy rainfall on the 24th and 25th.

A series of wildfires occurred early in the month in Carter and Wayne Counties. Most of the fires were less than 100 acres, and no structures were known to have burned. There were some bans on outdoor burning until heavy rainfall on the 24th and 25th.

The cumulative effect of this drought, a catastrophic ice storm in '09, winds from Hurricane Ike in '08, and a record late spring freeze in '07 resulted in a mortality spiral among trees and shrubs. According to a local arborist, the series of damaging weather events diminished the long-term ability of trees to recover from future events.

While the drought ended in December in some locations, the subsoil moisture remained low. For the year 2010, most locations ended the year with precipitation deficits of 10 to 13 inches. The long-term moisture deficits were reflected in below normal streamflow's on some waterways.

While the drought began during the summer of 2010, and a very dry January exacerbated it. Total precipitation for January was only 0.34 inch at Poplar Bluff. Normal monthly precipitation is about three inches. Subsoil moisture remained low.

05/18/2012- 01/12/2013 - (7.75 months in drought) One of the warmest and driest Mays on record worsened the rare spring drought over southeast Missouri. By the end of May, the drought was severe in the extreme southeast Missouri counties of New Madrid and Mississippi. Moderate drought conditions existed elsewhere to the south of the Perryville area. Soils continued to dry out, and topsoil moisture deficits began to be reported. Pasture land rapidly deteriorated. Streamflows were running below normal by the end of the month.

The spring drought worsened considerably across southeast Missouri as summer arrived. By the end of June, all of southeast Missouri except for the Perryville and Van Buren areas was upgraded to extreme drought. Severe drought spread across the remainder of southeast Missouri. Soil moisture deficits continued to increase. By the end of June, 80 to 100 percent of the region's topsoil moisture was reported as short or very short, and 70 to 95 percent of the subsoil moisture was reported as short or very short.

Many crops were showing stress. The majority of the corn and soybeans were listed in fair to poor condition. Increasing amounts of livestock and pasture were showing stress. The percentage of pastures rated as poor or very poor was growing. Ponds across the region were drying quickly. Fire danger increased. In the Mark Twain National Forest, open fires were prohibited due to high fire danger.

The drought worsened considerably across southeast Missouri as summer progressed. By the end of July, all of Southeast Missouri was upgraded to extreme to exceptional drought. The exceptional drought conditions were along and south of a line from Poplar Bluff to Jackson, including Cape Girardeau. The remainder of southeast Missouri was classified as having extreme drought conditions. Soil moisture deficits continued to increase. By the end of July, 90 to 100 percent of the region's topsoil and subsoil moisture was reported as short or very short. Many crops were showing stress, and the situation became dire for many farmers. A majority of the corn and soybeans were listed in poor to very poor condition. Increasing amounts of livestock and pasture were showing stress. The percentage of pastures rated as poor or very poor continued to grow. Ponds across the region were dry or drying quickly. Fire danger remained high. Fourth of July fireworks shows were cancelled or banned in many places. Streamflows were running below normal. Many crops were heavily damaged, and numerous counties were declared natural disaster areas. Corn crops were a partial or complete loss.

Significant improvement in drought conditions occurred during the month of September. Heavy rain from the remnants of Hurricane Isaac was a notable factor. The extreme to exceptional summer

drought gave way to only moderate drought from Cape Girardeau north and west. Soil moisture deficits decreased greatly. By the end of September, soil moisture was near normal. Most of the corn crop was either harvested or plowed under, and corn crop losses were expected to be very high. Pastures improved, but a majority of them remained in poor or very poor condition. Fire danger decreased significantly, and all bans on outdoor burning were lifted. Stream flows were running about normal.

Slight improvement in long-term drought conditions was observed during the month of October, though most locations still reported below normal precipitation for the month. By the end of the month, areas south and west of a line from Cape Girardeau to Greenville were in severe drought. The remainder of the drought area was classified as moderate. The main impact of the long-term drought was on farm ponds used for irrigating fields or raising livestock. Soil moisture was near normal. The drought began in May and continued into November in most areas.

Drought officially ended along and north of a line from Marble Hill to Cape Girardeau. The area of severe drought improved to moderate drought. By the end of the month, areas south and west of a line from Cape Girardeau to Marble Hill were in moderate drought. The main impact of the long-term drought was on farm ponds used for irrigating fields or raising livestock. The year-to-date rainfall deficit hovered around 18 inches. The drought began in May and continued into January in most areas.

Probability of Future Occurrence

The seven drought incidents reported by NOAA's National Center for Environmental Information spanned 26.75 months within twenty years of data, or 240 months. Using these figures, the average percentage probability of drought in the planning area in any given month can be calculated as 11.2% (26.75 months spent in drought / 240 months during which data was collected = .01115 * 100% = 11.2%). Interestingly enough, severe drought likelihood as calculated by the State of Missouri and reported within Table A.20 of the *2023 Missouri State Hazard Mitigation Plan*, was 1.31--tying Butler County for the two counties most likely to experience severe drought in the state.

It should be noted that although the timing and duration of drought is not predictable, long-range outlooks and predicted impacts of climate change could indicate an increased chance of drought.

Vulnerability

Vulnerability Overview

County level data from the 2023 Missouri State Hazard Mitigation Plan, was used as the best and most recent data available.

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 reduce forest 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.

In some communities, water shortages may result as a result of severe drought. Per the USGS's National Water Information System, there are two large lakes, two rivers, and numerous streams located in the planning area. There are, however, no springs or groundwater sites mapped in the county.

Per the USDA's Risk Management Agency, crop losses in Wayne County due to drought totaled $295,501 from 2019 to 2023. There were 75 instances of loss with payout during the five-year period. Eleven of the 75 losses/payouts, or 17.3%, were due to drought. 2023 was the year with the highest value of losses due to drought at $243,603, with one of 6 total loss claims due to drought during the year comprising $203,594. In all instances of crop losses due to drought in the county, the crop lost was either corn or soybeans, with soybeans comprising the majority of losses.

When examining specifics of the claims data, the most recent year (2022) was selected. Per the RMA's Cause of Loss Historical Data Files, landowners in Wayne County experienced $222,078 in total crop losses during 2022 across 20 claims. Four of the 20 claims were for corn, 2 were for sorghum, 10 were for soybeans and 4 were for pasture, rangeland, or forage. The causes of the losses during the year were drought (5), excess moisture (5), heat (4), and unknown (4).

According to the *2023 Missouri State Hazard Mitigation Plan*, Wayne County has a "Medium" drought rating. When determining the rating, the state considered the planning area's social vulnerability index, its crop exposure ratio rating, its annualized USDA crop claims paid, and its likelihood of drought occurrence. In Table A.20 of the state plan, it is reported that the total crop claims made for drought damage from over a recent 10-year period in Wayne County was $1,812,021. It is important to note that the figure equates to claims made, not paid. Per the 2017 USDA Census of Agriculture, total crop exposure for the planning area was $7,814,000.

Per the USDA, historically average annualized losses have totaled $181,202. This figure differs from that calculated using RMA Cause of Loss data for the five years spanning 2019-2022, which was $59,100.20 per year. Assuming the USDA produced average annualized loss figure was computed using older annual data, the disparity in loss amounts between the two calculations could be due to the fact that the number of harvested acres has decreased significantly since 2012.

Impact of Previous and Future Development

At the time this risk assessment was updated, no future development was planned for the county or its participating jurisdictions. There were also no expansion plans for the school districts participating within this plan update. The number of farms and harvested acres has only decreased in the planning aera, thereby reducing exposure to drought-related agricultural losses. In addition, the county's population has also decreased significantly, thereby reducing the demand placed upon local water supply systems.

Changing Future Conditions Considerations

A new analysis, performed for the Natural Resources Defense Council (NRDC), 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. While the site was populated with much narrative and appeals for financial support, maps showing affected areas were not found.

Per the NRDC, “Hotter temperatures increase the rate at which water evaporates from the air, leading to more severe and pervasive droughts. Already, climate change has pushed the American West into a severe “megadrought”—the driest 22-year stretch recorded in at least 1,200 years—shrinking drinking water supplies, withering crops, and making forests more susceptible to insect infestations. Drought can also create a positive feedback loop in which drier soil and less plant cover cause even faster evaporation.”

Hazard Summary by Jurisdiction

Regarding damages due to drought, there is little variation between jurisdictions in the planning area. In cities, the drought conditions would be the same as those experienced in rural areas, but the impacts would be different such as lawns and local gardens could be impacted. In addition, building foundations could be weakened due to shrinking and expanding soils.

Wayne County – While the county is considered by the state to be the county most likely to experience severe drought, damage due to such events has been limited to the agricultural sector.

City of Greenville – The city has two adequate and functioning wells. Historical droughts have not impacted water supply within the city. Due to lack of agricultural lands within city limits and adequate water supply, drought poses negligible risk to the city.

City of Piedmont – The city pulls its municipal water from the Black River. Drought has not impacted the city’s water supply in the past. Due to lack of agricultural lands within city limits and adequate water supply, drought poses negligible risk to the city.

City of Williamsville – The city has two functioning wells; and, historical drought events have not impacted municipal water supply. Due to lack of agricultural lands within city limits and adequate water supply, drought poses negligible risk to the city.

Village of Mill Spring – The village has a single source well and provides water for both its community members (62 households) and nearby Public Water Supply District No. 3 (128 households). While drought has never impacted water supply, it should be noted that only one well exists to supply approximately 190 households. Pump malfunctions are common to the village and prevent dependable water supply.

Clearwater R-I School District – Due to adequate water supply within the City of Piedmont, drought poses negligible risk to the district.

Greenville R-II School District - Due to adequate water supply within the City of Greenville, drought poses negligible risk to the district.

Problem Statement

Drought is a hazard that impacts large geographic regions of the country. The sector that is most impacted in Wayne County is the acres that are used for agricultural purposes. Drought causes damages to crops and can negatively impact the yield of crops depending on the time the drought occurs. Furthermore, community water supplies can become inadequate during extreme drought conditions.

- Wayne County may wish to develop partnerships with representatives of the agricultural sector to explore ways to mitigate crop loss during drought conditions.
- Communities and water districts within the county may wish to explore resource

sharing/interconnectivity among water providers or secondary water source options.

3.4.6 Extreme Temperatures

Hazard Profile

Hazard Description

Extreme temperature events, both hot and cold, can impact human health and mortality, natural ecosystems, agriculture and other economic sectors. According to information provided by FEMA, extreme heat is defined as temperatures that hover 10 degrees or more above the average high temperature for the region and last for several weeks. Ambient air temperature is one component of heat conditions, with relative humidity being the other. The relationship of these factors creates what is known as the apparent temperature. The Heat Index chart shown in Figure 3.16 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.

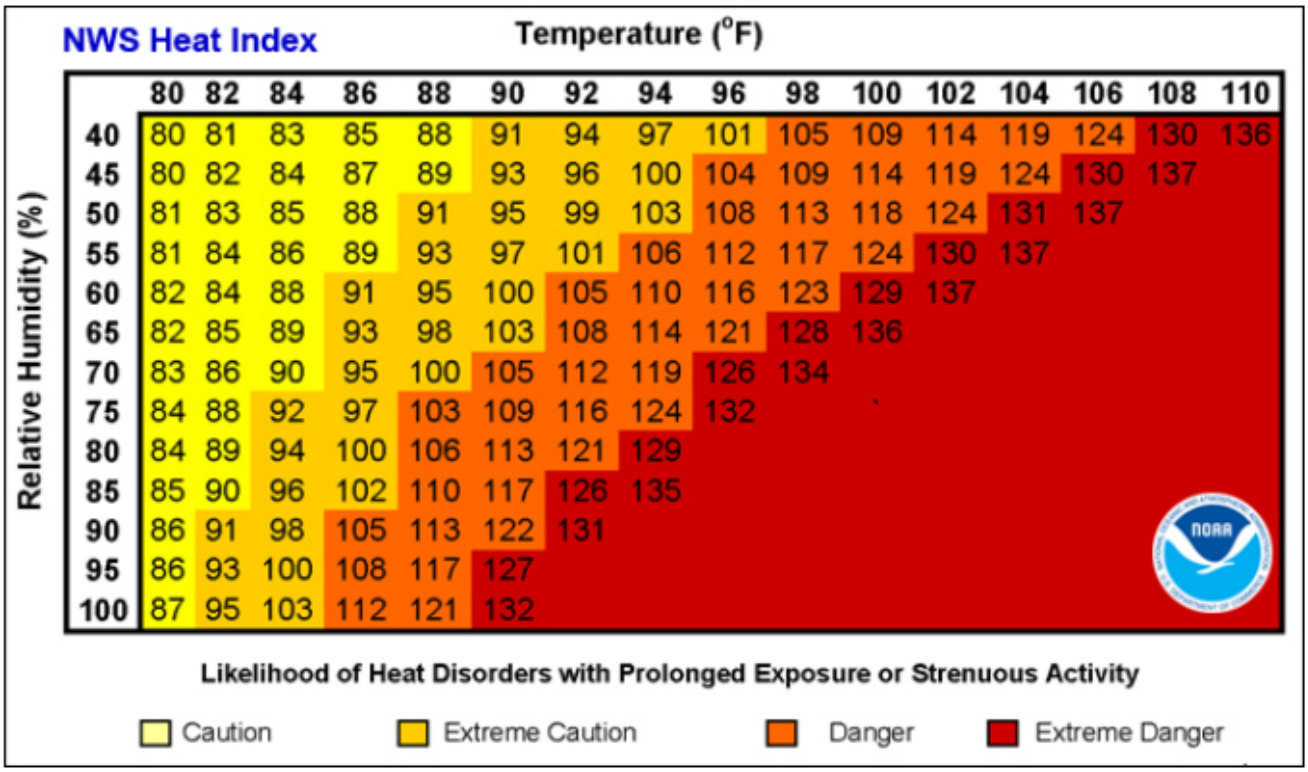
Geographic Location

Extreme heat is an area-wide hazard event; the risk of extreme heat does not vary across the planning area.

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.

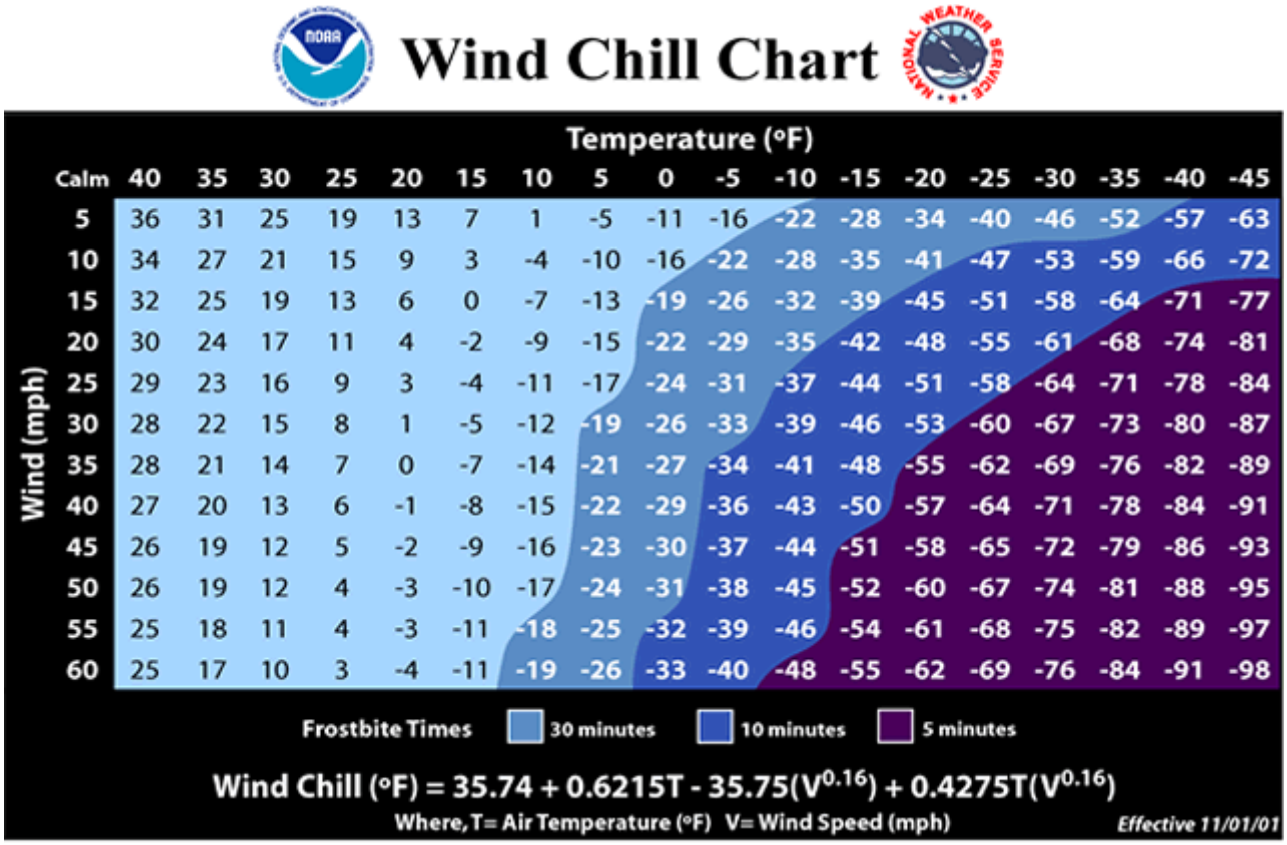
Figure 3.16. Heat Index (HI) Chart



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

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

Figure 3.17. Wind Chill Chart

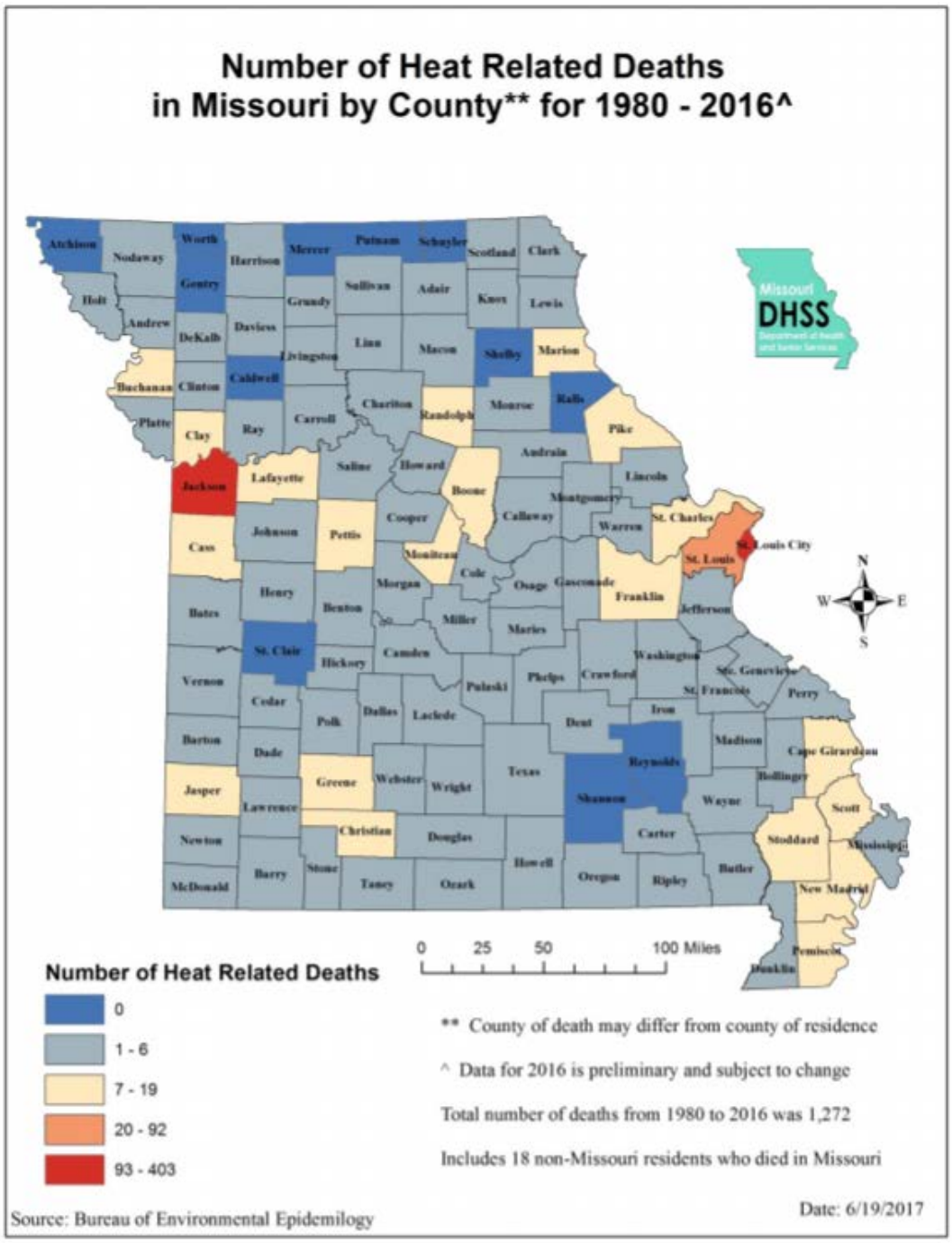


Source: https://www.weather.gov/safety/cold-wind-chill-chart

Previous Occurrences

According to the National Centers for Environmental Information (NCEI) database there were 2 extreme cold recorded events and 21 extreme heat recorded events in Wayne County from November 2003 to October 31, 2023 (7,305 days). Fortunately, no property damage, injuries or death resulted from the events. One extreme cold event occurred in late January, while the other occurred mid January. Of the 21 extreme heat events, 9.5% occurred in June, 71.4% occurred in July, and 19.1% occurred in August. The figure below shows the planning area as having experienced between 1 and 6 deaths due to extreme heat from 2000 – 2016.

Figure 3.18. Heat Related Deaths in Missouri 2000 - 2016



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

Extreme temperatures can cause stress to crops and animals, and also strain electricity delivery infrastructure overloaded during peak use of air conditioning during such 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. From 1996 to present, no deaths were recorded in the planning area, according to NCEI data. According to the National Weather Service among natural hazards, no other natural disaster—not lightning, hurricanes, tornadoes, floods, or earthquakes—causes more deaths.

Probability of Future Occurrence

Probability of future occurrence can be calculated using the data above (e.g. "x" number of reported days with extreme heat/cold throughout "y" number of years equals [(y*365.25 days)/x] probability in any given year). Using this formula, there is a 10% chance of an extreme cold event occurring in any given year. Data also indicate there are 1.05 extreme heat events occurring within the planning area each year. If the results indicate that more than one event would occur annually, state the average number of events annually.

It should be noted that extreme temperature events could be underreported in the NCEI as data was not collected on such events until 1996. Any deaths or injuries resulting from extreme temperature events prior to this date would not be reported within the database.

Changing Future Conditions Considerations

According to the *2018 Missouri State Hazard Mitigation Plan*, with higher greenhouse gas emissions, historically unprecedented warming is projected by the end of the century. Even under a pathway of lower greenhouse gas emissions, average annual temperatures are projected to most likely exceed historical record levels by the middle of the 21st century. For example, in southern Missouri, the annual maximum number of consecutive days with temperatures exceeding 95 degrees F is projected to increase by up to 20 days. Temperature increases will cause future heat waves to be more intense, and cold wave intensity is projected to decrease.

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

Mitigation against the impacts of future temperature increase may include increasing education on heat stress prevention, organizing cooling centers, allocating additional funding to repair and maintain roads damaged by buckling and potholes, and reducing nutrient runoff that contributes to algal blooms. Local governments should also prepare for increased use of public recreational facilities, utility systems, and healthcare centers. Improving energy efficiency in public buildings will also present an increasingly valuable savings potential.

Vulnerability

Vulnerability Overview

County level vulnerability data from the *2023 Missouri State Hazard Mitigation Plan* was used as the best and most recent data available. As described in Table A.23, the state assigned numerical values to each county's total population, percent of population over age 65, social vulnerability, and likelihood of event occurrence. The values were then summed to result in a total score as a measure of the county's vulnerability to extreme heat and extreme cold. Per Table A.24 in the state plan, Wayne County's vulnerability to both extreme heat and cold was determined to be "high." Only four counties of Missouri's 114 counties, were ranked "highly vulnerable" to extreme heat events, while 13 counties were ranked "highly vulnerable" to extreme cold events.

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.

Demographic data was obtained from the 2022 American Community Survey (ACS) 5-Year Survey to determine jurisdictions in the planning area with persons more vulnerable to extreme heat. Population percentages in each jurisdiction comprised of those under age 5 and over age 65 were determined. Data was not available for overweight individuals and those on medications vulnerable to extreme heat. Table 3.25 below summarizes vulnerable populations in the participating jurisdictions. 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 3.25. Wayne County, Missouri - Population Under Age 5 and Over Age 65

Jurisdiction	Population Under 5 yrs (%)	Population 65 yrs and over (%)
Wayne County*	4.5%	24.6%
City of Greenville	3.2%	22.3%
City of Piedmont	5.2%	18.7%
City of Williamsville	3.5%	21.9%
Village of Mill Spring	1.8%	22.9%
Missouri	5.9%	17.3%
United States	5.7%	16.5%

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

The table below lists typical symptoms and health impacts due to exposure to extreme heat.

Table 3.26. Typical Health Impacts of Extreme Heat

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

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

Potential Losses to Existing Development

According to USDA Risk Management Agency, losses to insurable crops due to extreme cold during the 5-year time period from 2019 to 2023 totaled $19,994.00. During the same time period, insured crop losses due to extreme heat totaled $76,280. When annualized, these historical losses show heat-related crop losses amounting to $15,256 per year and cold-related crop losses amounting to $3,999 per year. According to historical data available within the NCEI Storm Event Database, there have been no injuries or deaths associated with extreme heat and cold events in the county.

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. Fortunately, the planning area has lost population since the prior plan update. As a result, vulnerability of the planning area to extreme temperatures-barring climate change—is anticipated to decline.

Hazard Summary by Jurisdiction

Wayne County – The county has the largest proportion of persons aged 65 and over (24.6% of all jurisdictions in the planning area and higher than that of the state and nation. While there are agricultural lands within the balance of the county and a record of crop losses due to extreme temperatures, the number of acres of harvested land declined by nearly 50% from 2012 to 2017.

City of Greenville – the city is at minimal risk to the effects of extreme temperatures as no agricultural lands exist within its jurisdictional boundaries. Approximately 22.3% of residents are over 65 years of age—noticeably higher than those of the state and nation.

City of Piedmont - the city is at minimal risk to the effects of extreme temperatures as no agricultural lands exist within its jurisdictional boundaries. The city does have the highest proportion of children under 5 years of age (5.2%) when compared to other municipalities in the planning area, but the percentage aligns with those of the nation and state.

City of Williamsville - The city is at minimal risk to the effects of extreme temperatures as no agricultural lands exist within its jurisdictional boundaries. The proportion of residents aged 65 and over in the city is 21.9%--higher than both the state and the nation.

Village of Mill Spring – The village is at minimal risk to dangers imposed by extreme temperatures as little agricultural land exists within the village. The proportion of residents aged 65 and over in the city is 22.9%--higher than both the state and the nation.

Clearwater R-I School District – The school district is at minimal risk to dangers imposed by extreme temperatures. All district buildings housing human occupants are heated and air conditioned. As a result, policies requiring school closure during high heat events are not necessary.

Greenville R-II School District - The school district is at minimal risk to dangers imposed by extreme temperatures. All district buildings housing human occupants are heated and air conditioned. As a result, policies requiring school closure during high heat events are not necessary.

Problem Statement

Crops loss data shows the agricultural lands in the balance of Wayne County are susceptible to negative impacts from extreme cold and extreme heat. Furthermore, persons aged 65 and older are found in higher percentages throughout the planning area than in the state and nation.

- Wayne County, the City of Greenville, the City of Williamsville, and the Village of Mill Spring have large percentages of residents aged 65 years and over when compared to the state and nation. Persons in this population category are at greater risk for extreme-temperature related illnesses, injuries, and death. Possible solutions include establishing and promoting accessible heating or cooling centers in the community.
- As with drought, Wayne County may wish to develop partnerships with representatives of the

agricultural sector to explore crop varieties less susceptible to extreme temperatures.

3.4.7 Severe Thunderstorms Including High Winds, Hail, and Lightning

Hazard Profile

Hazard Description

Thunderstorms

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

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.

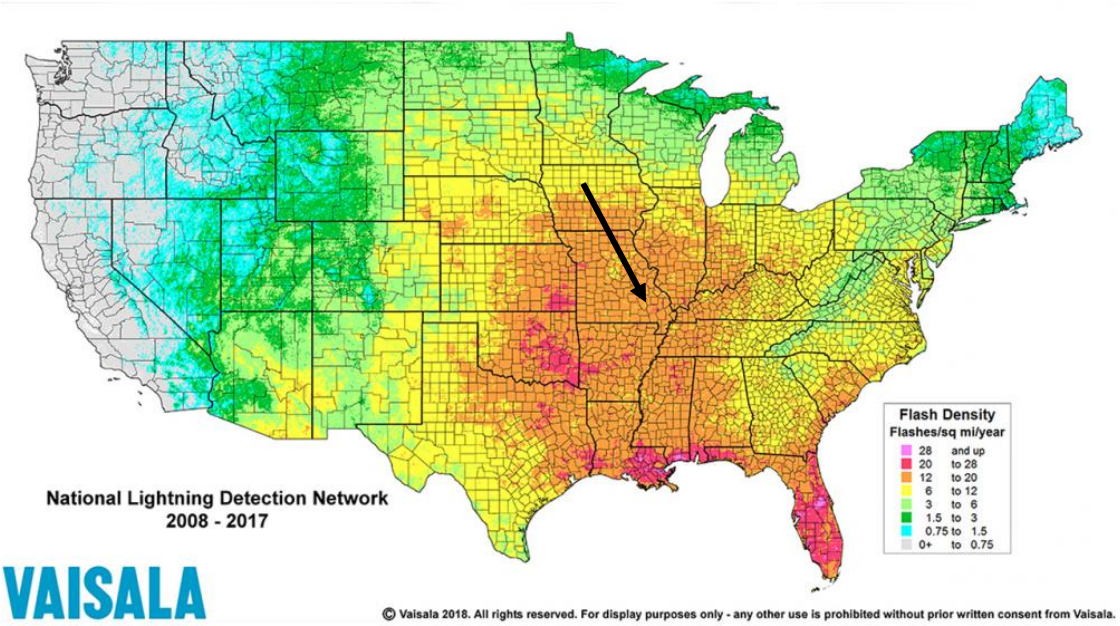
At the time when the updraft can no longer support the hailstone, it will fall down to the earth. For example, a ¼" diameter or pea sized hail requires updrafts of 24 miles per hour, while a 2 ¾" diameter or baseball sized hail requires an updraft of 81 miles per hour. According to the NOAA, the largest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

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

Figure 3.19, below, shows lightning frequency in the state. The planning area is indicated by a black arrow.

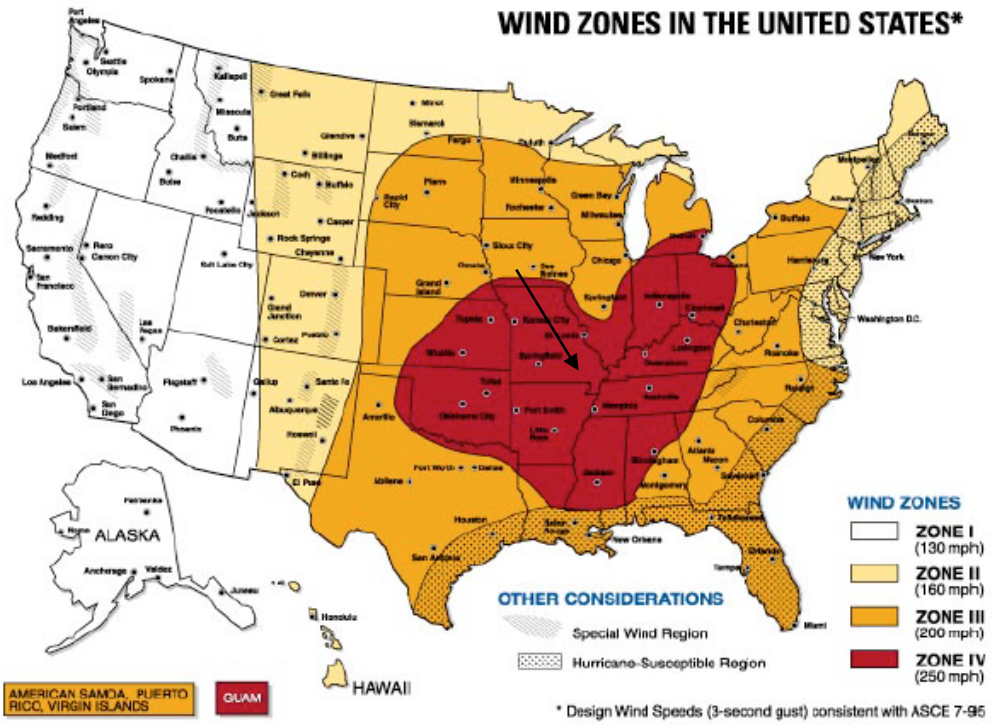
Figure 3.19. Location and Frequency of Lightning in the U.S.



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

Figure 3.20, below, shows wind zones in the United States. A black arrow indicates the location of the planning area.

Figure 3.20. 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), the table 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	>100	4.0+	Melon	Extensive structural damage. Risk of severe or even

Intensity Category	Diameter (mm)	Diameter (inches)	Size Description	Typical Damage Impacts
Hailstorms				fatal injuries to persons caught in the open

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

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

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

Previous Occurrences

The tables below list thunderstorm-related hazard events that have occurred in the planning area in the past ten years. Data from the NCEI regarding this hazard was categorized as hail, lightning, winds (including "high," "strong," and "thunderstorm"), or heavy rain events. There were 24 hail events within 15 different days recorded in the ten-year period. Only those events with hailstones larger than one inch in diameter are listed here.

Table 3.28. Hail Events, Diameter 1" or Greater - Jan 1, 2013 - December 31, 2022, Wayne County, Missouri

DATE	LOCATION	# DEATHS / # INJURIES	CROP DAMAGE / PROPERTY DAMAGE ($)	STONE SIZE (DIAMETER-INCHES)
5/27/2017	PIEDMONT	0 / 0	0 / 0	2.75
3/2/2020	GREENVILLE	0 / 0	0 / 0	1.5
3/2/2020	SHOOK	0 / 0	0 / 0	1
3/2/2020	GREENVILLE	0 / 0	0 / 0	1.5
4/8/2020	CLUBB	0 / 0	0 / 0	1.75
4/9/2021	PATTERSON	0 / 0	0 / 0	1.75
4/30/2022	PIEDMONT MUNI ARPT	0 / 0	0 / 0	1.5
4/30/2022	PIEDMONT	0 / 0	0 / 0	1
4/30/2022	GREENVILLE	0 / 0	0 / 0	1
5/15/2022	GREENVILLE	0 / 0	0 / 0	1
5/8/2023	CASCADE	0 / 0	0 / 0	1
5/15/2023	PIEDMONT	0 / 0	0 / 0	1
5/15/2023	WILLIAMSVILLE	0 / 0	0 / 0	1
7/17/2023	PIEDMONT	0 / 0	0 / 0	1.5
7/17/2023	WILLIAMSVILLE	0 / 0	0 / 0	1
TOTAL		0 / 0	0 / 0	

Source: NOAA, National Centers for Environmental Information, 2023

Per the NCEI, there were no lightning events occurring in the planning area between 2004 and 2023. According to the National Lightning Safety Council, there were 13 lightning induced fatalities in the U.S. None of those events occurred within the planning area or the State of Missouri. In all 13 lightning induced deaths, the victims were either outside or in a vehicle.

The table below lists high wind events with wind speeds of 40 miles per hour or greater in the planning area occurring between 2013 and 2023. There were 64 high wind events during the ten-year period, but only those greater than 40 mph are shown below to allow ease in data analysis. Curiously, all wind events are reported by the NCEI as resulting in a minimum of $1,000 in property damage. (No events caused $0 in property damage.) All wind events magnitude 39 mph or less resulted in $1,000 in property damage. Per the source, no crop damage resulting from high wind events in the county for the timeframe analyzed.

In 2008, two high wind events--one in January and one in September--caused region-wide damage amounting to $47.9 million. One person was injured, though not in the planning area. Wind speeds during the events measured 52 knots and 56 knots. Wayne County experienced $3 million during the September 2008 event with wind speeds measured between 60 and 75 miles per hour. Damage consisted of downed trees, power outages, and flattened corn resulting in a loss of 20-30 bushels per acre. Tree damage was significant enough that schools cancelled classes temporarily as transportation routes were blocked in multiple locations.

Table 3.29. Wind Events, 40 Miles Per Hour & Higher - Jan 1, 2013 - December 31, 2022, Wayne County, Missouri

DATE	LOCATION	# DEATHS / # INJURIES	PROPERTY DAMAGE / CROP DAMAGE ($)	MAGNITUDE SPEED (mph)
2/20/2014	COUNTYWIDE	0 / 0	1,000 / 0	40
5/9/2014	GREENVILLE	0 / 0	10,000 / 0	52
7/23/2014	WAPPAPELLO	0 / 0	2,000 / 0	52
4/9/2015	PIEDMONT	0 / 0	6,000 / 0	52
12/23/2015	GREENVILLE	0 / 0	15,000 / 0	61
2/28/2017	PIEDMONT	0 / 0	15,000 / 0	61
5/27/2017	GREENVILLE	0 / 0	60,000 / 0	61
11/18/2017	COUNTYWIDE	0 / 0	1,000 / 0	40
5/31/2018	WAPPAPELLO	0 / 0	10,000 / 0	52
6/28/2018	WAPPAPELLO	0 / 0	3,000 / 0	56
12/1/2018	PIEDMONT	0 / 0	4,000 / 0	52
5/21/2019	TASKEE STATION	0 / 0	4,000 / 0	56
10/21/2019	WILLIAMSVILLE	0 / 0	3,000 / 0	56
1/11/2020	SHOOK	0 / 0	3,500 / 0	78
4/28/2020	GREENVILLE	0 / 0	5,000 / 0	52
5/3/2020	TASKEE STATION	0 / 0	2,500 / 0	61
5/3/2020	MC GEE	0 / 0	10,000 / 0	56
7/20/2020	PIEDMONT MUNI ARPT	0 / 0	20,000 / 0	56

8/12/2021	PIEDMONT	0 / 0	1,000 / 0	52
6/26/2022	PIEDMONT	0 / 0	10,000 / 0	56
6/26/2022	WAPPAPELLO	0 / 0	1,000 / 0	52
7/27/2022	PIEDMONT	0 / 0	4,000 / 0	52
5/8/2023	GREENVILLE	0 / 0	50,000 / 0	61
TOTAL		0 / 0	$241,000 / 0	

Source: NOAA, National Centers for Environmental Information, 2023

Table 3.30. Heavy Rain Events - Jan 1, 2013 - December 31, 2022, Wayne County, Missouri

DATE	LOCATION	# DEATHS / # INJURIES	PROPERTY DAMAGE / CROP DAMAGE ($)	MAGNITUDE SPEED (mph)
8/5/2015	WAPPAPELLO	0 / 0	0 / 0	2.56’ in 8 hours
8/5/2015	SILVA	0 / 0	0 / 0	2.1” in 8 hours
9/8/2015	GREENVILLE	0 / 0	0 / 0	2.82” in 18 hours
11/18/2015	WILLIAMSVILLE	0 / 0	0 / 0	5.42” in 48 hours

Source: NOAA, National Centers for Environmental Information, 2023

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 summarize past crop damage as indicated by crop insurance claims. Per the data available, during the five-year period between 2019 and 2023, no claims were made for crop damage resulting from high wind, hail, or lightning. Excessive moisture/participation/rain, however, caused loss of crops in four of the five years, with an average loss of $78,777.80 per year in corn, soybeans, and a small amount of grain sorghum. The table below illustrates the limited magnitude of the hazard’s impact on the planning area’s agricultural economy.

Table 3.31. Crop Insurance Claims Paid in Wayne County from Excess Moisture/Precipitation/Rain, 2019-2023

Crop Year	Crop Name	Cause of Loss Description	Insurance Paid ($)
2019	Corn	Excess Moisture/Rain	103,217
2019	Soybeans	Excess Moisture/Rain	171,566
2020	Corn	Excess Moisture/Rain	7,725
2020	Soybeans	Excess Moisture/Rain	12,637
2020	All Other Crops	Excess Moisture/Rain	13,329
2021	Corn	Excess Moisture/Rain	8,120
2021	Soybeans	Excess Moisture/Rain	6,877
2022	Corn	Excess Moisture/Rain	52,676
2022	Grain Sorghum	Excess Moisture/Rain	5,094
2022	Soybeans	Excess Moisture/Rain	12,648
2023	None		0

Total			393,889

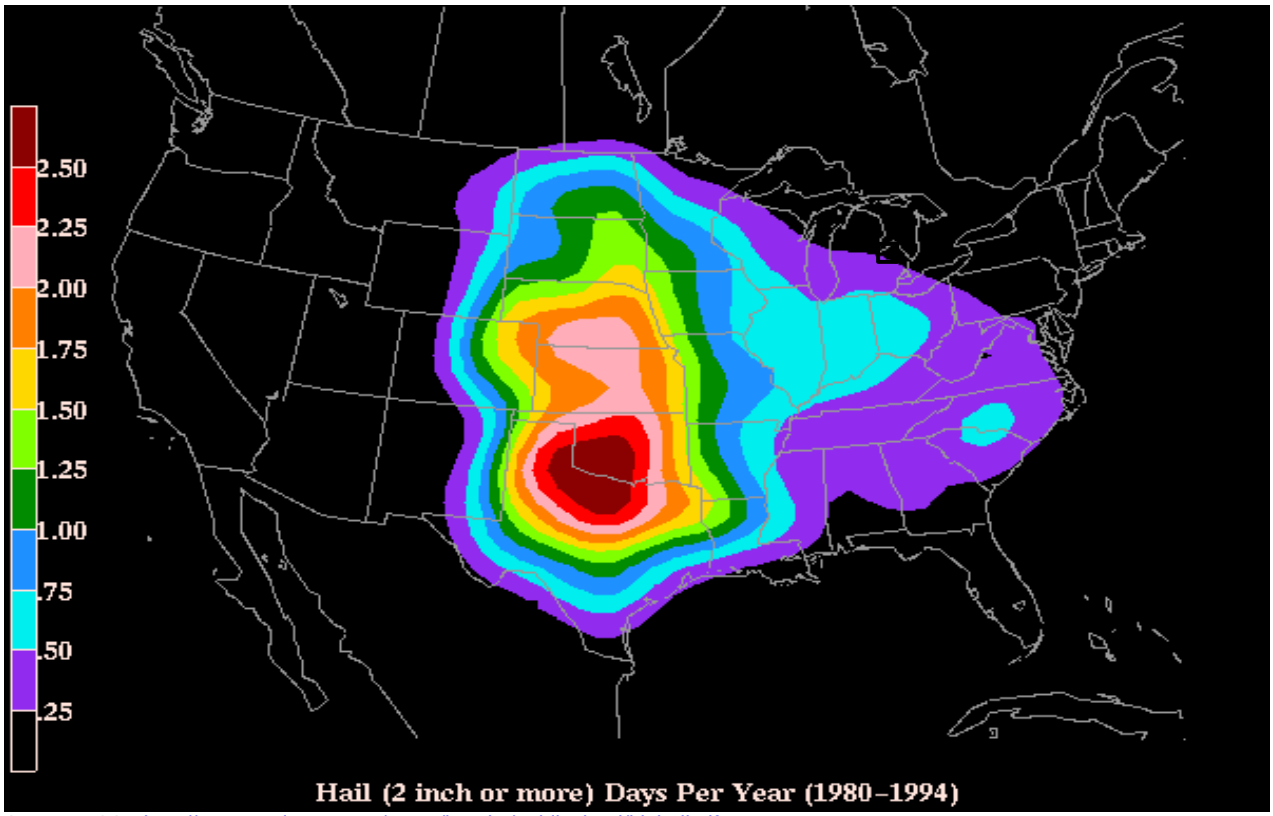
Source: USDA Risk Management Agency, Insurance Claims, https://www.rma.usda.gov/data/cause

Probability of Future Occurrence

Given the historical data presented above, the probability of a thunderstorm occurring in any twelve-month period within Wayne County is 100%. Lightning, which accompanies thunderstorms, is also 100% likely to occur within the county in any given year. The planning area should anticipate experiencing high wind events in any given year. The likelihood of a hail event producing hailstones 1" or larger is 2.4 events per year. The probability of a heavy rain event occurring in the county is 40% in any given year. Within the *2023 Missouri State Hazard Mitigation Plan*, planners calculated the likelihood of high wind, hail, and lightning events as occurring 2.65, 3.27, and .08 times per year, respectively.

The map below is based on hailstorm data from 1980-1994. It shows the probability of hailstorm occurrence (2" diameter or larger) based on number of days per year. The planning area is located by the red arrow. Describe the location of County A in terms of which zone it is in or use a graphic in the map showing the county location.

Figure 3.21. Annual Hailstorm Probability (2" diameter or larger), 1980- 1994



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

Changing Future Conditions Considerations

According to the *2023 Missouri State Hazard Mitigation Plan*, NASA's Earth Observatory provides an analysis on how climate change could, theoretically, increase potential storm energy by warming the surface and putting more moisture in the air through evaporation. The presence of warm, moist air near the surface is a key ingredient for summer storms that meteorologists have termed "convective available potential energy," or CAPE. With an increase in CAPE, there is greater potential for cumulus clouds to form. The study also counters this theory with the theory that warming in the Arctic could lead to less wind shear in the mid-latitude areas prone to summer storms, making the storms less likely.

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 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/

County level data from the *2023 Missouri State Hazard Mitigation Plan*, was used as the best and most recent data available. Per the plan, Wayne County's vulnerability to thunderstorms was categorized as "medium" among a scale including "low, medium-low, medium, medium-high, and high." Factors considered in the analysis were housing density (10.69 structures per square mile), building exposure ($1,271,311,000), % of mobile homes (23.8%), and social vulnerability (Medium-High). This data is listed in Table A.24 of the *2023 Missouri State Hazard Mitigation Plan*.

Potential Losses to Existing Development

Average annual loss—determined from historical loss data—was used to determine as an indicator of

potential future losses. Per the *2023 Missouri State Hazard Mitigation Plan*, the average annualized property loss due to high wind events within the planning area is $166,615 resulting in an annualized property loss ratio of .0001311. For hail events, the average annualized property loss was estimated at $6,538, with an annualized property loss ratio of .00000514. And, regarding lightning events, the average annualized property loss was estimated at $0.

Previous and Future Development

Development results in the exposure of more households and businesses vulnerable to damages from severe thunderstorms/ high winds/lightning/hail. Fortunately, little, if any, future development is anticipated within the planning area.

Hazard Summary by Jurisdiction

Although thunderstorms/high winds/lightning/hail events are area-wide, demographics factors may impact loss levels from one jurisdiction to another. Such factors include the percentage of housing built before 1939 and the percentage of housing stock comprised of mobile homes. Fortunately, no participating jurisdictions reported previous losses resulting from thunderstorms/high winds/lightning/hail events.

Wayne County – While the county's farm operators do occasionally experience crop losses due to heavy rain events, the damage, historically, has had minimal financial impact.

City of Greenville - The city has no specific exposure to damage from thunderstorm events when compared to the other participating jurisdictions. Lightning, high wind, heavy rain, and hail can occur anywhere at any time and are not specific to any one location. Given there is no crop production in the city, crop losses are not anticipated. Heavy rain events have resulted in flash flooding in the city.

City of Piedmont - The city has no specific exposure to damage from thunderstorm events when compared to the other participating jurisdictions. Lightning, high wind, heavy rain, and hail can occur anywhere at any time and are not specific to any one location. Given there is no crop production in the city, crop losses are not anticipated.

City of Williamsville - The city has no specific exposure to damage from thunderstorm events when compared to the other participating jurisdictions. Lightning, high wind, heavy rain, and hail can occur anywhere at any time and are not specific to any one location. Given there is no crop production in the city, crop losses are not anticipated.

Village of Mill Spring - The village has no specific exposure to damage from thunderstorm events when compared to the other participating jurisdictions. Lightning, high wind, heavy rain, and hail can occur anywhere at any time and are not specific to any one location. Given there is no crop production in the village, crop losses are not anticipated. Heavy rain events have resulted in flash flooding in the village.

Clearwater R-I School District - The school district's headquarters are located within the City of Piedmont, which has no heightened vulnerability to thunderstorms than any other participating jurisdiction.

Greenville R-II School District - The school district's headquarters are located within the City of Greenville. The city has experienced flash flooding due to heavy rain event in the past, though such events have not directly affected the school district.

Problem Statement

It should be noted that of the lightning deaths occurring within the U.S. during 2023, 100% occurred outside of the safety of a building. Twelve of the thirteen deaths were outside, and one was in a traveling vehicle. Residents should be strongly encouraged to remain indoors during thunderstorms to prevent injury or death from lightning strikes.

- The participating jurisdictions may wish to unite in an effort to educate the public regarding the dangers of lightning strikes when outdoors during thunderstorm events.
- Though crop damages due to high wind/heavy rain/hail events in the planning area are minimal overall, when they do occur, it is in the balance of the county. Wayne County may wish to encourage growers to purchase crop insurance to lessen the financial burden due to loss of crops resulting from high wind and /or heavy rain.

3.4.8 Severe Winter Weather

Hazard Profile

Hazard Description

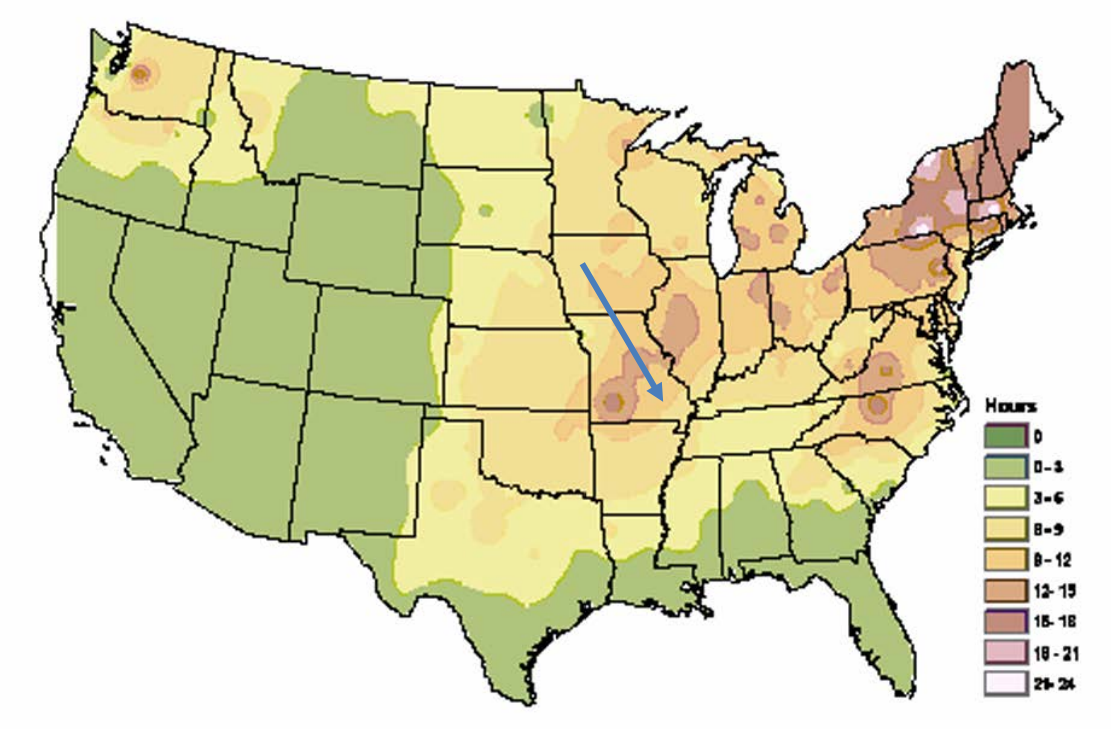
A major winter storm can last for several days and be accompanied by high winds, freezing rain or sleet, heavy snowfall, and cold temperatures. The National Weather Service describes different types of winter storm events as follows.

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

Geographic Location

As with thunderstorm events, the entire planning area is vulnerable to heavy snow, ice, extreme cold temperatures and freezing rain. The map below shows the number of hours of freezing rain per year across the U.S. The planning area is indicated by the blue arrow. Per the graphic, Wayne County appears to be located along the boundary of two zones: 8-9 hours and 9-12 hours of freezing rain per year. Local reports indicate the lower of the two estimates is more likely.

Figure 3.22. NWS Statewide Average Number of Hours per Year with Freezing Rain



Source: American Meteorological Society. “Freezing Rain Events in the United States” 71872 (2).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

The table below lists NCEI reported winter weather events and damages in the county for the past ten years. Blizzard, cold/wind chill, extreme cold/wind chill, heavy snow, ice storm, sleet, winter storm, and winter weather are included. The events have been listed chronologically to show when one event manifested itself in more than one type of weather. Of the events, seven (14.6%) were winter storms, six (12.5%) were wind chill/extreme cold events, three (6.3%) were heavy snow events, and the remainder (33 or 68.8%) were classified as winter weather events.

Table 3.32. NCEI Wayne County Winter Weather Events Summary, 2014-2023

Begin Date	End Date	Type of Event	Magnitude	# of Injuries	Property Damage ($)	Crop Damage ($)
11/16/2014	11/16/2014	Winter		0	0	0
12/1/2014	12/1/2014	Winter		0	0	0
1/11/2015	1/11/2015	Winter		0	0	0
1/15/2015	1/15/2015	Winter		0	0	0
2/15/2015	2/16/2015	Heavy Snow	Up to one foot of snow accumulation	0	0	0
2/17/2015	2/18/2015	Winter Weather		0	0	0
2/19/2015	2/19/2015	Cold/Wind Chill	Wind Chill=10-20 degrees below zero	0	0	0
2/20/2015	2/21/2015	Winter Storm	Up to one inch of sleet followed by .25" of freezing rain	0	0	0
2/28/2015	2/28/2015	Winter Weather		0	0	0
3/1/2015	3/1/2015	Winter Weather		0	0	0
3/4/2015	3/4/2015	Winter Storm	4 to 10 inches of snow	0	0	0
1/19/2016	1/20/2016	Winter Weather		0	0	0
2/14/2016	2/14/2016	Winter Weather		0	0	0
2/24/2016	2/24/2016	Winter Weather		0	0	0
1/5/2017	1/5/2017	Winter Weather		0	0	0
1/13/2017	1/13/2017	Winter Weather		0	0	0
1/1/2018	1/1/2018	Cold/Wind Chill	10 to 17 degrees below zero	0	0	0
1/11/2018	1/12/2018	Winter Weather		0	0	0
1/15/2018	1/15/2018	Winter Weather		0	0	0
1/16/2018	1/16/2018	Cold/Wind Chill	10 to 15 degrees below zero	0	0	0
2/6/2018	2/6/2018	Winter Weather		0	0	0
2/11/2018	2/11/2018	Winter Weather		0	0	0
4/7/2018	4/7/2018	Winter Weather		0	0	0
11/14/2018	11/15/2018	Winter Weather		0	0	0
1/11/2019	1/12/2019	Winter Weather		0	0	0
1/19/2019	1/19/2019	Heavy Snow	4 to 9 inches of snow, wind gust 40 to 50 miles per hour	0	0	0
2/15/2019	2/15/2019	Winter		0	0	0

		Weather				
3/3/2019	3/3/2019	Winter Weather		0	0	0
11/11/2019	11/11/2019	Winter Weather		0	0	0
1/1/2021	1/1/2021	Winter Weather		0	0	0
1/7/2021	1/7/2021	Winter Weather		0	0	0
1/27/2021	1/27/2021	Winter Weather		0	0	0
2/10/2021	2/10/2021	Winter Weather		0	0	0
2/14/2021	2/14/2021	Cold/Wind Chill	10 to 15 degrees below zero wind chill	0	0	0
2/14/2021	2/15/2021	Winter Storm	1-3 inches of snowfall per hour, visibility less than one-quarter of one mile	0	0	0
2/16/2021	2/16/2021	Cold/Wind Chill	10 to 15 degrees below zero wind chill	0	0	0
2/17/2021	2/18/2021	Winter Weather		0	0	0
1/6/2022	1/6/2022	Winter Weather		0	0	0
1/15/2022	1/15/2022	Winter Weather		0	0	0
2/2/2022	2/3/2022	Winter Storm	6 to 7 inches of snow	0	0	0
2/23/2022	2/24/2022	Winter Storm	.33 inches of ice under .75 inches of sleet	0	10,000	0
3/11/2022	3/11/2022	Winter Weather		0	0	0
11/12/2022	11/12/2022	Winter Weather		0	0	0
12/22/2022	12/22/2022	Winter Storm	2 wind chill, 3 inches of snowfall	0	0	0
12/22/2022	12/24/2022	Extreme Cold/Wind Chill	20 to 30 degrees below zero	0	0	0
1/24/2023	1/25/2023	Heavy Snow	6 to 9 inches of snow, tree damage, power outages, road closed	0	100,000	0
1/29/2023	1/30/2023	Winter Weather		0	0	0
1/30/2023	1/31/2023	Winter Storm	Sleet fell resulting in ice-covered roads	0	0	0
Total				**0**	**110,000**	**0**

Source: NCEI, data accessed October 2023

Event narratives for all winter storm events and some winter weather events describe tree damage, inhibited travel due to dangerous conditions, power outages, etc. Fortunately, no Presidential Disaster Declarations for Winter Storms were declared during the ten-year period reviewed; however,

three such events did occur during 2007, 2008, & 2009 (one event per year). All three of those events resulted in Presidential Disaster Declarations.

Winter storms, cold, frost and freeze can severely damage or delay crop production in the planning area. Per the table below, cold weather has had minimal impact on crops in Wayne County. Per data from the USDA's Risk Management Agency, payments for insured crop losses in the planning area as a result of cold conditions for the past five years equaled only $19,994.40.

Table 3.33. Crop Insurance Claims Paid in Wayne County as a Result of Cold Conditions and Snow, 2019-2023

Crop Year	Crop Name	Cause of Loss Description	Insurance Paid ($)
2019	All Other Crops	Cold/Wet Weather	9,997.20
2019	All Other Crops	Cold/Wet Weather	9,997.20
Total			**19,994.40**

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

Probability of Future Occurrence

Because one winter storm generally includes a variety of winter weather events, probability is most easily and effectively calculated considering winter weather as one event type. Using the historical occurrence data presented above (43 winter weather events in 10 years), probability is calculated as 4.3 winter weather events of any magnitude occurring in the planning area in any given year. Likelihood of occurrence of severe winter weather within the planning area as shown by the Missouri Hazard Mitigation Viewer was 3.67 events annually.

Changing Future Conditions Considerations

According to the *2023 Missouri State Hazard Mitigation Plan*, a shorter overall winter season and fewer days of extreme cold may have both positive and negative indirect impacts. Warmer winter temperatures may result in changing distributions of native plant and animal species and/or an increase in pests and non-native species. Warmer winter temperatures will result in a reduction of lake ice cover. Reduced lake ice cover impacts aquatic ecosystems by raising water temperatures. Water temperature is linked to dissolved oxygen levels and many other environmental parameters that affect fish, plant, and animal populations. 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 Overview

When assessing the vulnerability of the planning area to severe winter weather events, county level data from the *2023 Missouri State Hazard Mitigation Plan* was used as the best and most recent data available. Per the document, "The method used to determine vulnerability to severe winter weather across Missouri was statistical analysis of data from several sources: National Centers for Environmental Information (NCEI) storm events data (1996 to December 31, 2021), HAZUS Building Exposure Value data, housing density data from the U.S. Census (2019), and the calculated Social Vulnerability Index for Missouri Counties from the Hazards and Vulnerability Research Institute in the Department of Geography at the University of South Carolina."

"From the statistical data collected, five factors were considered in determining overall vulnerability to

severe winter weather as follows: housing density, building exposure, social vulnerability, likelihood of occurrence, and average annual property loss. Based on natural breaks in the statistical data, a rating value of 1 through 5 was assigned to each factor. Once the individual ratings were determined for the above factors, a combined vulnerability rating was computed for severe winter weather. These rating values correspond to the following descriptive terms: 1) Low 2) Medium-Low 3) Medium 4) Medium-High 5) High." Based upon the analysis, the state assigned a vulnerability rating of "Medium" to Wayne County.

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

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

Overhead power lines and infrastructure are also vulnerable to damage from winter storms. Ice accumulation during winter storm events damage to power lines due to the ice weight on the lines and equipment. Damage also occurs to lines and equipment from falling trees and tree limbs weighted down by ice. Potential losses could include the cost of repair/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 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 utility service are reported in FEMA's 2009 BCA Reference Guide. Using this information, the economic impact resulting from power loss is estimated at $126 per person per day of lost service.

Potential Losses to Existing Development

Average annual loss—determined from historical loss data—was used to determine as an indicator of potential future losses. Within the ten-year period between 2014 and 2023, the NCEI reports $110,000 in property damage and no crop damage among 43 incidents. Per data provided by the USDA, crop losses due to cold wet weather amounted to $19,994.40

Per the *Missouri Hazard Mitigation Viewer*, the average annualized property loss in Wayne County due to severe winter weather is $102,380.95, resulting in an annualized property loss ratio of .000081.

Previous and Future Development

Development results in the exposure of more households and businesses vulnerable to damage from severe winter weather. Fortunately, little, if any, future development is anticipated within the planning area.

Hazard Summary by Jurisdiction

Severe winter weather events typically occur over a large area irrespective of jurisdictional boundaries. Vulnerability to such events can vary among jurisdictions, however, due to housing

stock age or higher concentration of mobile homes. Communities with higher concentrations of mobile homes are more vulnerable to structural damage, while housing stock located within communities that have adopted building codes may be less vulnerable to damage. Per the American Community Survey (ACS), 2022 5-Year Estimates, the percentage of occupied housing stock in the planning area that were mobile homes ranged from 2.0% to 39.3% among Wayne County and its participating jurisdictions.

Wayne County – The percentage of all occupied housing units that are mobile homes in the county is estimated at 16.5% per the ACS. Relative to other jurisdictions within the planning area, this is a high percentage. Furthermore, the county has and enforces no building codes within its boundaries, rendering buildings constructed within its jurisdiction susceptible to damage from severe winter weather including accumulated ice. While the county's farm operators do occasionally experience crop losses due to winter weather events, the damage, historically, has had minimal financial impact.

City of Greenville - The percentage of mobile homes in the city is low (7.9%) compared with the remainder of the planning area. Furthermore, the city does have building codes, which, when followed, will help to protect structures from damage due to severe winter weather. Should a power loss occur, the city has multiple public buildings within its jurisdiction which could serve as a warming shelter.

City of Piedmont - The percentage of mobile homes in the city is low (2.0%) compared to the remainder of the planning area. Furthermore, the city has adopted building codes, which, when followed, will help to protect structures from damage due to severe winter weather. Should a power loss occur, the city has multiple public buildings within its jurisdiction which could serve as a warming shelter.

City of Williamsville - The city has not adopted building codes and holds a high percentage of occupied mobile homes (19.6%) rendering city residents more vulnerable to both personal and property damage. Should a power loss occur, the city has one or two public buildings within its jurisdiction which could serve as a warming facility.

Village of Mill Spring - The village is likely most vulnerable to personal injury and property damage due to severe winter storms when compared to its neighboring jurisdictions. The village has the highest percentage of occupied housing stock that is mobile homes at and estimated 39.3%. It is not known if the village has adopted building codes. The village also has no community building which can be used as a warming center should a power failure occur.

Clearwater R-I School District - No damage to district assets due to severe winter weather was reported by the district. Vulnerability to severe winter weather varies throughout the district's expansive service area.

Greenville R-II School District - No damage to district assets due to severe winter weather was reported by the district. Vulnerability to severe winter weather varies throughout the district's expansive service area.

Problem Statement

The Village of Mill Spring and the unincorporated portions of the county are perhaps most vulnerable to human injury and death due to severe winter weather. The City of Williamsville, the unincorporated portion of the county, the Village of Mill Spring, and the City Williamsville are likely most vulnerable to damage due to ice accumulation as no building codes exist within these jurisdictions.

- The Village of Mill Spring and the City of Williamsville may wish to adopt building codes.

- All participating jurisdictions may wish to cooperatively employe an inspector to enforce building codes, perhaps in conjunction with the region's planning commission.
- Those communities that have tornado saferooms (Greenville, Piedmont, and Williamsville) or other facilities (such as nutrition centers) may wish to develop plans to open those facilities to the public as warming stations during severe winter weather events.
- Wayne County and the Village of Mill Spring may wish to develop a plan to partner with the Cities of Greenville, Piedmont, and Williamsville to utilize their public facilities as warming centers during power outages due to severe winter weather.

3.4.9 Tornado

Hazard Profile

Hazard Description

Per the 2018 Missouri State Hazard Mitigation Plan, "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 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

It is important to note that tornadoes can occur anywhere within the planning area. As is shown in Figure 3.23, tornadoes typically follow a southwest to northwest pattern of travel.

Strength/Magnitude/Extent

Tornadoes are the most violent of all atmospheric storms—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, which often become airborne shrapnel causing additional damage. If wind speeds are high enough, these "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 Number	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 to take shelter. Tornadoes may not be visible on the ground if they occur after sundown or due to blowing dust or driving rain and hail.

Previous Occurrences

Table 3.37 below lists NCEI reported tornado events and damages since 2004 in the planning area. There were twelve tornadoes occurring during the 20-year period ranging from multiple EF1's to one EF3. Per the map presented in Figure 3.23, below, only sixteen tornadoes are reported as having occurred in the county since 1862. This is because only very destructive tornadoes were recorded prior to 1993.

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 Wayne County, 2004 – Present

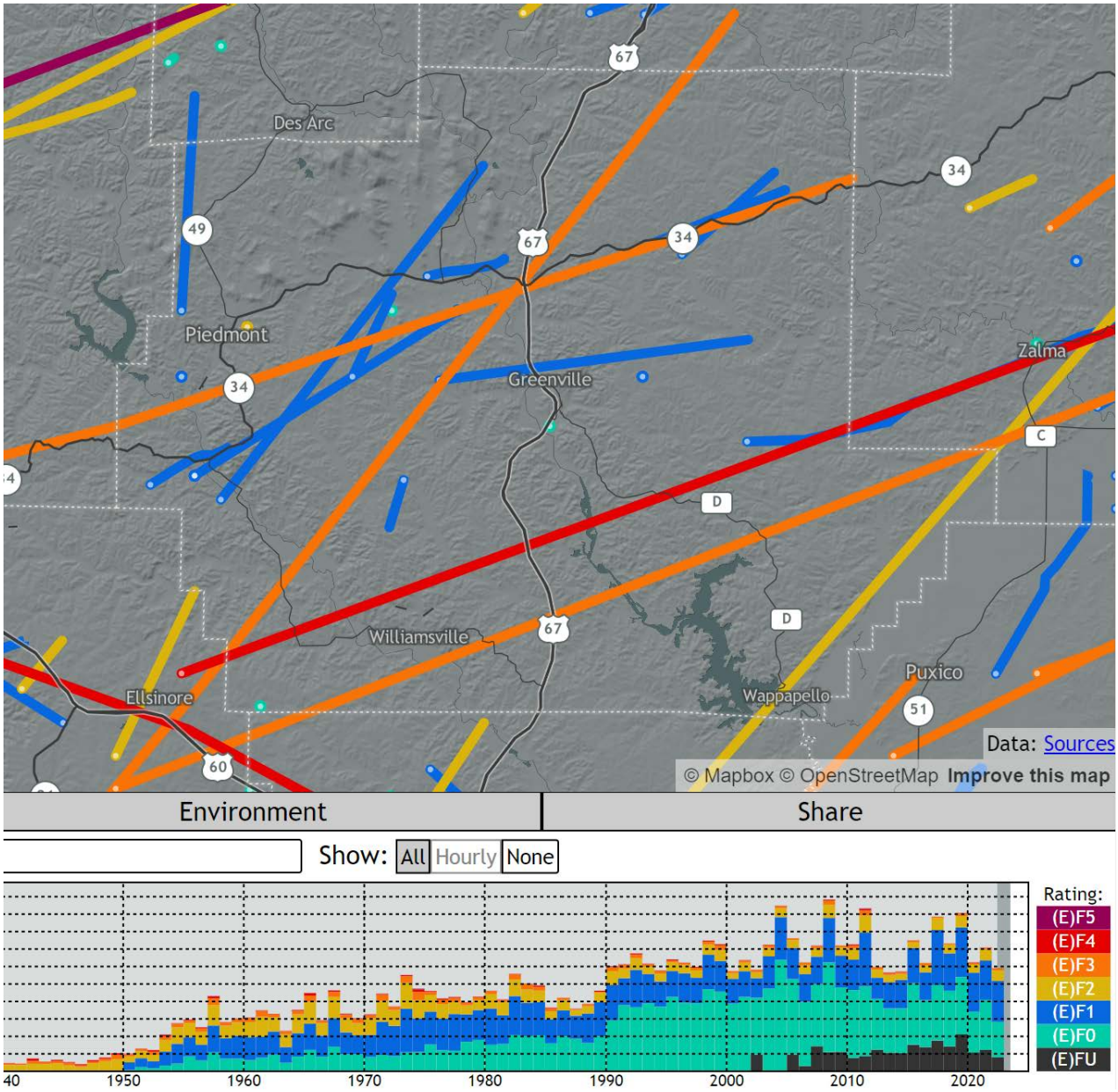
Date	Beginning Location	Ending Location	Length (miles)	Width (yards)	F/EF Rating	Death	Injury	Property Damage ($)	Crop Damage
4/24/2004	PATTERSON	PATTERSON	4	100	F1	0	0	100,000	0
5/1/2004	LEEPER	LEEPER	0.2	50	F1	0	0	5,000	0

4/19/2011	CLUBB	CASCADE	5.16	500	EF1	0	0	25,000	0
4/22/2011	OLD GREENVILLE	WILLIAMSVILLE	2.07	300	EF1	0	0	100,000	0
4/25/2011	SILVA	LOWNDES	11.78	200	EF1	0	0	25,000	0
4/25/2011	CLUBB	GRAVELTON	5.88	500	EF1	0	0	70,000	0
5/25/2011	LEEPER	BURCH	32.99	1200	EF3	0	2	500,000	0
5/25/2011	MILL SPRING	LODI	17.77	150	EF1	0	0	70,000	0
12/23/2015	MILL SPRING	MILL SPRING	2.95	50	EF1	0	0	5,000	0
12/23/2015	PATTERSON	PATTERSON	3.04	75	EF1	0	0	50,000	0
10/24/2021	SHOOK	MCGEE	4.73	400	EF1	0	0	20,000	0
4/5/2023	MILL SPRING	WILLIAMSVILLE	6.14	300	EF1	0	0	200,000	0
	Total					0	0	1,170,000	0

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

A map from tornadoarchive.com showing recorded historic tornado paths in the planning area since 1862 is provided below. The paths of sixteen tornadoes are shown. According to this data, the strongest tornado recorded in Wayne County occurred on May 30, 1917. Travelling fifty miles at a width of 400 yards, the F4 tornado caused eighteen fatalities and 200 injuries.

Figure 3.23. Wayne County Map of Historic Tornado Events



Source: Tornado Archive Data Explorer - Tornado Archive

Per insurance payout data provided by the USDA Risk Management Agency indicates that no drop damages resulting from tornado have occurred in the county within the past five years.

Probability of Future Occurrence

Given historical tornado occurrence data as reported by the NCEI, there have been 12 events in Wayne County within the past 20 years. Include probability calculations for tornado events of all magnitudes in one percentage. The probability of a tornado occurring anywhere in Wayne County can be calculated using the following formula: 12 number of reported tornados of any magnitude in 20 years equals 60% probability of a tornado of any magnitude event in the planning area in any

given year (12 events/20 years x 100%).

Changing Future Conditions Considerations

According to the *2023 Missouri State Hazard Mitigation Plan*, NASA's Earth Observatory provides an analysis on how climate change could, theoretically, increase potential storm energy by warming the surface and putting more moisture in the air through evaporation. The presence of warm, moist air near the surface is a key ingredient for summer storms that meteorologists have termed "convective available potential energy," or CAPE. With an increase in CAPE, there is greater potential for cumulus clouds to form. The study also counters this theory with the theory that warming in the Arctic could lead to less wind shear in the mid-latitude areas prone to summer storms, making the storms less likely.

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

Vulnerability

Vulnerability Overview

Wayne County is located in a region of the U.S. with high frequency of dangerous and destructive tornadoes referred to as "Tornado Alley". The figure below illustrates areas where dangerous tornadoes historically have occurred. As can be seen, all of Missouri is highlighted within the yellow "Tornado Alley" zone.

County level data from the *2023 Missouri State Hazard Mitigation Plan* used within this vulnerability analysis is the best and most recent data available. Per the state plan, "The method used to determine vulnerability to tornadoes across Missouri was statistical analysis of data from several sources: HAZUS building exposure value data, population density and mobile home data from the U.S. Census (2019), the calculated Social Vulnerability Index for Missouri Counties from the Hazards and Vulnerability Research Institute in the Department of Geography at the University of South Carolina, and storm events data (1950 to December 31, 2021) from the National Centers for Environmental Information (NCEI)."

"It is important to realize that one limitation to the NCEI data is that many tornadoes that might have occurred in uninhabited areas, as well as some in inhabited areas, may not have been reported. The incompleteness of the data suggests it is not appropriate for use in parametric modeling. In addition, NOAA data cannot show a realistic frequency distribution of different Fujita scale tornado events, except for recent years. Thus, a parametric model based on a combination of many physical aspects of the tornado to predict future expected losses was not used."

"The statistical model used for this analysis was probabilistic based purely on tornado frequency and historic losses. It is based on experience and forecasts the expected results for the immediate or extended future. From the statistical data collected, six factors were considered in determining overall vulnerability to tornadoes as follows: building exposure, population density, social vulnerability, percentage of mobile homes, likelihood of occurrence, and annual property loss. Based on natural breaks in the statistical data, a rating value of 1 through 5 was assigned to each factor. Once the ranges were determined and applied to all factors considered in the analysis, the ratings were combed to determine an overall vulnerability rating for tornadoes. These rating values correspond to

the following descriptive terms: Low (7-10), Medium-Low (11-12), Medium (13-14), Medium-High (15-16), and High (17-21)."

Per the state plan, Wayne County, with a vulnerability rating of 14, was classified as having "medium" vulnerability to tornadoes. The factor contributing to the rating included likelihood (.292 events per year), population density (16.96 persons per square mile), SOVI rating (medium-high), percentage of mobile homes (23.8%), total building exposure ($1,271,311,000), and total annualized property loss ($49,792).

Figure 3.24. Tornado Alley in the U.S.

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

Potential Losses to Existing Development

Using the above-described analyses, the state estimated Wayne County's annualized property loss due to tornado at $49,792, with a total building exposure of $1,271,311,000.

Within the past 20 years, Wayne County has seen 12 tornadoes, 11 of which were rated F-1 or EF-1. Per the EF-Scale, moderate damage is anticipated with such an event. This equates to roofs being severely stripped; mobile homes overturned or badly damaged; loss of exterior doors; windows and other glass broken.

Previous and Future Development

Development and resulting increases in population result in heightened exposure to damage from tornadoes. Fortunately, little, if any, future development is anticipated within the planning area.

Hazard Summary by Jurisdiction

A tornado can occur anywhere in the planning area, but some jurisdictions may suffer heavier damages because of housing stock age or a high concentration of mobile homes. Communities with higher concentrations of mobile homes are more exposed while communities that have adopted building codes may also be less vulnerable to damage. Per the American Community Survey (ACS), 2022 5-Year Estimates, the percentage of occupied housing stock in the planning area that were mobile homes ranged from 2.0% to 39.3% among jurisdictions.

Wayne County – The percentage of all occupied housing units that are mobile homes in the county is estimated at 16.5% per the ACS. Relative to other jurisdictions within the planning area, this is a high percentage. Furthermore, the county has and enforces no building codes within its boundaries, leaving its structures more susceptible to damage from tornadoes. While the county's farm operators can experience crop losses due to high winds associated with tornadoes, such damage has not been reported within the past five years.

City of Greenville - The city has within its boundaries a public tornado saferoom built to FEMA 361 Standards. The percentage of mobile homes in the city is low (7.9%) compared to the remainder of the planning area. Furthermore, the city does have building codes, which, when followed, will help to protect structures from damage due to tornadoes and high winds.

City of Piedmont - The city has within its boundaries a public tornado shelter built to FEMA 361 Standards. The percentage of mobile homes in the city is low (2.0%) compared to the remainder of the planning area. Furthermore, the city has adopted building codes, which, when followed, will help to protect structures from damage due to tornadoes and high winds.

City of Williamsville - The city has not adopted building codes and holds a high percentage of occupied mobile homes (19.6%) rendering city residents more vulnerable to both personal and property damage. Fortunately, the city does have within its jurisdictional boundaries a community tornado saferoom built to FEMA 361 Standards.

Village of Mill Spring - The village is likely most vulnerable to personal injury and property damage due to tornadoes when compared to its neighboring jurisdictions. The village has the highest percentage of occupied housing stock that is mobile homes at and estimated 39.3%. It is not known if the village has adopted building codes. There is no public tornado saferoom within the village or neighboring communities.

Clearwater R-I School District - No damage to district assets due to tornado was reported by the district. Vulnerability to tornado varies throughout the district's service area.

Greenville R-II School District - No damage to district assets due to tornado was reported by the district. Vulnerability to tornado varies throughout the district's service area.

Problem Statement

Residents of the Village of Mill Spring are most susceptible to injury and/or death due to tornadoes.

Structural damage due to tornadoes is most likely within the unincorporated portions of Wayne County, as well as within the Village of Mill Spring and the City of Williamsville.

- The Village of Mill Spring may wish to consider the construction of a community tornado saferoom in partnership with FEMA, SEMA, and CDBG.
- The Village of Mill Spring and the City of Williamsville may wish to adopt building codes.
- All participating jurisdictions may wish to cooperatively employe an inspector to enforce building codes, perhaps in conjunction with the region's planning commission.
- Those communities that have tornado saferooms (Greenville, Piedmont, and Williamsville) should ensure the public is knowledgeable of how and when to access the facility.

3.4.10 Wildfire

Hazard Profile

Hazard Description

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

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

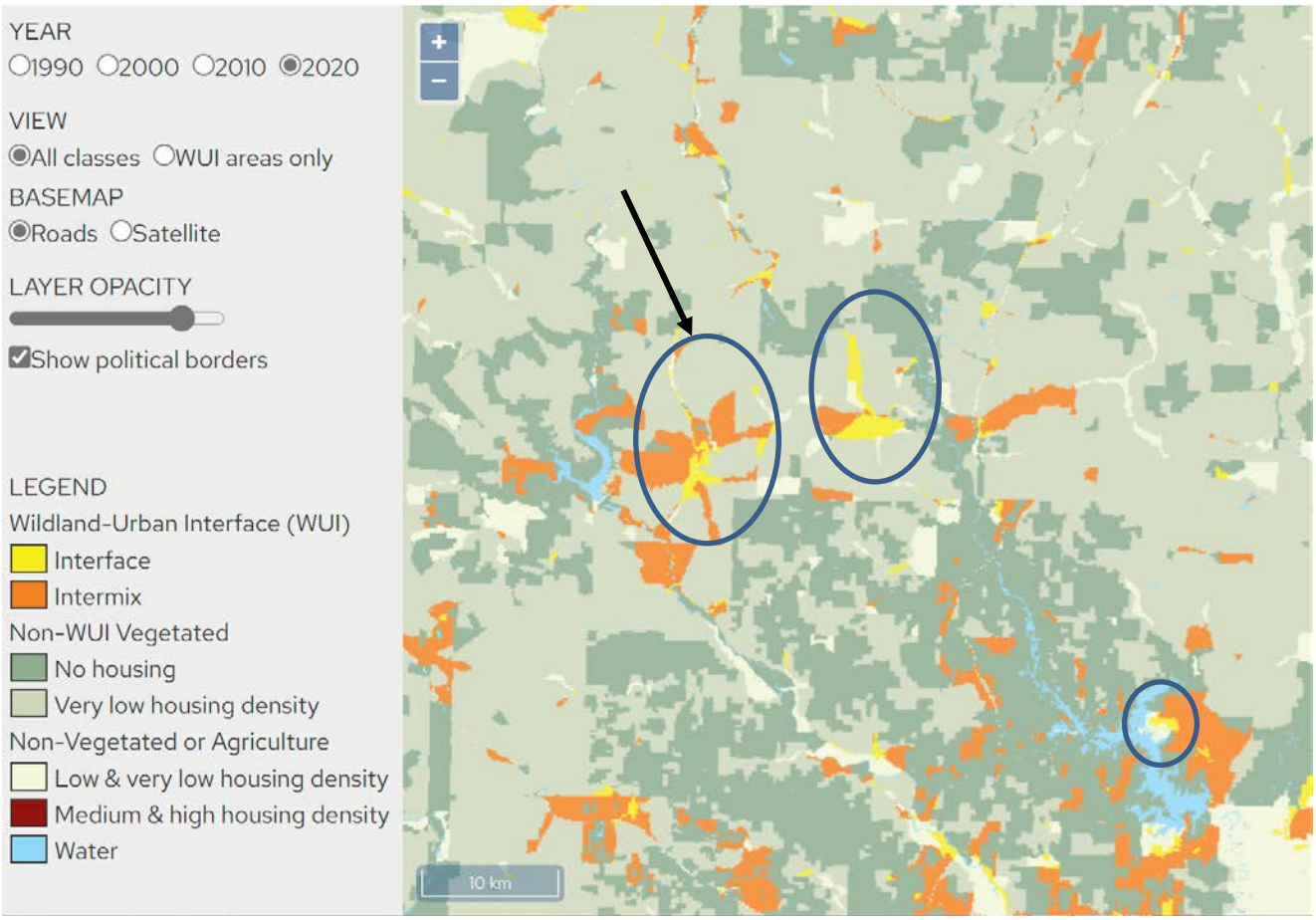
Most Missouri fires occur during the spring season between February and May. The length and severity of wildland fires depend largely on weather conditions. Spring in Missouri is usually characterized by low humidity and high winds. These conditions result in higher fire danger. In addition, due to the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

Damages due to wildfires are higher in communities with more wildland–urban interface (WUI) areas. This 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.

Discuss which communities are most at risk. The map below shows the WUI areas within the planning area, which consumes the majority of the image. Communities most at risk—when compared to other communities in the county—include the City of Piedmont, the community of Patterson and north along Missouri Highway 143, as well as a small section along County Road 522 east of Lake Wappapello. Unfortunately, political boundaries were not depicted on the map as described. The three areas of Wildland-Urban Interface (WUI) are shown in yellow and highlighted by the circles on the map. The arrow indicates the City of Piedmont. The remaining two WUI areas are located within the unincorporated portion of the county.

Figure 3.25. Wildland-Urban Interface Areas, Wayne County, Missouri, 2023



Source: University of Wisconsin Silvis Lab, https://silvis.forest.wisc.edu/data/wui-change/

Strength/Magnitude/Extent

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

Wildland fires in Missouri have been mostly a result of human activity rather than lightning or some other natural event. Wildfires in Missouri are usually surface fires, burning 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 to 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.

No information regarding the severity of damage from notable structural fires and wildland fires in the planning area was available for inclusion within this plan update.

Previous Occurrences

Per the Missouri Department of Conversation, there were 277 instances of wildfire in Wayne County for the ten-year period between 2014 and 2023. The fires ranged in size from one-tenth of an acre burned to 484 acres burned. Twelve of the events resulted in more than 100 acres burned. Seventy-three of the events were attributed to debris, eleven to powerlines, ten to arson, nine to campfire, five to equipment, and four to smoking. Other causes included fireworks, lightning, structure, and railroad. The majority of the wildfires resulted from unknown, undetermined, or miscellaneous causes.

The two participating school districts reported no wildfires as having impacted district assets.

Probability of Future Occurrence

Given the above reported data, the probability of wildfire within the planning area is 100% with an average of 28 events per year. The State of Missouri reports the likelihood of wildfire in the county as 20.8 event per year as found within its *2023 Missouri State Hazard Mitigation Plan*. The amount was based upon occurrences within an eighteen-year period.

Changing Future Conditions Considerations

Per the USGS National Land Cover Database (NLCD), land cover in the planning area consists mostly of deciduous trees. Per the *2023 Missouri State Hazard Mitigation Plan* on page 3.284, "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.

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.

Changes are project for location, intensity, frequency, and duration are summarized as follows:

- Location - Climate projections indicate an expansion of the wildfire hazard zone. Warmer, drier conditions also contribute to the spread of the insects that can weaken or kill trees, building up the fuels in a forest.
- Intensity - Climate projections indicate that there could also be an increase in the severity of fire.
- Frequency - Modeled projections of future climate identify a likely increase in the frequency of fire weather occurrence in Missouri and this region of the United States, including an increase in temperature and greater variance in rainfall.
- Duration - The fire season is likely to increase in duration and include a greater number of

days with weather that could support fire spread because of longer periods without rain during fire seasons."

Vulnerability

Vulnerability Overview

Data from the 2023 Missouri State Hazard Mitigation Plan was used to evaluate Wayne County's vulnerability to wildfire as the best and most recent data available. Limitations to the data do exist. For example, the state plan pulled incident data from the National Fire Incident Reporting System (NFIRS), but only 61% of fire departments in Missouri report to the NFIRS.

Potential Losses to Existing Development

Per the *2023 Missouri State Hazard Mitigation Plan*, historical losses can be used to estimate future losses. Over an eighteen-year period, 8,867.5 acres were burned within the planning area resulting in an average number of acres burned per year of 492.6.

To determine the threat of wildfire upon a particular community, the extent and location of Wildland-Urban Interface (WUI) areas can be evaluated. Analysis conducted by state planners showed 4,566 structures located within the county's 53,892.75 WUI acres. Of the structures, 3,546 are residential, 932 are agricultural, 76 are commercial, eight are educational, three are governmental, and one is industrial. The total estimated value of the structures is $763,018,037.

Using the total WUI acres in the county and the value of structures located in the WUI areas, a potential loss estimate can be calculated. Assuming all acres burned by wildfire are located within WUI areas, the potential loss per year is estimated at $6,974,791. This calculation uses the value of structures located within each WUI acre in the planning area as $14,158.

Impact of Previous and Future Development

Fortunately, no development is anticipated in the county including within wildland-urban interface areas.

Hazard Summary by Jurisdiction

Differences in vulnerability to wildfire exists throughout the county as some jurisdictions have more prevalent areas of wildland-urban interface. As shown on the map in Figure 3.25, the City of Piedmont, the community of Patterson, and an area east of Wappapello Lake appear to have the most potential for damage due to wildfire.

Wayne County – While the county's farm operators can experience crop losses due to wildfire, the damage, historically, has had minimal financial impact. However, two unincorporated areas of the county have wildland-urban interface (as indicated in yellow withing Figure 3.25). The community of Patterson and the area extending up Missouri State Highway 143 toward Sam A. Baker State Park are considered wildland-urban interface (WUI) areas. Additionally, a small area east of and adjacent to Lake Wappapello is also designated as WUI. The county may wish to identify mitigation actions regarding wildfire which target these two areas.

City of Greenville – The risk of wildfire to the city, though present, is less when compared to other participating jurisdictions. The area in and around the city is designated wildland-urban intermix (orange on the map in Figure 3.25). While the city should acknowledge and consider wildfire as a

threat to the health and safety of its residents, historical occurrences have shown the hazard to be less threatening than other natural hazard events.

City of Piedmont – The entire city and its surrounding area is located within a wildland-urban interface (WUI) area. Because of this, the potential of property damage as well as human injury/death due to wildfire is higher than in any other area of the county. The city should strongly consider developing mitigation actions addressing the threat of wildfire.

City of Williamsville – While the city is not heavily regarded as being located within a wildland-urban interface area, it is surrounded by wooded acres and located within a wildland-urban intermix area, which is subject to wildfire. The city should consider identifying mitigation actions which address the hazard.

Village of Mill Spring – While the village is regarded as being located within a wildland-urban intermix area, it may wish to consider mitigation actions addressing wildfire.

Clearwater R-I School District – The headquarters for the district are located within the City of Piedmont. As stated above, the City of Piedmont is predominantly—if not entirely—located within a wildland-urban interface area. Because of this, the majority—if not all—of the district's assets are located within an area most subject to damage resulting from wildfire. The district should strongly consider identifying multiple mitigation actions regarding the hazard and designed to protect its assets and student population.

Greenville R-II School District - The headquarters for the district are located within the City of Greenville which has lower vulnerability to wildfire when compared to other areas of the county. However, the district campus is located along the north side of the city and bounded on all sides by wooded areas. Because of this, the district may wish to strongly consider mitigation actions pertaining to the hazard of wildfire.

Problem Statement

Wildland fire threat varies throughout the planning area as shown within the map in Figure 3.25. The hazard is mostly likely to result in property damage, human injury/death in the communities of Piedmont, Patterson, and near Lake Wappapello.

- The entire City of Piedmont is located within an area identified as WUI. Possible solutions include review of local ordinances addressing the combustibility/flammability of new construction within the WUI.
- Wayne County in conjunction with the City of Piedmont and the community of Patterson should educate property owners and builders regarding the risk of new construction using flammable materials within the WUI.
- The City of Piedmont and Wayne County, on behalf of the community of Patterson, may wish to identify and arrange emergency access to water supply for use in the event of a wildfire near the area.