

3 - RISK ASSESSMENT

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3.1 HAZARD IDENTIFICATION

HAZARD ANALYSIS

The Greene County 2020 Hazard Mitigation participates updated the hazard profiles from the 2015 Mitigation Plan. This process included reviewing each profile, updating with new information from and adding any missing information that was unavailable or not completed in the 2015 Mitigation Plan. The 2020 Multi-Jurisdictional Hazard Mitigation Plan did not add or remove any hazards from the 2015 plan. The hazard analysis for Greene County will have three different sections of hazards including natural, technological and human caused. Each section of hazards will be explained below.

NATURAL HAZARDS

A natural hazard is a natural phenomenon that might have a negative effect on humans or the environment. In the 2020 Multi-Jurisdiction Hazard Mitigation Plan, natural hazards have been divided into two separate groups, weather related and other. Weather related events are the most likely hazards to affect the Springfield-Greene County area and include hazards like tornados, damaging wind, flood, hail, and lightening. Other natural hazards that are not weather related includes animal disease, earthquake, land subsidence, wildfires and communicable disease. More details for each natural hazard can be found in the hazard's individual profile.

TECHNOLOGICAL HAZARDS

A technological hazard can be defined has hazards originating from technological or industrial accidents, dangerous procedures, infrastructure failures or specific human activities that may cause the loss of life or injury, property damage, social and economic disruption or environmental degradation. This hazard section was added for the first time in the 2015 Mitigation Plan. Some of the technological hazards listed in the 2020 Multi-Jurisdictional Hazard Mitigation Plan are airplane crash, cave/mine collapse, dam failure, hazardous materials and train derailment. More details for each technological hazard can be found in the hazard's individual profile.

HUMAN-CAUSED HAZARDS

Human-caused hazards result from the intentional actions of an adversary, such as threatened or actual attacks against a community or group of people. Some of the human-caused hazards that 2020 Multi-Jurisdiction Hazard Mitigation Plan include are biological, chemical, civil unrest, cyber, explosives, nuclear and Radiological. More details for each human-caused hazard can be found in the hazard's individual profile.

A full list of hazards included in the 2020 Multi-Jurisdictional Hazard Mitigation Plan can be found on the next page.

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Identified Hazards for Greene County

NATURAL HAZARDS	TECHNOLOGICAL HAZARDS	HUMAN-CAUSED HAZARDS
<p>Weather:</p> <ul style="list-style-type: none">● Damaging Wind● Drought● Extreme Cold● Extreme Heat● Flood● Hail● Ice and Snow● Lightning● Tornado <p>Other:</p> <ul style="list-style-type: none">● Animal Disease● Communicable Disease● Earthquake● Land Subsidence (Sinkholes)● Wildfire	<ul style="list-style-type: none">● Airplane Crash● Cave/Mine Collapse● Dam Failure● Hazardous Materials● Power Failure● Train Derailment● Urban Fire	<ul style="list-style-type: none">● Biological● Chemical● Civil Unrest● Cyber● Explosives● Nuclear● Radiological● Sabotage● Targeted Violence● Waste

3.1.1 Review of Existing Mitigation Plans

The 2015 Multi-Jurisdictional Hazard Mitigation Plan made many changes to how the hazards were organized. One of the big changes that was made was the addition of the “Technological Hazards” section. Originally, the technological hazards were included in the human-caused hazards section of the plan. New hazards were added in 2015 including targeted violence, cyber and sabotage. Another change that was made in the 2015 Mitigation Plan was the separation of tornadoes, severe thunderstorms, hail and lightning. Originally, they were paired into one category called “Tornado, Severe Storms, Hail, and Lighting”. For the 2020 plan, the Mitigation Planning Committee (MPC) decided not to change any of the hazards or categories.

In Missouri, Local plans customarily include only natural hazards, as only natural hazards are required by federal regulations to be included. The MPC determined that it was important to include technological and human-caused hazards in the 2020 Multi-Jurisdictional Hazard Mitigation Plan because the community wants to mitigate all hazards, not just natural ones. Springfield-Greene County Office of Emergency Management is also EMAP accredited and according to Standard 4.1.1 “The Emergency management Program identifies the natural and human-caused hazards that potentially impact the jurisdiction using multiple sources. The Emergency management Program assessed the Risk and Vulnerability of people, property, the environment, and its own operations from these hazards.” In order to retain accreditation, the MPC must include human-caused hazards in the mitigation plan.

Compared to the Missouri State Hazard Mitigation Plan, Greene County included all the same hazard except for levee failure. Levee failure was excluded from the mitigation planning process as there are no mapped levees nor associated levee protected areas within or immediately upstream of Greene County.

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3.1.2 Review Disaster Declaration History

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

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

FEMA Disaster Declarations that Included Greene County, Missouri 1965-Present

DISASTER NUMBER	DESCRIPTION	DECLARATION DATE INCIDENT PERIOD	INDIVIDUAL ASSISTANCE (IA) PUBLIC ASSISTANCE (PA)
439	Severe Storms and Flooding	06/10/1974-06/10/1974	N/A
3017	Drought	09/24/1976-09/24/1976	N/A
867	Severe Storms and Flooding	05/15/1990-05/31/1990	N/A
995	Severe Storms and Flooding	06/10/1993-10/25/1993	N/A
1412	Severe Storms, Tornadoes and Flooding	04/24/2002-06/10/2002	IA: N/A PA: \$35,299,777.93
1463	Severe Storms, Tornadoes and Flooding	05/04/2003-05/04/2003	IA: \$8,779,157.72 PA: \$19,562,866.28
3232	Hurricane Katrina Evacuation	08/29/2005-10/01/2005	N/A
1631	Severe Storms, Tornadoes and Flooding	03/08/2006-03/13/2006	IA: \$1,587,654.75 PA: \$5,542,439.50
1673	Severe Winter Storms	11/30/2006-12/02/2006	IA: N/A PA: \$6,654,375.10
1676	Severe Winter Storms and Flooding	01/12/2007-01/22/2007	IA: N/A PA: \$106,468,427.80
1728	Severe Storms and Flooding	08/19/2007-08/21/2007	IA: N/A PA: \$5,571,824.46
3281	Severe Winter Storms	12/08/2007-12/15/2007	N/A
1748	Severe Winter Storms and Flooding	02/10/2008-02/14/2008	IA: N/A PA: \$10,068,998.77
1773	Severe Storms and Flooding	06/01/2008-08/13/2008	IA: \$5,367,078.69 PA: \$28,697,245.28
1749	Severe Storms and Flooding	04/17/2008-05/09/2008	IA: \$13,924,227.09 PA: \$26,045,574.54
3303	Severe Winter Storm	01/26/2009-01/28/2009	N/A
1847	Severe Storms, Tornadoes and Flooding	05/08/2009-05/16/2009	IA: \$5,417,824.37 PA: \$27,072,334.75
3317	Severe Winter Storm	01/31/2011-02/05/2011	N/A
3374	Severe Storms, Tornadoes, Straight-Line Winds and Flooding	12/22/2015-01/09/2016	N/A
4250	Severe Storms, Tornadoes, Straight-Line Winds and Flooding	12/23/2015-01/09/2016	IA: \$13,175,523.43 PA: \$36,886,888.84

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3.1.3 Research and Additional Sources

The following list are additional sources of data on locations and past impacts of hazards in the planning area:

- Missouri Hazard Mitigation Plans (2010, 2013, and 2018)
- Previously Approved planning area Hazard mitigation Plan, 2015
- Federal Emergency Management Agency (FEMA)
- Data Collection Questionnaires completed by each jurisdiction
- National Weather Service (NWS)
- State of Missouri GIS data
- National Oceanic and Atmospheric Administrations' (NOAA) National Centers of Environmental Information (NCEI)
- County and local Comprehensive Plans to the extent available
- County Emergency Management
- Missouri Department of Natural Resources
- Climate.gov
- Hazus
- Various articles and publications available on the internet. (Sources will be stated in body of the plan)
- Google Images
- SEMA Mitigation Viewer

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3.1.4 Hazards Identified

The following chart lists hazards that may affect one or all of the jurisdictions. An “x” indicates the jurisdiction is impacted by the hazard, and a “-“indicated that hazard is not applicable to that jurisdiction.

JURISDICTION	DROUGHT	EXTREME TEMPERATURES	FLOOD	HAIL	ICE AND SNOW	SEVERE THUNDERSTORMS	TORNADO	ANIMAL DISEASE	COMMUNICABLE DISEASE	EARTHQUAKE	LAND SUBSIDENCE	WILDFIRE	AIRPLANE CRASH	CAVE/MINE COLLAPSE	DAM FAILURE	HAZARDOUS MATERIALS	POWER FAILURE	TRAIN	URBAN FIRE	BIOLOGICAL	CHEMICAL	CIVIL UNREST	CYBER	EXPLOSIVES	NUCLEAR	RADIOLOGICAL	SABOTAGE	TARGETED VIOLENCE	WASTE
Greene County	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
Ash Grove	X	x	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		
Battlefield	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		
Fair Grove	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		
Republic	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		
Springfield	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		
Strafford	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		
Walnut Grove	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		
Willard	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		
Ash Grove	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		
Fair Grove	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		
Republic	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		
Springfield	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		
Strafford	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		
Walnut Grove	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		
Willard	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		
Ash Grove	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		
Battlefield	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		
Ebenezer	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		
Fair Grove	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		
Logan-Rogersville	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		

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Strafford	X	X	X	X	X	X	X	X	X	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X	X	X
Walnut Grove	X	X	X	X	X	X	X	X	X	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X	X	X
Willard	X	X	X	X	X	X	X	X	X	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X	X	X
Drury University	X	X	X	X	X	x	X	X	x	X	x	X	X		X	X	X	X	X	X	X	X	X	X	X	X	X
Missouri State University	X	X	X	X	X	X	X	X	X	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X	X	X
Ozarks Technical Community College	X	X	X	X	x	X	X	x	X	x	X	X	X		X	x	X	X	x	X	X	X	X	X	X	X	X

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3.1.5 Multi-Jurisdictional Risk Assessment

The 2020 Greene County Multi-Jurisdictional Hazard Mitigation Plan is an update to the previously approved 2015 Multi-Jurisdictional Hazard Mitigation Plan that was approved in July of 2015. Due to the limited differences in geography, topography, climate, and infrastructure between the multiple political jurisdictions within Greene County, it was determined that there was no significant variance in the risk and vulnerability to many of the hazards that were identified. Many of the hazards therefore, were analyzed holistically in order to gain a comprehensive picture of the risk and vulnerability of the hazard. Greene County's hazard analysis' and vulnerability studies include all municipalities, fire protection districts, school districts and higher education institutions. However, all participants were asked to include their own hazard analysis and vulnerability study only if they were different than the Greene County vulnerability. The differences in vulnerabilities will be discussed in each hazard's individual profile.

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 to hazards.

3.2.1 Total Exposure of Population and Structures

Table 3.2 Maximum Population and Building Exposure by Jurisdiction

JURISDICTION	2017 ANNUAL POPULATION ESTIMATE	BUILDING COUNT	BUILDING EXPOSURE (\$)	CONTENTS EXPOSURE (\$)	TOTAL EXPOSURE (\$)
Ash Grove	1,607	18	\$2,326,650	\$311,600	\$2,638,250
Battlefield	5,986	Info Not Provided	\$334,750	\$173,525	\$508,275
Fair Grove	1,623	4	\$4,468,854	\$2,699,000	\$7,167,854
Republic	15,890	3	\$5,800,000	\$2,500,000	\$8,300,000
Springfield	164,785	566	\$11,758,392	\$7,208,228	\$18,966,620
Strafford	2,152	Info Not Provided	\$182,559	\$109,478	\$292,037
Walnut Grove	612	7	\$868,949	\$340,000	\$1,208,949
Willard	5,426	4	\$1,136,839	\$242,300	\$1,379,139
Unincorporated Greene County	84,013	579	\$5,933,440	\$3,102,416	\$9,035,856

Source: Data Collection Questionnaire

*Battlefield, Springfield, Strafford and Unincorporated Greene County Data was provided by SEMA MSDIS.

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3.3 Building Values/Exposure by Usage Type

JURISDICTION	RESIDENTIAL COUNTS	COMMERCIAL COUNTS	INDUSTRIAL STRUCTURES	AGRICULTURAL COUNTS	TOTALS
Ash Grove	\$96,557	\$35,653	\$2,281	\$437	\$134,928
Battlefield	\$317,751	\$12,224	\$760	\$68	\$330,803
Fair Grove	\$87,689	\$20,033	\$2,281	\$880	\$110,883
Republic	\$843,067	\$124,276	\$15,208	\$1,323	\$983,874
Springfield	\$8,881,764	\$2,125,248	\$398,452	\$1,141	\$11,306,605
Strafford	\$136,461	\$29,880	\$6,844	\$290	\$173,475
Walnut Grove	\$44,994	\$9,507	\$0	\$233	\$54,734
Willard	\$297,553	\$31,578	\$10,646	\$823	\$340,600
Unincorporated Greene County	\$5,471,726	\$263,491	\$58,551	\$83,188	5,876,956
Totals	\$16,177,562	\$2,652,890	\$495,023	\$88,383	

Source: SEMA MSDIS

Table 3.4 Building County by Usage Type

JURISDICTION	RESIDENTIAL COUNTS	COMMERCIAL COUNTS	EXEMPT STRUCTURES	AGRICULTURAL COUNTS	TOTALS
Ash Grove	567	116	26	1	710
Battlefield	2,180	46	9	4	2239
Fair Grove	568	58	32	1	1368
Republic	7,912	2,379	49	23	10363
Springfield	53,772	8,745	1,210	15	63742
Strafford	837	187	31	0	1055
Walnut Grove	280	43	21	2	346
Willard	1,864	110	30	5	2009
Unincorporated Greene County	36,838	1,247	237	933	39255
Totals	104,818	12,931	1,645	984	121,357

Source: Greene County Assessor's Office; Parcel Database

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

PUBLIC SCHOOL DISTRICT	ENROLLMENT (2018)	ASSET COUNT	BUILDING EXPOSURE (\$)	CONTENTS EXPOSURE (\$)	TOTAL EXPOSURE (\$)
Ash Grove Public Schools	678	12	\$22,323,029	\$3,428,237	\$25,751,266
Fair Grove Public Schools	1,091	7	\$35,152,240	\$4,458,81	\$39,910,089
Republic Public Schools	4,790	36	\$133,275,691.20	\$27,031,799.95	\$160,307,491.20
Springfield Public Schools	24,937	Not Provided	Not Provided	Not Provided	Not Provided
Strafford Public Schools	1,186	14	\$48,774,986	\$8,353,571	\$57,128,557
Walnut Grove Public Schools	277	8	\$9,998,225.87	\$1,849,095	\$11,847,320.87
Willard Public Schools	4,523	Info not provided	Info Not Provided	Info Not Provided	Info Not Provided

Source: <http://mcds.dese.mo.gov/quickfacts/Pages/District-and-School-Information.aspx>; Data Collection Questionnaire

Table 3.6 Building Exposure by Jurisdiction-Higher Education Facilities

BUILDING EXPOSURE	ASSET COUNT	BUILDING EXPOSURE (\$)	CONTENTS EXPOSURE (\$)	OTHER EXPOSURE (\$)	TOTAL EXPOSURE (\$)
Missouri State University	114	\$1,432,596,667.67	\$192,880,509.70	474,378,168	2,099,855,045.37
Ozark Technical Community College	15	\$97,179,662	\$18,472,607	NA	\$115,652,269

Source: Data Collection Questionnaire, 2019

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3.2.2 Critical and Essential Facilities and Infrastructure

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

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

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

- Hazard Mitigation Viewer- <http://bit.ly/MoHazardMitigationPlanViewer2018>
- Greene County Multi-Jurisdictional Hazard Mitigation Plan-2015-2020
- Online websites/resources
- Data Collection Questionnaire

For a detailed inventory of all critical facilities, please see Appendix A.

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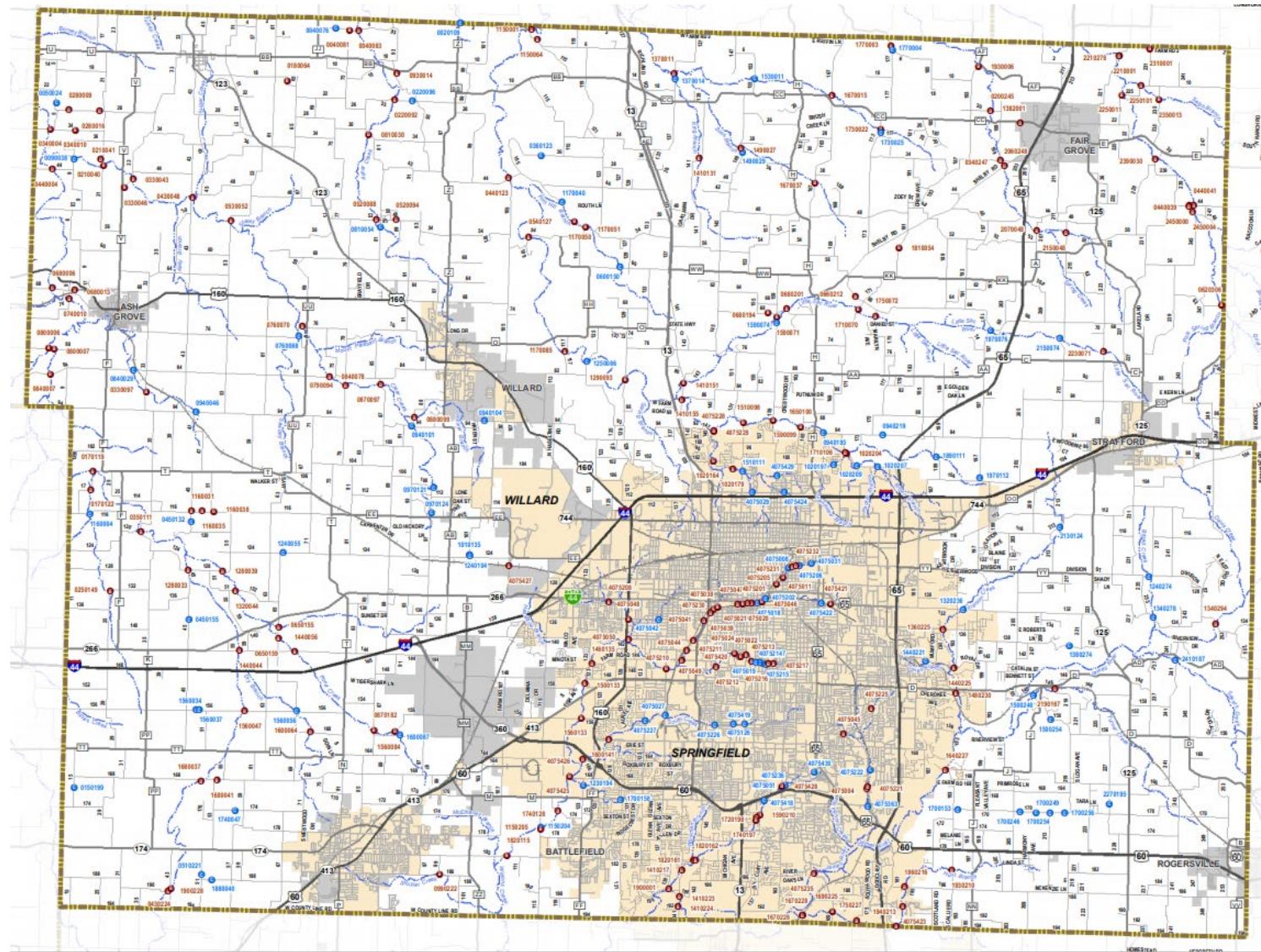
Table 3.6 Inventory of Critical/Essential Facilities and Infrastructure by Jurisdiction

JURISDICTION	AIRPORT FACILITY	BUS FACILITY	CHILDCARE FACILITY	CHURCHES	ELECTRIC POWER FACILITY	EMERGENCY COMMUNICATION	FIRE SERVICE	GOVERNMENT	HOUSING (2017 CENSUS DATA)	SHELTERS	HOSPITAL/HEALTH CARE	MILITARY	NATURAL GAS	NURSING HOMES	POLICE STATIONS	POTABLE WATER FACILITY	RAIL	SANITARY PUMP STATIONS	SCHOOL FACILITY	STORMWATER PUMP STATIONS	TIER II CHEMICAL FACILITIES	WASTEWATER	TOTAL
Ash Grove	X	X	6	10	X	X	1	1	669	1	X	X	X	1	X	X	X	1	3	X	6	X	24
Battlefield	X	X	3	6	X	X	5	1	2,375	0	X	X	X	x	1	X	X	X	X	X	3	X	12
Fair Grove	X	X	3	10	X	X	3	1	602	1	X	X	X	X	1	X	X	X	3	X	5	X	20
Republic	X	X	26	20	X	X	2	2	6,091	7	X	X	X	3	1	X	X	X	7	X	5	X	6,164
Springfield	2	1	147	210	4	1	1 5	53	81,04 5	60	13	1	2	25	3	2	2	19	91	X	302	2	82,00 0
Strafford	X	X	5	7	X	X	3	1	877	6	X	X	X	1	1	X	X	3	3	X	14	X	922
Walnut Grove	X	X	1	4	X	X	1	1	286	0	X	X	X	X	1	X	X	X	2	X	3	X	299
Willard	X	X	4	18	X	X	3	1	2,117	9	X	X	X	2	1	X	X	1	10	X	13	X	2,179
Greene County	X	X	X	4	X	X	8	4	130,9 15	N/A	X	X	X	x	1	X	X	X	X	X	43	X	130,9 75
Totals	2	1	195	289	4	1	4 1	65	224,9 77	84	13	1	2	32	11	2	2	24	119	X	394	2	226,2 61

Source: Missouri 2018 State Hazard Mitigation Plan and Hazard Mitigation Viewer; Data Collection Questionnaires; Hazus; Greene County Multi-Jurisdiction Hazard Mitigation Plan 2015-2020

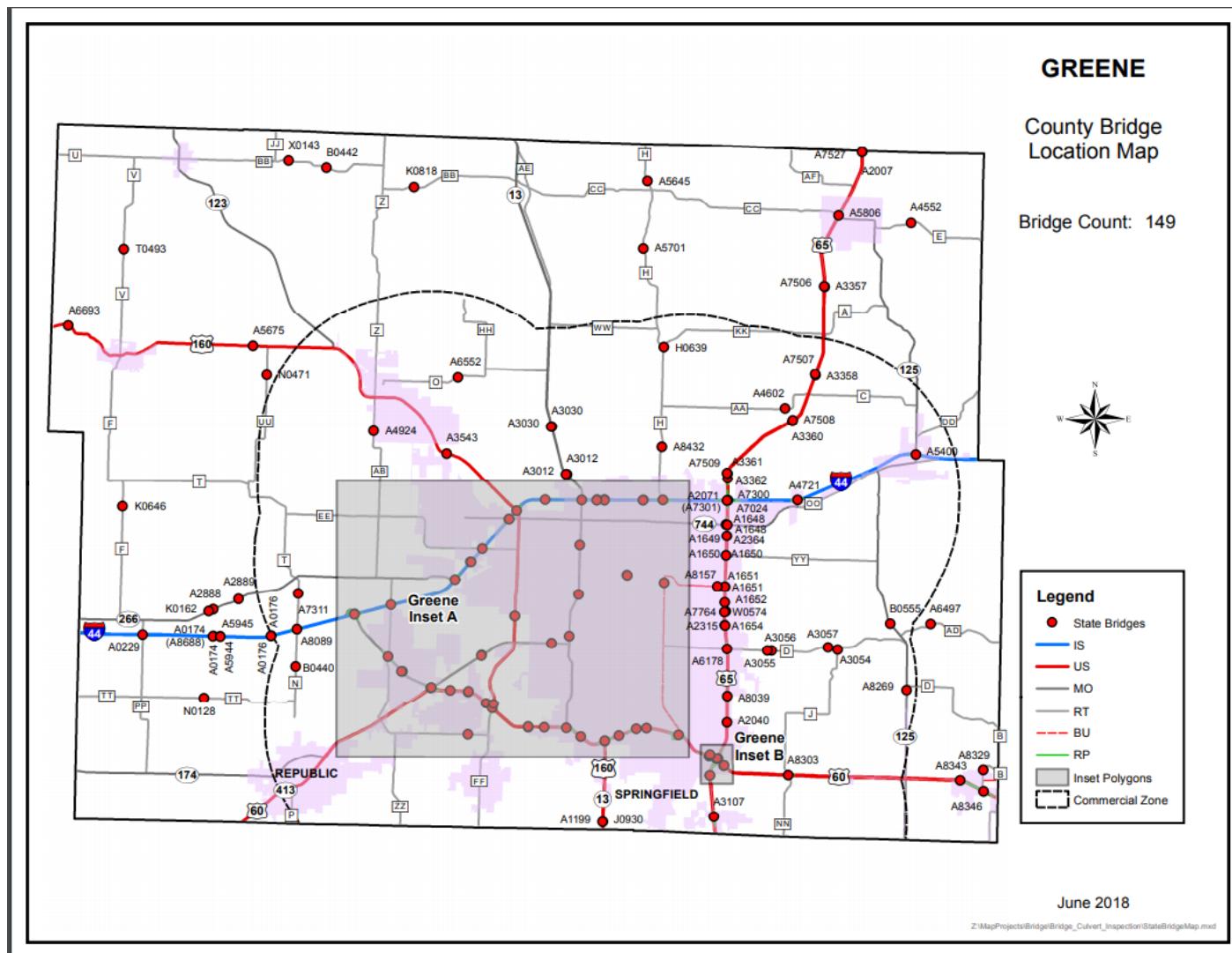
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Bridges - Non State Structures Greene County



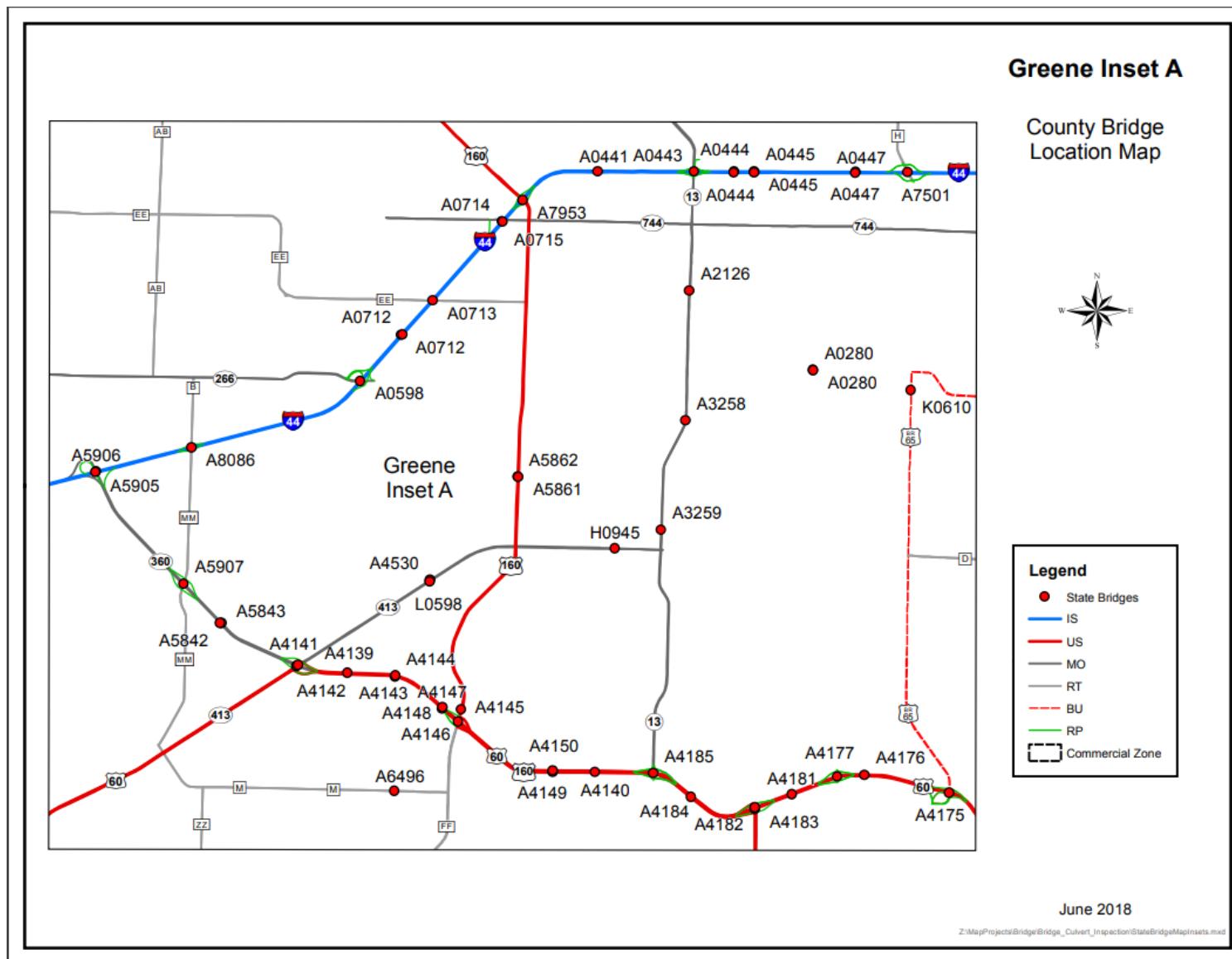
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Bridges - State Owned Greene County



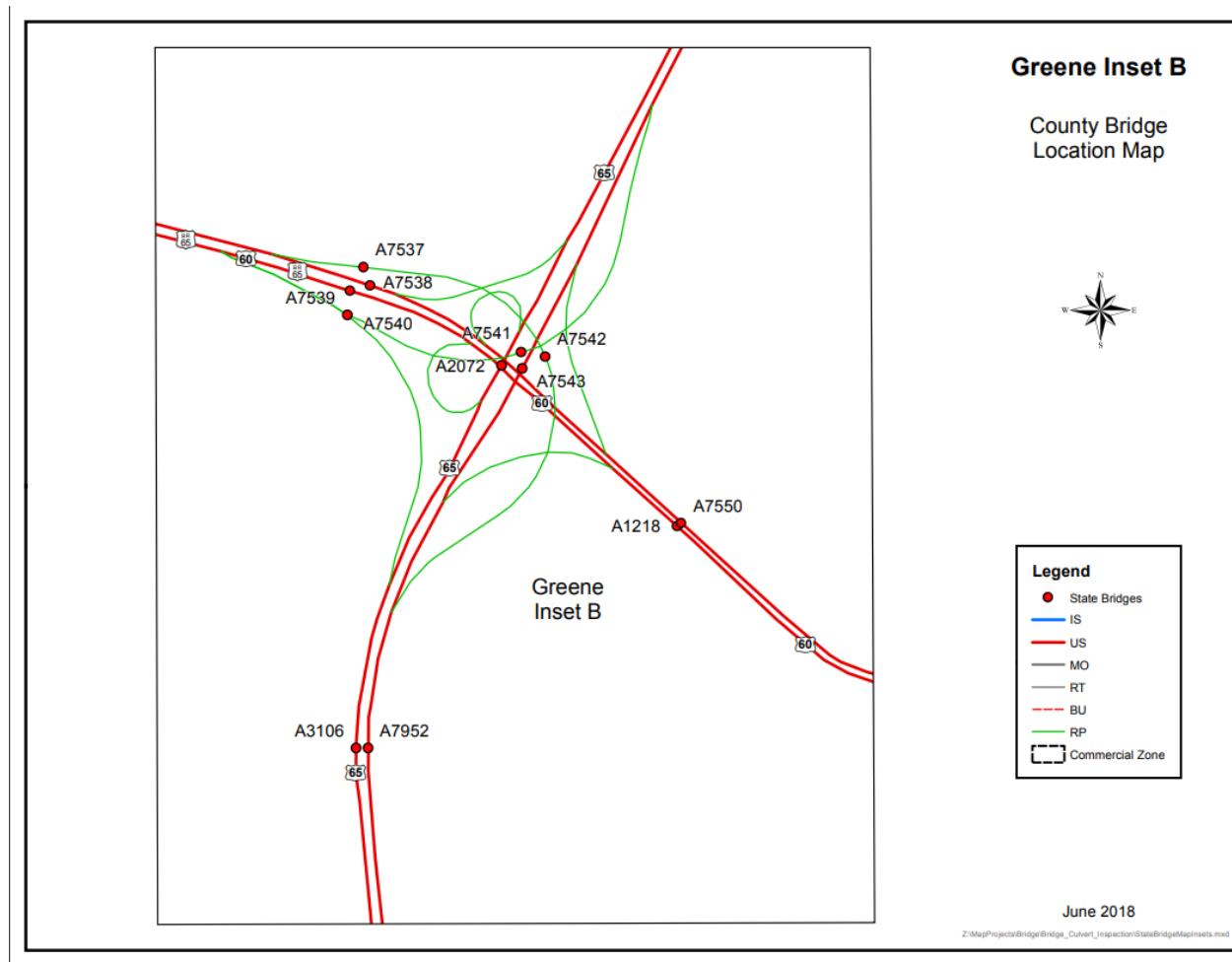
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State Owned Bridges - Greene County



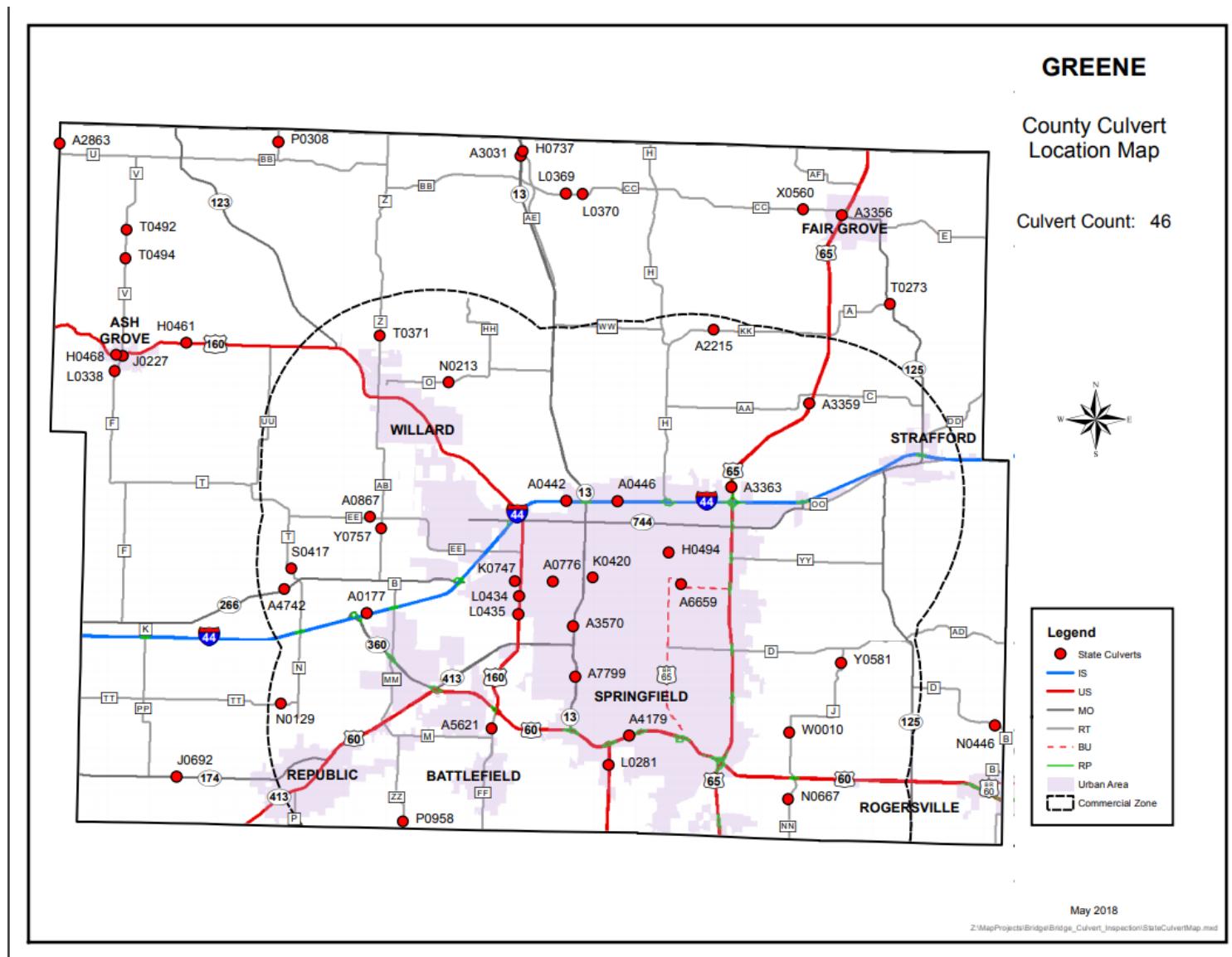
3 - RISK ASSESSMENT

State Owned Bridges - Greene County



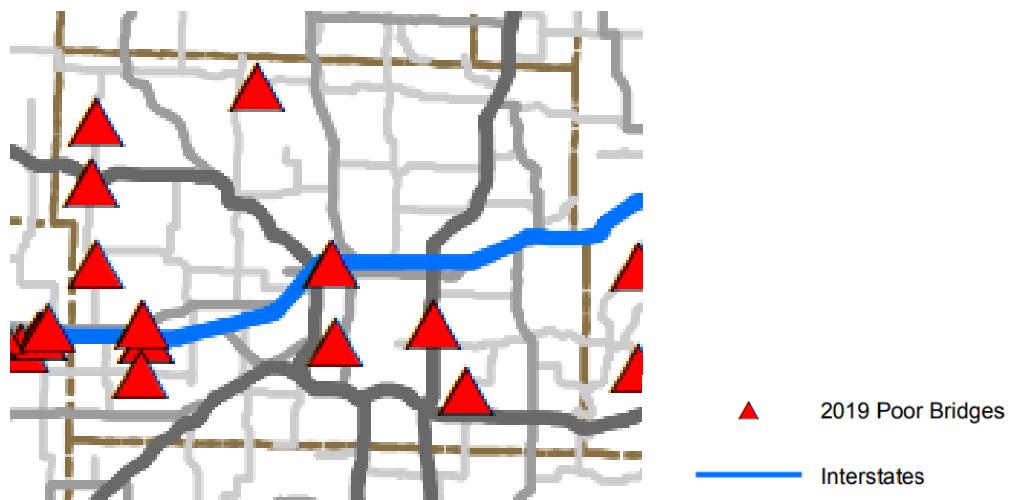
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State Owned Culverts - Greene County



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Greene County Structurally Deficient Bridges



Source: Missouri Department of Transportation

3.2.3 Other Assets

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

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

Table 3.7 Threatened and Endangered Species in Greene County

Common Name	Scientific Name	Status
Peregrine Falcon	Falco Peregrinus	Endangered
Northern Harrier	Circus Cyaneus	Endangered
Ozark Cavefish	Amblyopsis Rosae	Threatened
Eastern Spotted Skunk	Spilogale Putorius	Endangered
Gray Myotis (Gray Bat)	Myotis Grisescens	Endangered
Hellbender	Cryptobranchus Alleganiensis	Endangered
Indiana Bat	Myotis Sodalis	Endangered
Northern Long-Eared Bat	Myotis Septentrionalis	Threatened
Niangua Darter	Etheostoma Nianguae	Threatened

Source: U.S. Fish and Wildlife Service, Missouri Department of Conservation

The Missouri Department of Conservation (MDC) provides a database of land the MDC owns, leases, or manages for public use. Table 3.9 provides the names and locations of all parks and conservations areas in Greene County.

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Table 3.8 Parks in Greene County

PARK/CONSERVATION AREA	ADDRESS	CITY
Andy Dalton Shooting Range and Outdoor Education Center	4897 N Farm Road 61	Ash Grove
Ash Grove Park	450 E. Parkway St.	Ash Grove
Bois D'Arc CA		Bois D'Arc
Republic Parks and Recreation	711 E. Miller Rd.	Republic
Wilson's Creek National Battlefield	6424 W. Farm Road 182	Republic
Jr Martin Park	E. Park St.	Republic
Miller Park	701 E. Miller Rd.	Republic
Mildred McKee Park	600 S. McKee St.	Republic
Phenix Access	N Farm Road 33 & W Farm Road 44	Springfield
Crighton (Joe) Access	2932 Farm Road 193	Springfield
Fellows Lake	E Farm Road 66 & N Farm Road 175	Springfield
Lake Springfield	5701 S. Kissick Ave.	Springfield
Tailwaters Access	5701 S. Kissick Ave.	Springfield
Watershed Committee of the Ozarks (Valley Water Mill Lake)	2450 E. Valley Water Mill Rd.	Springfield
Rutledge-Wilson Farm Park	3825 W. Farm Road 146	Springfield
Nathanael Greene Park	2400 S. Scenic Ave.	Springfield
Jordan valley Park	635 E. Trafficway St.	Springfield
Springfield Skatepark	945 W. Meadowmere St.	Springfield
Phelps Grove Park	950 E. Bennett St.	Springfield
Sequoiota Park	3500 S Lone Pine Ave.	Springfield
Grant Beach Park	1300 N. Grant Ave	Springfield
Doling Family Center	301 E. Talmage St.	Springfield
Ritter Springs Park	3683 W. Farm Road 92	Springfield
Washington Park	1600 N. Summit Ave.	Springfield
Springfield Conservation Center	4601 S. Nature Center Way.	Springfield
Founders Park	330 E. Water St.	Springfield
Jenny Lincoln Park	300 E. Harrison St.	Springfield
Overhill Park	1117 S. Overhill Ave	Springfield
Shawness Park LP	1329 E. Lark St.	Springfield
Wild Animal Safari	124 Jungle Dr.	Strafford
Frisco Highline Trail	11956 State Highway BB	Walnut Grove
Little Sac Woods CA	10301 N. Farm Road 115	Willard
Jackson Street Park	222 W. Jackson St.	Willard
Rocky Barrens Conservation Area	W. Farm Road 74	Willard

Source: Missouri Department of Conservation; Community Websites

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Historic Places

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 Park Service, under the Secretary of the Interior, administers the National Register. Properties listed in the National Register include districts, sites, building structures, and objects that are significant in American history, architecture, archeology, engineering, and culture.

Disasters have taken a heavy toll on historic landmarks in the past. Many historic properties were built before modern building codes are located in areas that are prone to disasters. Protecting historic resources, structures, sites and landscapes that have been nationally registered are important for disaster resilience.

Table 3.9 Greene County Properties on the National Register of Historic Places

PROPERTY	ADDRESS	CITY	DATE LISTED
Abou Ben Adhem Shrine Mosque	601 St. Louis St.	Springfield	09/09/1982
Ambassador Apartments	1235 E. Elm St.	Springfield	10/29/2008
Anderson, Elijah Teague, House	406 N. Pine St.	Republic	11/14/1980
Bailey School	501 W. Central St.	Springfield	11/02/2016
Bentley House	603 E. Calhoun	Springfield	11/14/1980
Benton Avenue AME Church	830 N. Benton	Springfield	10/14/2001
Berry Cemetery	1431 W. Farm Road 74	Ash Grove	11/13/2004
Beverly Apartments	529 Cherry St.	Springfield	07/10/2017
Boegal and Hine Flour Mill-Wommack Mill	38 S. Main St.	Fair Grove	11/06/1986
Boone, Nathan House	7850 N. State Highway V	Ash Grove	10/01/1969
Camp Manor Apartments	423 E. Elm St.	Springfield	12/06/2005
Campbell Avenue Historic District	200 and 300 Blocks of S. Campbell Ave, and 300 Block of Park Central	Springfield	06/25/1999
Campbell Avenue Historic District Boundary Increase	318 and 322-326 S. Campbell Ave.	Springfield	12/23/2005
Christ Episcopal Church	601 E. Walnut St.	Springfield	03/26/1987
College Apartments	408 E. Walnut St.	Springfield	05/01/2003
Commercial Street Historic District	Commercial St.	Springfield	05/24/1983
Day House	614 South St.	Springfield	11/07/1976
Fallin Brothers Building	211-229 S. Market Ave.	Springfield	07/25/2012
Finkbiner Building	509-513 W. Oliver St.	Springfield	05/25/2005
Franklin Springfield Motor Co. Building	312-314 E. Olive St.	Springfield	11/15/2006
Gillioz Theater	325 Park Central E.	Springfield	07/09/1991
Gilmore Barn	US 160 3.5 Miles E. of Ash Grove	Ash Grove	04/08/1994
Gottfried Furniture Co. Building	326 Boonville Ave.	Springfield	12/18/2007
Greene County Courthouse	940 N. Boonville Ave.	Springfield	11/14/2007
Heer's Department Store	138 Park Central Square	Springfield	10/24/2002
Heercleff	6405 S. Campbell Ave.	Springfield	11/07/2016
Holland Building	205 Park Central East	Springfield	11/15/2000
Hotel Sansone	312 Park Central E.	Springfield	05/05/2000
Jefferson Street Footbridge	Jefferson Ave	Springfield	09/02/2003
Keet-McElhaney House	435 E. Walnut St.	Springfield	03/22/1984

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King, J.E, Manufacturing Co.	1350 St. Louis St.	Springfield	07/27/2005
Kite, Robert B. and Vitae A Apartment Building	769-771 South Ave.	Springfield	01/28/2004
Landers Theater	311 E. Walnut St.	Springfield	08/12/1977
Lincoln School	815 N. Sherman	Springfield	05/31/2000
McDaniel building	316 Park Central E.	Springfield	10/22/2014
Marquette Hotel	400 E. Walnut St.	Springfield	05/05/2000
Marx-Hurlburt Building	311-315 E. Park Central Square	Springfield	09/02/2003
Mid-Town Historic District	Roughly bounded by Pacific, Clay, Pythian, Summit, Calhoun, Washington, Central, Benton, Division, and Jefferson	Springfield	07/13/1989
Mid-Town Historic District Boundary Increase	Roughly alone N. Robberson Ave. and N Jefferson Ave	Springfield	08/09/2002
Netter-Ullman Building	317 Park Central East	Springfield	04/18/2003
Oberman, D.M. Manufacturing Co. Building	600 N. Boonville	Springfield	04/18/2002
Old Calaboose	409 W. McDaniel St	Springfield	11/14/1980
Palace Hotel	501 College St.	Springfield	11/27/2002
Pearl Apartments and Windsor Apartments	728 and 722 S. Jefferson St.	Springfield	12/06/2005
Producers Ice and Manufacturing Company	524 W. Chase St.	Springfield	01/29/2018
Producers Produce Co. Plant	501 N. Main Ave.	Springfield	04/12/2010
Pythian home of Missouri	1451 E. Pythian St.	Springfield	10/07/2009
Rail Haven Motel	203 S. Glenstone Ave.	Springfield	05/10/2010
Rock Fountain Court Historic District	2400 W. College St.	Springfield	04/02/2003
Route 66 Steak 'N Shake	1158 E. St. Louis St.	Springfield	08/01/2010
St. John's Mercy Hospital Building	620 W. Scott st.	Springfield	09/02/2003
St. Paul Block	401 South Ave.	Springfield	01/15/2009
Schneider, Henry Building	600 College St. and 219-231 S. Main Ave.	Springfield	08/24/2006
South Avenue Commercial Historic District	Walnut and Pershing Sts. South and Robberson Aves	Springfield	06/25/1999
South-McDaniel-Patton Commercial Historic District	Roughly bounded by S. Campbell Ave, W. McDaniel St, South Ave, and W. Walnut St.	Springfield	03/07/2003
Springfield Furniture Co.	601 N. National Ave.	Springfield	07/05/2006
Springfield Grocer Co. Warehouse	323 N. Patton Ave.	Springfield	07/08/2010
Springfield National Cemetery	1702 E. Seminole St.	Springfield	08/27/1999
Springfield Public Square Historic District	149,138,137,134,127,132,124, and 122 Park central Square, 219,221 South Ave.	Springfield	05/05/2006
Springfield Public Square Historic District Boundary Increase	E. Side Public Square, Part of the 300 block Park Central E., N. Side of 200 Block of W. Olive St.	Springfield	01/13/2010
Springfield Seed Co. Office and Wholesale Building	319 N. Main Ave.	Springfield	09/14/2006
Springfield Warehouse and Industrial Historic District	E. Water, W. Mill and W. Phleps St. And Boonville Ave.	Springfield	06/25/1999
Stone Chapel	Drury College Campus, Benton and Central St.	Springfield	10/21/1982

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U.S. Customhouse and Post Office	830 Boonville Ave.	Springfield	06/27/1979
Walnut Street Historic commercial District	Walnut Street	Springfield	06/25/1999
Walnut Street Historic District	Roughly bounded by McDaniel, Walnut, Elm Sts. and Sherman Parkway	Springfield	03/21/1985
Walnut Street Historic District Boundary Decrease	Along East Elm Street	Springfield	10/19/2001
Walnut Street Historic District Boundary Increase	Roughly along E. Walnut St. From the 700 and 800 Blocks	Springfield	08/05/2002
West Walnut Street Commercial Historic District	Roughly 400-300 blocks of West Walnut Street and 300-400 block of South Campbell Ave.	Springfield	03/20/2002
Wilhoit, E.M. Building	300-330 E. Pershing St.	Springfield	01/31/2005
Wilshire Apartments	520 S. Jefferson St.	Springfield	04/10/2008
Wilson's Creek National Battlefield	6424 W. Farm Road 182	Springfield	10/15/1966
Wise Feed Co. Building	438-440 S. Campbell Ave.	Springfield	01/06/2003
Woods-Evertz Stove Co. Historic District	Bounded by N. Jefferson Ave., E Phleps St., N. Roberson Ave. and E. Tampa St.	Springfield	10/23/2003

Source: Missouri Department of Natural Resources-Missouri National Register Listings by County

Table 3.10 Major Employers in Greene County

LARGEST EMPLOYERS	INDUSTRY	NUMBER OF EMPLOYEES
CoxHealth	Healthcare	11,669
Mercy Hospital	Healthcare	10,950
Walmart	Retail	5,372
Springfield Public Schools	Education	4,100
State of Missouri	Government	4,018
Bass Pro Shops/Tracker Marine	Retail/Manufacturing	3,341
United States Government	Government	3,005

Source: Springfield Business Journal

Table 3.11 Agriculture-Related Jobs in Greene County

COUNTY	FARM EMPLOYMENT	AG-RELATED EMPLOYMENT	AGRIBUSINESS EMPLOYMENT	AGRIBUSINESS % TOTAL EMPLOYMENT
Greene	1,683	3,784	5,467	2.6%

Source: Missouri Economy

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3.3 Land Use Development

3.3.1 Development Since Previous Plan Update

Since the plan update the population of Greene County has increased steadily. As the population grows in the planning area, the risk of hazards also increases. More people and property in the planning area can lead to more injuries, death or property damage from all our identified hazards.

Table 3.12 County Population Growth 2010-2017

JURISDICTION	TOTAL POPULATION 2010	TOTAL POPULATION 2017	2010-2017 NUMBER OF CHANGE	2000-2017 PERCENT OF CHANGE
Greene County	275,174	286,759	11,585	4.21%
Ash Grove	1,680	1,607	-73	-4.35%
Battlefield	5,044	5,986	942	18.68%
Fair Grove	1,343	1,623	280	20.85%
Republic	13,772	15,890	2,118	15.80%
Rogersville	2,935	3,665	730	24.87%
Springfield	158,945	165,785	6,840	4.30%
Strafford	1,879	2,152	273	14.53%
Walnut Grove	767	612	-155	-20.21%
Willard	4,960	5,426	466	9.40%

Source: U.S. Census 2013-2017 American Community Survey, 5-year Estimates

*Population includes the portions of these cities in adjacent counties

Population growth or decline is generally accompanied by increases or decreased in the number of housing units. Table 3.14 will prove the change in numbers of housing units in Greene County from 2010-2017.

Table 3.13 Change in Housing Units, 2010-2017

JURISDICTION	TOTAL HOUSING UNITS 2010	HOUSING UNITS 2017	2010-2017 NUMBER OF CHANGE	2010-2017 PERCENT OF CHANGE
Greene County	125,387	130,915	5,528	4.41%
Ash Grove	661	669	8	1.21%
Battlefield	2,210	2,375	165	7.47%
Fair Grove	580	602	22	3.79%
Republic	6,139	6,091	-48	-0.78%
Rogersville	1,240	1,411	171	13.79%
Springfield	77,620	81,045	3,425	4.41%
Strafford	922	877	-45	-4.88%
Walnut Grove	306	286	-20	-6.54%
Willard	2,038	2,117	79	3.88%

Source: U.S. Census 2013-2017 American Community Survey, 5-year Estimates

*Total Housing Units includes the portions of these cities in adjacent counties

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3.3.2 Future Land Use and Development

Greene County has seen steady growth over the last 20 years. In 2000, the projected population for the county was 241,015 the population for 2017 was 289,819. The chart below demonstrates population change and net migration for Greene County.



Current Greene County Zoning Ordinance allows for many zoning districts:

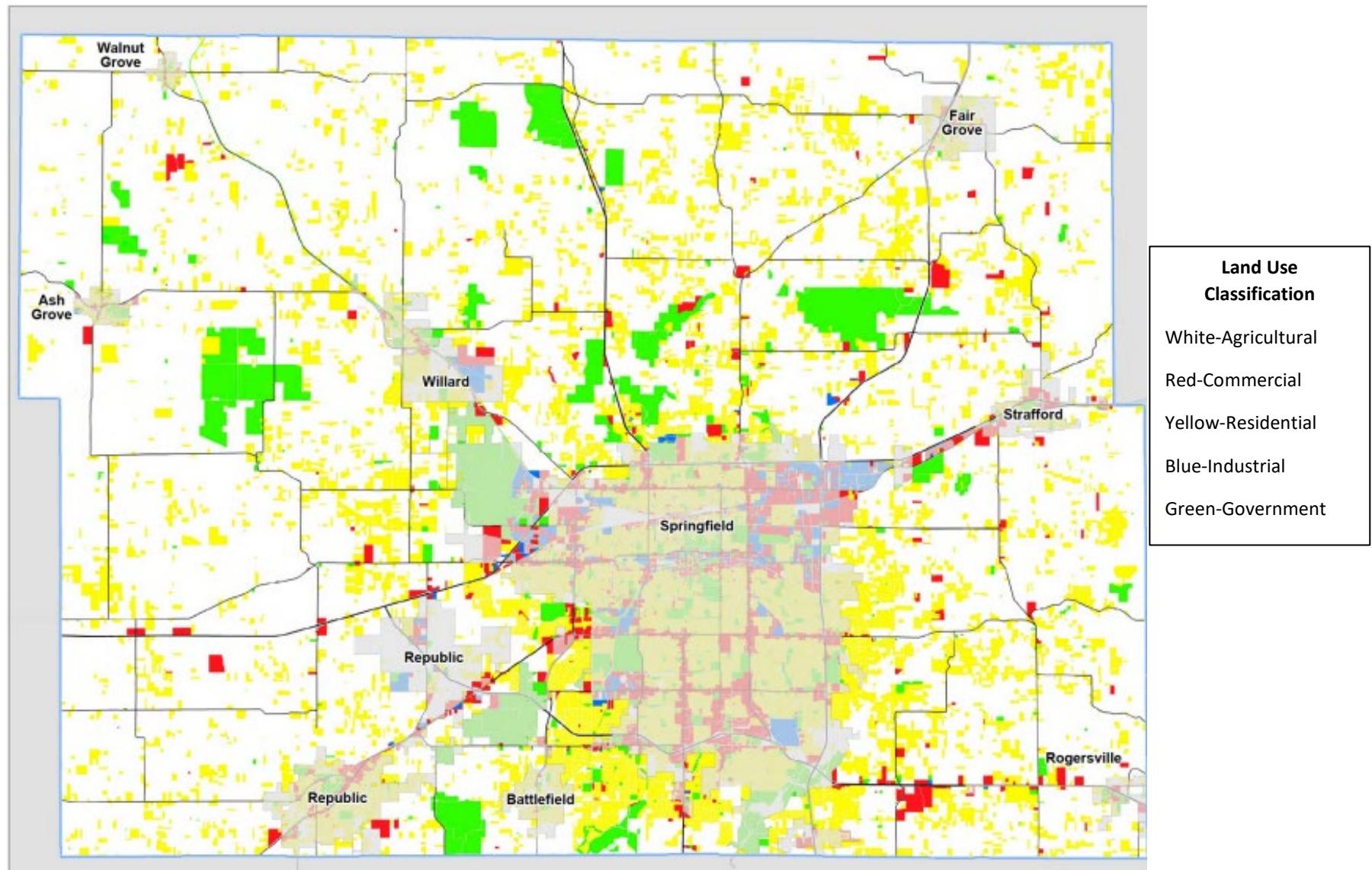
- Agriculture
- Agricultural-Residential
- Rural Residential
- Urban Residential
- One and Two Family Residential
- Multi-Family Residential
- Neighborhood commercial
- General Commercial
- Rural Commercial
- Professional Office
- General Office
- Light Manufacturing
- General Manufacturing
- General Manufacturing
- Plow Assignment District
- Conservation Development District

Each district allows differing land uses, required setback and other regulations. Additionally some “non-conforming” zoning dating from prior to the development of current zoning regulations also exists. Current zoning does not necessarily match the current land us. The Future Land Use Map depicts what zoning changes may occur in the future. The Planning Board and County Commission will use changes in zoning to achieve the land uses as specified in the Land Use Plan.

All land use information on the following pages is from the Greene County Land Use Plan from 2018. The Land Use Plan is updated every five years. This plan can be found at <https://greenecountymo.gov/files/files.php?id=1567>.

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Current Land Use Map - 2018



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Urban Growth

Urban Growth Areas on the Land Use Plan are those areas which have been designated by each municipality as their desired area for future growth. Future growth in these areas will occur as public water, sewer and roads are provided. It is anticipated the municipalities will annex their respective growth areas.

The Urban Services Area around the City of Springfield is an area where extension of sewer service is planned. This area will be regulated in the same manner as the urban growth areas. The City of Springfield has also designated an urban reserve area, beyond the Urban Services Area. This was set aside for future urban growth beyond the Urban Services Area.

Rural Development Patterns

Since the adoption of the Urban Service Area in 1984, it has been the policy of Greene County Planning and Zoning to permit the subdivision of properties into three and five acre lots anywhere throughout the County. Greene County's ability to regulate subdivision is limited to a degree by State law which does not grant authority over the subdivision of properties into parcels ten acres or greater in size (RSMo. 64.211-64.295). The Land Use Plan designates areas which are recommended for residential development with a minimum of three acres as designated in the RR-1 zoning district. These areas were developed by analyzing existing patterns of land subdivision and depict areas where tracts of three and five acres were the predominant existing land use.

Environmental Goals

A few goals that the Greene County Land Use Plan identified for the environment were:

- Preservation of agriculture and farmland
- Water quality preservation
- Green space conservation and connections
- Promotion of sustainable building
- Promotion of urban infill
- Promote conservation of resources
- Community education

Future Land Use

Future Development Trends The composition of development is largely determined by the market forces of supply and demand. Greene County has many acres of open, undeveloped land, and all future development will be dependent on this supply of developable land. Land supply is restricted by the ability to provide utilities and transportation services. Current development trends have produced many residential lots of three to five acres. Many large parcels are being divided into ten acre tracts, which require no Planning and Zoning review.

Many new concepts in development are only beginning to emerge in Greene County. 'New Urbanism,' 'Neo-Traditional Development,' and 'Green Development' are growing trends. New Urbanism focuses on compact, smart development with close proximity to transit systems and encourages mixed uses. Neo-Traditional Development emphasizes a compact, connected neighborhood design. Green Development encourages sustainable living, using renewable resources, minimizing environmental impact, and maximizing efficiency.

In Greene County, these trends mean the forces of development may be much different than in the past. Greene County should remain competitive with other real estate markets by encouraging developments which are responsive to these trends. Mixed use, such as commercial and residential either shared within the same building or in close proximity, may become more common.

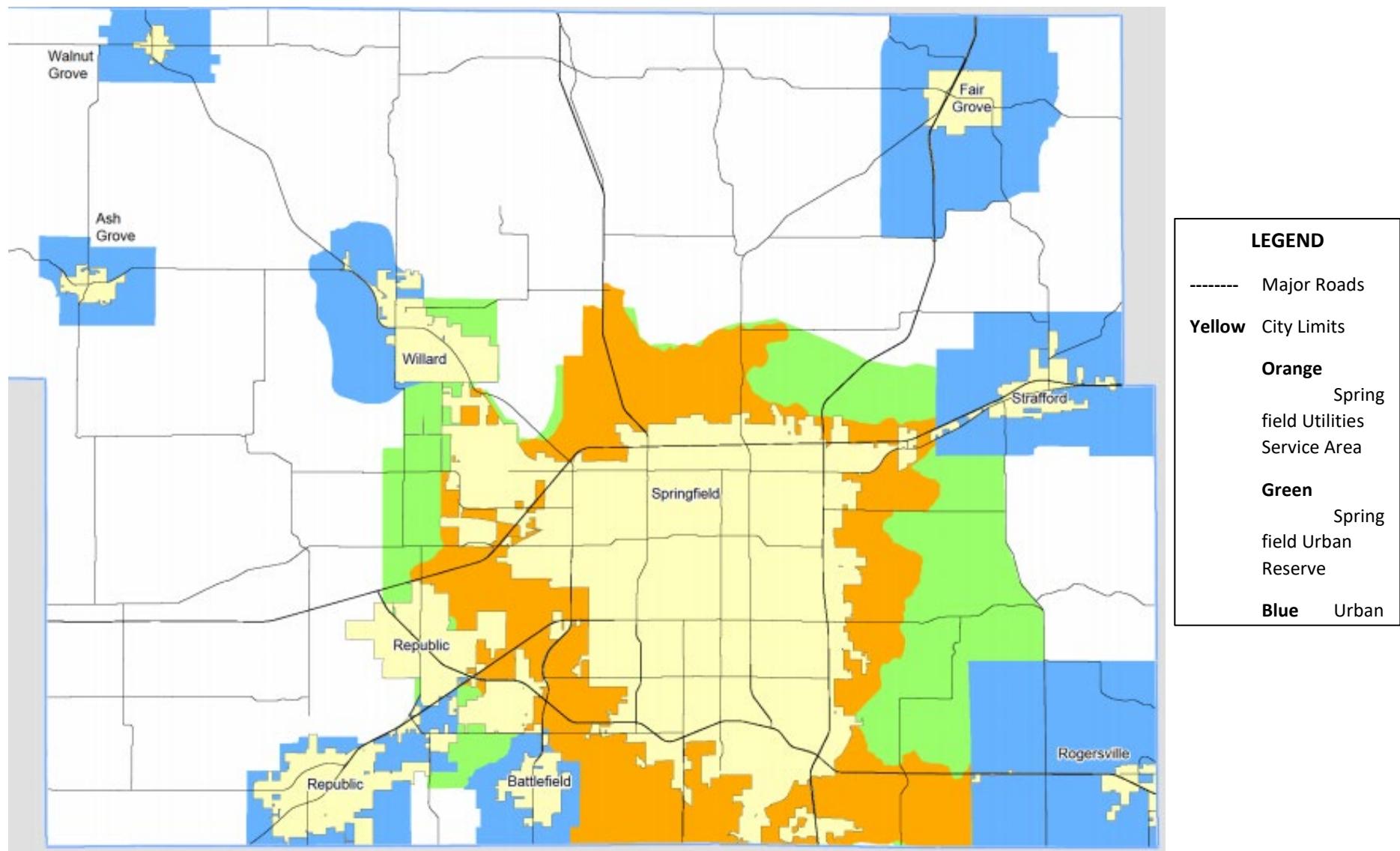
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The Future Land Use Plan is divided into a few broad land use districts:

- Urban and rural residential
- Urban and rural commercial
- Manufacturing
- Mixed use
- Agricultural
- Community and public lands
- Urban growth boundaries

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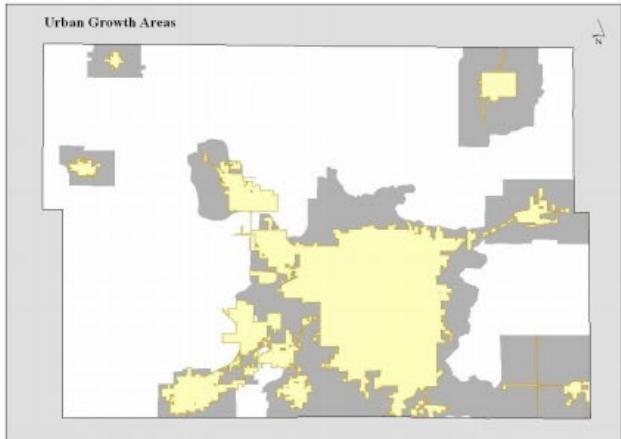
Greene County Urban Growth Areas - 2018



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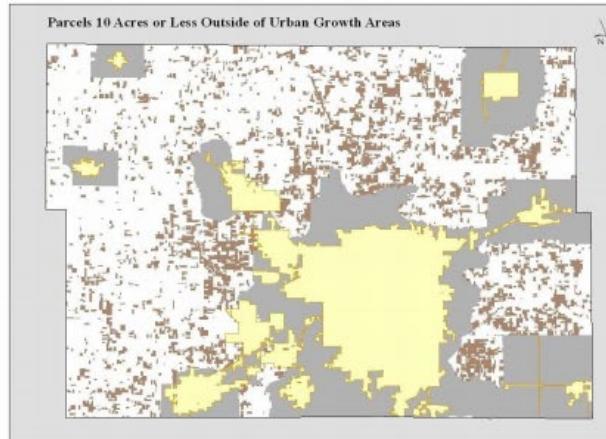
Rural Development Patterns Map - 2018

Fig. 1



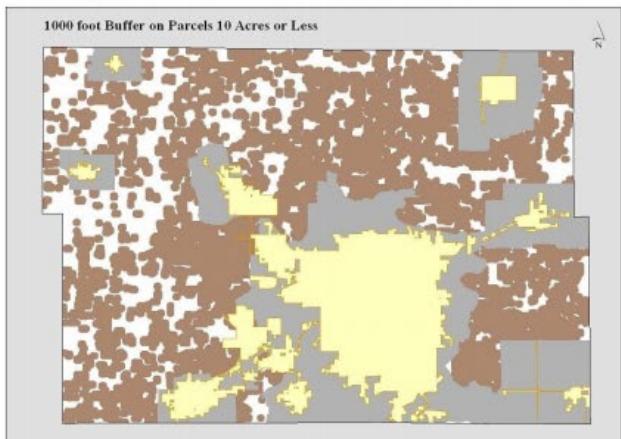
Urban Growth Areas as reported by municipalities

Fig. 2



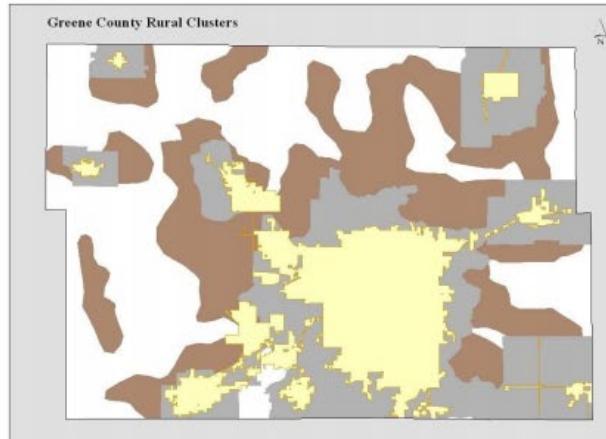
Parcels of ten (10) acres or less

Fig. 3



1,000 ft. buffer surrounding parcels of ten (10) acres or less

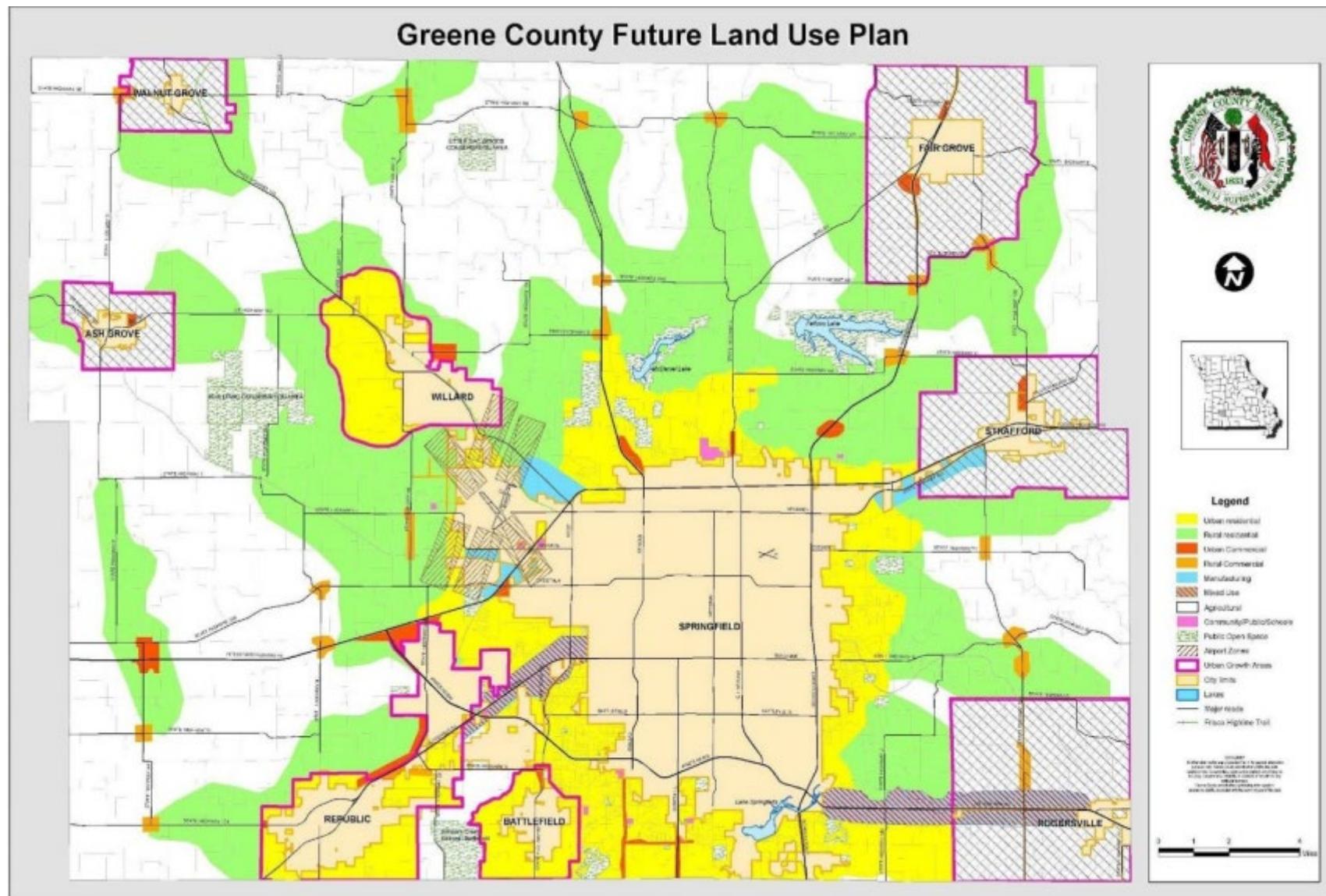
Fig. 4



Rural Clusters

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Future Land Use - 2018



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3.3.3 Jurisdiction Future Development

MUNICIPALITY FUTURE DEVELOPMENT

Ash Grove

The City of Ash Grove has many different available lots that could be used for future development. The City of Ash Grove is looking at a potential large residential development coming to the City. The development could bring 100+ single family homes to the area. This would greatly affect Ash Grove's economy. The development could also impact the school district by increasing the enrollment. Revitalization of Historic Man Street including a bakery, bistro, micro-distillery, shops and event menu are in various stages of preparing to open. The City also has two industrial manufacturing facilities that are seeking new contracts and adding new positions.

Replacement of a police and fire station are being discussed. Options including a joint Public Safety Building housing police, emergency management, EOC, with the possibility of adding the fire department; combined with Community Safe Room/Community Center Gym.

Battlefield

In 2018, it was announced that Russell Cellular was bringing a 40,000 square foot corporate headquarters to Battlefield. The location would be directly off Republic Road and Highway FF. The location is projected to bring 135 new jobs to the area. As of August 2019, the construction of the building was still taking place. There has not been a projected opening date.

Other future growth for the City of Battlefield comes in a residential form. The Township opened in 2019 and consists of 83 independent living, 46 assisted living, and 16 memory care apartments. The Township Apartments are located across from the future Russell Cellular on Republic Road and Highway FF.

Other residential growth that is expected to take place in Battlefield is 200+ houses coming to the city, including one gated community consisting of 7 luxurious houses.

Fair Grove

According to the Fair Grove Comprehensive Plan, there are four areas of focus which are the industrial park and surrounding area, South Orchard Boulevard, Historic Old Wommack Mill and areas directly east of the school campus. The community would also like to see economic, housing, environment community services and transportation development. The following developmental plans came from Fair Grove's Comprehensive Plan which was updated in 2017.

Industrial Park

The industrial park straddles both sides of U.S. Highway 65 without a connection between the two sides. To correct the issue, the industrial park has been consolidated on the western side of the highway, on the south side of Shelby Road in proximity to the fire station. In light of recent rezoning of parcels at the intersection of Shelby Road and Sunset Street to R-4, this area is proposed to be reclassified as multi-family with the lot directly behind the fire station maintained as open space for a potential City park. The parcels on the eastern side of the highway would be re-classified to correctly reflect the current use and in consideration of the surrounding area as sing-family residential.

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South Orchard Boulevard

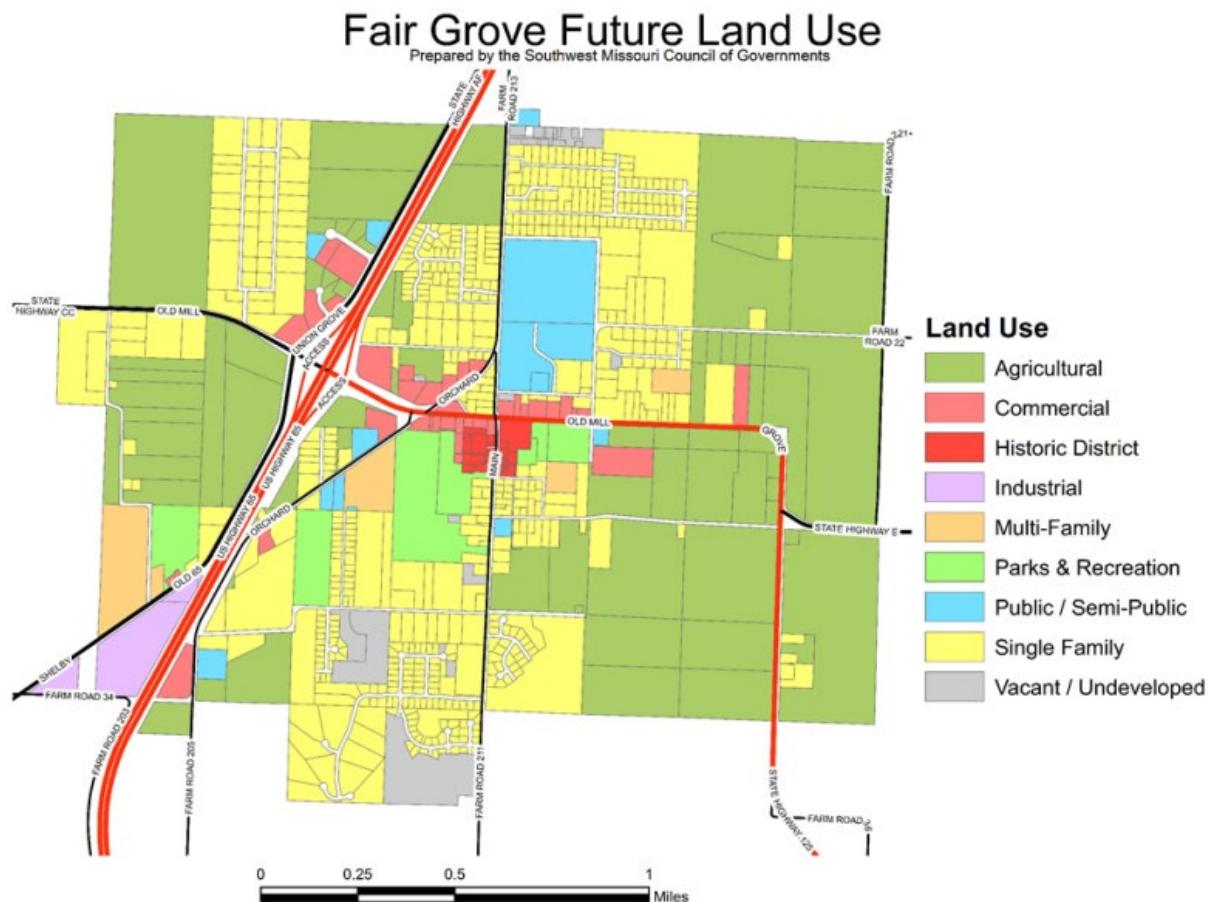
In consideration of the impending development of a senior center and the likelihood of the adjacent land owner developing more senior housing, the adjoining parcel should be reclassified to multi-family to aid in this development. The parcels located near the intersection of Highway 125 and U.S. Highway 65 are proposed to be commercial to support in-fill development, possibly attracting a fast dining-style restaurant.

Old Wommack Mill

In consideration of the intense use this area experiences during festivals, the lots surrounding the Mill should be reclassified as open space and acquired by the Historical Society to limit development and preserve open space for festival use.

Areas Directly East of School Campus

Currently agricultural/open space, this is an area of potential development immediately next to the school campus, a prime location for residential development. This residential development would provide an option for families to locate within walking distance of the schools.



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Republic

The City of Republic has been consistently growing for many years. The City is expected to have more growth over the next several years. There is potentially seven new subdivisions coming to the city with over 120 single family homes. The City is also seeing more commercial development with 23 commercial properties joining the city. A driving range golf course is currently being built across from the Republic High School, located on Republic Road.

Springfield

The City of Springfield is in process of updating their 20 year Comprehensive plan. As of September 2019, the City was just kicking off the planning process and was in phase one which is creating a detailed profile of what Springfield is currently. The Comprehensive Plan with outline land use development, economic development, housing and neighborhoods, transportation and mobility, community facilities, capital improvements and infrastructure, natural resources, resiliency, parks, open space, cultural and historic resources, public health, community character and place making. At this time of writing this plan, development information was not available. The City of Republic has several projects at pre-application stages but due to agreements between individuals and City may not be disclosed.

Strafford

The City of Strafford is in the process of developing the Delp Historic Route 66 Park. This project has been planned by the Strafford Park Committee over the past 3 years. The purpose of the park has several aspects:

- Provide a downtown park as part of the city of Strafford Parks System
- Create a focal point/photo opportunity for Route 66 tourists in Strafford
- Re-create three historic buildings that no longer exist, that were prominent in Strafford's history. Those being the Frisco Depot, Bumgarner Store and Delp Hotel
- Provide location to display historical information regarding the Strafford area.

The re-created Frisco depot will be located immediately east of City Hall. It will be equipped with restrooms and an environmentally controlled area for the display of Strafford historic information. The Bumgarner Store and Delp Hotel facades will be connected to pavilions equipped with outdoor tables.

According to the Greene County Land Use Plan 2018- areas near Strafford and many other areas in Greene County may be appropriate for urban commercial development in the future. As stated in the Greene County Land Use Plan 2018, the areas designated for manufacturing are those which are close to major roadway, air, and rail transportation systems. Areas near the Springfield/Branson National Airport and along State Highway OO (from Springfield to Strafford) are appropriate for manufacturing and industrial uses.

Walnut Grove

As of now, there are no major developments planned for Walnut Grove.

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Willard

The City of Willard and MODOT is currently working on “US Highway 160 Project by MODOT”. The project will have the following:

- Widen Route 160 to four lanes between I-44 in Springfield and Jackson Street in Willard
- Resurface the existing lanes of Route 160 between I-44 in Springfield and Route AB in Willard
- Traffic barrier all between lanes in areas
- Intersection improvements:
 - J-Turn at Farm Road 123/Westgate Avenue
 - Right-in/Right-out at Haseltine Road (Farm Road 115)
 - Roundabout at Farm Road 94 near quarry
 - Add left-turn lane at Hughes Road
 - Roundabout at Farm Road 103/Melville Road/Hunt Road
 - Add a pedestrian underpass at Hunt Road
 - Roundabout at Jackson Street
 - Add turn lanes at Greene County Route AB

The project will start construction in mid-summer 2019 and will continue until late 2020. Some traffic impacts include, lane closing at times on Route 60 and side streets closes at times for connection into new highway lanes. The image below demonstrates the Highway 160 project.



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SCHOOL DISTRICT FUTURE DEVELOPMENT

Ash Grove Public School District

In order for the Ash Grove school district to expand and grow, more housing and development needs to take place within the school district boundaries.

Fair Grove Public School District

In the City of Fair Grove's Comprehensive Plan, Goal One of Community Services Section is to continue support for local schools and parks systems. Objective two specifically mentions the Fair Grove School District. The District would like to encourage dual-enrollment programs through OTC.

The district has plans to remodel the bathrooms in the high school. They also would like to build a bus bay with a fuel take on site. Other projects include remodels to different areas of the elementary school and replacing air conditions systems on all buildings.

Republic Public School District

The school district completed a project from the previous mitigation plan to improve traffic in front of the high school on Route M. A round-a-bout was placed at one of the entrances to the high school to help the flow of traffic. The project was completed for the start of the 2019 school year. The school district is also looking to improve the intersection of Highway ZZ and Hines Street by Republic High School.

Springfield Public School District

The Springfield School District passed a tax in April of 2019 that would give the district money to complete 39 projects in the next three years. The initial wave of projects in the bond issue known as "Proposition S" includes:

- Construction on an early childhood center on the campus of Carver Middle School
- Demolition and construction of a larger, reconfigured Delaware Elementary
- Renovation and expansion of Sunshine Elementary

Other projects funded by the bond include:

- Secure entrances at 31 schools
- Construction of a new Boyd Elementary at Division Street and Sherman Avenue and a new Jarrett Middle School on the Campus of Portland Elementary.
- Renovation of Williams Elementary and addition of a preschool mini-hub
- Reconfiguration and renovation of a significant portion of Hillcrest High School

Strafford Public School District

The Strafford Public School District is planning on building a new elementary building. They also have plans to renovate the old elementary, high school and middle school building.

Walnut Grove Public School District

As of now, there are no major development plans for the Walnut Grove Public School District.

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Willard Public School District

The Willard School District has plans to build FEMA safe rooms in multiple different schools to protect both students and staff member from severe weather and tornados. No other future development plans are in place at this time. The district is projected to have a 2% annual increase in enrollment. Roadway improvements are taking place in the City of Willard that could boost traffic and development in the Willard School District area.

SPECIAL DISTRICT FUTURE DEVELOPMENT – FIRE PROTECTION DISTRICTS

Ash Grove Fire Protection District

The City of Ash Grove is looking at potentially building that would be a multi-purpose emergency response building including a police station, fire station, Emergency Operations Center, Community Gym, etc. The plans are still being discussed and no official action has been taken.

Battlefield Fire Protection District

No major development is planned for the Battlefield Fire Protection District.

Ebenezer Fire Protection District

No major development is planned for the Ebenezer Fire Protection District.

Fair Grove Fire Protection District

No major development is planned in the Fair Grove Fire Protection District

Logan-Rogersville Fire Protection District

No major development is planned in the Logan-Rogersville Fire Protection District.

Strafford Fire Protection District

No major development is planned in the Strafford Fire Protection District.

Walnut Grove Fire Protection District

No major development is planned for the Walnut Grove Fire Protection District.

Willard Fire Protection District

The Willard Fire Protection District is steadily growing at around 4% each year. The District is stretch then as far as labor and equipment costs to provide the best the community. There is now major development planned for the district, but expansion could be needed in the future.

SPECIAL DISTRICT FUTURE DEVELOPMENT – UNIVERSITIES

Missouri State University

Over the last 5 years, Missouri State has done many renovations and construction including the Glass Hall remodel that was completed in October of 2017. Other projects included improvement to academic facilities like Ellis Hall that was completed in September of 2017. Another addition to the campus was a new design and construction of a health and wellness center. The center is twice the size of the old facility and is located at the same site. This project was completed in March of 2018.

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The University has many planned projected including a renovation to Hill Hall that will improve access and provide modernization of the building that was built in 1924. The project will include electrical and mechanical system upgrades and improvement to lab, office and classroom space.

There is also plans for a new residence hall located near the downtown area. The facility will reflect the historical surrounding and is designed to engage the street life with the building occupants.

The University is also looking to add a multi-purpose addition to the southwest corner of the Greenwood Laboratory School near the intersection of Bear Boulevard and Hampton Street Transit way. This is currently the location of the outdoor paved basketball court. The addition is to include a new south “front” entrance, an adjacent office, a lobby supporting the school, restrooms, and a multipurpose center capable of seating eight hundred people. The existing utility building will be incorporated into the final design plan.

The University also has plans to add on to the Plaster Center. There is a necessity for a build out of approximately 30,000 square feet of unusable space within the Robert W. Plaster Center for Free Enterprise in order to accommodate the expansion of the cooperative Missouri State University and Missouri University of Science and Technology engineering program.

Some possible future projects include:

- Alumni Events Center
- Renovations to Carrington Hall
- Redesigned and modernize Cheek Hall
- Craig Hall Renovation
- Electronic Arts Building
- Intermodal Transfer Station
- Indoor Practice Facility
- Jordan Valley Innovation Center
- Renovation of Kemper Hall
- Grand Street improvements
- Renovation to McDonald Hall
- Improvements to Meyer Library
- Multicultural Center
- Ozarks Science Center
- Professional Building
- Student Union Expansion
- Renovation of Temple Hall
- Tent Theatre Pavilion
- Welcome Center-New Bookstore
- Theatre and Dance Building

Ozark Technical Community College

Ozark Technical Community College is currently building a new campus located in Republic. The campus will be located alone U.S 60 highway and is projected to be finished August 2020. The \$7.29 million project is the largest and most visible result of a tax proposal approved in April 2019 to expand funding for OTC.

The College also Plans to construct a Center for Advancement Manufacturing building. The college also is planning on remodeling Lincoln hall historic building.

OTC is projected to see a 6.1% increase of enrollment in the next five years.

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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, locations, strength/magnitude/extent, previous events, future probability, a discussion of risk variation between jurisdictions, and how anticipated development could impact the 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 events.

All hazards will be profiled individually in alphabetical order by category. Greene County has three different categories of hazards: natural, technological and human-caused. For this plan, Damaging Winds, Lightning and Hail have been grouped into one hazard profile, "Severe Thunderstorms". Extreme Cold and Extreme Heat have also been grouped into one hazard profile, "Extreme Temperatures". The hazards "Ice and Snow" have been renamed in the Hazard Profile to "Severe Winter Weather". Greene County still considers these as separate hazards and will be discussed with great detail in the hazard profile. 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 profiled for each identified hazard 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 Greene County that are affected by the 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. 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 record help form a solid basis for probability calculations.
- **Probability of Future Occurrence:** The frequency of recorded past events is used to estimate the likelihood of future occurrences.
- **Changing Future Conditions Considerations:** In addition to the probability of future occurrence, changing future conditions should also be considered, including the effects of long-term changes in weather patterns and climate on the identified hazards.

VULNERABILITY ASSESSMENTS

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

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

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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 in Greene County Multi-Jurisdictional Hazard Mitigation Plan 2020-2025 will be based on:

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

Within the Vulnerability Assessment, the following headers will be addressed:

- **Vulnerability Overview:** This section will provide an overall summary of each jurisdiction's vulnerability to the identified hazards. The overall summary of vulnerability identifies structures, systems, populations or other community assets as defined by the community that are susceptible to damage loss for hazard events.
- **Potential Losses to Existing Development:**
- **Previous and Future Development:** This section will include information on how changes in development have impacted the community's vulnerability to this hazard.
- **Hazard Summary by Jurisdiction:** This section will provide an overview of the variation and factual basis for the variation.

PROBLEM STATEMENTS

Each hazard analysis will conclude with a brief summary of the problems created by the hazard in the planning areas, and possible ways to resolve those problems.

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3.4.1 Natural Hazard: Drought

HAZARD PROFILE

Hazard Description

Droughts is generally defined as a condition of moisture levels significantly below normal for an extended period 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 in 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 plants, 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.



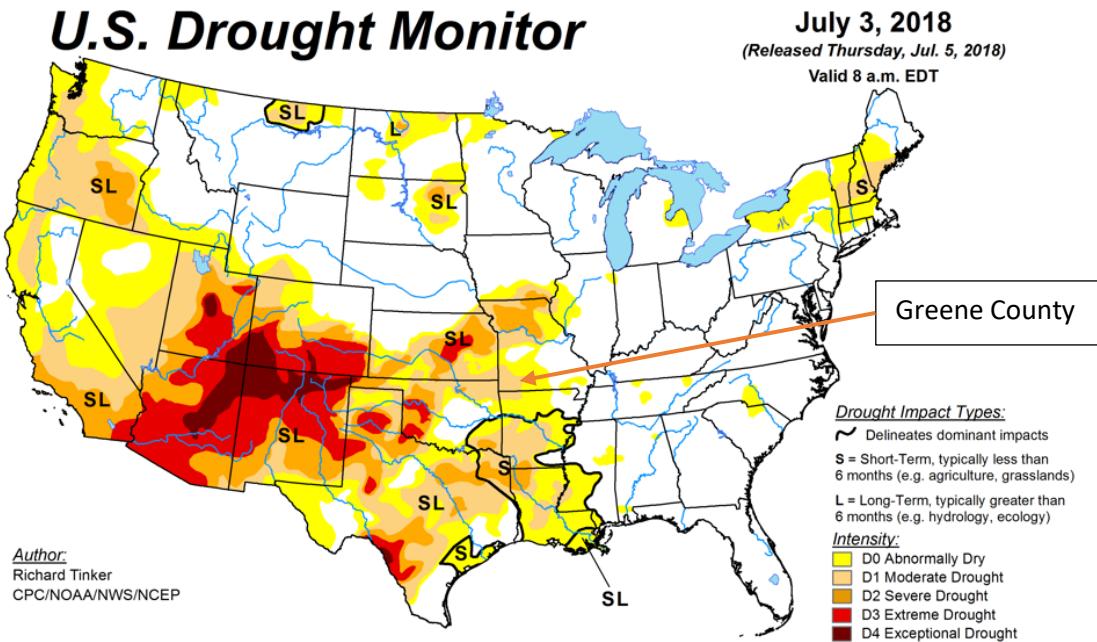
Geographic Location

The entire planning area is at risk to drought. Drought most directly impacts the agricultural sector. There are approximately 253,310 acres in Greene County that is used for farming. Farming is spread across all jurisdictions in Greene County.

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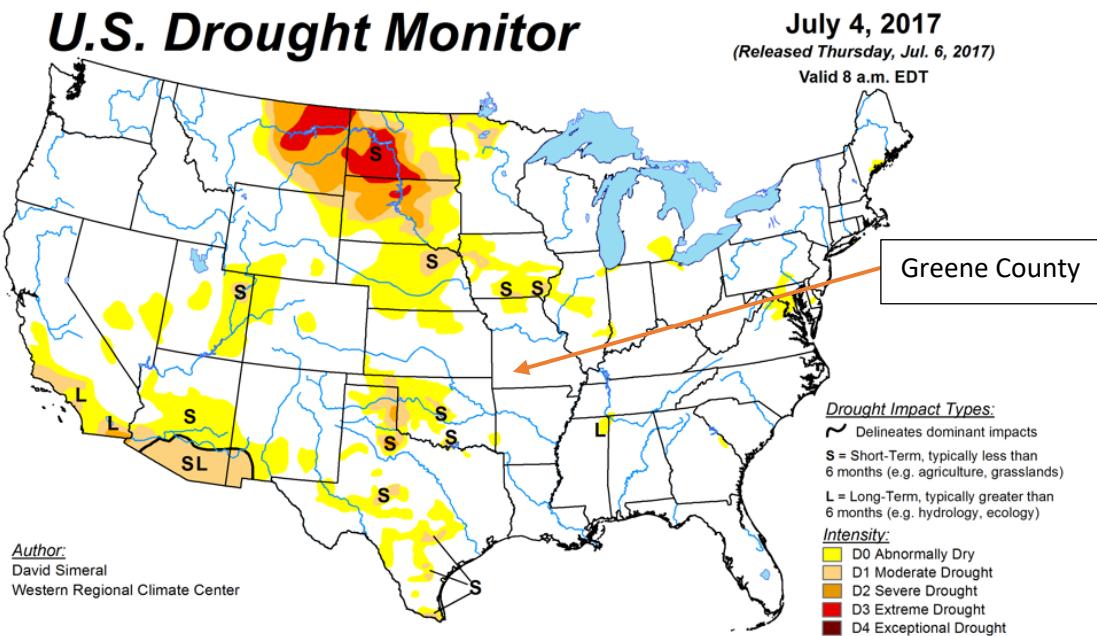
U.S. Drought Monitor Map of Missouri-Trends

July 2018



Source: <https://droughtmonitor.unl.edu/maps/maparchive.aspx>

July 2017



Source: <https://droughtmonitor.unl.edu/maps/maparchive.aspx>

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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.

Palmer also developed a formula for standardizing drought calculations for each individual locations based on 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.

Palmer Drought Severity Index

MEASURE	MEANING
Above 4.0	Extreme Moist Spell
3.0 to 3.9	Very Moist Spell
2.0 to 2.9	Unusually Moist Spell
1.0 to 1.9	Moist Spell
0.5 to 0.9	Incipient Moist Spell
0.4 to -0.4	Near Normal Conditions
-0.5 to -0.9	Incipient Drought
-1.0 to -1.9	Mild Drought
-2.0 to -2.9	Moderate Drought
-3.0 to -3.9	Severe Drought
Below -4.0	Extreme Drought

Previous Occurrences

January – April 2006

Greene County did experience drought from January to April of 2006 due to a lack of precipitation in the winter months. As spring began, Greene County began to have more events producing enough precipitation to rectify the drought conditions. There were no reports of property or crop damage during this drought.

Insured Crop Loss Payments-2018

YEAR	CROP	REASON	TOTAL AMOUNT OF LOSS
2018	Corn	Drought	\$3,547.00
2018	Corn	Drought	\$145,227.44
2018	Corn	Drought	\$105,455.13
2018	Soybeans	Drought	\$2,161.00
2018	Soybeans	Drought	\$91,461.80
2018	Soybeans	Drought	\$94,276.72
Source: rma.usda.gov/data/cause.html			TOTAL: \$442,129.09

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Insured Crop Loss Payments-2017

YEAR	CROP	REASON	TOTAL AMOUNT OF LOSS
2017	Corn	Drought	\$3,969.00
2017	Soybeans	Drought	\$4,930.50
2017	Soybeans	Drought	\$12,517.00
Source: rma.usda.gov/data/cause.html		TOTAL:	\$21,143.50

Insured Crop Loss Payments-2016

YEAR	CROP	REASON	TOTAL AMOUNT OF LOSS
2016	Corn	Drought	\$33,277.00
2016	Soybeans	Drought	\$8,168.00
Source: rma.usda.gov/data/cause.html		TOTAL:	\$41,445.00

Insured Crop Loss Payments-2015

YEAR	CROP	REASON	TOTAL AMOUNT OF LOSS
2015	Soybeans	Drought	\$874.50
Source: rma.usda.gov/data/cause.html		TOTAL:	\$874.50

Over the last 5 years, the amount of crops effected by drought have increased. Insurance payouts have greatly increased from 2015 to 2018. The charts above are only displaying amounts that only insured farmers have received money. It is safe to say that many more crops in the planning area have been affected by drought over the last five years.

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Previous Events 2010-2018

BEGIN DATE	END DATE	NAME OF EVENT	DESCRIPTION
06/01/2018	03/25/2019	Missouri Cattle Deaths	Drought during the summer reduced available hay and grass supplies, leaving farmers to feed questionable quality hay to their livestock. Hay that was given had large amounts of Nitrates, causes up to 200 cattle deaths across the state (including Greene County)
10/11/2018	N/A	High Nitrate Levels	Missouri Farmers were warned to test baled cornstalks before feeding because the droughty summer caused high levels of nitrates.
08/05/2018	08/05/2018	Crops Suffering	Grass was brown and crunchy, farm crops were suffering. Tree leaves were turning yellow due to lack of moisture.
04/16/2017	N/A	Toxic Fescue	All Missouri Farmers were warned that forages under stress from the winter drought and warm spring might set seed heads early.
06/01/2016	03/21/2017	Livestock Water Shortage and Grass Fires	As drought conditions worsened in SW Missouri, water sources for livestock such as streams and ponds were decreasing. Fire departments reported many grass fires effects crops.
06/15/2012	07/02/2012	Crops Struggling	Many reports of failed corn acres, cattle water supply very low, farmers buying hay from other states and starting to feed.
01/09/2013	05/16/2013	USDA Disaster Declaration	USDA declared many counties (Including Greene) as primary and secondary disaster areas related to drought in January
07/21/2011	N/A	Drought Increasing Cost of Hay	Drought has decreased the hay supply and driven up the cost of hay, making it a challenge for Greene County farmers to replace hay lost.
07/01/2011	10/18/2011	USDA Disaster Declaration	USDA declared many counties (Including Greene) as primary and secondary disaster areas related to drought from July 1-August 30.

Source: droughtreporter.unl.edu

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Probability of Future Occurrence

The probability for hazards in Greene County is determined using Calculated Priority Risk Index (CPRI). It is probable for a drought to occur within the next three years in Greene County. For a full description of the CPRI for droughts, refer to Appendix B.

Changing Future Conditions and Considerations

According to the Missouri State Hazard Mitigation Plan, severe drought is a natural part of Missouri and Greene County's climate. Future increases in evaporation rates due to higher temperatures may increase the intensity of naturally-occurring droughts. Although Greene County typically receives wetter weather in the spring, summer droughts are likely to be more severe. Higher evaporation and lower summer rainfall are likely to reduce river flows.

The number of heavy rainfall events is predicted to increase, yet researchers currently expect little change in total rainfall amounts, indicating that the periods between heavy rainfalls will be marked by an increasing number of dry days.

VULNERABILITY

Vulnerability Overview

The Missouri State Hazard Mitigation Plan places Greene County in Region B when looking at droughts. Region B is central and east-central Missouri. According to the plan, Region B has moderate drought susceptibility. Groundwater resources are adequate to meet domestic and municipal water needs, but due to required well depths, irrigation wells are very expensive. The topography is generally unsuitable for row-crop irrigation.

Potential Losses to Existing Development

The National Drought Monitor Center at the University of Nebraska at Lincoln summarized the potential impacts of drought as follows: Drought can create economic impacts on agriculture and related sectors, including forestry and fisheries, because of the reliance of these sectors on surface and subsurface water supplies. In addition to losses in yields in crop and livestock production, drought is associated with increases in insect infestations, plant disease, and wind erosion. Droughts also bring increased problems with insects and diseases to forest and reduce growth. The incidence of forest and range fires increase 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.

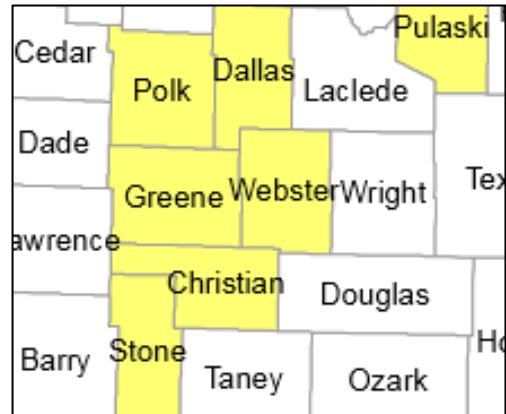
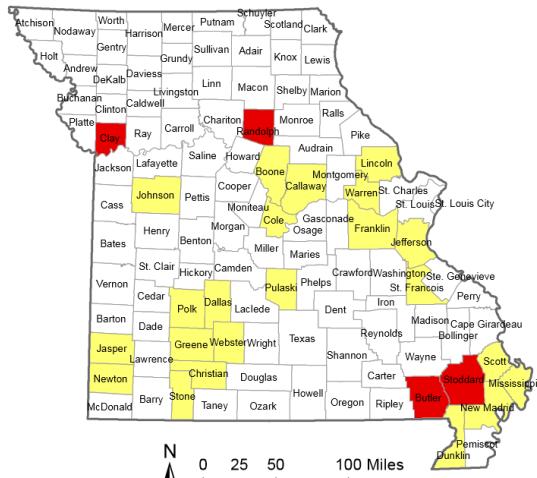
Droughts can put Greene County's agriculture and rural areas at risk. Droughts may also cause Greene County to become more susceptible to urban or wildfires. A drought accompanied by extreme heat incidents can be especially harmful and devastating.

A new analysis, performed for the Natural Resources Defense Council, examined the effects of climate change on water supply and demand in the contiguous United States. The study found that more than 1,200 counties would face higher risk for 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.

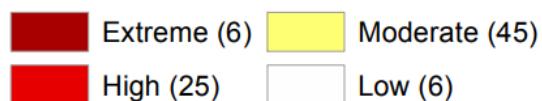
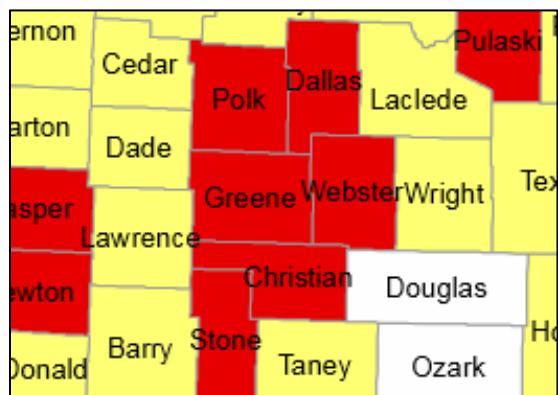
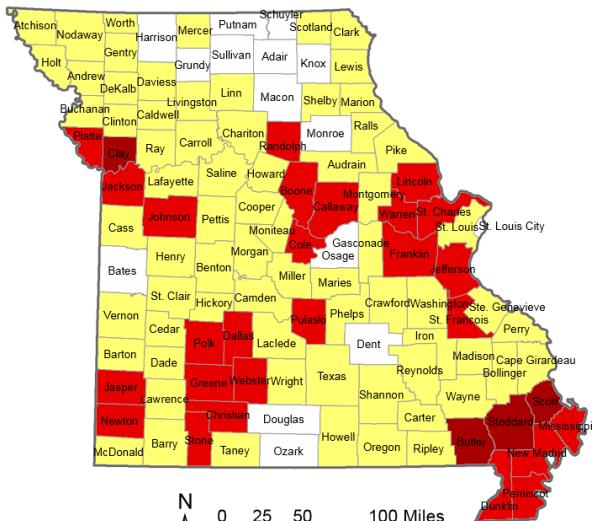
3 - RISK ASSESSMENT

Below is the water sustainability for Greene County with and without climate change:

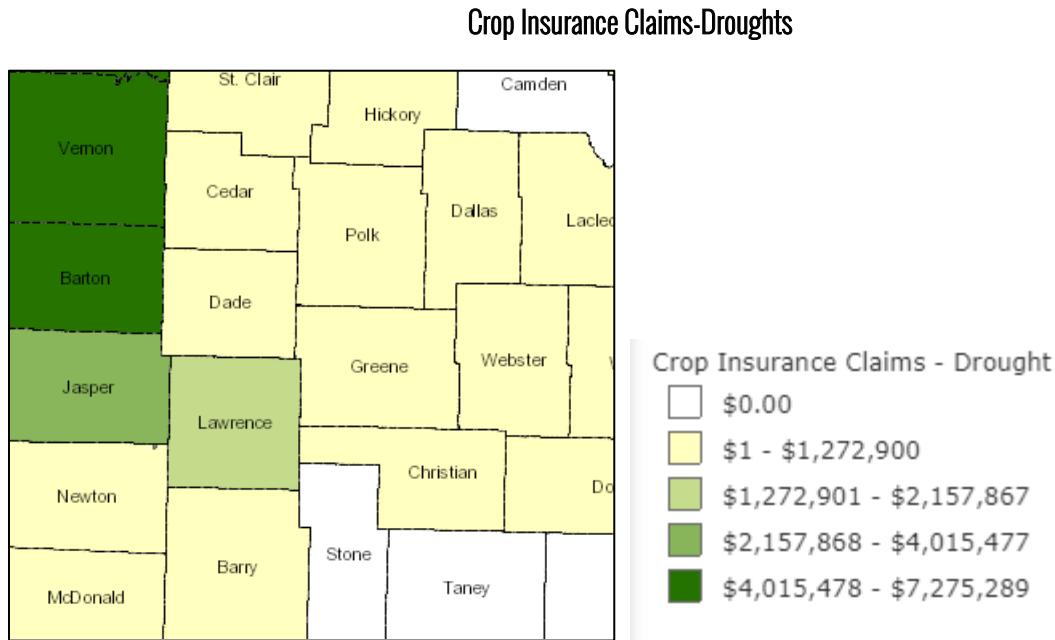
Missouri Water Sustainability without Climate Change-Year 2050



Missouri Water Sustainability with Climate Change-Year 2050



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Impact of Previous and Future Development

Greene County is a growing community. As the population of the county grows, the risk of more people being affected by drought grows as well. When the population grows in a community, so does the demand for treated water, but this can add additional strain on water supply systems. There is plenty of land in Greene County that isn't being used for anything specific at this moment, leaving room for both urban and agricultural development. Increases in acreage planted with crops could cause more agricultural losses if the planning area suffered a severe drought.

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EMAP Consequence Analysis

EMAP Impact Analysis: Drought

SUBJECT	DETERRIMENTAL IMPACTS
Public	Droughts can create many safety concerns. Wildfires and urban fires are at elevated risk during droughts. Droughts can pose threats to citizens through water shortages and extreme heat that is often accompanied by droughts. Children, the elderly, and those with respiratory problems are at elevated risks. Illnesses can also come from contaminated water. These elements create multiple safety concerns.
Responders	Greene County has no reports on life threatening situations to responders or any impact to response function due to a drought. Responders can be vulnerable to fatigue and this can cause response functions to be impacted.
Continuity of Operations	There have been no reports of impact on service operations due to droughts in Greene County.
Property, Facilities, and Infrastructure	Property damage is often minor but is impacted especially when considering the issues that may arise due to a water shortage. There have been no reports of infrastructure damages due to droughts in Greene County. However, water shortage can create an impact to some infrastructure.
Environment	Significant widespread damage has occurred in Greene County due to drought incidents. The environment can take years to recover from droughts. Wildfires and wildlife is also highly affected. Water and soil contamination is also probable.
Economic Condition of Jurisdiction	Many rural areas depend on crops and livestock, while the cities need a large amount of water to support the larger populations. Many rural homes and areas that survive off their own wells will also suffer greatly from a drought.
Public Confidence in the Jurisdiction's Governance	Public confidence can be affected if food and water supplies are scarce. This factor is heavily depended on how the crisis is handled by the government.

*For more details on Consequence Analysis, refer to Appendix B.

Hazard Summary by Jurisdiction

All jurisdictions in Greene County could be affected by extreme droughts. In cities, the drought conditions would be the same as those experiencing drought in rural areas, but the impacts could be different. For example, areas with local gardens could be impacted more than areas without gardens. All areas could see a decrease in water supply across the areas affecting homes, businesses and schools.

PROBLEM STATEMENT

Droughts can be extreme hazards that can last months or even years. Droughts pose a threat to all areas in Greene County. Jurisdictions with agriculture are more likely to see larger impacts from droughts. Droughts can come at any given point in a year, though more susceptible during the summer months. Drought can lead to decreases in

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water supply, loss in agriculture crops and can even effect the public's health. Mitigation actions for droughts include public education, public shelters that provide drinking water and drought monitoring. Participating Jurisdictions did not include drought mitigation projects in this Mitigation Plan.

3.4.2 Natural Hazard: Earthquake

HAZARD PROFILE

Hazard Description

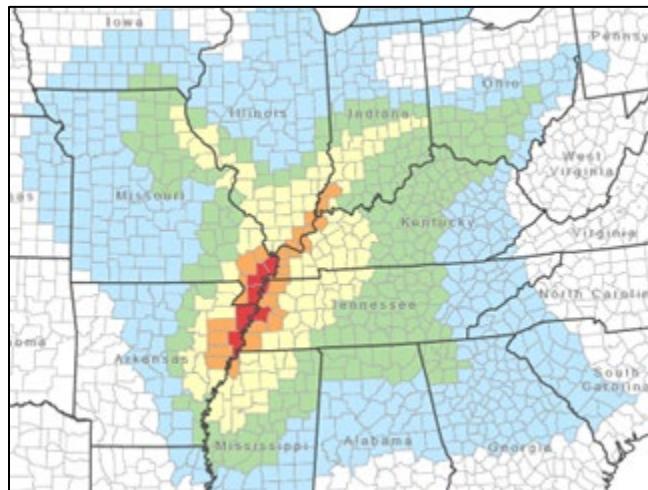
An earthquake is a sudden motion or trembling that is caused by a release of energy accumulated within or along the edge or the earth's tectonic plates.

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 earth quake 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.



Geographic Location

New Madrid Seismic Zone



According to The Missouri Department of Natural Resources, The New Madrid Seismic Zone (NMSZ) is the most active seismic area in the United States, east of the Rocky Mountains. The NMSZ is located in southeastern Missouri, northeastern Arkansas, western Tennessee, western Kentucky and southern Illinois. The active faults in the NMSZ are poorly understood because they are not expressed at the ground surface where they can be easily studied. The faults are hidden beneath 100-200-foot thick layers of soft river deposited soils called alluvium. Microseismic earthquakes (magnitude less than 1.0 to about 2.0), measured by seismographs but not felt by humans, occur on average every other day in the

NMSZ. A large earthquake from the New Madrid Seismic Zone would affect all of Missouri, including Greene County and potentially many other states across the country.

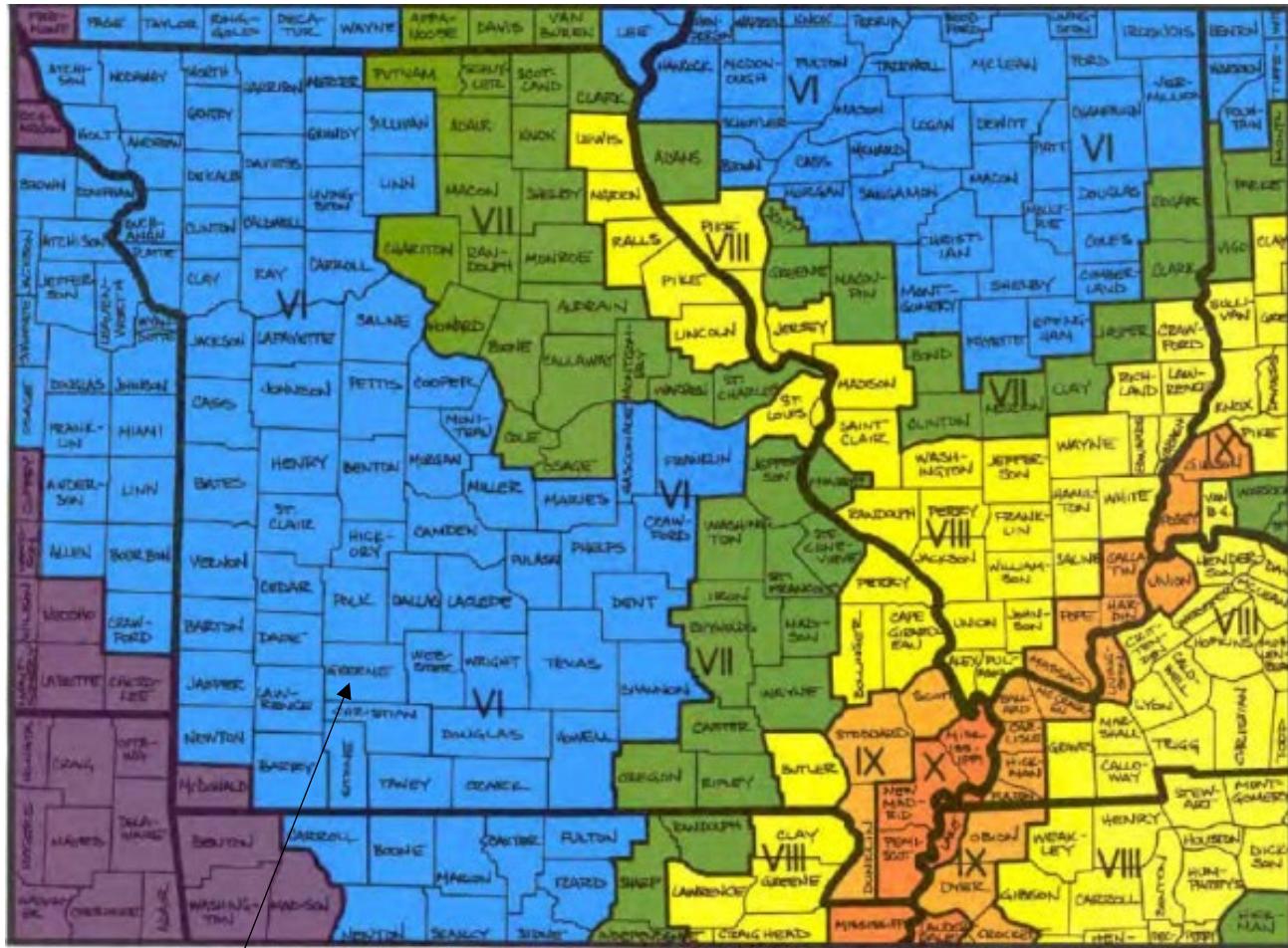
Nemaha Ridge

The Nemaha Ridge, also known as the Nemaha Uplifts, is located in the Central United States. It is a buried structural zone associated with a granite high in Pre-Cambrian basement that extends from approximately Omaha, Nebraska to Oklahoma City, Oklahoma. The ridge is associated with the seismically active Humboldt Fault zone. It

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is also associated with the Proterozoic Midcontinent Rift System, which extends into northern Kansas about fifty miles west of the Nemaha. Earthquakes produced from this area are not as severe as the New Madrid Seismic Zone.

Impact Zones for Earthquake Along the New Madrid Fault



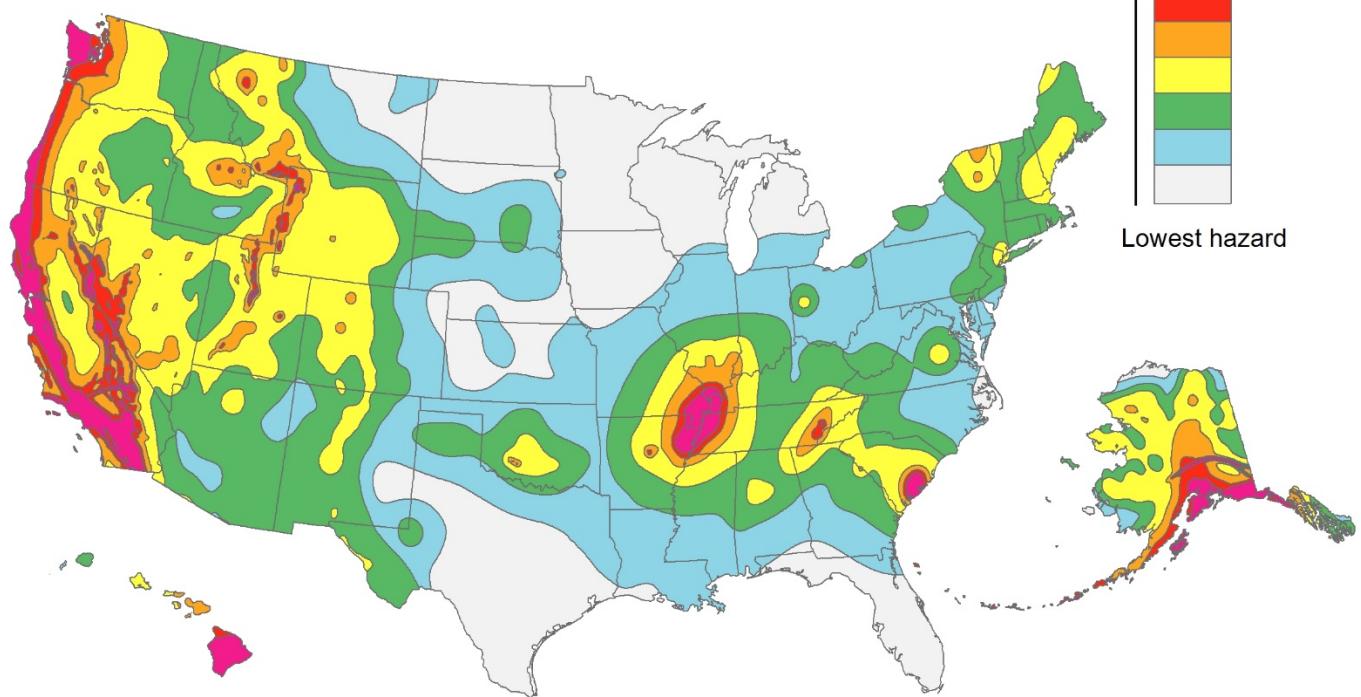
Greene County

This graphic shows the highest project Modified Mercalli intensities from a potential 7.6 earthquake whose epicenter could be anywhere along the New Madrid Seismic Zone.

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Modified Mercalli Intensity Scale			
I	Instrumental: detected only by instruments	VII	Very strong: noticed by people in autos Damage to poor construction
II	Very feeble: noticed only by people at rest	VIII	Destructive: chimneys fall, much damage in substantial buildings, heavy furniture overturned
III	Slight: felt by people at rest Like passing of a truck	IX	Ruinous: great damage to substantial structures Ground cracked, pipes broken
IV	Moderate: generally perceptible by people in motion Loose objects disturbed	X	Disastrous: many buildings destroyed
V	Rather strong: dishes broken, bells rung, pendulum clocks stopped People awakened	XI	Very disastrous: few structures left standing
VI	Strong: felt by all, some people frightened Damage slight, some plaster cracked	XII	Catastrophic: total destruction

United States Seismic Hazard Map



Sources: United States Geological Survey

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Strength/Magnitude/Extent

The extent or severity of earthquakes is generally measured in two ways: 1) The Richter Magnitude Scale is a measure of earth quake 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 earthquake is ten times bigger in magnitude. Each whole number increase in magnitude represent a tenfold increase in measured amplitude because of the logarithm. Each whole number step in the magnitude scale represents a release of approximately 31 times more energy.

Modified Mercalli Intensity Scale

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

Previous Occurrences

New Madrid 1811-1812

A series of three very large earthquakes in the years 1811-1812 are generally referred to as the New Madrid earthquakes. On the basis of the large area of damage (600,000 square kilometers), the widespread area of perceptibility (5,000,000 square kilometers), and the complex physiographic changes that occurred, the New Madrid earthquakes of 1811-1812 rank as some of the largest in the United States. These earthquakes were by far the largest east of the Rocky Mountains in the U.S. and Canada. Damage associated with these earthquakes was 10 times as large as that of the damage from the 1906 San Francisco earthquake.

Probability of Future Occurrence

The probability for hazards in Greene County is determined using Calculated Priority Risk Index (CPRI). It is unlikely for an earthquake to occur within the next 10 years in Greene County. For a full description of the CPRI for earthquakes, refer to Appendix B.

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Changing Future Conditions and Considerations

According to the 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

The impacts and severity of earthquakes in Missouri can be significant. Counties closer to the New Madrid Fault could potentially see catastrophic damage. Greene County is placed in the “VI” portion of the Modified Mercalli Intensity Scale in the event of a 7.6 magnitude earthquake in the NMSZ. This means that the entire planning area could feel ground movement. There is a risk for poorly built buildings being damaged. Glasses and dishes could be broken. People even could have trouble walking at some points. Pictures could fall off walls and cracks may appear in the plaster in walls. Greene County would also be at risk for an influx in population as people who are closer to the fault, may evacuate to portions of Greene County.

Missouri Earthquake Insurance

Missouri is the third largest market for earthquake insurance among the states, exceeded only by California and Washington. Earthquake coverage is not included on most homeowner's insurance policies. It must be purchased as separate coverage. Earthquake coverage pays for damage caused by the shaking and cracking that can damage homes. Earthquake insurance usually features two high deductibles; rather than dollar amounts, it's a percentage of the cost of rebuilding the home and a separate deductible for the home's contents. Deductibles of 10-15 percent are common. The Missouri Department of Insurance, Financial Institutions and Professional Registration (DIFP) prepared a report in August 2015 on the state of earthquake coverage in Missouri. The report notes that earthquake coverage has become less available and less affordable over the last 15 years.

Potential Losses to Existing Development

Annualized Loss Scenario- Completed in Missouri State Mitigation Plan

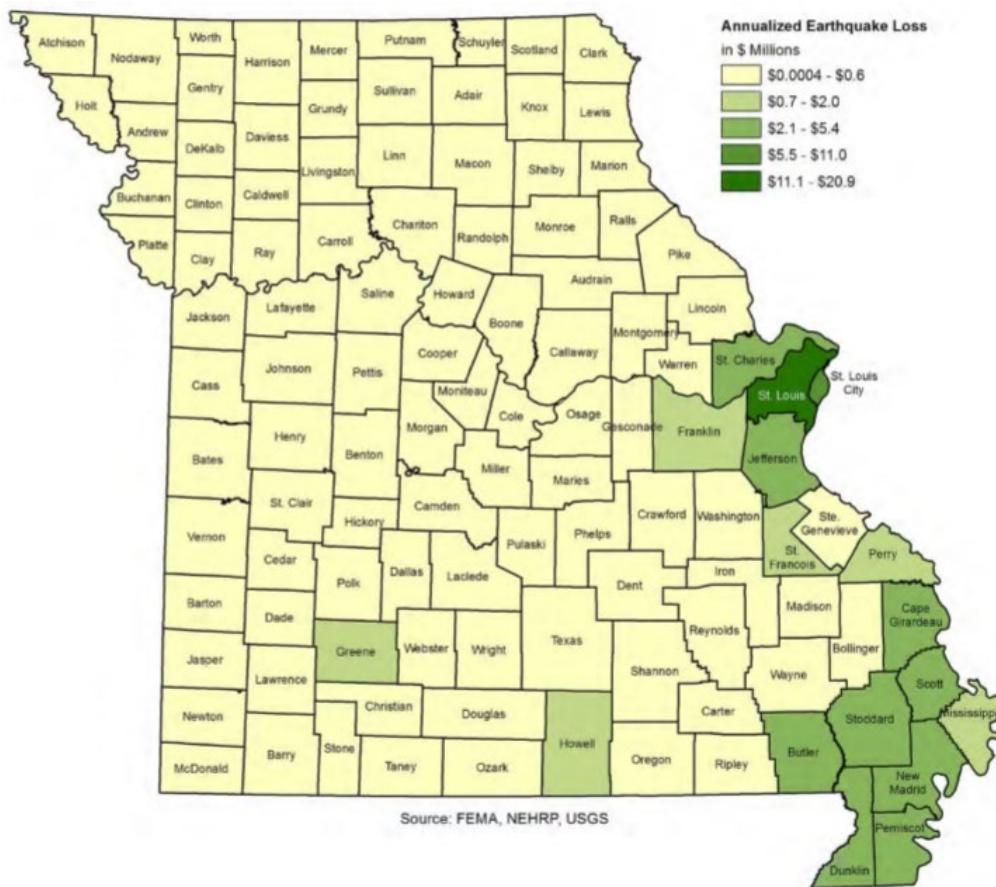
Hazus V 3.2 was used to analyze vulnerability and estimate losses to earthquakes. All Hazus analyses were run using Level 1 building inventory database comprised of updated demographic and aggregated data based on the 2010 census. An annualized loss scenario that enabled an “apples to apples” comparison of earthquake risk for each county was synthesized from a FEMA nationwide annualized loss study (FEMA 366 Hazus Estimated Annualized Earthquake Losses for the United States April 2017). The Central United States Earthquake Consortium provided state-wide National Earthquake Hazards Reduction Program (NEHRP) site classification and soil liquefaction characteristics. Furthermore, the Missouri Department of Natural Resources provided more detailed, quad-based NEHRP site classification and soil liquefaction characteristics for the areas surrounding the City of St. Louis. These data sets were used as additional, Level 2 data inputs to enhance the accuracy of earthquake hazard modeling. It should be noted that some of the National Earthquake Hazard Reduction Program (NEHRP) site classification attributes were slightly altered for incorporation into the Hazus platform. Areas that were classified as “C to D” were reattributed as “D” since in these instances Hazus does not allow the data in its original format. State

The results of the updated annualized loss scenario are shown in Figure 3.91. The map shows direct economic losses to buildings annualized over eight earthquake return periods (100, 250, 500, 750, 1,000, 1,500, 2,000, and

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2,500 years). HAZUS defines annualized loss as the expected value of loss in any one year. The software develops 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 various return periods averaged on a 'per year' basis. It is the summation of all HAZUS supplied return periods multiplied by the return period probability (as a weighted calculation). This is the scenario that FEMA uses to compare relative risk from earthquakes and other hazards at the county level nationwide. The trend shows dollar losses to be most significant in the southeastern portion of the State and in the urbanized areas near St. Louis. This is consistent with the southeastern portion of the State's proximity to the New Madrid Seismic Zone and the fact that the more developed areas in the region are likely to suffer the most building losses, particularly where there are large numbers of unreinforced masonry buildings.

HAZUS-MH Earthquake Loss Estimation: Annualized Loss Scenario-Direct Economic Losses to Buildings

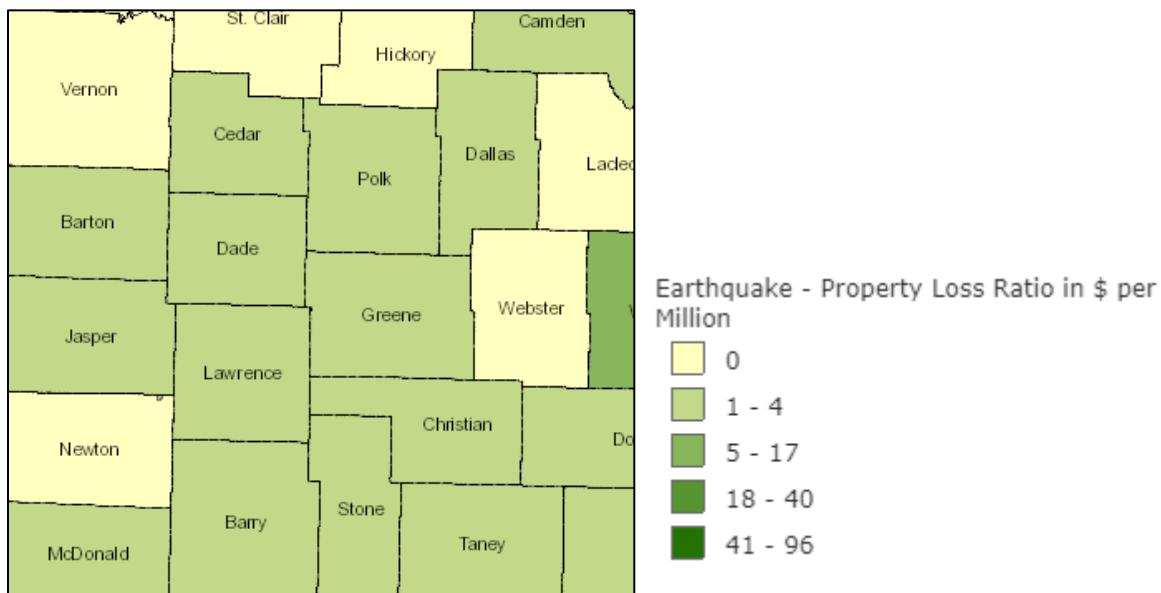


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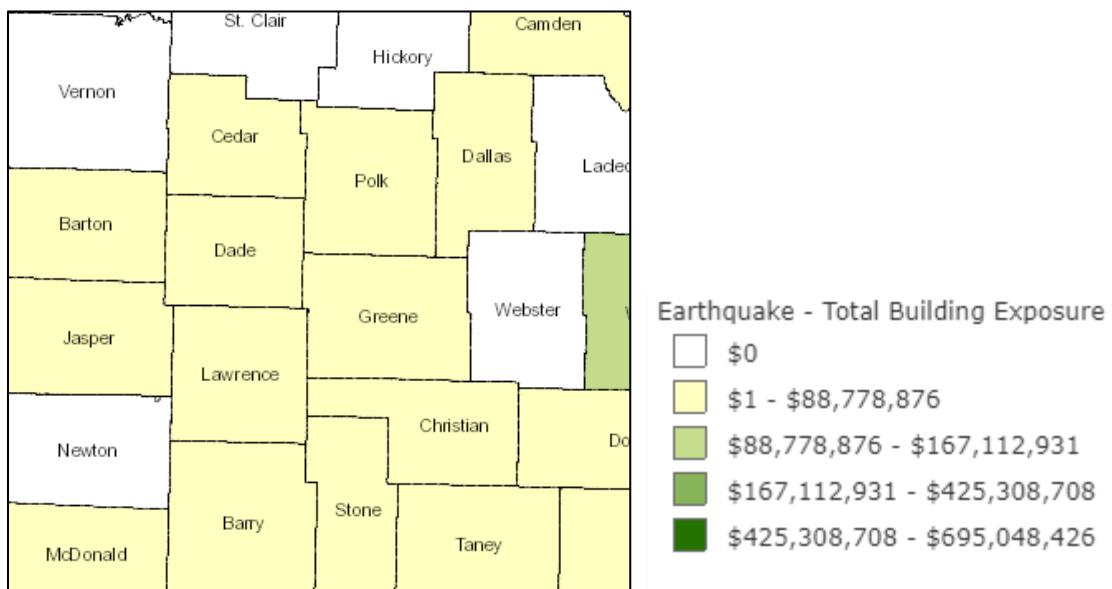
HAZUS-MH Earthquake Loss Estimation: Annualized Loss Scenario

COUNTY	TOTAL LOSSES, IN \$ THOUSANDS	LOSS PER CAPITA, IN \$ THOUSANDS	LOSS RATIO, IN \$ PER MILLION
Greene	\$1,337	\$0.0049	\$42

Earthquake-Property Loss Ratio in \$ per Million



Earthquake-Total Building Exposure



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Impact of Previous and Future Development

Future development is not expected to increase the risk other than contributing to the overall exposure of what could become damaged as a result of an event.

EMAP Consequence Analysis

EMAP Impact Analysis: Earthquakes

SUBJECT	DETERRIMENTAL IMPACTS
Public	An earthquake that affected Greene County would most likely result in few minor injuries and no deaths. There would be small safety concerns for the public.
Responders	There would be little to no impacts on responders and response function in Greene County due to an earthquake.
Continuity of Operations	An earthquake would cause little to no impact on service operations.
Property, Facilities, and Infrastructure	Greene County could experience property damages to buildings that are not structurally sound or of poor quality. An earthquake could also create a minor impact to some key infrastructures such as road damage or power losses in some areas; however, it would not be widespread. Earthquakes may cause damage to weak facilities, windows could be break, and other minor isolated instances of damage.
Environment	The environment would experience little to no impact from an earthquake.
Economic Condition of Jurisdiction	Damages to property, facilities, or infrastructure will have a very minor impact on Greene County's economy.
Public Confidence in the Jurisdiction's Governance	An earthquake would result in little to no loss in public confidence in governance in Greene County.

*For more details on Consequence Analysis, refer to Appendix B.

Hazard Summary by Jurisdiction

Earthquake intensity is not likely to vary greatly throughout the planning area causing the risk to be the same throughout the planning area. Damages could variate throughout the planning area. For example, Ash Grove has older properties that could experience more damages to homes and properties than other jurisdictions. Springfield has a larger amount of buildings, which could financially be more of an issue for Springfield than in other jurisdictions. Though the planning area is hundreds of miles away from the New Madrid Seismic Zone, Greene County is still at risk for some minor damages and an influx in population if the NMSZ does have a large event.

PROBLEM STATEMENT

The New Madrid Seismic Zone puts all of Missouri, including Greene County at risk for large earthquakes. Large earthquakes could present damage and injury to our planning area. Vulnerable populations and older homes/buildings are more at risk when looking at a large earthquake. Possible mitigation solutions for large earthquakes in Greene County would include education which is done in Greene County public school districts currently. Other solutions include education for large businesses, bolting large furniture to the wall and other individual preparation. In this Mitigation plan, no participating jurisdictions created a mitigation project for Earthquakes.

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3.4.3 Natural Hazard: Extreme Temperatures

HAZARD PROFILE

Hazard Description

Extreme temperatures 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 lasts for several weeks. Ambient air temperature is one component of what conditions, with relative humidity being the other. The relationship of these factors creates what is known as the apparent temperature. The Heat Index (HI) Chart, which is shown below, 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-regulation 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 those 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

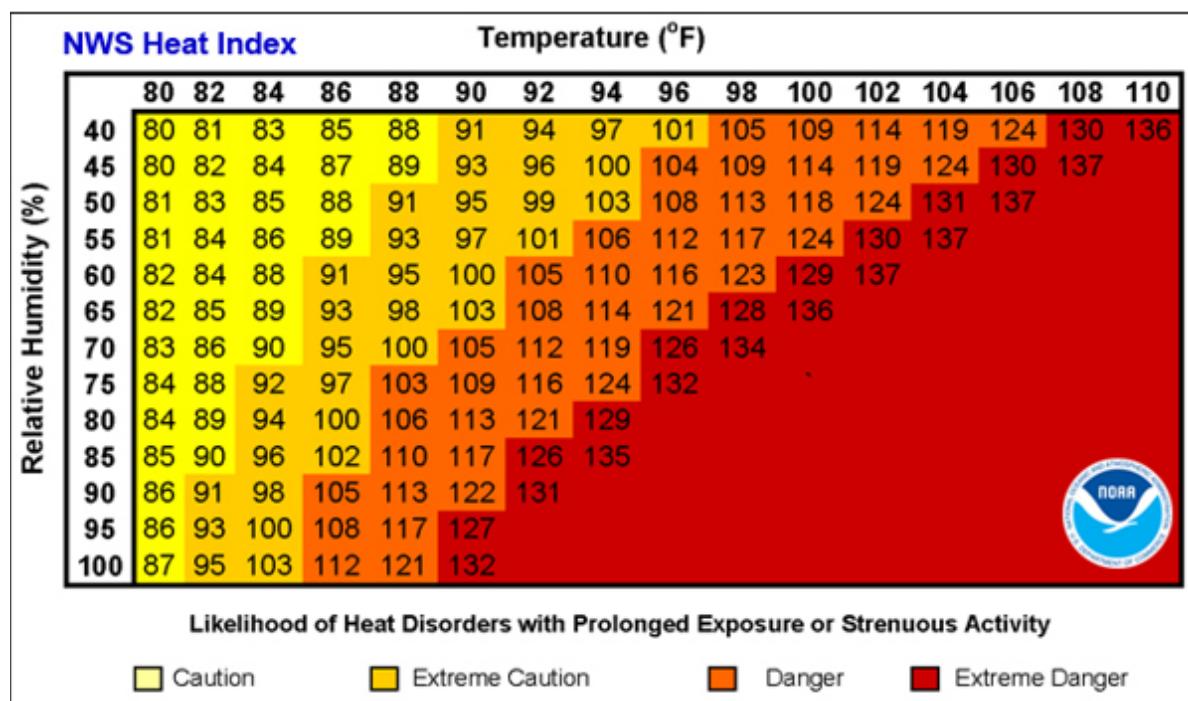
Extreme temperatures both hot and cold, are area-wide hazard events. The risk of extreme heat or extreme cold temperatures do not vary across the planning area and can affect all populations in Greene County.

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Strength/Magnitude/Extent

The National Weather Service (NWS) has an alert system in place (advisories or warnings) when the Heat Index (HI) 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 and (2) when the night time minimum heat index is 80 degrees Fahrenheit or above. A heat advisory is issued when temperatures reach 105 degrees and a warning is issued at 115 degrees.

Heat Index (HI) Chart



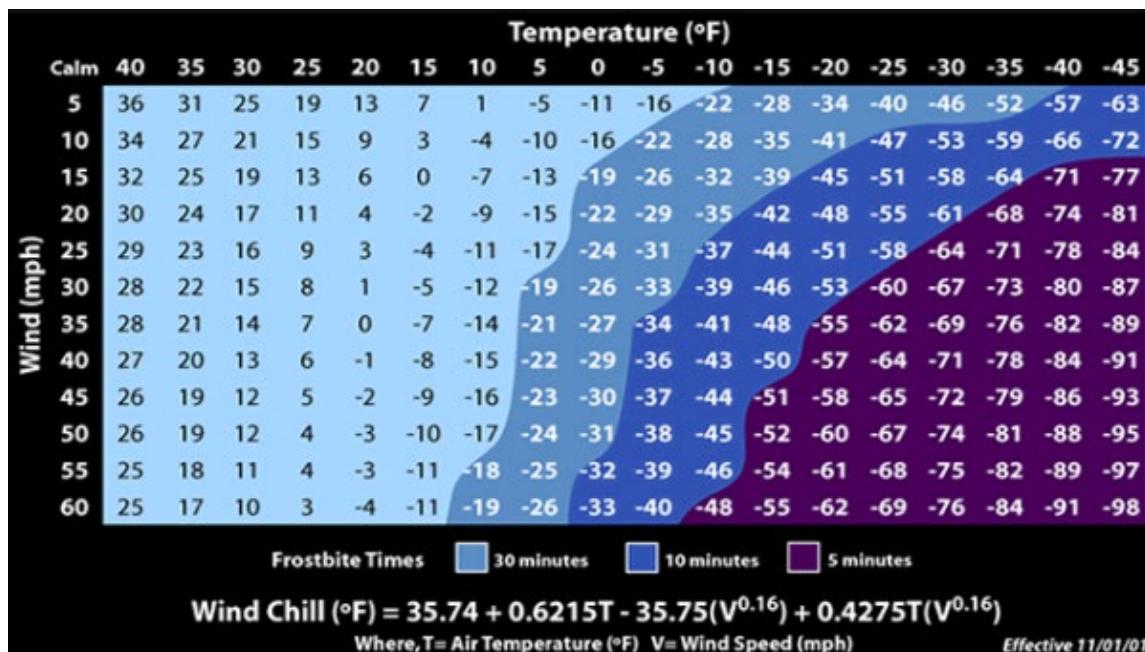
Source: National Weather Service: <https://www.weather.gov/safety/heat-index>

*Note: Exposure to direct sun can increase Heat Index (HI) 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 National Weather Service 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 that 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.

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Wind Chill Chart



Source: National Weather Service: <https://www.weather.gov/safety/cold-wind-chill-chart>

Previous Occurrences

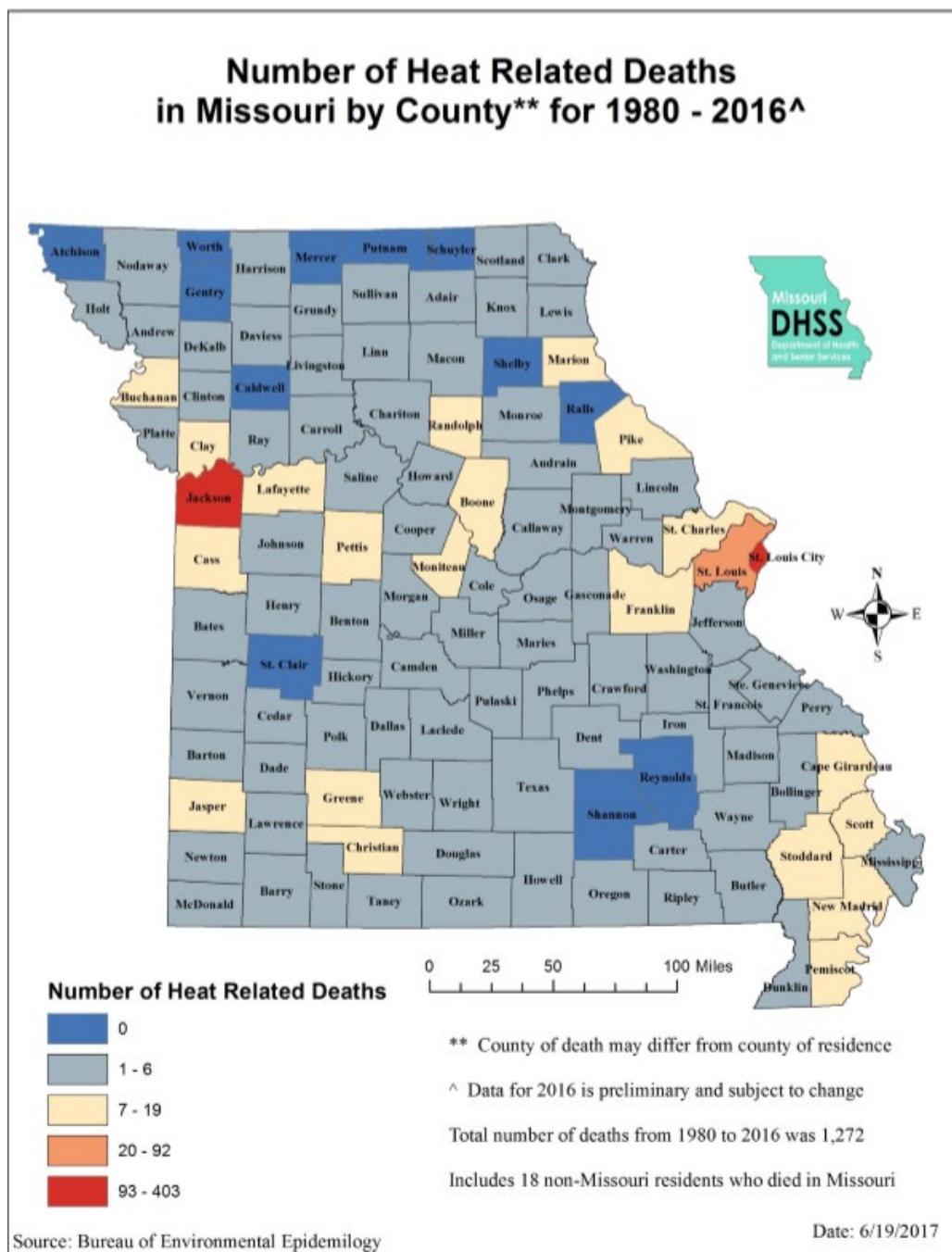
Record Temperatures-Springfield

TEMPERATURE	DEGREE FAHRENHEIT	DATE SET
Heat (High)	113	07/14/1954
Cold (Low)	-29	02/12/1899

Source: National Weather Service

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Heat Related Deaths- 1980-2016



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Extreme temperatures, including both heat and cold, can cause stress to crops and animals. According to USDA Risk Assessment Agency, Losses to insurable crops during the 10 year time period from 2008-2018 were \$120,403.34. Extreme heat can also strain electricity delivery and infrastructures can be overloaded during peak use of air conditioning during extreme heat events. Another type of infrastructure damage from extreme heat is road damage. When asphalt is exposed to prolonged, extreme heat, it can cause buckling of asphalt-paved roads, driveways and parking lots.

From 1988-2011, there were 3,496 fatalities in the U.S attributed to summer heat. This translates to an annual national average of 146 deaths. The National Weather Service stated that among natural hazards, no other natural disasters—not lightning, hurricanes, tornadoes, floods or earthquakes—caused more deaths.

Agricultural Insurance Claims Due to Extreme Temperature Events-2018

CROP	REASON	TOTAL AMOUNT OF LOSS
Wheat	Cold Wet Weather	\$501.00
Corn	Heat	\$3050.04
Corn	Cold Winter	\$1,359.00
Soybeans	Heat	\$3,121.00
Soybeans	Cold Wet Weather	\$15,249.00
TOTAL:		\$23,280.04

Agricultural Insurance Claims Due to Extreme Temperature Events-2017

CROP	REASON	TOTAL AMOUNT OF LOSS
Corn	Heat	\$6,807.00
Soybeans	Heat	\$10,408.60
TOTAL:		\$17,215.60

Agricultural Insurance Claims Due to Extreme Temperature Events-2016

CROP	REASON	TOTAL AMOUNT OF LOSS
Soybeans	Cold Wet Weather	\$220.00
TOTAL:		\$220.00

Agricultural Insurance Claims Due to Extreme Temperature Events-2015

*There were no agricultural insurance claims due to extreme temperature events in 2015.

Probability of Future Occurrence

The probability for hazards in Greene County is determined using Calculated Priority Risk Index (CPRI). It is likely for an extreme temperature events to occur within the next three years in Greene County. For a full description of the CPRI for Extreme Temperatures, refer to Appendix B.

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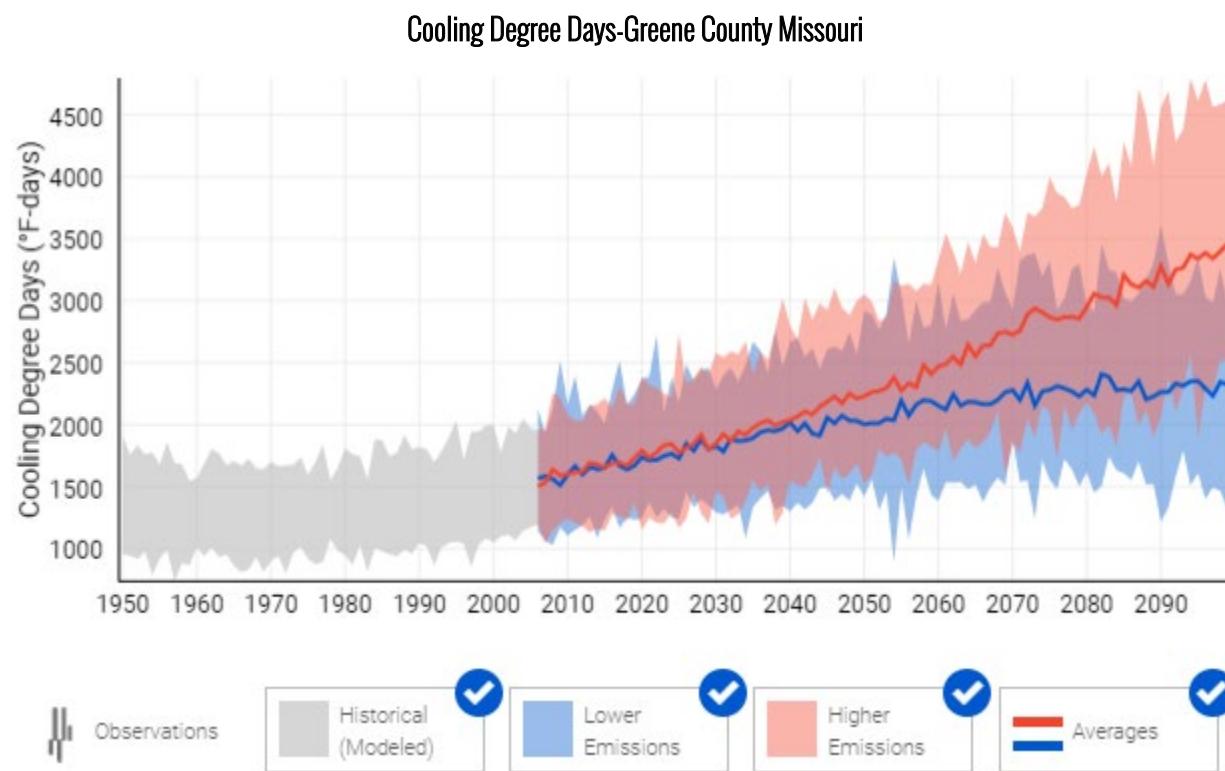
Changing Future Conditions and Considerations

According to the Missouri State Mitigation Plan, under higher emissions pathway, 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. Temperature increase will cause future heat waves to be more intense, a concern for Greene County which already experiences hot and humid conditions.

The impacts of extreme temperatures are experienced most in elderly and other vulnerable populations. Extreme temperatures lead to the higher demand for electricity as people try to stay warm or cool. Greene County has a growing population and as the population of the county grows, the more risk extreme temperatures can be.

Number of Cooling Degree Days

The number of cooling degree days at any location reflects the amount of energy people use to cool a building when it is warm outside. Higher numbers of cooling degree days indicate higher demand for energy.



Source: U.S. Climate Resilience Toolkit: <https://crt-climate-explorer.nemac.org/location/?county=Greene+County&city=Greene+County,%20MO&fips=29077&lat=37.33112149999999&lon=-93.50034540000001>

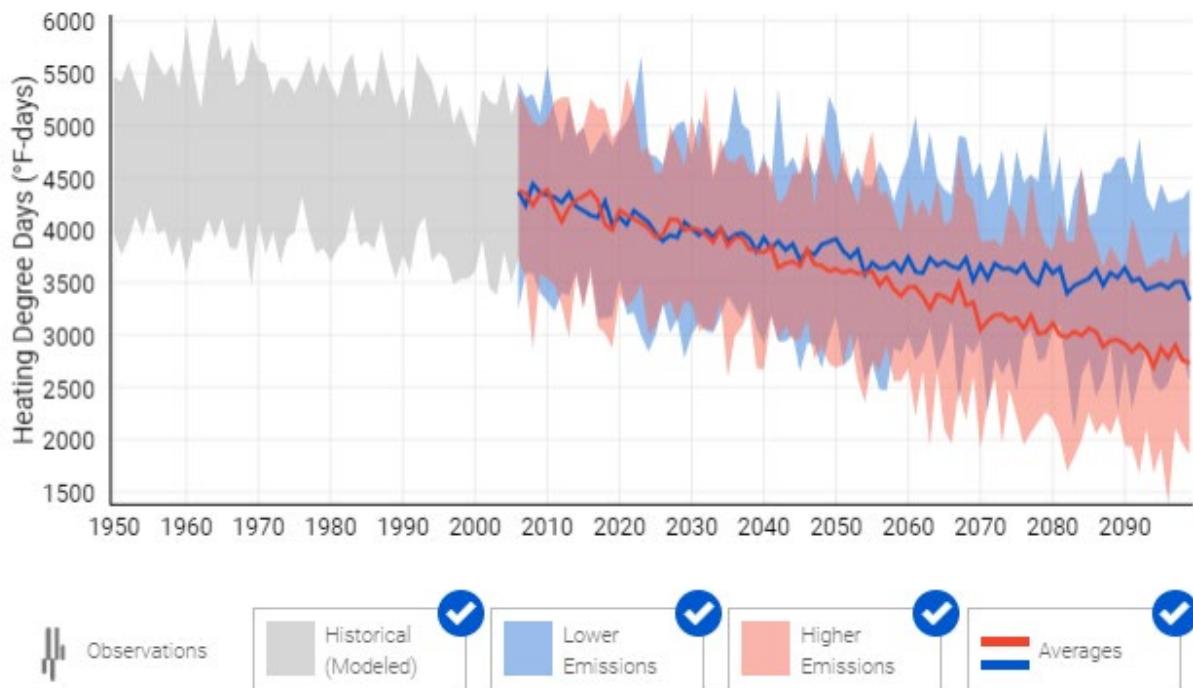
In the chart above, there is a steady increase in the number of cooling degree days for the next 70 years. In those 70 years, Greene County could see an influx in population causing extreme heat to become more dangerous than it is right now.

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Heating Degree Days

The number of heating degree days at any location reflects the amount of energy people use to heat a building when it is cool outside. Lower number of heating degree days indicate lower demand for energy.

Heating Degree Days-Greene County



Source: U.S. Climate Resilience Toolkit: <https://crt-climate-explorer.nemac.org/location/?county=Greene+County&city=Greene+County,%20MO&fips=29077&lat=37.33112149999999&lon=-93.50034540000001>

Both the graphs above show that it is possible in the next 70 years to see hotter days more frequently. Extreme heat can be potentially dangerous to Greene County's vulnerable populations and can also cause a rise in energy use.

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VULNERABILITY

Vulnerability Overview

The entire planning area is at risk for experiencing extreme temperatures including both hot and cold. 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.

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

Typical Health Impacts of Extreme Heat

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

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

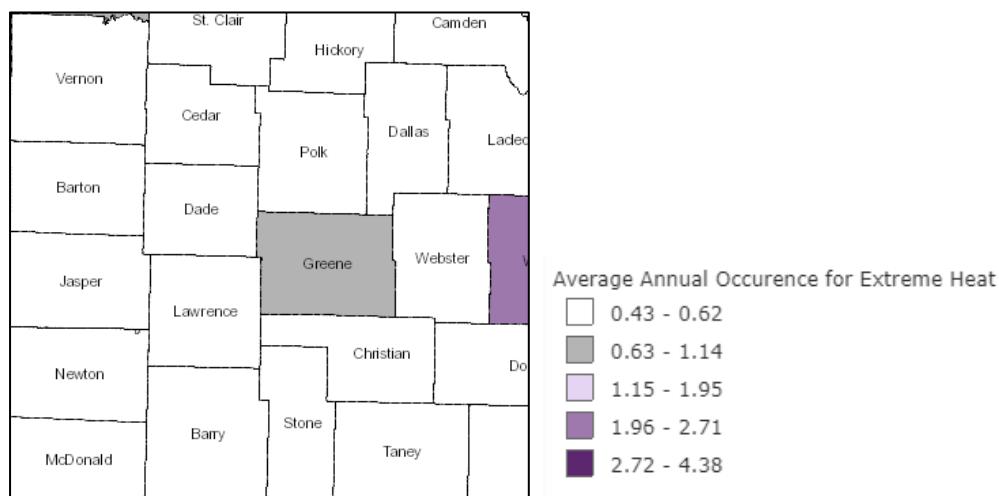
Health Impacts of Extreme Cold

- Heart Problems
- Hypothermia
- Frostbite

Hypothermia

When a body temperature sinks below 96°F, a person has hypothermia. Hypothermia can occur in temperatures as warm as 60°F. Older adults and children are at most risk. Some tips to help avoid hypothermia are: dress in layers, wrap up well when going outside in the cold, avoid breezes and drafts indoors and eat hot food and drink throughout the day.

Average Annual Occurrence for Extreme Heat



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Potential Losses to Existing Development

The planning area can expect to see more agricultural losses due to extreme temperatures, more so extreme heat. As demonstrated in the agricultural charts earlier in this section, agricultural insurance claims are continuing to increase. Temperatures are getting warmer and as temperatures get warmer, agricultural property become more at risk.

Impact of Previous and Future Development

The entire planning area, excluding Walnut Grove is experiencing population growth. Population growth can result in increased in the age-groups that are most vulnerable to extreme heat temperatures. Population growth also increases the strain on electricity infrastructure, as more electricity is needed to accommodate the growing population. The planning area is anticipating rapid growth in the next decade.

EMAP Consequence Analysis

SUBJECT	DETERRIMENTAL IMPACTS
Public	Greene County has documented cases of injuries and illnesses from extreme heat incidents every year. The elderly, youth, and over or underweight populations are at increased risk for health related illnesses. People are also extremely vulnerable to extreme heat if they work outdoors, are military personnel, or athletes. Although there have been no reports of death due to extreme cold in Greene County, deaths occur every year in Missouri. Greene County has documented cases of injuries and illnesses from extreme cold incidents.
Responders	There are no reports of life threatening issues to responders, and no reports of impact on response functions. However, extreme temperatures can create safety issues to responders.
Continuity of Operations	There have been no reports of impact on service operations in Greene County.
Property, Facilities, and Infrastructure	Extreme heat in Greene County has resulted in minor isolated instances of property damage. Extreme cold may cause frozen pipes. Greene County has experienced minor instances of infrastructure damages due to extreme heat. There have been no reports of facility damage due to extreme temperatures.
Environment	Extreme temperatures can negatively affect wildlife, plants, and trees.
Economic Condition of Jurisdiction	Extreme heat incidents in Greene County have affected the economic condition in areas throughout Greene County. Cities need a large amount of water to keep injury and illness from growing. Many rural homes and areas that service off their own wells will also suffer greatly from extreme heat if there is a lack of water. Extreme heat will also slow productivity.
Public Confidence in Jurisdiction's Governance	Public confidence can be affected. Water supplies are scarce in extreme heat. The confidence in the government can rise or fall depending on how the situation is handled.

* For more details on Consequence Analysis, refer to Appendix B.

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Hazard Summary by Jurisdiction

Those at greatest risk for heat-related illness and deaths include children up to five years of age, people 65 years of age and older, people who are overweight and people who are ill or on certain medications. To determine jurisdictions within the planning area with populations more vulnerable to extreme heat, demographic data was obtained from the 2017 census on population percentages in each jurisdiction comprised of those under age 5 and over age 65. Data was not available for overweight individuals and those on medications vulnerable to extreme heat. The table below summarizes vulnerable populations in the participating jurisdictions. Note that schools 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.

Greene County Population Under age 5 and Over Age 65, 2017

JURISDICTION	POPULATION UNDER AGE 5 (PERCENT)	POPULATION OVER AGE 65 (PERCENT)
Greene County	6.11%	15.48%
Ash Grove	9.71%	18.54%
Battlefield	8.12%	15.77%
Fair Grove	11.03%	13.80%
Republic	8.74%	11.55%
Rogersville	8.87%	9.17%
Springfield	5.86%	14.87%
Strafford	6.23%	17.61%
Walnut Grove	5.40%	19.29%
Willard	6.86%	11.85%

Source: U.S. Census Bureau, 2017

*Note: Rogersville is located in multiple counties, the population data is not specific to Greene County.

PROBLEM STATEMENT

Extreme temperatures can be dangerous to the entire planning area. Extreme temperatures can cause health issues to vulnerable populations and can have a negative effect on agriculture. All jurisdictions have a larger percent of population over the age 65. This population is a greater risk for experiencing health complications from extreme temperatures. Extreme temperatures are projected to get worse over the next several years. Possible mitigation solutions include organizing outreach to the vulnerable elderly populations, including establishing and promoting accessible heating or cooling centers in the community and creating a database in coordination with the Health department to track those individuals at risk. A few projects and actions are listed in the Mitigation Strategy of this Mitigation plan that map out what our participating jurisdictions want to do to Mitigate extreme temperatures in Greene County.

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3.4.4 Natural Hazard: Flood

HAZARD PROFILE

Hazard Description

A flood is a 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.



Flash Flood



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.

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 water 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.

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 characteristic, modeling techniques, monitoring and advanced warning systems has increased the warning time for flash floods.

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Ice Jam Flood

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

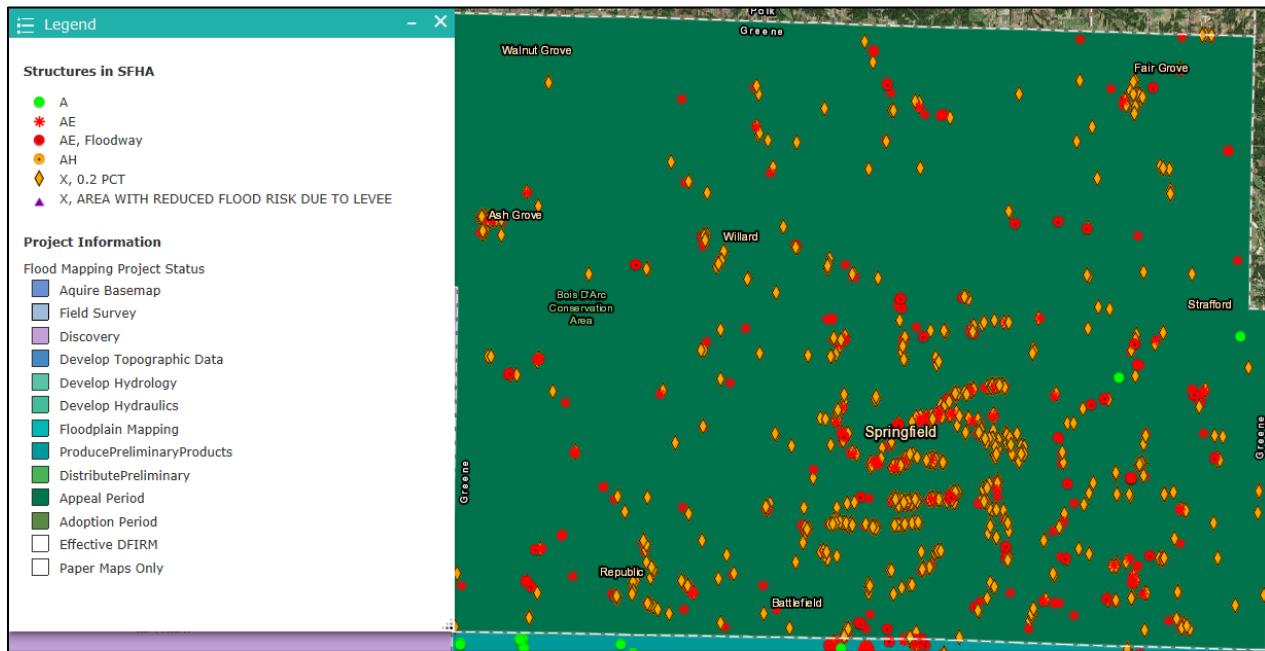
Sheet Flooding

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.

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 damaged 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.

Geographic Location

Riverine flooding is most likely to occur in Special Flood Hazard Areas (SFHA). The map below comes from SEMA's Flood Mapping Project, the map maps out structures that are located in SFHAs.



As you can see, many structures are located within SFHAs throughout the entire planning area.

The Table on the next page shows flood events that have taken place in the planning area. These flood events took place between 1996-2018. These were just events that were recorded in the NCEI Database, there may be additional flood events that took place, but were not reordered.

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Greene County NCEI Flood Events by Location-1996-2018

LOCATION	TOTAL NUMBER OF EVENTS
Greene County	
• Greene County (Zone) - 6 Flood Events	
• Countywide - 1 Flood Event	
• North Portion - 1 Flood Event	
• Brookline -2 Flood Events	
• Cody - 3 Flood Events	
• Elwood - 1 Flood Event	
• Galloway - 5 Flood Events	
• Hickory Barren - 2 Flood Events	
• Mumford - 1 Flood Event	
• Nichols - 2 Flood Events	
• Phenix - 1 Flood Events	
• Plano - 1 Flood Event	
• Pleasant Valley - 2 Flood Events	
• Sequiota - 2 Flood Events	
• Wildwood Estates - 4 Flood Events	
City of Ash Grove	34 Flood Events
• Ash Grove - 0 Flood Events	
City of Battlefield	0 Flood Events
• Battlefield - 1 Flood Event	
City of Fair Grove	1 Flood Events
• Fair Grove - 1 Flood Events	
City of Republic	1 Flood Events
• Republic - 4 Flood Events	
• Republic Westport AR - 1 Flood Event	
City of Springfield	5 Flood Events
• Springfield - 12 Flood Events	
• Springfield Bar H AR - 2 Flood Events	
City of Strafford	14 Flood Events
• Strafford - 0 Flood Events	
City of Walnut Grove	0 Flood Events
• Walnut Grove - 0 Flood Events	
City of Willard	0 Flood Events
• Willard - 0 Flood Events	

Flash Flooding occurs in SFHAs and those locations in the planning area that are low-lying. They also occur in areas without adequate drainage to carry away the amount of water that falls during intense rainfall events. The table located on the next page includes the number of flash flood events by location recorded in NCEI between the years 1996-2018. These are only events that were reported, there might be flash flooding events that took place within the planning area, but was not recorded in the NCEI.

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Greene County NCEI Flash Flood Events by Location, 1996-2018

LOCATION	TOTAL NUMBER OF EVENTS
Greene County	
• Greene County (Zone) - 5 Flash Flood Events	
• Countywide - 8 Flash Flood Events	
• Central Portion - 2 Flash Flood Events	
• North Portion - 2 Flash Flood Events	
• South Portion - 3 Flash Flood Events	
• Bois D'Arc - 3 Flash Flood Events	
• Brookline - 6 Flash Flood Events	
• Cherry Valley Estates - 3 Flash Flood Events	
• Cody - 8 Flash Flood Events	
• Ebenezer - 7 Flash Flood Events	
• Elwood - 4 Flash Flood Events	
• Galloway - 5 Flash Flood Events	
• Hickory Barren - 3 Flash Flood Events	119 Flood Events
• Langston - 2 Flash Flood Events	
• Mentor - 1 Flash Flood Event	
• Mulroy - 2 Flash Flood Events	
• Mumford - 2 Flash Flood Events	
• Nichols - 19 Flash Flood Events	
• Phenix - 5 Flash Flood Events	
• Plano - 1 Flash Flood Event	
• Pleasant Valley - 1 Flash Flood Event	
• Sacville - 1 Flash Flood Event	
• Sequiota - 11 Flash Flood Events	
• Turners - 3 Flash Flood Events	
• Wildwood Estates - 2 Flash Flood Events	
City of Ash Grove	1 Flood Event
• Ash Grove - 1 Flash Flood Event	
City of Battlefield	10 Flood Events
• Battlefield - 10 Flash Flood Events	
City of Fair Grove	10 Flood Events
• Fair Grove - 10 Flash Flood Events	
City of Republic	1 Flood Event
• Republic - 0 Flash Flood Events	
• Republic Westport AR - 1 Flash Flood Events	
City of Springfield	68 Flood Events
• Springfield - 51 Flash Flood Events	
• Springfield Bar H AR - 6 Flash Flood Events	
• Springfield Downtown Airport - 7 Flash Flood Events	
• Springfield Airport - 4 Flood Events	
City of Strafford	3 Flood Events
• Strafford - 3 Flash Flood Events	
City of Walnut Grove	8 Flood Events
• Walnut Grove - 8 Flash Flood Events	

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City of Willard	2 Flood Events
• Willard - 2 Flash Flood Events	

Strength/Magnitude/Extent

Missouri, including Greene County, has a long and active history of flooding over the past century. Floods take a heavy toll on 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 across Missouri and Greene County.

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.

The areas adjacent to rivers and stream banks that carry excess flood water during rapid runoff are called floodplains. A flood plain is defined as the lowland and relatively flat areas adjoining rivers and streams. The term 100 year flood, or base flood, is the area in the floodplain that is subject to a one percent or greater chance of flooding in any given year based upon historical records. Floodplains are a vital part of a larger entity called a basin. A basin is defined as all the land drained by a river and its branches.

In some cases, flooding may not necessarily be directly attributable to a river, stream or lake overflowing. Rather, it may simply be a combination of excessive rainfall and/or snowmelt, saturated ground and inadequate drainage. With no place to go, water will find the lowest elevations, areas that are not often in the "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. Flooding also occurs due to combined storm and sanitary sewers that cannot handle the tremendous flow of water that often accompanies storm events. Typically, the result is water backing up into basements, which damages mechanical systems and can create serious health and safety concerns. To reduce the impact of this problem, the Springfield Public Works Department enacted a program to provide backflow prevention valves to homeowners at a reduced cost to assist homeowners in mitigating the effects of flood backflow.

National Flood Insurance Program Participation



NATIONAL FLOOD INSURANCE PROGRAM

According to FEMA, The National Flood Insurance Program (NFIP) aims to reduce the impact of flooding on private and public structures. It does so by providing affordable insurance to property owners, renters and businesses and by encouraging communities to adopt and enforce floodplain management regulations. These efforts help mitigate the effects of flooding on new and improved structures. Overall, the program reduces the socioeconomic impacts of disasters by promoting the purchase and retention of general risk insurance, but also of flood insurances, specifically.

All jurisdictions in the planning area participate in NFIP. The chart on the next page lists dates and community ID numbers for the planning area.

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NFIP Participation in Greene County

COMMUNITY ID NUMBER	COMMUNITY NAME	NFIP PARTICIPANT (Y/N/ SANCTIONED)	CURRENT EFFECTIVE MAP DATE	REGULAR-EMERGENCY PROGRAM ENTRY DATE
290782	Greene County	Yes	12/17/2010	06/15/1983
290751	City of Ash Grove	Yes	12/17/2010	07/16/1980
290863	City of Battlefield	Yes	12/17/2010	05/27/2014
290591	City of Fair Grove	Yes	12/17/2010	01/30/2004
290148	City of Republic	Yes	12/17/2010	06/04/1980
290658	City of Rogersville	Yes	09/17/2010	03/30/1981
290149	City of Springfield	Yes	12/17/2010	07/03/1978
290506	City of Strafford	Yes	12/17/2010	07/30/1999
290946	City of Walnut Grove	Yes	NSFHA	02/07/2002
290653	City of Willard	Yes	12/17/2010	10/10/2003

Source: NFIP Community Status Book, 2018

*Note: NSFHA: No Special Flood Hazard Area

NFIP Policy and Claim Statistics as of 09/30/2018

COMMUNITY NAME	POLICIES IN FORCE	INSURANCE IN FORCE	WRITTEN PREMIUM-IN FORCE	TOTAL PAYMENTS
City of Ash Grove	10	\$1,659,500	\$15,908	\$1,675,408
City of Battlefield	3	\$840,000	\$1,112	\$841,112
City of Fair Grove	7	\$949,200	\$5,122	\$954,322
City of Rogersville	4	\$1,120,000	\$1,501	\$1,121,501
City of Springfield	159	\$46,221,400	\$224,953	\$46,446,353
City of Strafford	2	\$590,000	\$693	\$590,693
City of Willard	16	\$1,961,800	\$15,525	\$1,977,325
Greene County	130	\$32,781,900	\$81,389	\$32,863,289

Repetitive Loss/Severe Repetitive Loss Properties

Greene County Repetitive Loss Properties

Repetitive Loss Properties are those properties with at least two flood insurance payments of \$1,000 or more in a 10-year period. According to the Flood Insurance Administration, jurisdictions included in the planning are have a combined total of 20 repetitive loss properties.

COMMUNITY NAME	TOTAL LOSSES	PROPERTIES	TOTAL BUILDING PAYMENTS	TOTAL CONTENTS VALUE	TOTAL PAYMENTS	AVERAGE PAYMENTS
Greene County	23	7	\$432,499	\$39,360	\$471,859	\$20,516
City of Springfield	29	13	\$687,071	\$470,912	\$1,157,983	\$39,930

Source: SEMA

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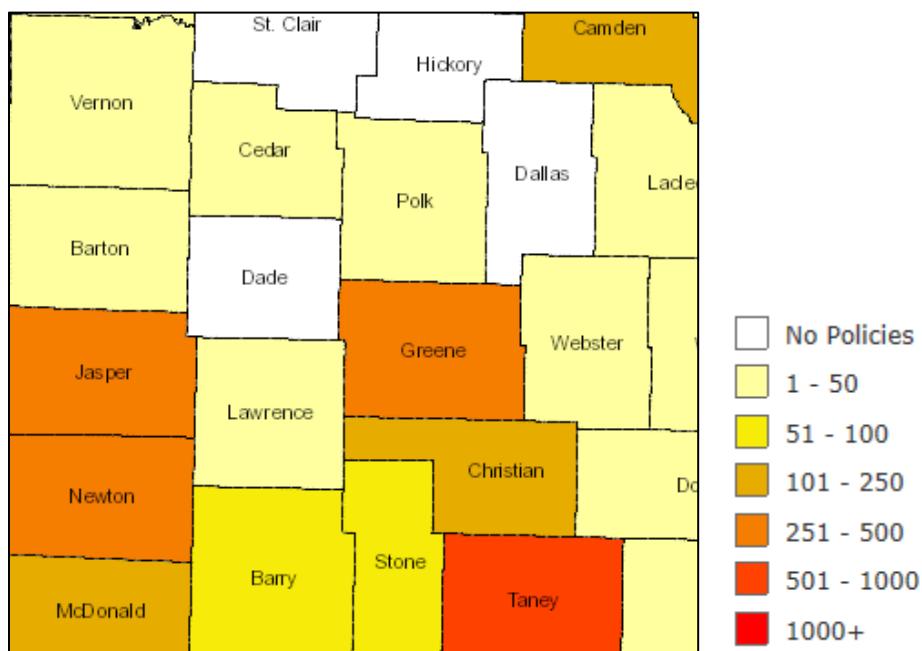
Due to Federal restrictions, this is the best available data that could be obtained by the state February 2020.

Severe Repetitive Loss

Severe Repetitive Loss (SRL): A SRL property is defined as a single family property (consisting of one-to-four residences) that is covered under flood insurance by the NFIP. The property has to have; (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 \$20,000; or (2) for which at least two separate claims payments have been made with the cumulative amount of each claims exceeding the reported value of the property.

According to the State Emergency Management Plan, Greene County does not currently have any severe repetitive Loss properties.

Flood Policies



Previous Occurrences

September 1993

One of the area's most notable flood disasters was the flash flooding events in September of 1993, which caused \$50.5 million in damages in Greene County.

July 2000

Additionally, flash flooding in July of 2000 caused \$9 million in damages of which \$4 million were attributed to a local industrial plant. Much of the residential damage occurred in the Shadowwood Subdivision located immediately south of the Springfield City limits and east of Campbell Street, an area between Sunshine and Grand west of West Bypass, and a mobile home park on the corner of Scenic and Bennett.

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August 2007

Walnut Grove experienced excessive rainfall associated with the remnants of Tropical Storm Erin on August 20, 2007. Many roads and low water crossings were washed out and had to be fully repaired. A bank in Walnut Grove was damaged by the flood. Because many roads were washed out in Walnut Grove and Greene County, several water rescues occurred. The estimate of property damage for this event was \$2 million.

March 2008

On March 18, 2008, four to seven inches of rain fell across Greene County created dangerous conditions caused by flash flooding. Nearly all county roads experienced flooding, and the county lacked a supply of barricades to block all flooded areas from motorists. One death occurred in this flood when an elderly couple's vehicle was surrounded by water in a park southeast of Springfield. The couple was observing flooded areas along the James River when the river rose so quickly that it swept them into the river. The male, age 67, died from a heart attack. The female was later rescued by the Logan-Rogersville Swift Water Rescue Team. The car was almost fully submerged by the time the rescue team positioned themselves near the car. The rescue took two hours. The property damage for this flash flood event was \$1 million.

June 2008

In the middle of June 2008, Springfield received approximately 4" of rainfall perpetuating a flooding disaster due to heavily saturated land from previous storms. The flooding of Galloway Creek damaged many specialty and antique shops in the historic Galloway Village. Additionally, the flood washed away tons of rock from the railroad line to the James River Power Plant. This disrupted coal shipments for several days until workers finished the repairs. There were approximately 35 water rescues. The flood in Greene County received a Presidential Disaster Declaration.

April 2011

Multiple rounds of thunderstorms produced very heavy rainfall across the Ozarks over the course of a week in April of 2011. A persistent trough over the central plains brought multiple upper level storm systems over the region which produced intense thunderstorms with very heavy rainfall. Some areas saw storm total rainfall amounts up to a foot or more. The flooding caused \$500,000 worth of damage.

June 2013

In June of 2013, near the intersection of South Campbell Road and Republic Road, there were several roadways that were underwater up to 3 feet deep. Water flooded several businesses in that area. Several cars were stranded in high water. Numerous roadways and neighborhoods had flooding as well as several homes being affected by flood waters. Flash flooding affected some of the infrastructure like washing out communication lines and boxes in south Springfield.

June 2015

Heavy rain fall in June of 2015 lead to multiple road closures. The storm came from Tropical Storm Bill. The rate of rainfall spanned from one-fourth inches to three-fourth inches per hour. The flooding shut down major roads in Greene County and surrounding counties including MO 125. The storm flooded both Lake Springfield and The James River.

December 2015

A slow moving storm system brought several waves of heavy rainfall to the region from the early morning of December 26th into the morning of December 28th. Storm rainfall amounts of 5-12 inches were common across Greene County and Missouri Ozarks. These rainfall amounts resulted in historic flooding across the region. Major

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highways and interstates flooded at times and were closed. This storm system resulted in 14 confirmed fatalities (not all in Greene County), thousands of road closures, hundreds of swift water rescues, a record release of water out of Table Rock Dam, and many more.

October 2016

A nearly stationary front bisected southern Missouri during the day of October 19th 2016. Scattered showers and isolated thunderstorms developed in the early morning hours, and became more numerous and stronger during the afternoon as instability increased. Due to the training of the storms along the stationary front during the day and evening, some locations received 2-3 inches of rain and some flooding developed, mainly in low lying areas and near smaller creeks and streams.

April-May 2017

Major flooding across Greene County and many other surrounding counties took place being April 28th and continued to May 3. An estimated 7-9 inches of rain fell across the county. 4-8 inches with some areas of far southern and south central Missouri receiving 10-12 inches of rain. Many bridges were destroyed. Fourteen people had to be rescued from high water. The Springfield-Greene County Office of Emergency Management recorded over 170 damage reports from Greene County citizens whose homes, properties, or businesses were affected. There were many road closures spread across the county. This flooding resulted in a federal disaster declaration. The storm across the State of Missouri caused over \$86 million in damages.

September 2018

During the late hours of September 7th, 2018 heavy rain moved into the Greene County area. Flash flooding caused road closures and dangerous weather across Greene County. Unfortunately, a Greene County Sheriff's Deputy was returning from service from a 911 call when his patrol car was swept off the road near Fair Grove. The deputy was unable to get rescued in time and died.

April-May 2019

Many storm systems spread across the area producing large amounts of rain at different times making it hard to get flooding under control in Greene County. Severe storms started moving in the area April 30th of 2019 and continued into the first few days of May. The first storm produced large amounts of rain and tornadoes across the area. Later in May, another big round of storms pushed through the area over multiple days dumping multiple inches of rain across the area. This flooding event lead to multiple road closures and water rescues throughout the area.

The tables beginning on the next page will demonstrate flash flood and flood event summaries across Greene County between 1996-2018. These are just events that were reported to the National Centers for Environmental Information (NCEI). There could be more events that are not included in these charts.

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NCEI Greene County Flash Flood Events Summary, 1996-2018

YEAR	NUMBER OF EVENTS REPORTED	NUMBER OF DEATHS REPORTED	NUMBER OF INJURIES REPORTED	PROPERTY DAMAGES REPORTED	CROP DAMAGES REPORTED
1996	4	0	1	\$0	\$0
1997	3	0	0	\$0	\$0
1998	3	0	0	\$0	\$0
1999	2	0	0	\$0	\$0
2000	7	0	0	\$8,435,000	\$0
2001	7	0	0	\$320,000	\$0
2003	5	0	0	\$0	\$0
2004	3	0	0	\$0	\$0
2005	6	0	0	\$10,000	\$0
2006	4	0	0	\$0	\$0
2007	14	0	0	\$8,000,000	\$0
2008	15	0	0	\$1,100,000	\$0
2009	14	0	0	\$0	\$0
2010	24	0	0	\$0	\$0
2011	1	0	0	\$500,000	\$0
2012	2	0	0	\$0	\$0
2013	28	0	0	\$1,000,000	\$0
2014	8	0	0	\$85,000	\$0
2015	31	0	0	\$5,810,000	\$0
2016	8	0	0	\$500,000	\$0
2017	16	1	0	\$500,000	\$0

Source: NCEI, 1996-2018 Data.

Note: Events listed above are just events that were reported to NCEI.

NCEI Greene County Flood Events Summary, 1996-2018

YEAR	NUMBER OF REPORTED EVENTS	NUMBER OF REPORTED DEATHS	NUMBER OF REPORTED INJURIES	PROPERTY DAMAGES	CROP DAMAGES
2001	1	0	0	\$0	\$0
2002	2	0	0	\$1,250,000	\$0
2005	3	0	0	\$0	\$0
2007	1	0	0	\$0	\$0
2008	2	0	0	\$0	\$0
2009	3	0	0	\$0	\$0
2010	4	0	0	\$0	\$0
2011	4	0	0	\$0	\$0
2012	5	0	0	\$0	\$0
2013	1	0	0	\$0	\$0
2014	0	0	0	\$0	\$0
2015	10	0	0	\$1,660,000	\$0
2016	3	0	0	\$1,000	\$0
2017	1	0	0	\$0	\$0
2018	4	0	0	\$5,000	\$0

Source: NCEI, 1996-2018 Data.

Note: Events listed above are just events that were reported to NCEI.

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Probability of Future Occurrence

The probability for hazards in Greene County is determined using Calculated Priority Risk Index (CPRI). It is highly likely for a flooding event to occur within the next year in Greene County. For a full description of the CPRI for flooding, refer to Appendix B.

Changing Future Conditions and Considerations

According to the Missouri State Hazard Mitigation Plan, over the last half century, average annual precipitation in most of the Midwest has increased by 5 to 10 percent. It is likely (66%-100% probability) that the frequency of heavy precipitation or the proportion of total rain fall 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 late 21st Century. As rain increases, more flooding will be likely in Greene County.

According to the Missouri State Hazard Mitigation Plan, 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 receded 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.

VULNERABILITY

Vulnerability Overview

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

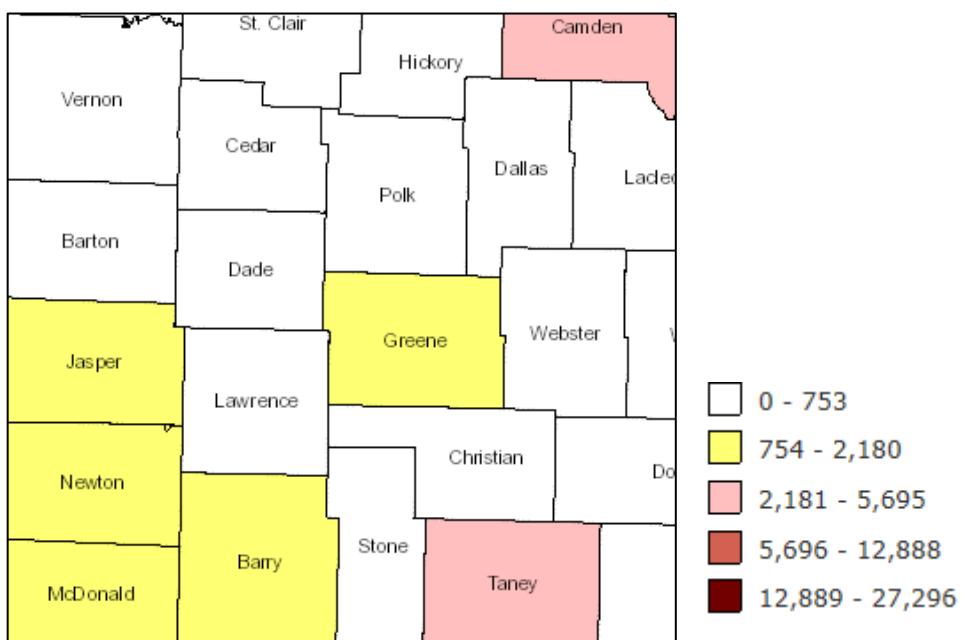
Public Health concerns may result from flooding, requiring disease and injury surveillance. Community sanitation to evaluate flood-affected food supplies may also be necessary. Private water and sewage sanitation could be impacted, and vector control (for mosquitoes and other entomology concerns) may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

All jurisdictions in Greene County can prepare for larger amounts of rain at once in the future. This increases the risk of flooding across the planning area.

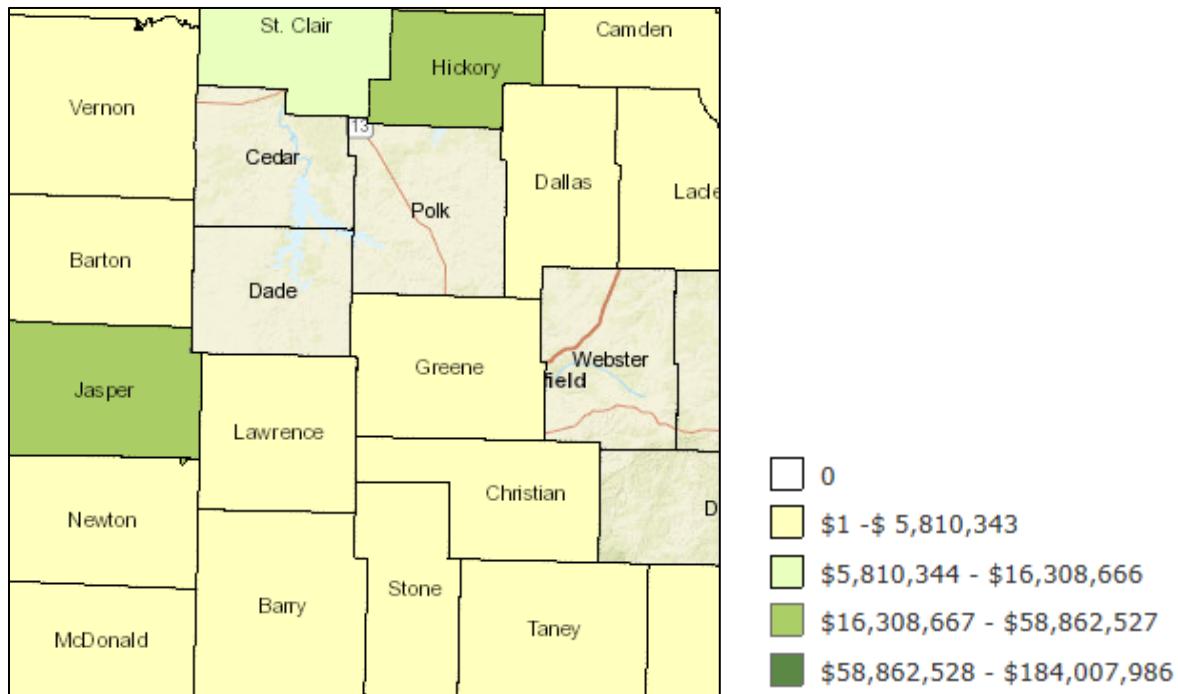
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People Affected by Flood



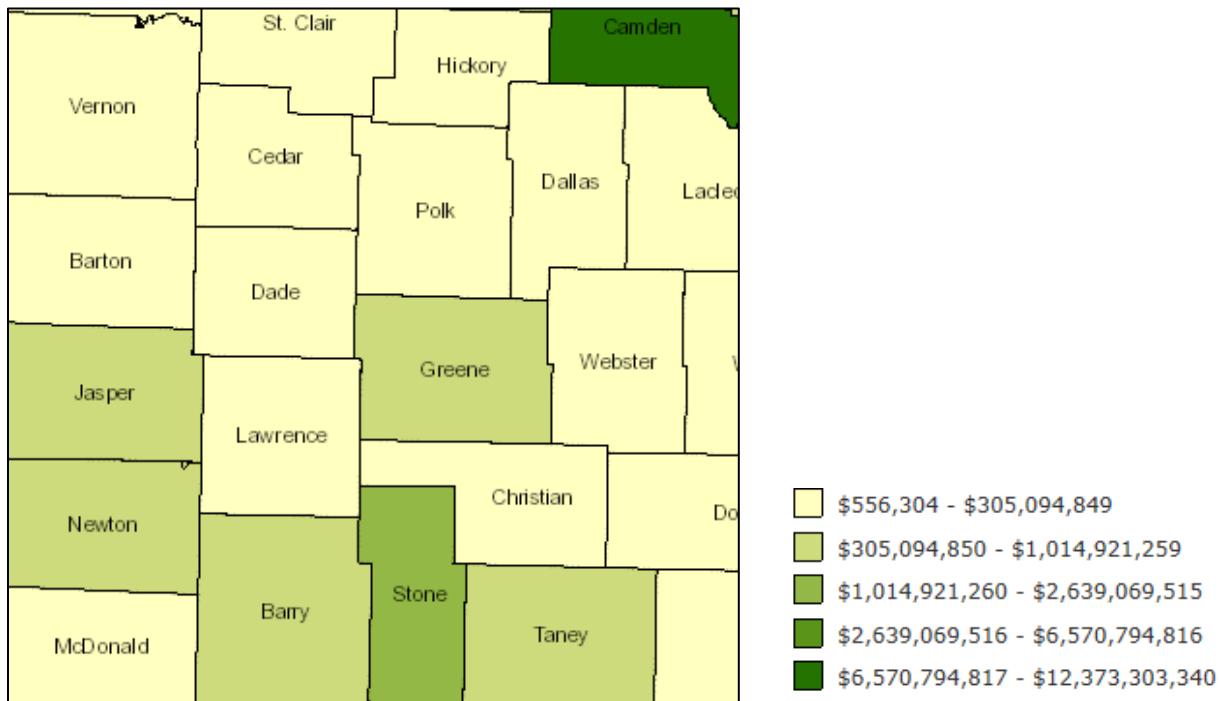
Potential Losses to Existing Development

Flood Losses by County- 1978-2018

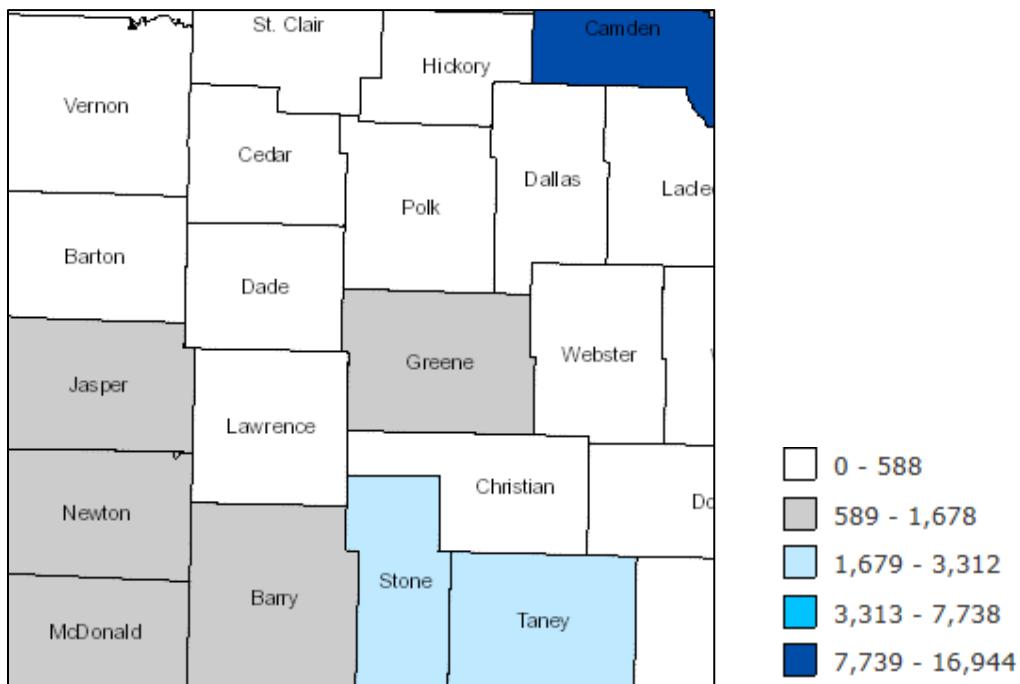


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Total Building Exposure by Flood (100 Year)

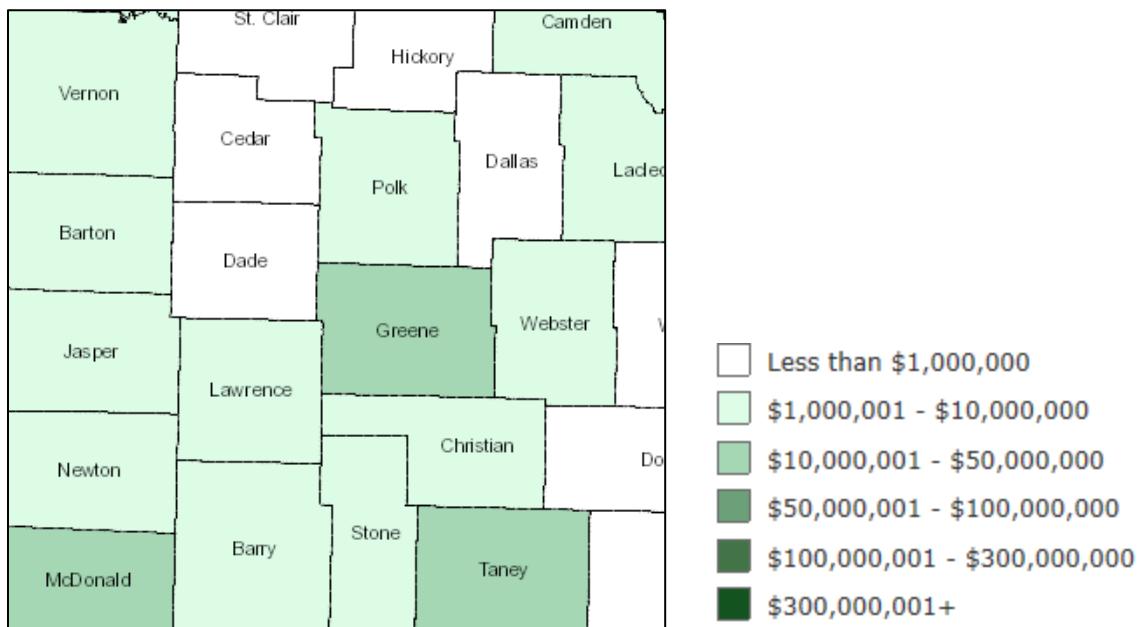


Buildings Impacted by Flood (100 Year)



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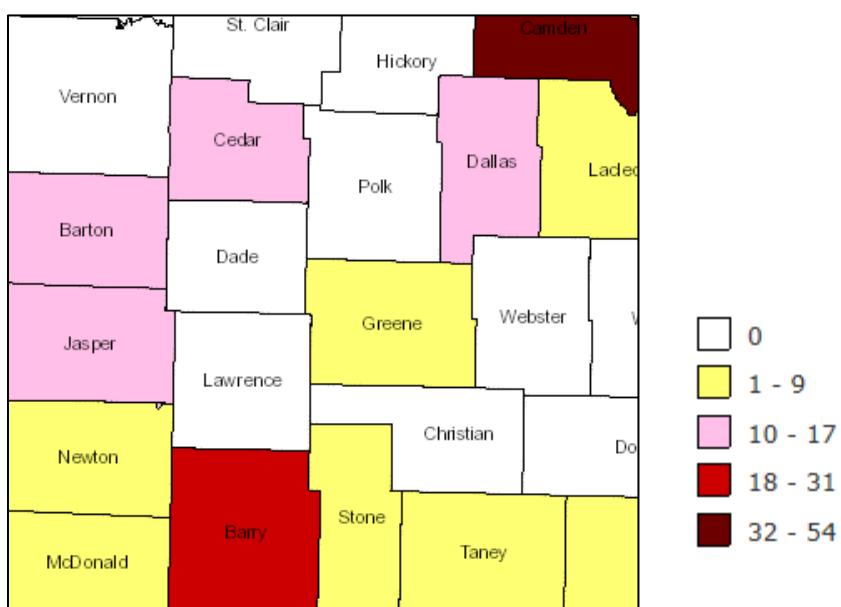
Flood Coverage



Impact of Previous and Future Development

Future development could impact flash and riverine flooding in the planning area. Development in low-lying areas near rivers and streams could be dangerous areas to expand on. Future development would also increase impervious surfaces causing additional water run-off and dragline problems during heavy rainfall events. The population of Greene County is projected to keep going for many years. An increase in population will include future development in many areas across Greene County.

State Facilities in SFHA by County



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EMAP Consequence Analysis

EMAP Impact Analysis: Flooding

SUBJECT	DETERRIMENTAL IMPACTS
Public	Risk of death or injury is elevated from rising creeks, tributaries, and storm water run-off that cross a section or roadway. Floods can also create health concerns from disease, and sanitation problems.
Responders	The potential for dangerous life safety issues to responders is high in performing water rescues. Many flooding incidents in Greene County take hours to perform, impacting response functions. Flooded roads can also present a challenge in transportation for all responders.
Continuity of Operations	Multiple critical services and operations are suspended or delayed across the jurisdiction due to elements such as road safety, infrastructure damages and power outages.
Property, Facilities, and Infrastructure	Numerous neighborhoods and businesses have had damages from flooding in Greene County. There have been multiple instances of significant widespread property damage. Flooding in Greene County has washed out many roadways. Roads that are not permanently damaged are often impacted and typically experience a dangerous amount of water flowing over them. Critical infrastructures including banks, railroads, power lines, and power plants have also been affected by flooding. Infrastructure damages include multiple areas throughout the jurisdiction. Flooding can also result in widespread minor damaged or sometime significant damages to facilities.
Environment	Flooding can negatively affect soil make-up and wildlife.
Economic Condition of Jurisdiction	During floods, roads, bridges, houses and automobiles either become unsafe or are destroyed. Additionally, the government deploys firemen, police and other emergency apparatus to help the affected. Businesses can also be damaged or completely destroyed and unable to return to normalcy until repairs are done. This can greatly impact the economic condition throughout Greene County.
Public Confidence in Jurisdiction's Governance	Flooding has had little to no impact on public confidence in the governance.

*For more details on Consequence Analysis, refer to Appendix B.

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Hazard Summary by Jurisdiction

All areas within Greene County experience flooding. Some areas may see more flooding than others due to design of roads and amount of low water crossings. Areas that have many low water crossings may experience more transportation issues than other jurisdictions. Areas that have SFHA's are also more likely to flood. Some areas in Greene County that have SFHA's are the City of Willard, City of Ash Grove, some parts of City of Strafford, many areas in City of Fair Grove, some parts of City of Republic, many different areas in City of Springfield and large areas in unincorporated Greene County. All of the Fire Protection Districts cover areas in Greene County have some SFHA's. The Springfield Public School District currently has a middle school that floods majorly when the city receives large amounts of rain. They created a project to relocate their school and is actively working on moving it because there have been times where the parking lot was not accessible.

The list of SFHA's are located on this website of Greene County.

<http://cosmo.maps.arcgis.com/apps/webappviewer/index.html?id=4a085ab96e4e4a83891f07289820fd77>

PROBLEM STATEMENT

Flooding has been, and will continue to be a serious issue in Greene County. There are some areas in the county that may suffer more than others, but all areas are at risk. Flooding can also come with other risks such as severe thunderstorms or tornadoes which also pose a large risk to the planning area. Flooding can cause road and property damage and can even lead to public health concerns. Researching years' worth of data and studying the patterns of floods in the planning area, the best mitigation solution is to continue with the flood buyout program in Greene County. Mitigation efforts that would also be beneficial to the Greene County area are stormwater management projects and road retrofitting. These projects have been listed in the Mitigation Strategy section of this Hazard Mitigation Plan.

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3.4.5 Natural Hazard: Land Subsidence/Sinkholes

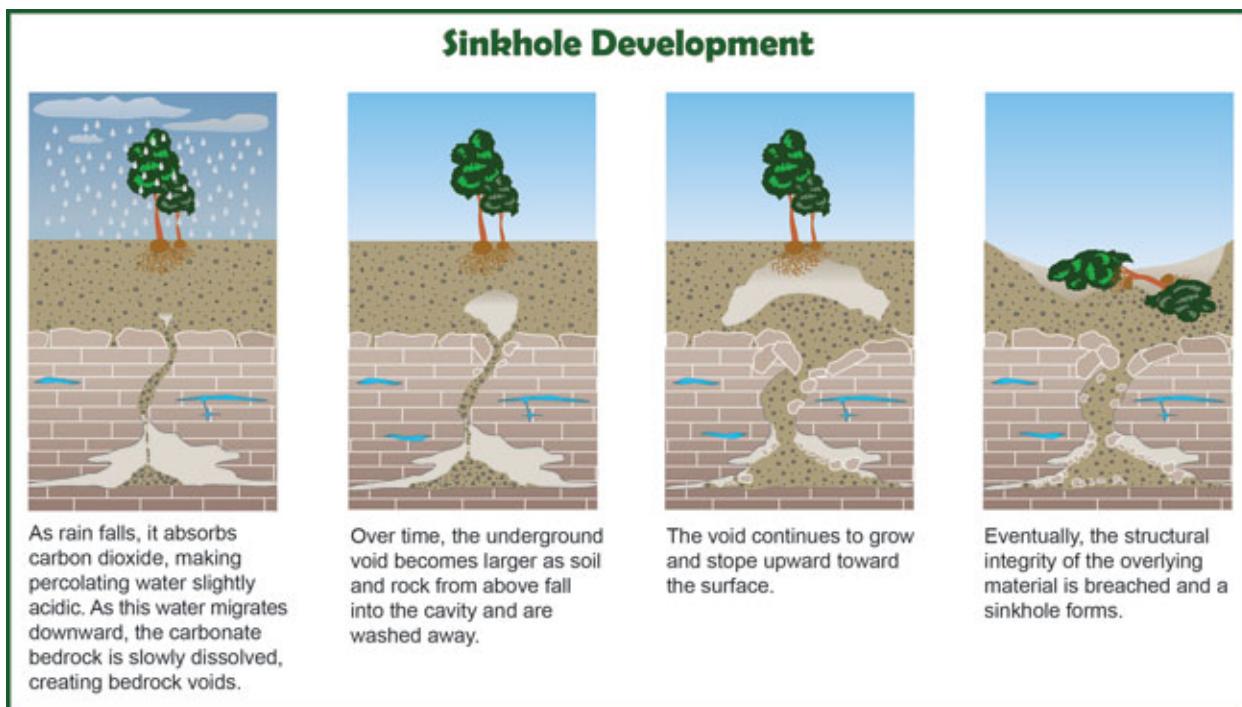
HAZARD PROFILE

Hazard Description

Sinkholes are common where the rock below the land surface is limestone, carbonate rock, salt beds, or rocks that naturally can be dissolved by ground water circulation 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 withdraw, and drainage of organic soils. In addition, sinkholes can develop as a result of subsurface void spaces created over time due to the erosion of subsurface limestone (karst).

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

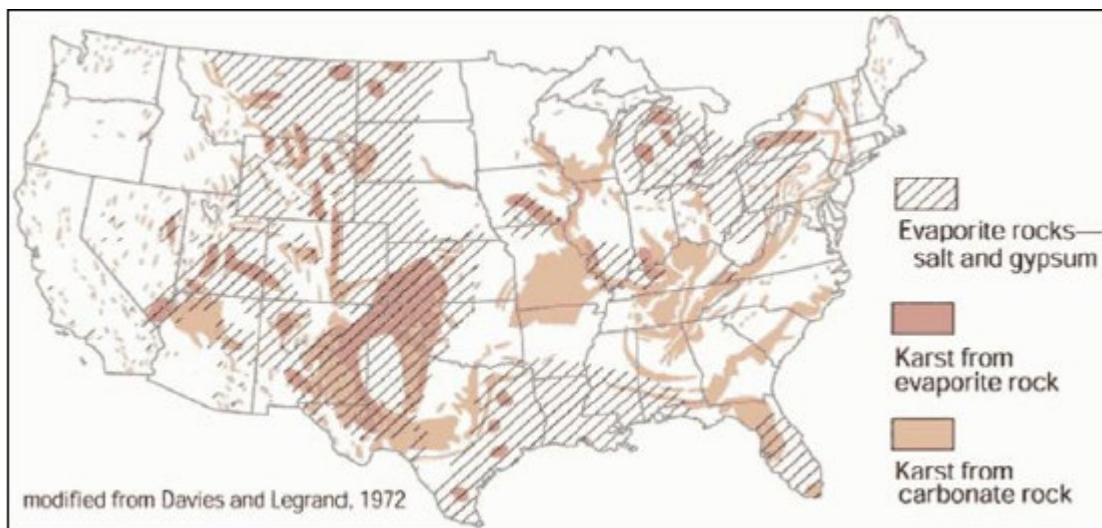
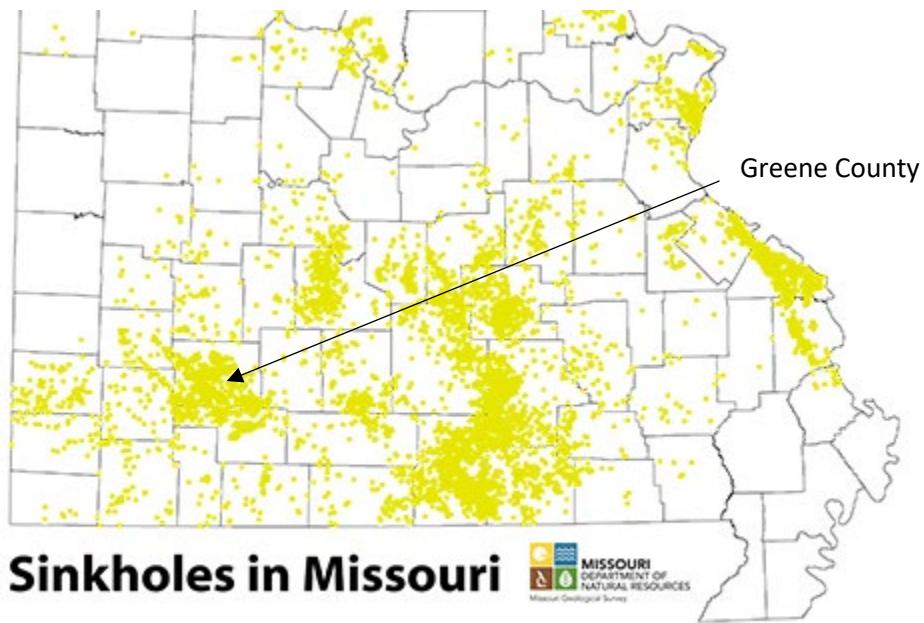
In the case of sinkholes, the rock below the surface is rock that has been dissolving by circulating groundwater. As the rock dissolves, spaces and caverns form, and ultimately the land above the spaces collapses. In Missouri, sinkhole problems are usually a result of surface materials above openings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



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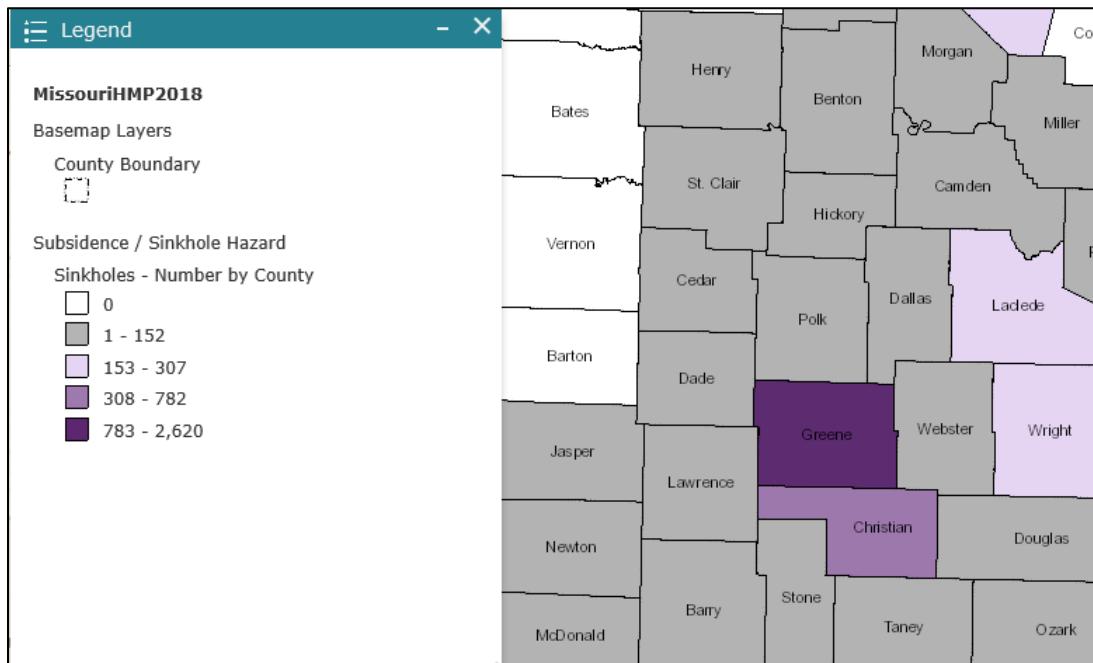
Geographic Location

Sinkholes are very popular in Greene County. According to the Missouri State Hazard Mitigation Plan written in 2018, there are 1292 sinkholes and 359 mines in Greene County. While sinkholes have not caused significant property damage or loss of life to date, they have, on numerous occasions, caused minor property damage, mainly to roadways after the sinkhole breaches to top soil.



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Number of Sinkholes by County



Strength/Magnitude/Extent

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

Previous Occurrences

August 2013

The City of Springfield Utility crews discovered a 50 feet wide and 25 feet deep sinkhole near Walnut Lawn at Cox while installing water mains.

August 2012

A sinkhole caused a road to collapse near the Springfield-Branson National Airport. A water main snapped when the concrete collapsed. The hole likely formed after heavy rains.

June 2009

A sinkhole approximately 70 foot wide and 30 foot deep was located at the bottom of a rain runoff area in Battlefield had to be patched as it threatened a city sewer lift station.

March 2009

A sinkhole 15 foot wide and 15 foot deep was found near McBride Elementary School in Springfield. The hole was across the street from the school. Officials examined the sinkhole and were able to fill it safely.

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Probability of Future Occurrence

The probability for hazards in Greene County is determined using Calculated Priority Risk Index (CPRI). It is very likely for a sinkhole event to occur within the next three years in Greene County. For a full description of the CPRI for land subsidence/sinkholes, refer to Appendix B.

Changing Future Conditions and Considerations

According to the Missouri State Hazard Mitigation Plan, direct effects from changing climate conditions such as an increase in droughts could contribute to an increase in sinkholes. These changes raise the likelihood of extreme weather, meaning the torrential rain and flooding conditions which often lead to the exposure of sinkhole 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 heavy influx of rain.

VULNERABILITY

Vulnerability Overview

Sinkholes vary in size and location. These factors will determine the impact of the hazard, which could manifest as the loss of a personal vehicle, a building collapse or damage to infrastructure such as roads, water or sewer lines. Groundwater contamination is also a possible impact of a sinkhole because of the relationship of sinkholes to groundwater.

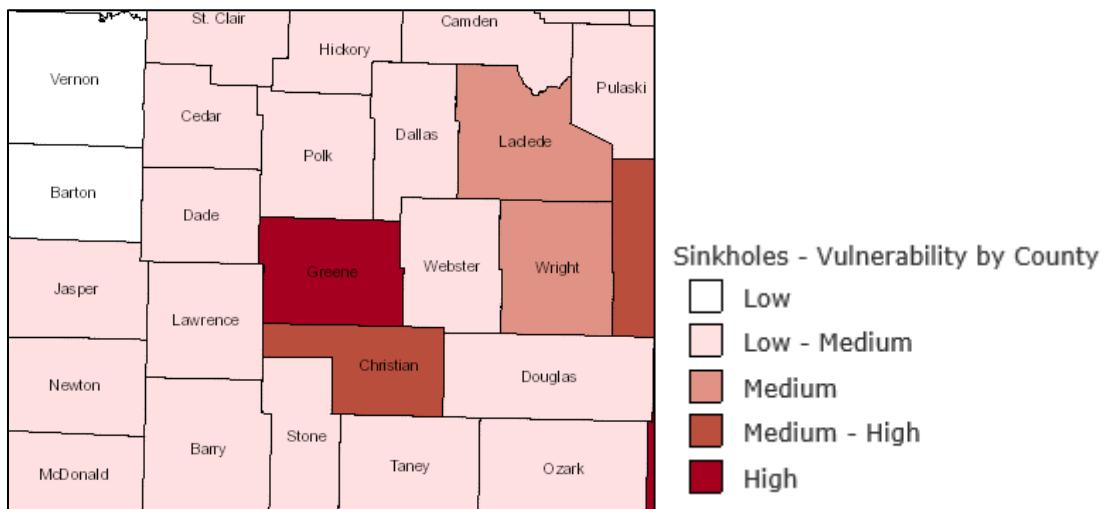
Using the Missouri Hazard Mitigation Viewer, the sinkhole hazard layer was used in conjunction with the MSDIS structure file to determine structures that fall within sinkhole areas as well as structures that are within a buffered distance of 50 feet of sinkholes. The number of mines per county was reported as available from the Department of Natural Resources. Based on natural breaks in the data, a rating value of 1 through 5 was assigned with the designations shown below.

Sinkhole Rating Values

FACTOR	1 (LOW)	2 (LOW-MEDIUM)	3 (MEDIUM)	4 (MEDIUM-HIGH)	5 (HIGH)
Sinkholes per County	0	1-200	201-400	401-800	801+
Mines Per County	0-100	101-250	251-500	501-750	751+

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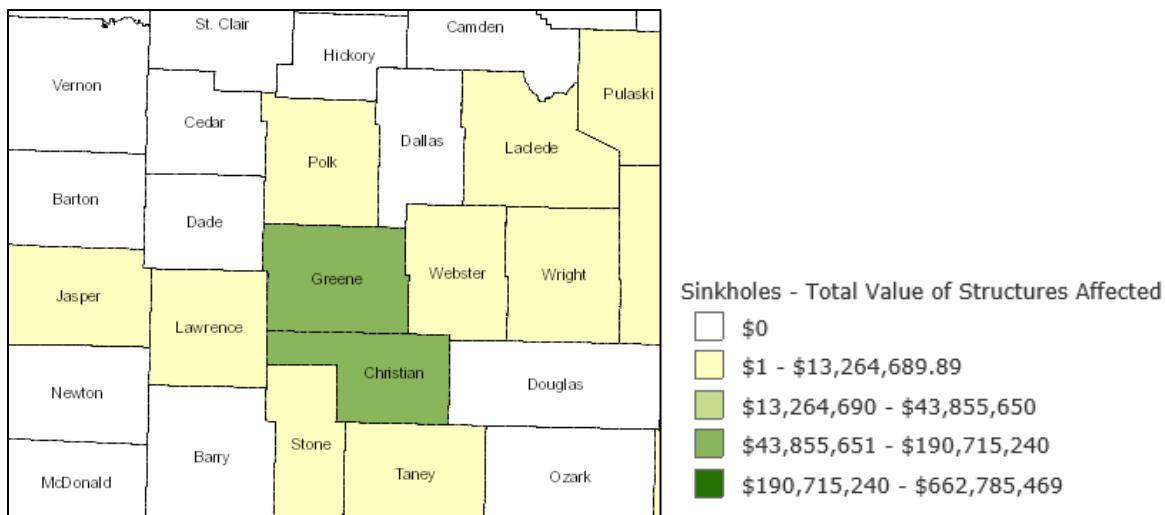
Sinkhole Rating Value - Greene County



Potential Losses to Existing Development

From GIS data collected the figures below show the potential for losses due to sinkholes. The first table shows the potential for losses due to sinkholes. The next two tables show the number of structures, the value of the structures and the population potentially impacted by sinkholes.

Ranking of Structures Potentially Impacted by Sinkholes - Greene County

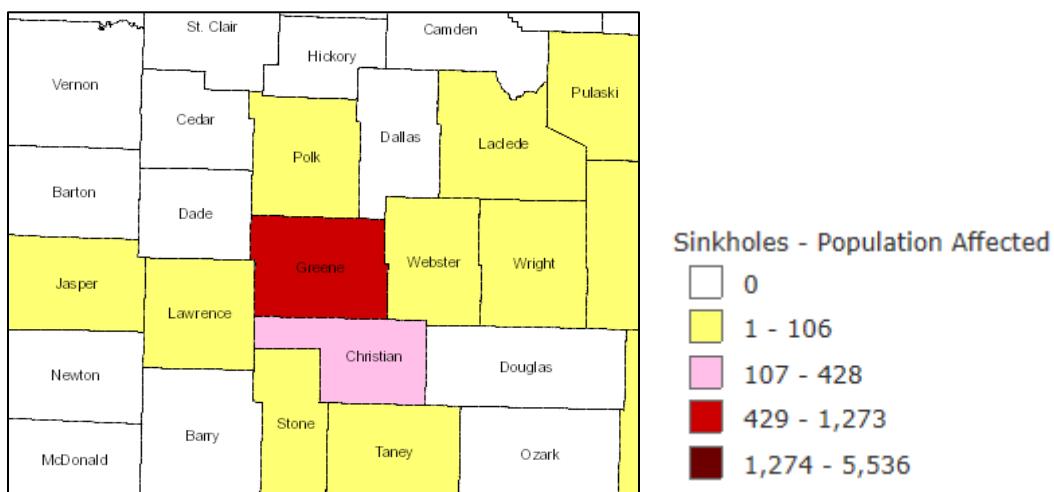


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Number and Value of Structures with Population Potentially Impacted- Greene County

COUNTY	NUMBER OF STRUCTURES	VALUE OF STRUCTURES	POPULATION
Greene	676 (Total)	\$190,715,240.29 (Total)	1,272.8
• Agriculture	86	\$21,835,375,.36	
• Commercial	37	\$31,752,303.08	
• Industrial	2	\$1,666,747.47	
• Residential	551	\$135,460,814.37	

Ranking of Population Potentially Impacted by Sinkholes-Greene County



Impact of Previous and Future Development

Greene County was listed as one of the top 10 counties with housing unit gains between 2010-2015. The population of Greene County is anticipated to keep growing. With population growth and increased development could cause and increase in exposure. Greene County does have building regulations that restrict building on areas where a sinkhole is located. It also limits how close properties can be built around sinkholes.

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EMAP Consequence Analysis

Impact Analysis: Land Subsidence/Sinkholes

SUBJECT	DETՐIMENTAL IMPACTS
Public	Land subsidence can be very dangerous and creates many safety concerns for residential or commercial areas.
Responders	There would be little to no impact on responders and response functions in Greene County due to land subsidence.
Continuity of Operations	Land subsidence has little to no impact on service operations.
Property, Facilities, and Infrastructure	Greene County could experience minor isolated instances of property damage in forms such as building and home foundations. Sinkholes have caused destruction on roadways, and must be filled in to repair road or continue construction on new roadways. This has happened in multiple areas in Greene County. Greene County has experienced little to no impact on facilities due to land subsidence.
Environment	Sinkholes create a direct link to the water supply, and depending on the location of the sinkholes, can directly contaminate drinking water. Contamination in the form of litter or trash, as well as chemicals from roadways can be washed into an open sinkhole especially if near a road or busy commercial area.
Economic Condition of Jurisdiction	Sinkholes can cause damage when expanding. Greene County has repaired multiple roadways in which a sinkhole caused damage. Land subsidence has a minor economic impact.
Public Confidence in the Jurisdiction's Governance	Land subsidence causes little to no loss of public confidence in governance in Greene County.

*For more details on Consequence Analysis, refer to Appendix B.

Hazard Summary by Jurisdiction

The entire area is at risk for experiencing complications from sinkholes. There isn't enough data to say that one area located within Greene County is more at risk than another. There are over 1,000 sinkholes spread across the county that we know of. There could be many more that have not been discovered yet.

PROBLEM STATEMENT

Sinkholes vary in size and location and cause an extreme amount of damage and property loss. Sinkholes can even cause injury or death. The entire planning area is at risk for experiencing damage from a sinkhole. Population growth and climate change can cause more sinkholes in the planning area over the next several years. Though there are not certain areas that are more at risk, all jurisdictions in the planning area should mitigate against this hazard. According to the Missouri State Mitigation Plan, Greene County is one of the counties listed as most likely area to be affected by sinkhole damage. Mitigation efforts include increasing knowledge and provide education, determining the risk and planning before a sink hole appears. There have been other large scale projects done in other parts of the country that involve relocating homes in the areas of known sinkholes. No participating jurisdiction created a Mitigation project involving sinkhole mitigation for this Mitigation Plan.

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3.4.6 Natural Hazard: 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 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 3.4.4) and tornadoes (discussed separately in Section 3.4.8)



High Winds



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

at speeds of more than 150 miles per hour. Damaging straight-line winds are high winds across a wide area that can reach speeds of 140 miles per hour.

Lightning

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

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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 $\frac{1}{4}$ inch

diameter or pea-sized hail requires updrafts of 24 miles per hour, while a $2\frac{3}{4}$ inches diameter or baseball-sized hail requires an updraft of 81 miles per hour. According to 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.

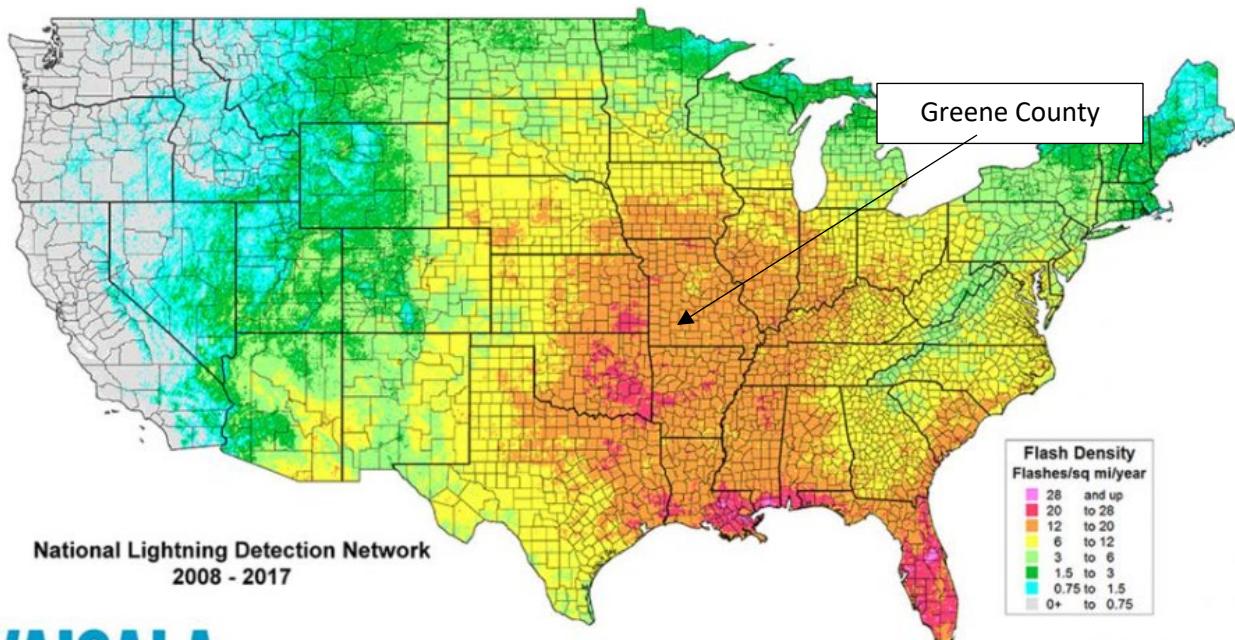
Geographic Location

Thunderstorms, high winds, hail and lightning are area wide hazards that can happen anywhere in Greene County. Although these events occur similarly throughout the planning area, damages are more likely to occur in more densely developed urban areas.

The following page has a map of lightning frequency in the United States.

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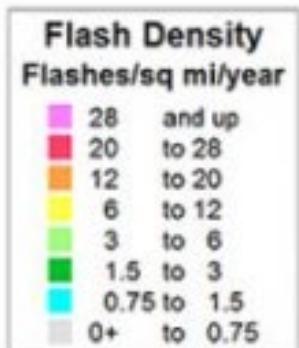
Location and Frequency of Lightning



VAISALA

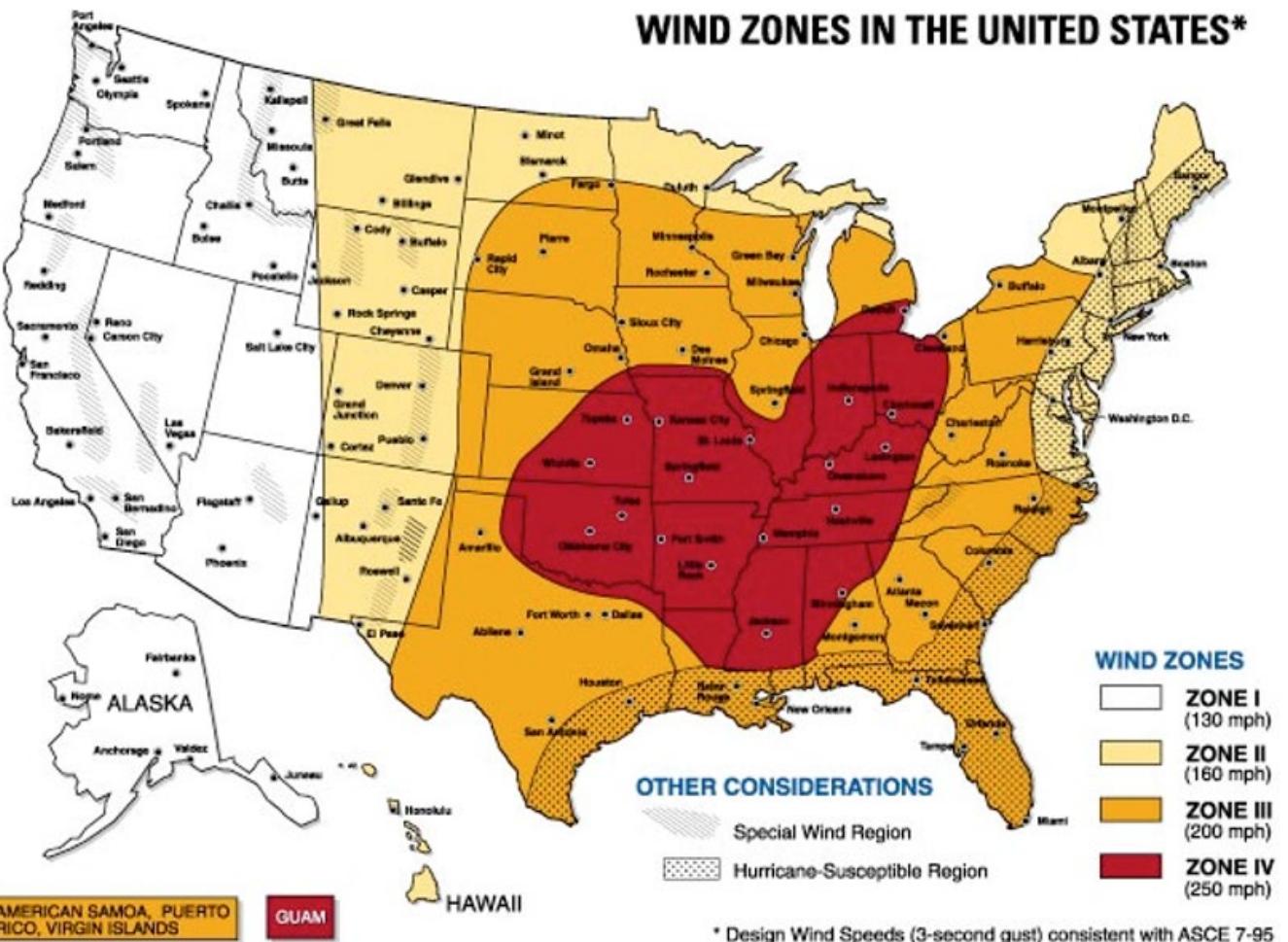
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Source: <https://www.vaisala.com/en/products/data-subscriptions-and-reports/data-sets/nldn>



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Wind Zones in the United States



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

Greene County is located within Wind Zone IV. This zone is high risk. During high winds, it is recommended to take shelter as a protection.

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Strength/Magnitude/Extent

Hail

Based on information provided by the Tornado and Storm Research Organization (TORRO), the table below describes typical damaged impacts of the various sizes of hail. In addition to hail diameter, factors including number and density of hailstones, hail fall speed and surface wind speeds affect severity.

INTENSITY CATEGORY	DIAMETER (MM)	DIAMETER (INCHES)	SIZE DESCRIPTION	TYPICAL DAMAGE IMPACTS
Hard Hail	2-9 mm	0.2-0.4 in	Pea	No Damage
Potentially Damaging	10-15 mm	0.4-0.6 in	Mothball	Slight General Damage to plants and crops
Significant	16-20 mm	0.6-0.8 in	Marble, Grape	Significant damage to fruit, crops and vegetation
Severe	21-30 mm	0.8-1.2 in	Walnut	Severe damage to fruit and crops, damage to glass and plastic structures, paint and wood scored
Severe	31-40 mm	1.2-1.6 in	Pigeon's egg > Squash Ball	Widespread glass damage, vehicle bodywork damage
Destructive	41-50 mm	1.6-2.0 in	Golf Ball > Pullet's Egg	Wholesale destruction of glass, damage to tiled roofs, significant risk of injuries
Destructive	51-60 mm	2.0-2.4 in	Hen's Egg	Bodywork of grounded aircraft dented, brick walls pitted
Destructive	61-75 mm	2.4-3.0 in	Tennis Ball > Cricket Ball	Severe roof damage, risk of serious injuries
Destructive	76-90 mm	3.0-3.5 in	Large Orange > Softball	Severed damage to aircraft bodywork
Super Hailstorms	91-100 mm	3.6-3.9 in	Grapefruit	Extensive structural damage. Risk of severe or even fatal injuries to persons caught in the open
Super Hailstorms	>100 mm	4.0+ in.	Melon	Extensive structural damage. Risk of severe or even fatal injuries to persons caught in the open

Source: Tornado and Storm Research Organization (TORRO), Department of Geography, Oxford Brookes University

Winds

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. Roofs, windows and homes can also be damaged as wind speeds increase.

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Lightning

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

NCEI Reported Hail Events with Hail Size 1 Inch or Larger - 2008-2018

LOCATION	DATE	SIZE OF HAIL	INJURIES	DEATHS	PROPERTY DAMAGE
Springfield/Republic/Fair Grove/Unincorporated Greene County	01/07/2008	1.0-3.0in	0	0	\$300,000
Republic	01/08/2008	1.75in	0	0	\$0
Unincorporated Greene County	02/04/2008	1.0in	0	0	\$0
Willard/ Springfield/ Battlefield/Unincorporated Greene County	06/15/2008	1.0-1.75in	0	0	\$0
Springfield/Unincorporated Greene County	06/19/2008	1.0-2.75in	0	0	\$0
Springfield/Unincorporated Greene County	06/21/2008	1.0-1.25in	0	0	\$0
Willard	06/28/2008	1.0in	0	0	\$0
Springfield	11/06/2008	1.0in	0	0	\$0
Republic	04/09/2009	1.75in	0	0	\$0
Springfield	04/23/2010	1.0in	0	0	\$0
Unincorporated Greene County	04/30/2010	1.0in	0	0	\$0
Springfield	06/19/2010	1.0in	0	0	\$0
Willard	07/11/2010	1.0in	0	0	\$0
Republic	09/02/2010	1.0in	0	0	\$0
Springfield	11/22/2010	1.50-1.75in	0	0	\$0
Willard/Springfield/Strafford/Unincorporated Greene County	11/24/2010	1.0-1.75in	0	0	\$0
Unincorporated Greene County	12/31/2010	1.0in	0	0	\$0
Springfield/Strafford/Walnut Grove	04/22/2011	1.0-1.75in	0	0	\$0
Republic/ Unincorporated Greene County	04/23/2011	1.0in	0	0	\$0
Ash Grove/Springfield/Fair Grove/ Unincorporated Greene County	05/25/2011	1.0in-2.75in	0	0	\$160,000
Unincorporated Greene County	07/02/2011	1.75in	0	0	\$0
Springfield	07/03/2011	1.0-1.75in	0	0	\$0
Fair Grove	04/27/2012	1.0in	0	0	\$0
Willard	05/20/2012	1.0in	0	0	\$0
Republic	06/11/2012	1.0in	0	0	\$0
Battlefield/Unincorporated Greene County	08/16/2012	1.0in	0	0	\$0
Springfield/Unincorporated Greene County	09/21/2012	1.0in	0	0	\$0
Republic	10/12/2012	1.0in	0	0	\$0
Springfield	03/17/2013	1.0in	0	0	\$0

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Unincorporated Greene County	06/15/2013	1.0-2.0in	0	0	\$0
Republic	06/28/2013	1.0in	0	0	\$0
Unincorporated Greene County	07/03/2013	1.0in	0	0	\$0
Unincorporated Greene County	07/04/2013	1.0in	0	0	\$0
Unincorporated Greene County	08/05/2013	1.0in	0	0	\$0
Unincorporated Greene County	03/27/2014	1.0in	0	0	\$0
Battlefield/Springfield/ Unincorporated Greene County	04/24/2014	1.0-1.25in	0	0	\$0
Ash Grove/Unincorporated Greene County	06/06/2014	1.0-2.5in	0	0	\$0
Unincorporated Greene County	03/24/2015	1.0in	0	0	\$0
Springfield/ Unincorporated Greene County	03/25/2015	1.0-1.75in	0	0	\$0
Unincorporated Greene County	04/01/2015	1.0in	0	0	\$0
Republic	04/21/2015	1.0in	0	0	\$0
Battlefield	03/13/2016	1.0in	0	0	\$0
Fair Grove	04/26/2016	1.0in	0	0	\$0
Battlefield/Fair Grove	03/01/2016	1.0in	0	0	\$0
Walnut Grove/Fair Grove/Strafford/Springfield/ Unincorporated Greene County	03/09/2017	1.0-1.5in	0	0	\$0
Unincorporated Greene County	04/04/2017	1.5in	0	0	\$0
Fair Grove/ Unincorporated Greene County	05/10/2017	1.0in	0	0	\$0
Republic	05/19/2017	1.25in	0	0	\$0
Willard/ Springfield/ Walnut Grove/ Strafford/ Unincorporated Greene County	05/27/2017	1.0in-1.75in	0	0	\$0
Unincorporated Greene County	06/01/2017	1.0in	0	0	\$0
Unincorporated Greene County	05/16/2018	1.0in	0	0	\$0
Strafford	05/19/2018	1.0in	0	0	\$0
Battlefield/ Springfield/ Unincorporated Greene County	06/14/2018	1.0-1.75in	0	0	\$5,000
Fair Grove	07/20/2018	1.0in	0	0	\$0
Springfield	08/10/2018	1.0-1.75in	0	0	\$2,000
Springfield	08/30/2018	1.0in	0	0	\$0
Total					\$467,000

Source: National Centers for Environmental Information

*Note: The events listed are only events that were reported to National Centers for Environmental Information (NCEI).

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NCEI Reported Thunderstorm Wind Events - 2008-2018

LOCATION	DATE	KTS (KNOTS)	MPH (MILES PER HOUR)	INJURIES	DEATHS	PROPERTY DAMAGE
Republic/ Springfield/ Strafford/ Unincorporated Greene County	01/07/2008	52-61 KTS	59-70 MPH	0	0	\$35,000
Battlefield/ Springfield	01/08/2008	52-87 KTS	59-100 MPH	0	0	\$20,000
Springfield	03/31/2008	50-69 KTS	57-79 MPH	0	0	0
Ash Grove	04/23/2008	50 KTS	57 MPH	0	0	\$1,000
Springfield	05/02/2008	56 KTS	64 MPH	0	0	0
Willard	05/10/2008	50 KTS	57 MPH	0	0	0
Willard	06/03/2008	50 KTS	57 MPH	0	0	0
Springfield	06/15/2008	50-56 KTS	57-64 MPH	0	0	0
Springfield/ Unincorporated Greene County	06/19/2008	50-70 KTS	57-80 MPH	0	0	\$335,000
Battlefield	06/28/2008	52 KTS	59 MPH	0	0	0
Battlefield	07/08/2008	50 KTS	57 MPH	0	0	0
Battlefield/ Springfield	07/22/2008	50-52 KTS	57-59 MPH	0	0	\$1,000
Battlefield/ Springfield	07/26/2008	50-54 KTS	57-62 MPH	0	0	0
Unincorporated Greene County	08/06/2008	50 KTS	57 MPH	0	0	0
Springfield	08/14/2008	50 KTS	57 MPH	0	0	0
Republic/ Springfield/ Unincorporated Greene County	11/06/2008	50-56 KTS	57-64 MPH	0	0	0
Springfield	12/27/2008	50 KTS	57 MPH	0	0	0
Willard/ Fair Grove/ Unincorporated Greene County	03/08/2009	56-74 KTS	64-85 MPH	0	0	\$20,000
Republic/ Willard	03/24/2009	52 KTS	59 MPH	0	0	0
Republic/ Springfield/ Walnut Grove/ Unincorporated Greene County	04/09/2009	50-70 KTS	57 MPH	0	0	\$2,000
Unincorporated Greene County	05/08/2009	78 KTS	89 MPH	0	4	\$15,000,000
Springfield/ Unincorporated Greene County	05/13/2009	50-57 KTS	57-65 MPH	0	0	\$5,000
Strafford	06/10/2009	52 KTS	59 MPH	0	0	0
Willard/ Walnut Grove/ Springfield	06/16/2009	52-61 KTS	59-70 MPH	0	0	\$2,100

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Battlefield/ Republic	06/23/2009	61-70 KTS	70-80 MPH	0	0	\$27,000
Springfield/ Unincorporated Greene County	06/24/2009	52 KTS	59 MPH	0	0	0
Unincorporated Greene County	07/29/2009	50 KTS	57 MPH	0	0	0
Springfield/ Unincorporated Greene County	08/19/2009	52 KTS	59 MPH	0	0	0
Springfield	04/24/2010	54 KTS	62 MPH	0	0	0
Unincorporated Greene County	05/13/2010	52 KTS	59 MPH	0	0	0
Springfield/ Battlefield/ Fair Grove/ Unincorporated Greene County	06/16/2010	52-61 KTS	59-70 MPH	0	0	\$27,000
Springfield	06/19/2010	52 KTS	59 MPH	0	0	\$6,000
Springfield	07/16/2010	52 KTS	59 MPH	0	0	0
Ash Grove	08/13/2010	52 KTS	59 MPH	0	0	\$5,000
Strafford/ Fair Grove	08/15/2010	52 KTS	59 MPH	0	0	\$1,000
Unincorporated Greene County	09/02/2010	50 KTS	57 MPH	0	0	\$0
Unincorporated Greene County	09/15/2010	52-74 KTS	59-85 MPH	0	0	\$40,000
Unincorporated Greene County	10/26/2010	52 KTS	59 MPH	0	0	\$2,000
Springfield/ Unincorporated Greene County	11/22/2010	52-56 KTS	59-64 MPH	0	0	\$5,000
Springfield	11/24/2010	52 KTS	59 MPH	0	0	\$1,000
Unincorporated Greene County	04/10/2011	52 KTS	59 MPH	0	0	\$25,000
Republic	05/12/2011	52-53 KTS	59-60 MPH	0	0	\$7,000
Unincorporated Greene County	05/25/2011	52 KTS	59 MPH	0	0	0
Republic/ Springfield	06/14/2011	52 KTS	59 MPH	0	0	0
Ash Grove/ Walnut Grove/ Fair Grove/ Springfield/ Unincorporated Greene County	06/18/2011	52-61 KTS	59-70 MPH	0	0	\$10,000
Unincorporated Greene County	07/23/2011	52 KTS	59 MPH	0	0	\$10,000
Springfield/ Battlefield	07/24/2011	59-61 KTS	67-70 MPH	0	0	\$2,000
Springfield	07/30/2011	52 KTS	59 MPH	0	0	\$5,000
Strafford	08/07/2011	52 KTS	59 MPH	0	0	\$5,000
Republic	02/29/2012	52-56 KTS	59-64 MPH	0	0	\$1,000
Republic	05/01/2012	52 KTS	59 MPH	0	0	\$0

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Ash Grove/ Springfield	06/11/2012	52-61 KTS	59-70 MPH	0	0	\$112,000
Springfield/ Unincorporated Greene County	07/07/2012	52 KTS	59 MPH	0	0	\$29,000
Ash Grove/ Springfield/ Strafford/ Republic/ Unincorporated Greene County	08/04/2012	50-61 KTS	57-70 MPH	0	0	\$3,000
Republic/ Springfield/ Unincorporated Greene County	08/08/2012	51-54 KTS	58-62 MPH	0	0	\$10,000
Battlefield	08/16/2012	52 KTS	59 MPH	0	0	0
Springfield/ Walnut Grove/ Fair Grove/ Unincorporated Greene County	09/07/2012	52-61 KTS	59-70 MPH	0	0	\$5,000
Republic/ Unincorporated Greene County	10/13/2012	52-61 KTS	59-70 MPH	0	0	\$20,000
Ash Grove/ Walnut Grove/ Unincorporated Greene County	10/17/2012	52-61 KTS	59-71 MPH	0	0	\$9,000
Springfield/ Unincorporated Greene County	01/29/2013	52 KTS	59 MPH	0	0	\$10,000
Battlefield/ Unincorporated Greene County	05/20/2013	50-52 KTS	57-59 MPH	0	0	\$1,000
Battlefield/ Unincorporated Greene County	06/15/2013	52 KTS	59 MPH	0	0	0
Republic/ Battlefield/ Springfield/ Republic	06/28/2013	52-61 KTS	59-70 MPH	0	0	\$250,000
Willard/ Unincorporated Greene County	08/03/2013	52 KTS	59 MPH	0	0	0
Unincorporated Greene County	04/03/2014	52 KTS	59 MPH	0	0	0
Unincorporated Greene County	05/26/2014	52 KTS	59 MPH	0	0	\$1,000
Battlefield/ Springfield	06/05/2014	52 KTS	59 MPH	0	0	\$2,000
Walnut Grove	07/07/2014	52 KTS	59 MPH	0	0	\$1,000
Walnut Grove/ Ash Grove/ Republic/ Springfield/ Battlefield/	07/08/2014	51-52 KTS	58-59 MPH	0	1	\$56,000

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Unincorporated Greene County						
Springfield/ Unincorporated Greene County	09/01/2014	52 KTS	59 MPH	0	0	\$40,000
Ash Grove/ Fair Grove/ Unincorporated Greene County	10/02/2014	52 KTS	59 MPH	0	0	\$1,000
Unincorporated Greene County	04/21/2015	52 KTS	59 MPH	0	0	0
Republic/ Springfield/ Willard	05/17/2015	52-56 KTS	59-64 MPH	0	0	\$32,000
Ash Grove/ Willard/ Unincorporated Greene County	05/29/2015	52 KTS	59 MPH	0	0	\$15,000
Unincorporated Greene County	06/13/2015	52 KTS	59 MPH	0	0	\$5,000
Willard/ Fair Grove/ Unincorporated Greene County	07/14/2015	52 KTS	59 MPH	0	0	\$1,000
Fair Grove	07/15/2015	52 KTS	59 MPH	0	0	\$5,000
Springfield/ Unincorporated Greene County	07/24/2015	52 KTS	59 MPH	0	0	\$5,000
Ash Grove/ Walnut Grove	08/10/2015	52 KTS	59 MPH	0	0	0
Springfield	08/23/2015	52 KTS	59 MPH	0	0	\$5,000
Republic/ Battlefield	04/27/2016	52-61 KTS	59-70 MPH	0	0	\$210,000
Battlefield/ Unincorporated Greene County	06/23/2016	52-56 KTS	59-64 MPH	0	0	\$3,000
Springfield	06/30/2016	52 KTS	59 MPH	0	0	\$0
Republic	07/08/2016	52 KTS	59 MPH	0	0	\$0
Walnut Grove/ Unincorporated Greene County	08/25/2016	52 KTS	59 MPH	0	0	\$1,000
Ash Grove	10/19/2016	52 KTS	59 MPH	0	0	\$2,000
Fair Grove	03/01/2017	52 KTS	59 MPH	0	0	0
Springfield/ Unincorporated Greene County	03/06/2017	52-56 KTS	59-64 MPH	0	0	\$65,000
Springfield	03/09/2017	52 KTS	59 MPH	0	0	\$1,000
Willard/ Unincorporated Greene County	04/04/2017	52 KTS	59 MPH	0	0	\$5,000
Springfield	04/26/2017	52 KTS	59 MPH	0	0	\$0
Battlefield/ Unincorporated Greene County	05/19/2017	52 KTS	59 MPH	0	0	0
Fair Grove/ Republic/ Battlefield	05/27/2017	52-60 KTS	59-69 MPH	0	0	0

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Springfield/ Unincorporated Greene County	06/01/2017	52 KTS	59 MPH	0	0	\$1,000
Springfield	06/17/2017	52 KTS	59 MPH	0	0	0
Springfield	06/22/2017	61 KTS	70 MPH	0	0	\$25,000
Battlefield, Springfield, Unincorporated Greene County	06/23/2017	51-52 KTS	58-59 MPH	0	0	\$1,000
Springfield	06/30/2017	52-61 KTS	59-70 MPH	0	0	\$10,000
Ash Grove	08/05/2017	52 KTS	59 MPH	0	0	\$1,000
Springfield/ Unincorporated Greene County	10/21/2017	52 KTS	59 MPH	0	0	\$6,000
Fair Grove	10/22/2017	53 KTS	60 MPH	0	0	\$0
Willard/ Springfield	12/04/2017	52-70 KTS	59-80 MPH	0	0	\$14,000
Unincorporated Greene County	05/03/2018	52 KTS	59 MPH	0	0	\$5,000
Unincorporated Greene County	05/25/2018	52 KTS	59 MPH	0	0	0
Battlefield	06/14/2018	52 KTS	59 MPH	0	0	\$4,000
Springfield/ Republic/ Unincorporated Greene County	06/26/2018	52-58 KTS	59-66 MPH	0	0	\$4,000
Battlefield/ Republic/ Springfield/ unincorporated Greene County	07/19/2018	52-61 KTS	59-70 MPH	0	0	\$50,000
Ash Grove	08/09/2018	52 KTS	59 MPH	0	0	0
Battlefield/ Springfield/ Willard/ Unincorporated Greene County	08/10/2018	52 KTS	59 MPH	0	0	\$46,000
Republic	08/19/2018	52 KTS	59 MPH	0	0	\$1,000
Willard	09/20/2018	52 KTS	59 MPH	0	0	0
Battlefield/ Republic/ Fair Grove/ Springfield/ Unincorporated Greene County	12/01/2018	52-72 KTS	59-82 MPH	0	0	\$234,000
Total						\$17,021,000

Source: National Centers for Environmental Information

*Note: The events listed are only events that were reported to the National Centers for Environmental Information (NCEI).

3 - RISK ASSESSMENT

NCEI Reported Lightning Events with Injuries or Property Damage- 2008-2018

LOCATION	DATE	INJURIES	DEATHS	PROPERTY DAMAGE
Springfield	005/01/2009	0	0	\$10,000
Unincorporated Greene County	06/24/2009	1	0	\$0
Unincorporated Greene County	07/06/2011	0	0	\$5,000
Unincorporated Greene County	02/25/2013	0	0	\$300,000
Fair Grove	04/23/2013	0	0	\$50,000
Fair Grove	05/31/2013	0	2	\$0
Unincorporated Greene County	07/03/2013	0	0	\$50,000
Springfield	03/25/2015	0	0	\$2,000
Republic	05/10/2015	0	0	\$300,000
Unincorporated Greene County	03/30/2016	0	0	\$5,000
Unincorporated Greene County	03/21/2017	0	0	\$30,000
Total				\$752,000

Source: National Centers for Environmental Information

*Note: The events listed are only events that were reported to National Centers for Environmental Information (NCEI).

The only data what was available on the National Centers for Environmental Information about lightning was data that included injuries or property loss. Greene County experiences a lot more lightning strikes throughout the year.

Crop Insurance Claims

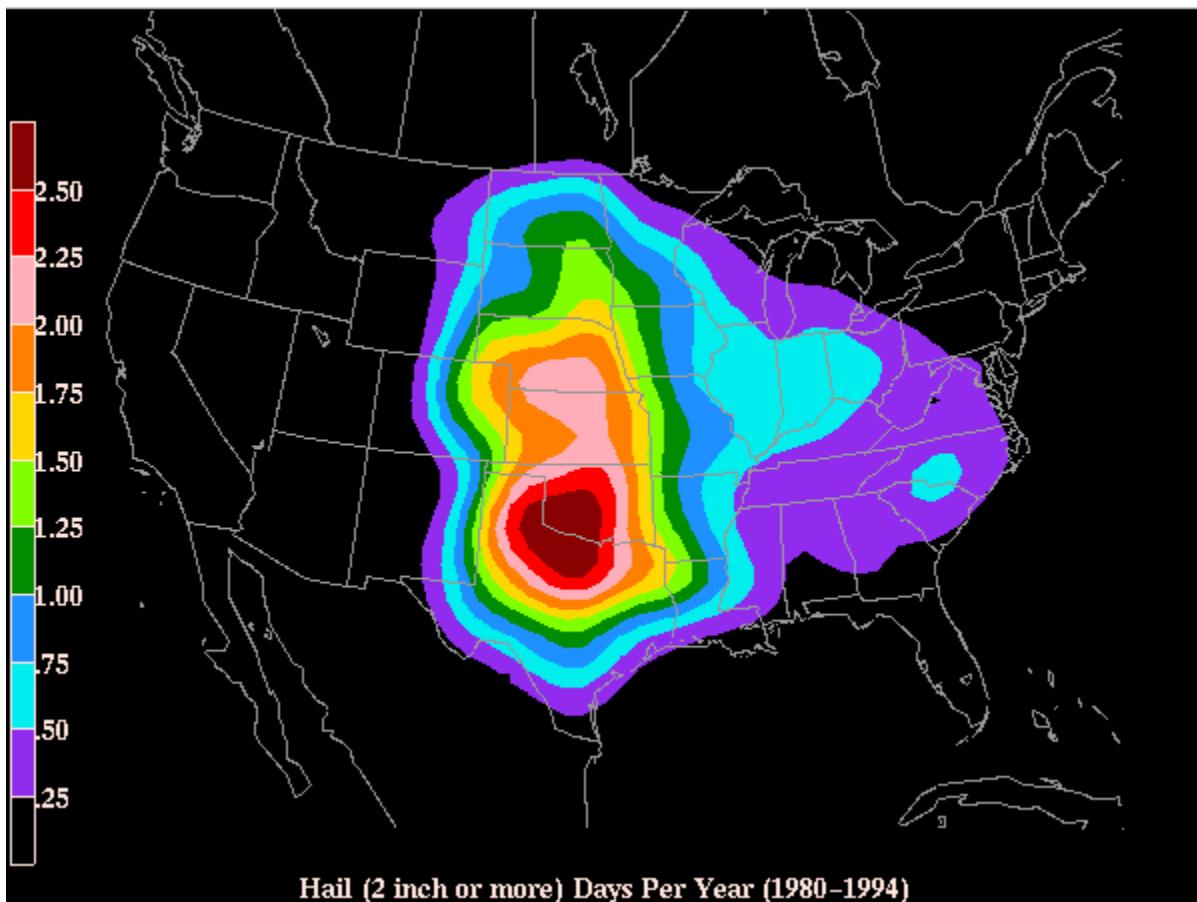
Severe storms that include high winds, hail and lightning can also cause damages to crops and farmland. Over the last 5 years, there have been very few insurance claims that have been paid out because of hail, winds and lightning. Majority of the insurance payouts were due to excess moisture because of heavy rainfall. There were a few insurance payouts from lightning and high winds, which totaled to be \$48,769.40.

Probability of Future Occurrence

The probability for hazards in Greene County is determined using Calculated Priority Risk Index (CPRI). It is highly likely for a severe thunderstorm to occur within the next year in Greene County. For a full description of the CPRI for severe thunderstorms, refer to Appendix B.

3 - RISK ASSESSMENT

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



Source: https://www.nssl.noaa.gov/users/brooks/public_html/bighail.gif

Changing Future Conditions and Considerations

According to the 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 a 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.

The Missouri State Hazard Mitigation Plan also states that predicted increases in temperature could help create atmospheric conditions that are fertile breeding grounds for severe thunderstorms and tornadoes in Missouri. As the population of Greene County continues to grow, the chance for more impact to housing, life, and property in both the public and private sectors increases. In the future, it is predicted that many areas, including Greene County, will see more severe weather.

3 - RISK ASSESSMENT

VULNERABILITY

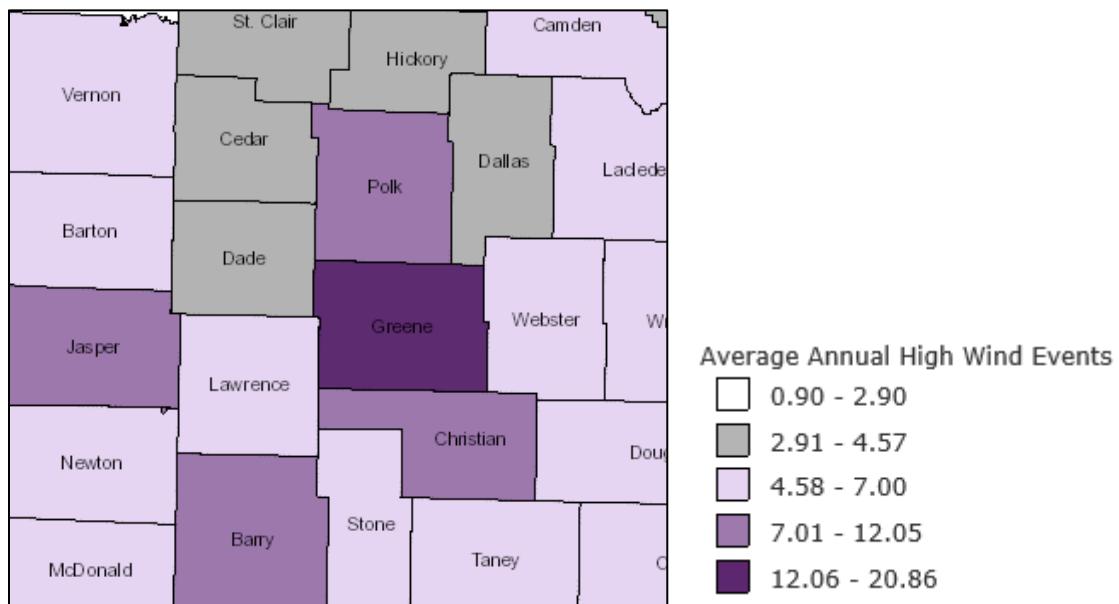
Vulnerability Overview

Severe thunderstorm losses are usually attributed to the associated hazards of hail, downburst winds, lightning and heavy rains. Losses due to hail and high winds 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. (Section 3.4.4) Hailstorms cause damage to property, crops, and the environment, and can injure and even kill livestock. In the United States, hail causes more than \$1 billion in damage to property and crops each year. Even relatively small hail can shred plants to ribbons in a matter of minutes. Vehicles, roofs of buildings and homes, and landscaping are also commonly damaged by hail. Hail has been known to cause injury to humans, occasionally fatal injury.

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

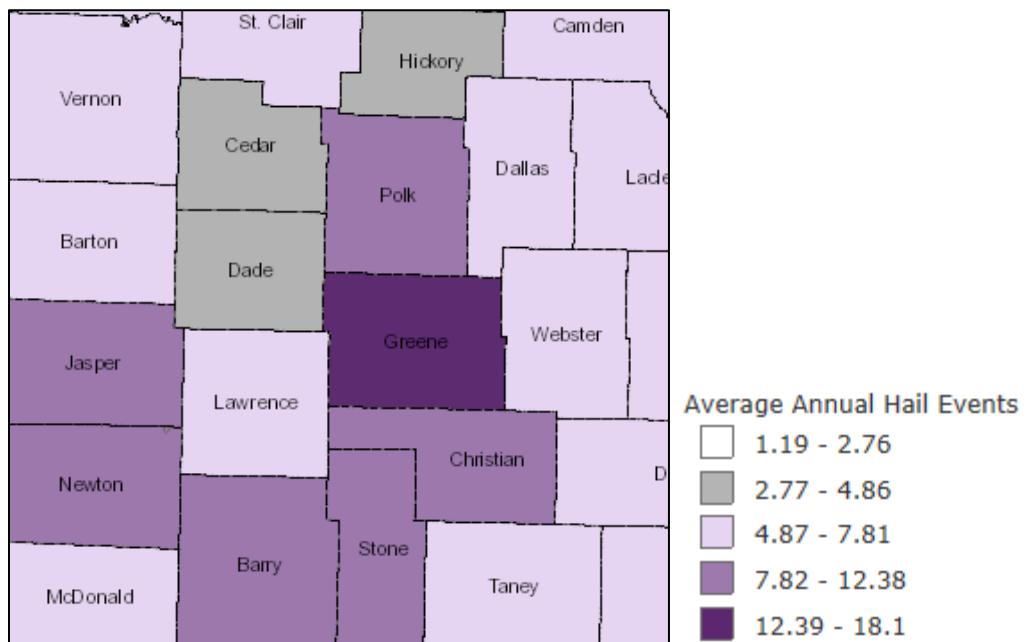
Most lightning damages occur to electronic equipment located inside buildings. But structural damage can also occur when a lightning strike causes a building fire. In addition, lightning strikes can cause damages to crops, if fields or forested lands are set on fire. Communications equipment and warning transmitters and receivers can also be knocked out by lightning strikes.

Average Annual High Wind Events

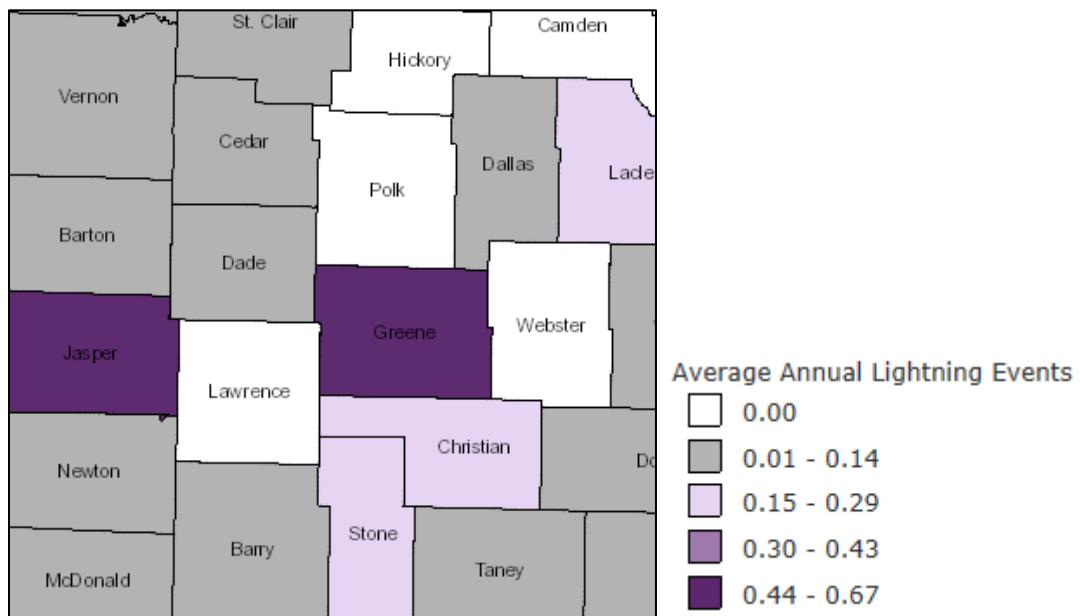


3 - RISK ASSESSMENT

Average Annual Hail Events

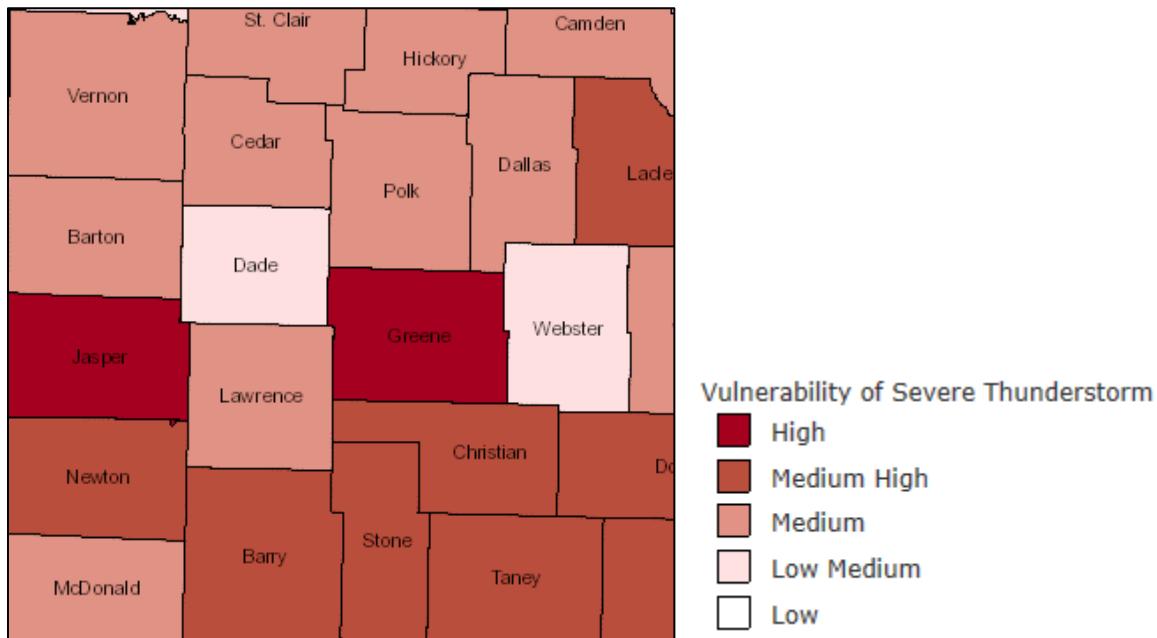


Average Annual Lightning Events



3 - RISK ASSESSMENT

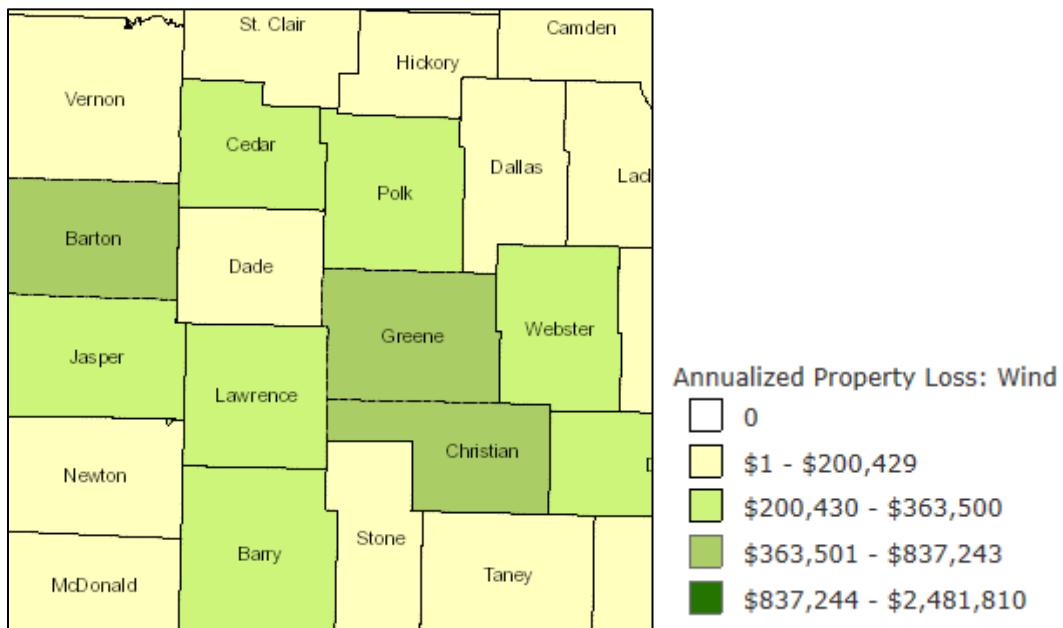
Overall Vulnerability of Severe Thunderstorms



Potential Losses to Existing Development

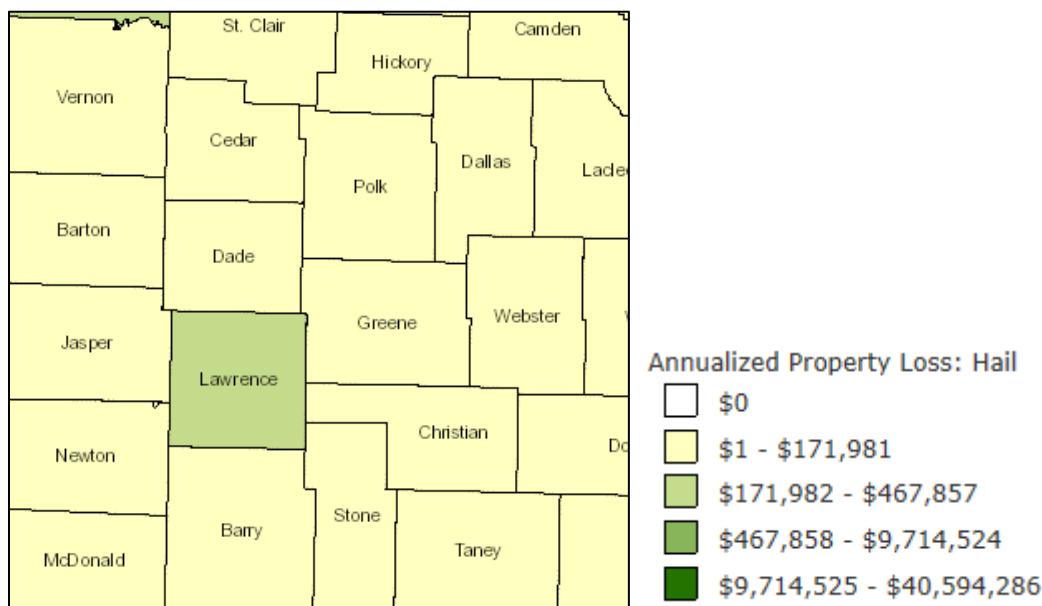
In the past, severe storms have had a history of causing damage. In 2008, a severe storm came through Greene County causing about \$300,000 in damages. In 2011, golf ball-sized hail covered the ground and destroyed \$10,000 in crops at a local orchard. Damaging winds have caused over \$17 million in damage between 2008-2018. Between the years 2008-2018, lightning has caused over \$700,000 in damage. Greene County has a lot of property that is vulnerable to severe storms.

Annualized Property Loss: Wind

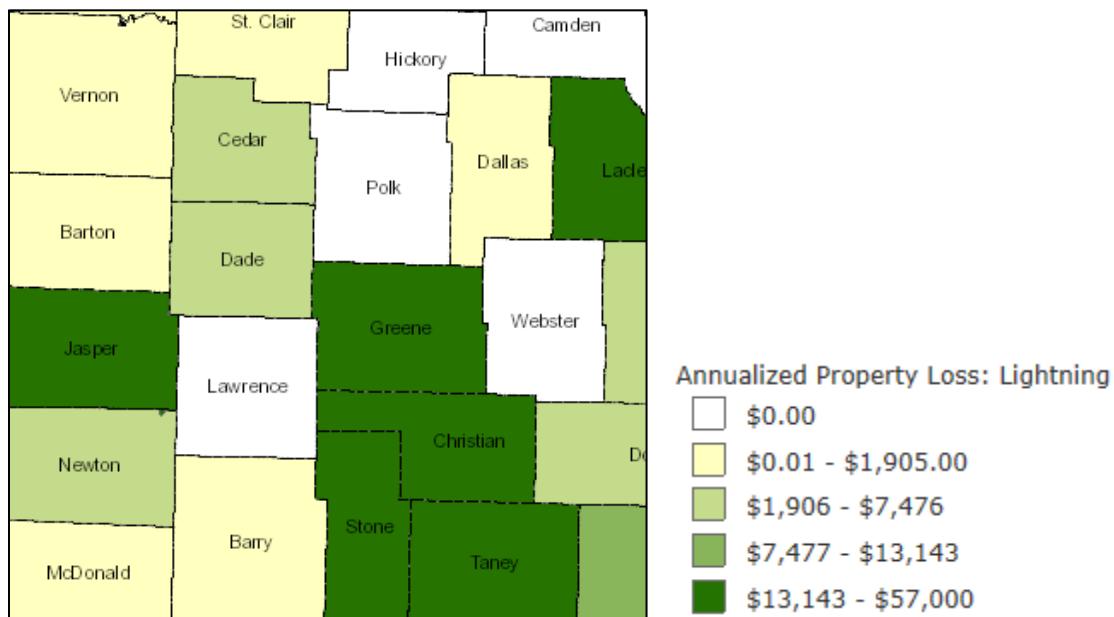


3 - RISK ASSESSMENT

Annualized Property Loss: Hail



Annualized Property Loss: Lightning



Previous and Future Development

Greene County has seen consistent population growth over the last 10 years. Over the next 10 years, the population will continue to grow and businesses will continue to develop across the area. Additional development results in the exposure of more households and businesses to damages from severe thunderstorms, high winds, lightning and hail.

3 - RISK ASSESSMENT

EMAP Consequence Analysis

EMAP Impact Analysis: Severe Thunderstorms

SUBJECT	DETՐИMENТАL IMPACTS
Public	Although damaging winds can cause injury or even death, Greene County has never experienced any of these consequences. Damaging winds can create unsafe situation such as downed power lines and falling debris from trees. There is little to no impact on public safety in Greene County due to hail. There is a significant safety concern during lightning. Injuries and minimal number of deaths have occurred.
Responders	Safety and functionality of responders can be impacted by road conditions (fallen trees or power lines) or from power failure. However, damaging wind has not caused these types of conditions to interfere with the safety and functionality of responders in Greene County. There is little to no impact of the safety and functionality in Greene County due to hail. If lightning is still present at time of response, there is a potential for safety issues. There should be no impact to response functions.
Continuity of Operations	Severe thunderstorms have caused little to no impact on service operations.
Property, Facilities, and Infrastructure	Damaging wind: Damaging winds cause many property damages. Trees and utility poles have been knocked over onto cars or even houses. Roofs have also been damaged from these strong winds. These damages are typically minor isolated instances, but frequently in Greene County. Damaging winds create the most problems in taking down utility services and power to the community. This can impact all other critical infrastructure sectors. Facility damages occur frequently and typically have several instances of significant damage. As discussed in the damaging wind vulnerability, schools buildings, stores, and other entities have had significant damage from damaging winds. Hail: hail causes minor isolated instances of property damage in Greene County. Hail has also has little to no impact on critical infrastructure and facility damage.
Environment	Damaging winds have no affected the environment in terms of the floodplains or waste, but have downed numerous trees. Hail and lightning has caused little to no impact on the environment.
Economic Condition of Jurisdiction	The economy is impacted by damaging wind when power is no longer available. This can cause problems for businesses and their operations, and power also causes an economic impact on utility services. Lightning and hail have causes little to no impact on Greene County's economy.
Public Confidence in the Jurisdiction's Governance	Severe thunderstorms have little to no impact on the public confidence in governance.

*For more details on Consequence Analysis, refer to Appendix B.

3 - RISK ASSESSMENT

Hazard Summary by Jurisdiction

Severe thunderstorm events are area-wide hazards. There are some demographics that can cause higher losses in one jurisdiction as compared to another. The City of Ash Grove has 248 homes that were built in 1939 or earlier. Older homes are more at risk in suffering damage from high winds and hail than newer homes are. In Walnut Grove, over 18% of their total housing units are also homes that were built in 1939 or earlier putting them at higher risk for damage as well.

PROBLEM STATEMENT

Severe thunderstorms carry multiple risks for Greene County including damages and injury from high winds, hail and lightning. The entire planning area suffers from many severe thunderstorms year round. In the past, severe thunderstorms have been known to cause millions of dollars' worth of damage. The National Centers for Environmental Information (NCEI) Storm Events Database notes over 150 storm events between the years 2008-2018 causing over \$18 million in damages. NASA and meteorologists predict that in the future severe thunderstorms could become more popular nation-wide. Possible mitigation solutions include review of local ordinance and building codes to address high winds and/or construction techniques to include structural bracing, straps and clips, or anchor bolts. Several participating jurisdictions created mitigation projects for severe storms, they are included in the Mitigation Strategy section of the Mitigation Plan.

3 - RISK ASSESSMENT

3.4.7 Natural Hazard: Severe Winter Weather

HAZARD PROFILE

Hazard Description

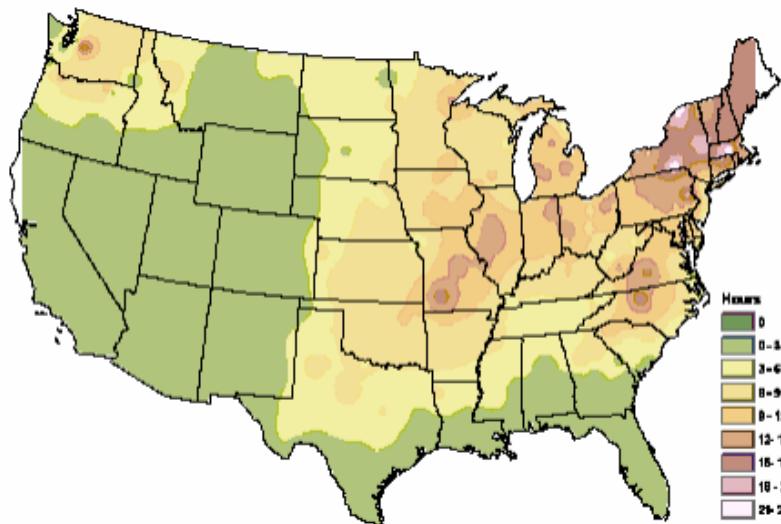
A major winter storm can last for several days and be accompanied by high winds, freezing rain or sleet, heavy snowfall, and cold temperatures. The National Weather Service (NWS) describes different types of winter storm events as follows.

- Blizzard- winds of 35 miles per hour or more with snow and blowing snow reducing visibility to less than $\frac{1}{4}$ 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 occurs near sunrise between the months of December and March.
- Sleet- Rain drops that freeze into ice pellets before reaching the ground. Sleet usually bounces when hitting a surface and does not stick to objects.

Geographic Location

The entire county is vulnerable to heavy snow, ice, extreme cold temperatures and freezing rain.

NWS Statewide Average Number of Hours per Year with Freezing Rain



Greene County experiences
18-21 hours of freezing rain
per year.

3 - RISK ASSESSMENT

Source: American Meteorological Society

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. National Weather Service 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 Fahrenheit or lower.
- Wind Chill Warning- Wind chill temperatures of -35 degrees Fahrenheit or lower are expected. This is a life-threatening situation.

Previous Occurrences

TYPE OF EVENT	INCLUSIVE DATE	NUMBER OF INJURIES	PROPERTY DAMAGES	CROP DAMAGES
Ice Storm	02/11/2008	0	0	0
Ice Storm	02/21/2008	0	0	0
Heavy Snow	03/04/2008	0	0	0
Winter Storm	01/26/2009	0	0	0
Winter Storm	01/28/2009	0	0	0
Winter Storm	03/20/2010	0	0	0
Blizzard	02/01/2011	0	\$40,000	0
Winter Storm	02/21/2013	0	0	0
Winter Storm	12/05/2013	0	0	0
Winter Storm	12/20/2013	0	0	0
Winter Storm	01/05/2014	0	0	0
Winter Storm	03/002/2014	0	0	0
Winter Storm	02/15/2015	0	0	0
Winter Storm	02/20/2012	0	0	0
Winter Storm	02/28/2015	0	0	0
Winter Weather	01/19/2016	0	\$500,000	0
Winter Weather	12/16/2016	0	\$100,000	0
Ice Storm	01/13/2017	0	\$50,000	0
Winter Weather	02/10/2018	0	0	0
Frost/Freeze	04/06/2018	0	0	0

3 - RISK ASSESSMENT

Source: National Centers for Environmental Information (NCEI) Storm Data

January 2007

The worst natural disaster to ever impact Greene County, including the city of Springfield, occurred from major ice accumulations in January of 2007. Most of the ice accumulations occurred on Friday night January 12th, however, two other episodes of ice accumulations occurred on the 13th and 14th. Power outages and catastrophic tree damage were the main impacts resulting from this historic event. Power outages occurred for over three weeks in many areas. Several indirect fatalities due to the extreme elements were documented. Carbon monoxide poisoning occurred within a few homes as gas generators were being used in garages, which allowed for dangerous levels of carbon monoxide to seep into houses. Damages including debris removal were estimated at 121.69 million.

Presidential Disaster Declarations for Winter Storms - Greene County

DISASTER NUMBER	INCIDENT PERIOD	TYPE OF DISASTER	INDIVIDUAL ASSISTANCE	PUBLIC ASSISTANCE
EM-3303	Jan 26, 2009- Jan 28, 2009	Severe Winter Storms	\$0	\$0
DR-1748	Feb 10, 2008-Feb 14, 2008	Severe Winter Storms	\$0	\$10,068,998.77
EM-3281	Dec 08, 2007-Dec 15, 2007	Severe Winter Storms	\$0	\$0
DR-1676	Jan 12, 2007-Jan 22, 2007	Severe Winter Storms and Flooding	\$0	\$106,468,427.80
DR-1403	Jan 29, 2002-Feb 13, 2002	Ice Storm	\$0	\$43,824,367.31

Source: FEMA Disaster Decelerations

Winter storms, cold, frost and freeze take a toll on crop production in the planning area. The table below shows the USDA's Risk Management Agency payments for insured crop losses in the planning area as a result of cold conditions and snow between 2008-2018.

Crop Insurance Claims Paid in Greene County as a Result of Cold Conditions and Snow-2008-2018

CROP YEAR	CROP NAME	CAUSE OF LOSS DESCRIPTION	INSURANCE PAID (\$)
2018	Wheat	Cold Wet Weather	\$501.00
2018	Corn	Cold Winter	\$1359.00
2018	Soybeans	Cold Wet Weather	\$15,249.00
2016	Soybeans	Cold Wet Weather	\$220.00
2012	Corn	Frost	\$818.00
2011	Corn	Cold Wet Weather	\$1442.00
Total			\$19,589

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

3 - RISK ASSESSMENT

Probability of Future Occurrence

The probability for hazards in Greene County is determined using Calculated Priority Risk Index (CPRI). It is highly likely for severe winter weather to impact Greene County in the next year. For a full description of the CPRI for severe winter storms, refer to Appendix B.

Changing Future Conditions and Considerations

According to the Missouri State Hazard Mitigation Plan, as both temperature and precipitation increase during the winter months, freezing rain will be more likely. Additional wintertime precipitations 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. The Missouri State Hazard Mitigation Plan also mentions that 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. Warmer winter temperatures will also result in a reduction of lake ice cover. Reduced lake ice cover impacts aquatic ecosystem by raising water temperatures.

VULNERABILITY

Vulnerability Overview

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

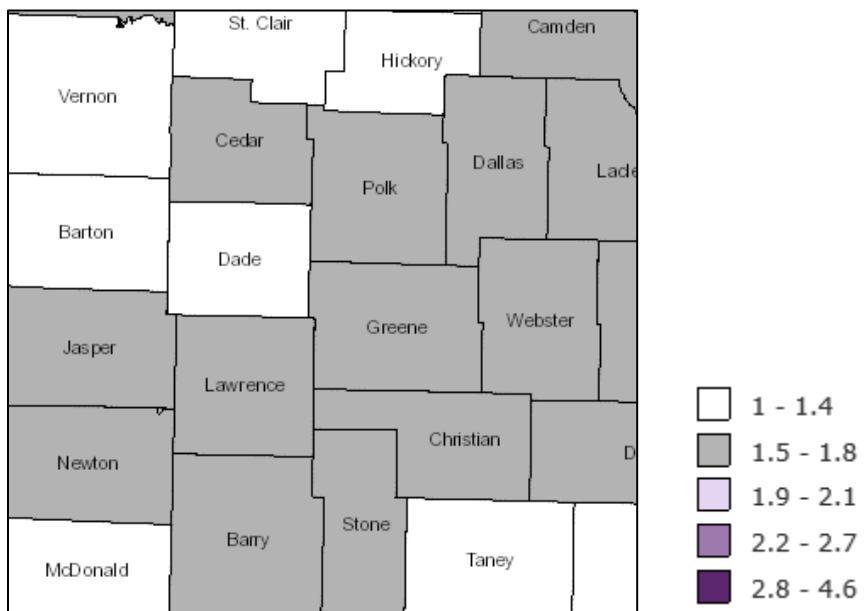
Buildings with overhanging tree limbs are more vulnerable to damage during winter storms when limbs fall. Businesses experience loss of income as a result of closure during power outages. In general, heavy winter storms increase wear and tear on roadways though the cost of such damages is difficult to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

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

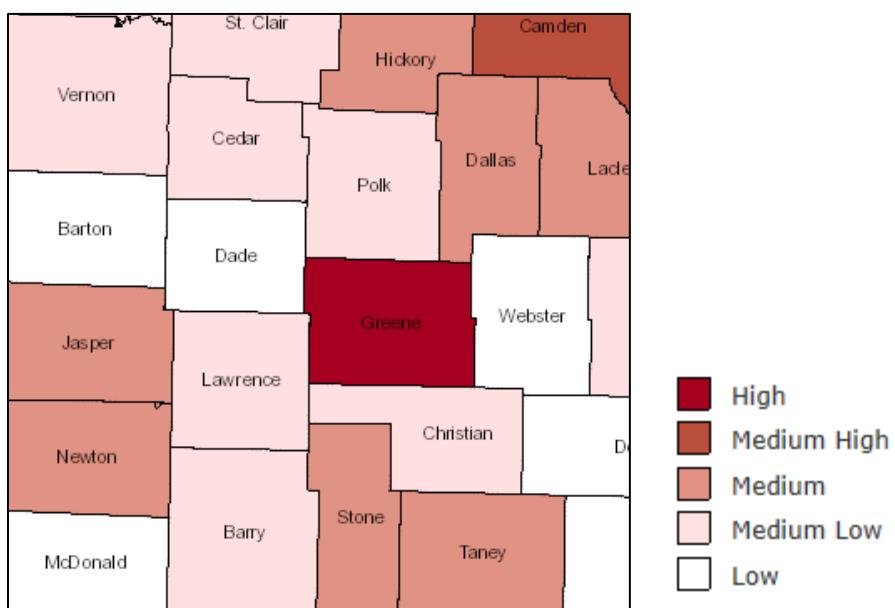
Secondary effects from loss of power could include burst water pipes in homes without electricity during winter storms. Public safety hazards include risk of electrocution from downed power lines. Specific amounts of estimated losses are not available due to the complexity and multiple variables associated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

3 - RISK ASSESSMENT

Average Annual Occurrence of Severe Winter Weather Events



Vulnerability Rating

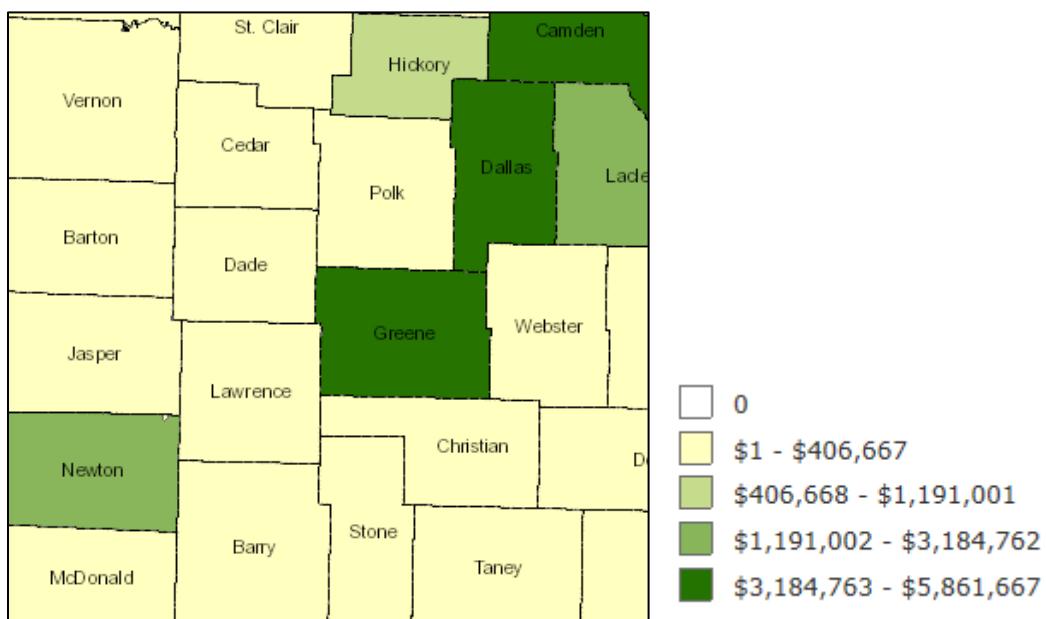


3 - RISK ASSESSMENT

Potential Losses to Existing Development

The Ice Storm that took place in January 2007 caused an estimated 121.69 million dollars in damage including debris removal. Greene County has received an estimated \$160,361,793 in public assistance from presidential disaster declarations. Severe winter weather has had history of causing large amounts of damage

Annualized Property Loss



Previous and Future Development

Greene County has seen consistent population growth over the last 10 years. Over the next 10 years, the population will continue to grow and businesses will continue to develop across the area. Additional development results in the exposure of more households and businesses to damages from severe winter weather including both ice and snow. All structures and populations are at risk for experiencing damages from winter storms including government buildings and schools.

3 - RISK ASSESSMENT

EMAP Consequences Analysis

Impact Analysis: Severe Winter Weather

SUBJECT	DETՐIMENTAL IMPACTS
Public	Indirect fatalities, illnesses and injuries occur including carbon monoxide poisoning (from generators) and health hazards such as frostbite and hypothermia. Roads create extremely dangerous driving hazards that cause serious accidents.
Responders	Potential life safety issues are present to responders. Response function will also be severely impacted. This is not only from transportation hazards, but also from overwhelming calls.
Continuity of Operations	Delivery of services level of impact will heavily depend on the transportation and communication infrastructure status. Ice roads will create delays for almost all functions, and even suspension of some services.
Property, Facilities, and Infrastructure	Ice and snow causes multiple widespread property damages. There have been over 100 million dollars in damages since 1996. Houses and vehicles are damaged from the weather as well as the debris from fallen tree limbs, power lines, and other debris. Widespread power outages, downed telephone and cable lines as well as communication towers create damages to transportation, energy and other communication sectors. Structure damages to facilities can be minor or significant depending on the incident.
Environment	In the 2007 Ice Storm, there was catastrophic tree damage. Although this severity is not typically, there are usually multiple instances of significant damage.
Economic Condition of Jurisdiction	Damages and cost of debris removal are very costly. Businesses may have to shut down for weeks during the incident, and then once it is over, there may be a need for restoration.
Public Confidence in the Jurisdiction's Governance	The community relies on the government to begin responding to the event as soon as it begins (clearing roads, setting up shelters, etc.) If these types of tasks are not done well, there may be push back from the community.

*For more details on Consequence Analysis, refer to Appendix B.

Hazard Summary by Jurisdiction

Severe winter weather is a countywide risk that could potentially affect every jurisdiction in the planning area. Buildings with large amounts of assets could see more damage than others. Jurisdictions that have larger amounts of mobile home parks, like Springfield, can also see more damage from severe winter storms. Buildings that have occupancy may also be more at risk for seeing larger amounts of damage.

3 - RISK ASSESSMENT

PROBLEM STATEMENT

Severe winter storms can produce large amounts of damage across the entire planning area. In the past, winter storms have proved just how devastating damages can be. Severe winter storms can bring down power lines, trees, and communication cables and towers. Power outages create risk for fire as home occupants seek use of alternative fuel sources to produce heat. Power outages can also generate health risks if people do not have alternative ways to keep warm. Severe winter weather can also create a huge loss agriculture and crops. Severe winter storms is a large hazard for Greene County and can cause a huge impact to the planning community. There are several mitigation solutions that help with severe winter weather including the purchasing of generators, creation of shelters in the planning area, burying power lines to prevent power outages and education. Many participating jurisdictions created projects for the purchasing of generators to help with all severe storms. These projects are located in the Mitigation Strategy section of the Mitigation Plan.

3 - RISK ASSESSMENT

3.4.8 Natural Hazard: Tornado

HAZARD PROFILE

Hazard Description

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



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

northward in the spring and its recession south during the fall, the jet stream crosses Missouri, causing the large thunderstorms that breed tornadoes.

Tornadoes spawn from the largest thunderstorms. The associated cumulonimbus clouds can reach heights of up to 55,000 feet above ground level and are commonly formed when Gulf air is warmed by solar heating. The moist, warm air is overridden by the dry cool air provided by the jet stream. This cold air pressed 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 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.

3 - RISK ASSESSMENT

Geographic Location

Tornadoes can take place at any location in the planning area.

Strength/Magnitude/Extent

Tornadoes are the most violent of all atmospheric storms and are capable of tremendous destruction. Wind speeds can exceed 250 miles per hour and damage paths can be more than one mile wide and 50 miles long. Tornadoes have been known to lift and move object weighting more than 300 tons a distance of 30 feet, toss homes more than 300 feet from their foundations, and siphon millions of tons of water from water bodies. Tornadoes also can generate a tremendous amount of flying debris or "missiles," which often become airborne shrapnel that causes additional damage. If wind speeds are high enough, missiles can be thrown at a building with enough force to penetrate windows, roofs, and walls. However, the less spectacular damage is much more common.

Tornado magnitude is classified according to the EF-Scale (Enhanced Fujita Scale). The EF-Scale 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 2, 2007. The table below will explain the different scales.

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: 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 the table below. 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 of damage is located online at www.spc.noaa.gov/efscale/ef-scale.html.

3 - RISK ASSESSMENT

Enhanced Fujita Scale with Potential Damage

SCALE	WIND SPEED	RELATIVE FREQUENCY	POTENTIAL DAMAGE
EF0	65-85	53.5%	Lights. 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 EFO)
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 completely 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	.70%	Devastating. Well-constructed houses and whole frame houses completely levelled; cars thrown and small missiles generated.
EF5	>200	<.1%	Explosive. Strong frame houses levelled off foundations and swept away; automobile-sized missiles fly through the air in excess of 300 ft.; steel reinforced concrete structure badly damaged; high rise buildings have significant structural deformation; incredible phenomena will occur.

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

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

Previous Occurrences

There are limitations to the use of NCEI tornado data that must be noted. For example, one tornado may contain multiple segments as it moved geographically. A tornado that crosses a county line or state line is considered a separate segment for the purpose 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.

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NCEI Reported Tornado Events-1950-2018

LOCATION	DATE	EF RATING	DEATHS	INJURIES	PROPERTY DAMAGES
Greene County	08/08/1950	F1	0	0	\$250
Greene County	07/23/1955	F1	0	0	\$250
Greene County	02/24/1956	F0	0	0	\$250
Greene County	03/12/1961	F1	0	1	\$2,500
Greene County	03/22/1966	F1	0	0	\$2,500
Greene County	04/23/1967	F1	0	0	\$25,000
Greene County	07/28/1967	F1	0	0	\$2,500
Greene County	12/14/1971	F2	1	22	\$2,500,000
Greene County	09/10/1975	F2	0	5	\$2,500,000
Greene County	12/24/1982	F2	0	1	\$2,500,000
Greene County	04/29/1983	F2	0	3	\$2,500,000
Greene County	04/29/1983	F3	1	19	\$25,000,000
Greene County	04/30/1983	F1	0	0	\$0
Greene County	10/18/1984	F1	0	0	\$2,500
Greene County	11/15/1988	F1	0	0	\$25,000,000
Greene County	05/22/1989	F2	0	0	\$250,000
Greene County	05/20/1990	F2	0	0	\$0
Greene County	11/29/1991	F4	2	64	\$25,000,000
Walnut Grove	04/26/1994	F1	0	0	\$50,000
Springfield	05/27/1995	F1	0	0	\$300,000
Springfield	06/26/2001	F0	0	0	\$0
Springfield	10/10/2001	F1	0	5	\$250,000
Battlefield	05/04/2003	F3	1	12	\$14,700,000
Battlefield	03/12/2006	F2	0	4	\$650,000
Ash Grove	05/03/2006	F0	0	0	\$0
Springfield	10/17/2007	EF1	0	0	\$150,000
Republic	01/07/2008	EF2	0	0	\$2,000,000
Greene County	01/07/2008	EF3	1	0	\$1,000,000
Greene County	01/07/2008	EF2	0	0	\$1,000,000
Springfield	01/08/2008	EF1	0	0	\$50,000
Springfield	06/19/2008	EF1	0	0	\$150,000
Battlefield	02/10/2009	EF1	0	0	\$350,000
Republic	05/08/2009	EF1	0	0	\$1,000,000
Springfield	05/08/2009	EF1	0	0	\$200,000
Ebenezer	05/08/2009	EF0	0	0	\$100,000
Greene County	06/18/2011	EF1	0	0	\$0
Ebenezer	06/18/2011	EF0	0	0	\$30,000
Willard	10/13/2012	EF0	0	0	\$25,000
Springfield	07/21/2013	EF0	0	0	\$100,000
Ash Grove	10/13/2014	EF0	0	0	\$0
Battlefield	04/27/2016	EF0	0	0	\$100,000
Greene County	05/19/2017	EF0	0	0	\$100,000
Greene County	05/03/2018	EF0	0	0	\$100,000
Republic	12/01/2018	EF1	0	0	\$175,000
Total			6	136	\$110,296,000

Source: NCEI Storm Data

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January 2008

On January 7, 2008, the Missouri Ozarks experienced an unusually early outbreak of severe weather. It began in the afternoon on January 7, 2008, and continued into the early morning hours on January 8, 2008. Several supercell thunderstorms spawned at least 33 tornadoes that caused significant damage to homes, trees and power lines. The supercell thunderstorms were followed by another violent squall line that produced damaging straight line winds in excess of 70 mph. The storms also produced torrential rainfall and flash flooding. This event produced approximately \$4 million in property damages and caused one fatality.

June 2008

On June 19, 2008 where a tornadic supercell caused roof damage to Harry Cooper Supply, an industrial building in Springfield. A supercell thunderstorm tracked north to south down the Highway 65 corridor producing damaging winds and hail the size of baseballs. As the storm moved into the area, an EF1 tornado developed and caused damage to furniture stores on the east side of town. Further, downdraft winds from a tornadic supercell caused major tree and power line damage in a neighborhood east of Springfield.

February 2009

Springfield experienced an EF1 tornado on February 10, 2009 that touched down near the southern end of the city. Approximately two dozen houses and businesses were damaged, and many trees and power lines were knocked over causing nearly 250 residences to go without power.

May 2009

On May 8th 2009, confirmed tornadoes touched down in Willard, Ebenezer and Republic. The roof of Fair Grove High School was torn off. Bleachers near the football field were completely demolished. The new baseball field was also destroyed. Fire Station 3 in Ebenezer was completely demolished, ruining equipment inside. This storm received a Presidential Disaster Declaration. Total damage assessments are estimated at \$4.6 million.

June 2011

A National Weather Service Survey Team determined that an EF-1 tornado with winds estimated of 80-90 mph touched down about four miles northeast of Everton and continued into Greene County. The tornado had a path width of 100-200 yards and continued for 9 miles snapping and uprooting several trees after entering Greene County just west of the Sac River. The tornado had a total path length of about 11 miles before lifting.

July 2013

A National Weather Service Storm Survey indicated that an EF-0 tornado touched down near the intersection of East Cairo Street and South Pickwick Avenue. The tornado traveled east along East Cairo Street and lifted at the intersection of East Cairo Street and Glenestone. The tornado caused several large tree branches to be blown down and damage to roofs to several houses along with several power lines to be blown down. Several windows to homes and businesses were broken or blown out. At least two businesses had roof and window damage. Winds were estimated around 60 mph with a path width of 50 yards and about half a mile length.

December 2018

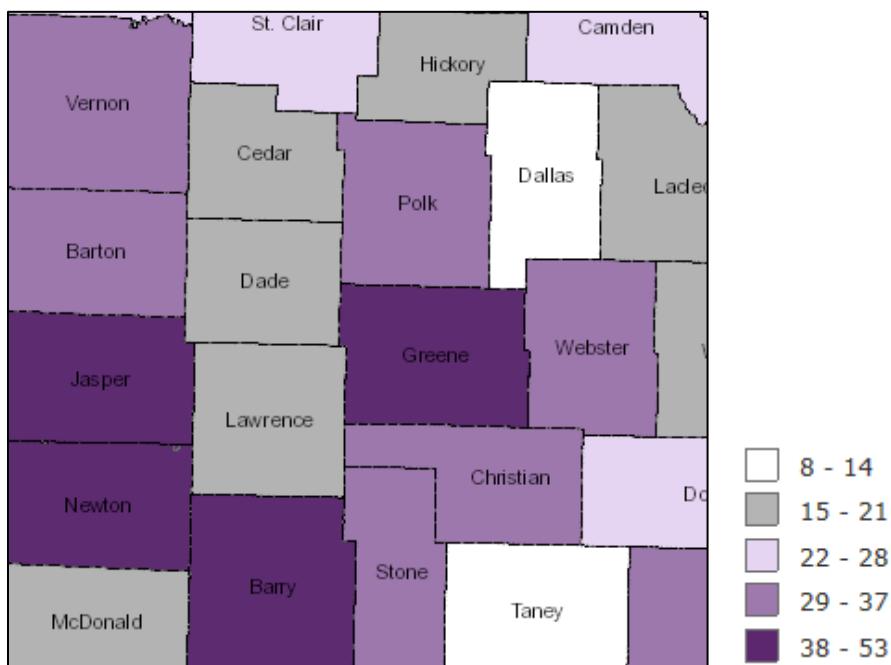
An EF-1 tornado developed approximately 3 miles west of Republic and tracked northeast and dissipated within the city limits of Republic. Two large barns were destroyed and numerous trees were uprooted. Several homes sustained minor roof damage.

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April-May 2019

The spring of 2019 consisted of major flooding and multiple tornadoes impacting different areas of Greene County. April 30th there were 3 confirmed tornadoes, 2 in Willard and 1 in Rogersville. The Rogersville tornado consisted of major damage, destroying 3 homes and damaging 103 more. There were no fatalities in Greene County with this storm. The same night a tornado came through Christian County, affecting many homes. Later in May, another confirmed tornado came through a portion of Greene County. The tornado did not do major damage and was only in the county for a short time.

Number of Tornadoes



In the last 10 years, there have been no insurance claim payouts reported to the USDA because of tornado damage.

Probability of Future Occurrence

The probability for hazards in Greene County is determined using Calculated Priority Risk Index (CPRI). It is highly likely for a tornado to occur within the next year in Greene County. For a full description of the CPRI for tornadoes, refer to Appendix B.

Changing Future Conditions

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

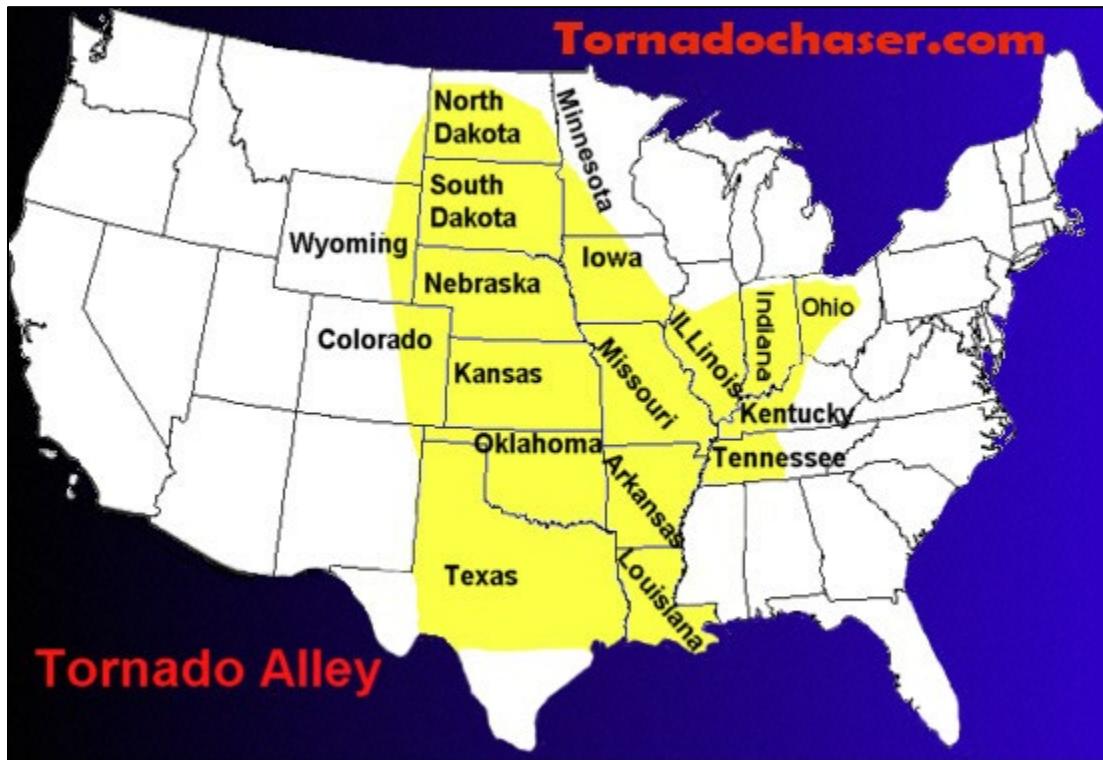
3 - RISK ASSESSMENT

VULNERABILITY

Vulnerability Overview

Tornadoes are extremely dangerous storms that can injure or kill people. Tornadoes that touch down, typically cause thousands or even millions of dollars' worth of damage. Over the years, Greene County has experienced a lot of different tornadoes that have caused millions of dollars' worth of damage. Greene County is located in the region of the U.S. with high frequency of dangerous and destructive tornadoes referred to as "Tornado Alley". The map below illustrates the areas where dangerous tornadoes have historically occurred.

Tornado Alley in the U.S.

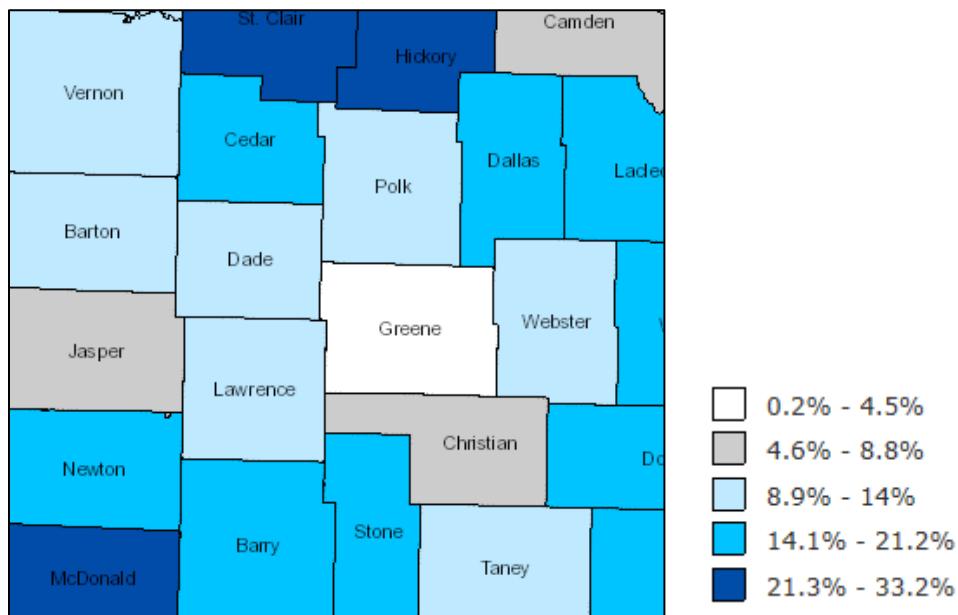


Source: <http://www.tornadochaser.net/tornalley.html>

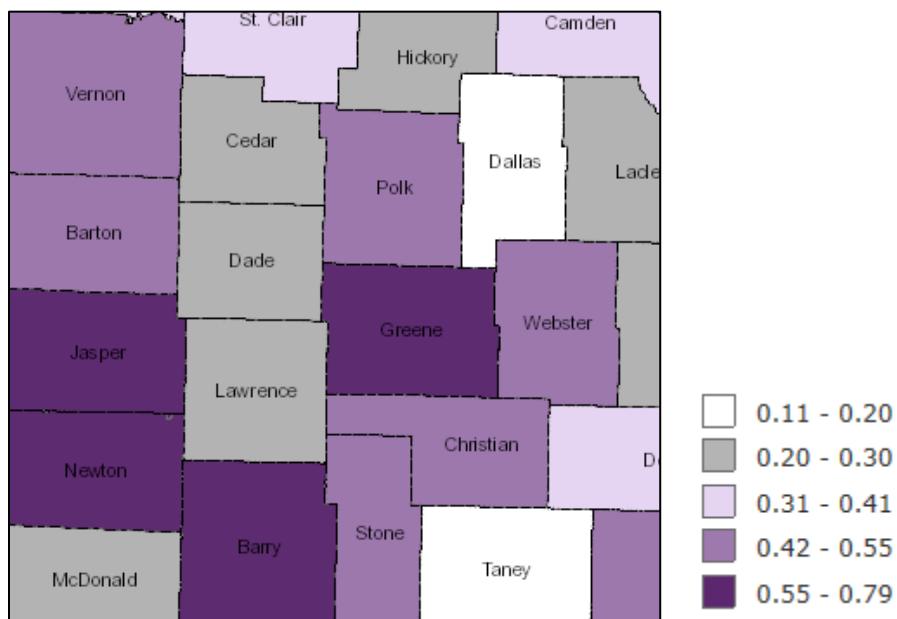
All of the planning area is at risk for experiencing effects from a tornado touch down. More vulnerable populations are ones who live in mobile homes. In Greene County, we have a relatively low percentage of people who are living in mobile homes, but we still have thousands of people more at risk.

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Percentage of Mobile Homes-2015

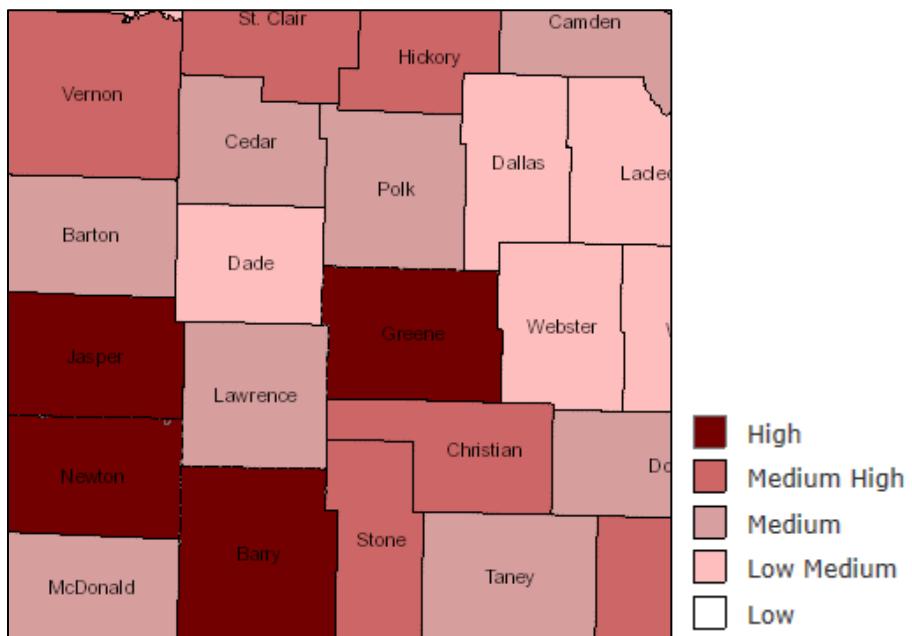


Average Annual Occurrence for Tornado



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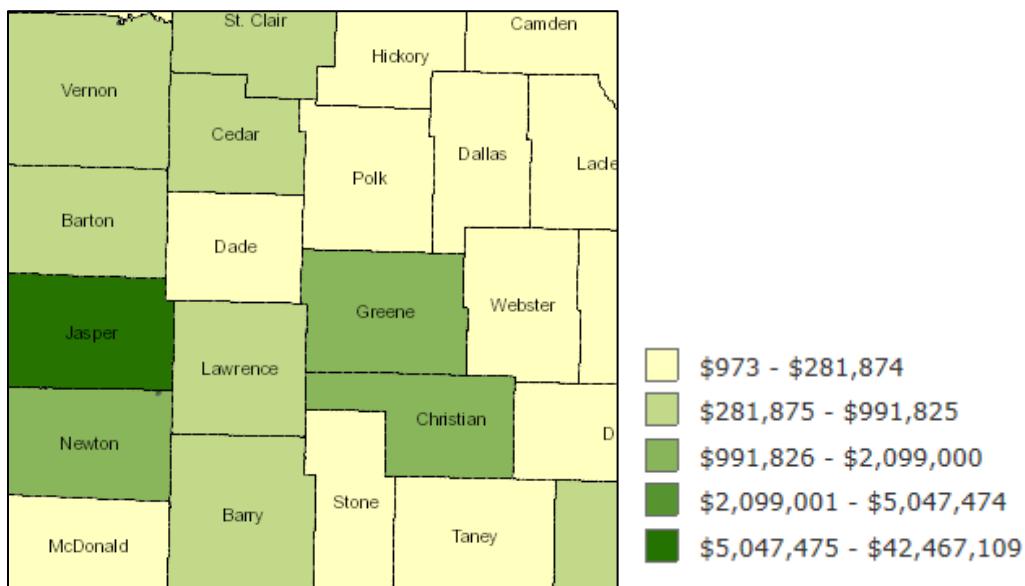
Tornado Hazard



Potential Losses to Existing Development

Tornadoes have been known to create large amounts of damage to homes, businesses, agriculture, power lines, trees, etc. Tornado damage is often times extensive and involves weeks, sometimes months' worth of clean up. One of the biggest issues with tornado damage is debris clean up. Debris can be spread for miles after a tornado touch down. Debris can also close down roads and make transportation of debris more difficult.

Annualized Property Loss



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Previous and Future Development

Greene County will continue to see an increase in population. As the population grows, so does that amount of houses that are being built. As houses and businesses grow in the planning area, so does the risk for experiencing large amounts of damage from tornadoes. Research is predicting that tornadoes are going to continue to increase as the climate changes. As the population grows, it is important that we remember how dangerous mobile home parks are to tornadoes and other high wind events.

EMAP Consequence Analysis

EMAP Impact Analysis: Tornadoes

SUBJECT	DETERRIMENTAL IMPACTS
Public	Tornadoes in Greene County have caused injuries and death. There are widespread safety concerns associated with tornado incidents, and many times storms will produce more than 1 tornado, creating even more safety concerns.
Responders	Responders face potentially life-threatening safety issues, and response functions can be impacted depending on weather conditions and debris amount and make up.
Continuity of Operations	Delivery of services can be hampered across the jurisdiction due to infrastructure damages and overwhelming demand.
Property, Facilities, and Infrastructure	Tornadoes have caused widespread significant damages within Greene County. Many homes have been heavily damaged or completely destroyed due to multiple tornadoes that have passed through the county. Infrastructure is damaged through downed power lines, poles and communication towers. Transportation can also be affected through debris and downed trees that block roads. Facilities in Greene County have had widespread significant damages. Fair Grove High School, Glendale High School, and Harry Copper Supply industrial building, and other businesses experienced severe damage.
Environment	Minor isolated instances of environmental damages are found in a tornado incident in the form of fallen or damaged trees.
Economic Condition of Jurisdiction	The economic impact on Greene County can be major with widespread loss. Businesses may be destroyed or forced to make repairs before being operable again. This creates loss in the economy and for individuals.
Public Confidence in the Jurisdiction's Governance	There may be minor isolated instances of loss in public confidence if response and recovery operations are not executed quickly and effectively.

*For more details on Consequence Analysis, refer to Appendix B.

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Hazard Summary by Jurisdiction

Tornadoes are a hazard that the entire planning area is at risk for. There are some jurisdictions that could suffer more damage because of housing statistics and other vulnerabilities. The City of Ash Grove has a lot of older homes within the city limits. Older homes are more at risk for experiencing damages from high winds and tornadoes. 872 or 21.97% of Ash Grove homes were built in 1960 or before. 224 or 5.64% homes were built before 1939. The City of Walnut Grove also has a large amount of older homes. 145 or 50.69% of the homes within the city limits of Walnut Grove are built in 1960 or before. Jurisdictions that have adopted building codes may be less vulnerable to damages, but not all of our jurisdictions have done this.

In the past, some of our jurisdictions have been more prone to tornadoes than others. The City of Battlefield and City of Republic have experienced some larger tornadoes that have produced a lot of damage to the cities. Our jurisdictions that have seen repeat tornadoes are more vulnerable to experience damage than the jurisdictions that don't experience frequent tornadic storms.

PROBLEM STATEMENT

When a severe storm becomes tornadic, it puts the entire planning area at risk to suffer serious damages. Tornadoes can cause high winds, which can lead to roof damages, power outages, home uprooting, tree uprooting, etc. Tornadoes can cause catastrophic damage to property and injure or kill human and animal life. Tornado events are frequent in Greene County and with climate change tornadoes could become more frequent in the planning area. Greene County's population will continue to grow, putting more properties and people at risk for experiencing damages from tornadoes. The planning area community should be vigilant in preparing and mitigating against tornadic storms. Participating jurisdictions created many actions to help protect their communities from tornados. Many projects in the Mitigation Strategy Section of this plan include the construction of FEMA Safe Rooms or other tornado shelters and update or placement of storm warning sirens. Other mitigation options are education and drills.

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3.4.9 Natural Hazard: Wildfire

HAZARD PROFILE

Hazard Description

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

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



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

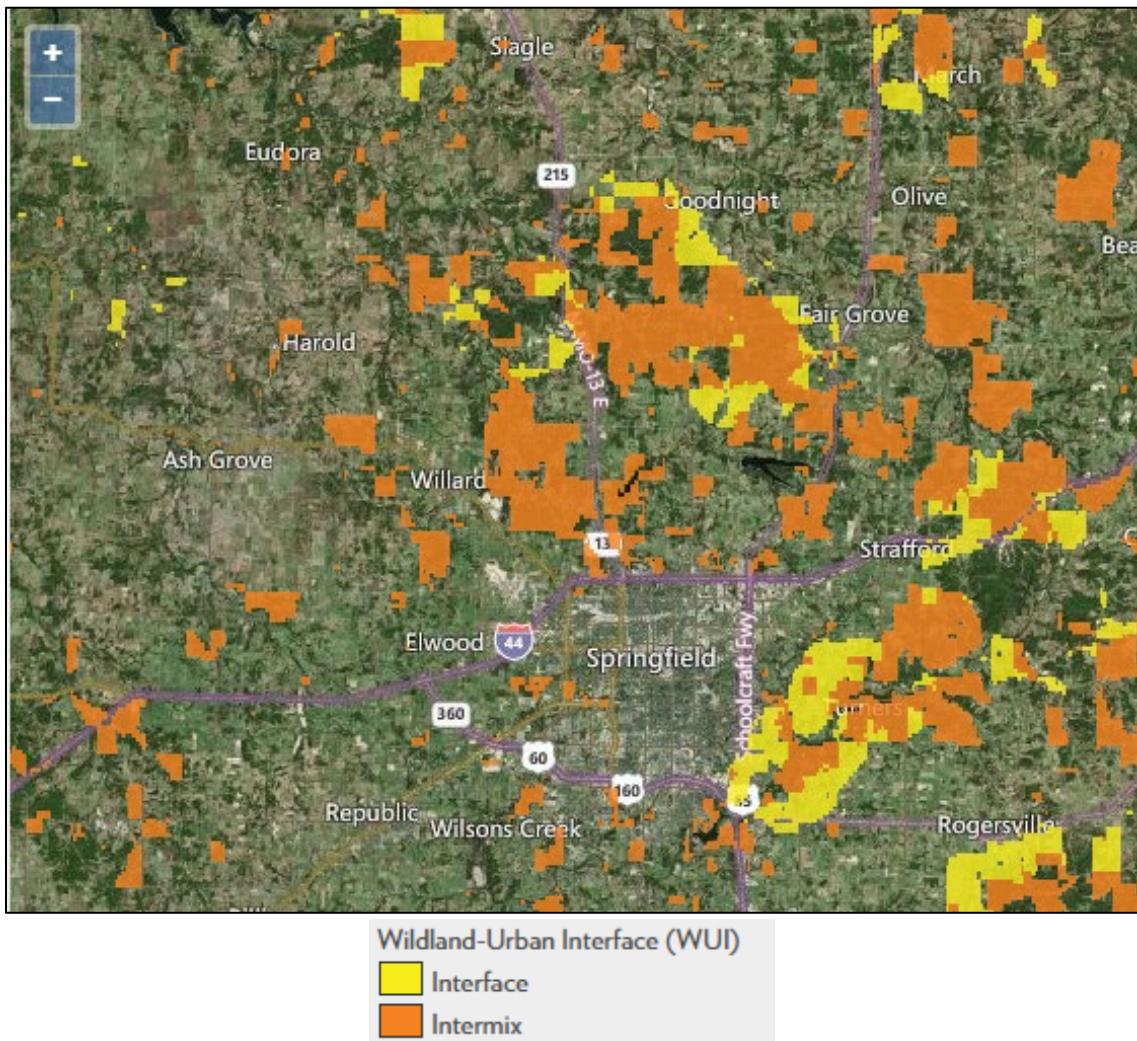
Geographic Location

Damages due to wildfire would be higher in communities with more Wildland Urban Interface (WUI) areas. WUI is the area where houses meet or intermingle with undeveloped wildland vegetation. The WUI is thus a focal area for human-environment conflicts, such as the destruction of home by wildfires, habitat fragmentation, introduction of exotic species, and biodiversity decline.

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.

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Wildland Urban Interface (WUI)



Communities in the planning area that are most at risk are highlighted orange and yellow. Those areas include Willard, Turners (unincorporated Greene County) Fair Grove, Strafford.

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 the near the fires.

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

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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.

Previous Occurrences

Wildfires-Greene County 2015-2018 with Greater than 2 Acre Burned

DISCOVERED DATE	STATION	CAUSE	ACRES BURNED
01/18/2015	Springfield Forestry	Debris	10
01/18/2015	Logan-Rogersville	Debris	10
01/21/2015	Ebenezer	Debris	10
01/23/2015	Strafford	Unknown	5
01/24/2015	Springfield Forestry	Debris	3
01/24/2015	Logan-Rogersville	Debris	3
02/02/2015	Fair Grove	Unknown	20
02/02/2015	Fair Grove	Equipment	10
02/10/2015	Walnut Grove	Unknown	5
02/12/2015	Fair Grove	Debris	6
03/07/2015	Walnut Grove	Debris	40
03/07/2015	Ebenezer	Unknown	10
03/08/2015	Walnut Grove	Debris	5
03/16/2015	Walnut Grove	Debris	5
03/16/2015	Fair Grove	Unknown	4
03/25/2015	Strafford	Miscellaneous	5
03/25/2015	Ebenezer	Debris	7
04/25/2015	Ebenezer	Miscellaneous	3
10/19/2015	Ebenezer	Unknown	3
10/20/2015	Fair Grove	Unknown	8
10/22/2015	Walnut Grove	Debris	20
11/11/2015	Fair Grove	Unknown	5
11/24/2015	Strafford	Unknown	5
01/27/2016	Springfield Forestry	Debris	6
01/29/2016	Ebenezer	Unknown	3
01/30/2016	Ebenezer	Miscellaneous	5
02/05/2016	Fair Grove	Unknown	170
02/05/2016	Strafford Fire	Unknown	5
02/06/2016	Ebenezer	Unknown	180
02/06/2016	Springfield Forestry	Debris	3
02/08/2016	West Republic	Unknown	9
02/10/2016	Walnut Grove	Debris	5
02/11/2016	Springfield Forestry	Debris	5
02/15/2016	Walnut Grove	Debris	20
02/19/2016	Walnut Grove	Not Reported	20

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02/19/2016	Walnut Grove	Debris	3
02/19/2016	Walnut Grove	Debris	3
02/29/2016	Ebenezer	Debris	5
02/29/2016	Walnut Grove	Unknown	3
03/03/2016	Walnut Grove	Debris	20
03/05/2016	Strafford	Debris	5
03/05/2016	Ebenezer	Unknown	50
03/05/2016	Ebenezer	Unknown	6
03/05/2016	Ebenezer	Unknown	10
03/05/2016	Walnut Grove	Debris	30
03/05/2016	Ebenezer	Unknown	6
03/05/2016	Ebenezer	Unknown	10
03/05/2016	Ebenezer	Unknown	5
03/05/2016	Walnut Grove	Debris	5
03/06/2016	Walnut Grove	Debris	5
03/11/2016	West Republic	Not Reported	58
03/14/2016	Walnut Grove	Debris	30
03/15/2016	West Republic	Debris	15
03/19/2016	Fair Grove	Unknown	30
03/21/2016	Fair Grove	Unknown	3
04/21/2016	Springfield Forestry	Debris	14
11/22/2016	Ebenezer	Debris	15
12/15/2016	Fair Grove	Unknown	70
12/20/2016	Ebenezer	Debris	7
12/28/2016	Ebenezer	Campfire	3
12/29/2016	Ebenezer	Debris	7
12/31/2016	Fair Grove	Miscellaneous	3
01/10/2017	Walnut Grove	Unknown	5
01/28/2017	Ebenezer	Debris	10
01/29/2017	Logan-Rogersville	Debris	9
01/30/2017	Strafford	Unknown	10
02/16/2017	Walnut Grove	Unknown	5
03/08/2017	Ebenezer	Debris	6
07/08/2017	Walnut Grove	Debris	20
07/20/2017	Walnut Grove	Debris	10
01/06/2018	Fair Grove	Unknown	2.09
01/25/2018	Ebenezer	Debris	3.82
01/25/2018	Fair Grove	Unknown	2.04
01/25/2018	Ebenezer	Debris	2.5
01/27/2018	Station 1	Debris	61.65
02/03/2018	Ebenezer	Debris	2.38
02/03/2018	Ebenezer	Debris	2.83
02/26/2018	Ebenezer	Debris	4.41
03/09/2018	Ebenezer	Debris	23.2
03/13/2018	Walnut Grove	Unknown	4.02
03/14/2018	Fair Grove	Debris	7.23
04/05/2018	Ebenezer	Debris	4.58
04/05/2018	Ebenezer	Debris	2.38
04/12/2018	Ebenezer	Debris	4.82
04/21/2018	Ebenezer	Debris	10.87

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04/21/2018	Fair Grove	Debris	7.58
08/13/2018	MDC Forestry	Debris	33.84
08/13/2018	Ebenezer	Debris	50.7
08/13/2018	Fair Grove	Unknown	38.8

Source: <https://mdc6.mdc.mo.gov/Applications/MDCFireReporting/Home/FireReportSearch>

Probability of Future Occurrence

The probability for hazards in Greene County is determined using Calculated Priority Risk Index (CPRI). It is highly likely for a wildfire to occur within the next in the next year in Greene County. For a full description of the CPRI for wildfires, refer to Appendix B.

Changing Future Conditions and Considerations

According to the Missouri State Hazard Mitigation Plan, changes in rainfall are unlikely to substantially reduce forest cover in Missouri, although the composition of trees in the forests may change. More drought would reduce forest productivity, and changing futures conditions are also likely to increase the damage from insects and diseases. 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 n frequency and intensity during summer months under projected future scenarios. Droughts can lead to dead or dying vegetation and landscaping material close to structures which creates fodder for wildfires within both the urban and rural settings.

VULNERABILITY

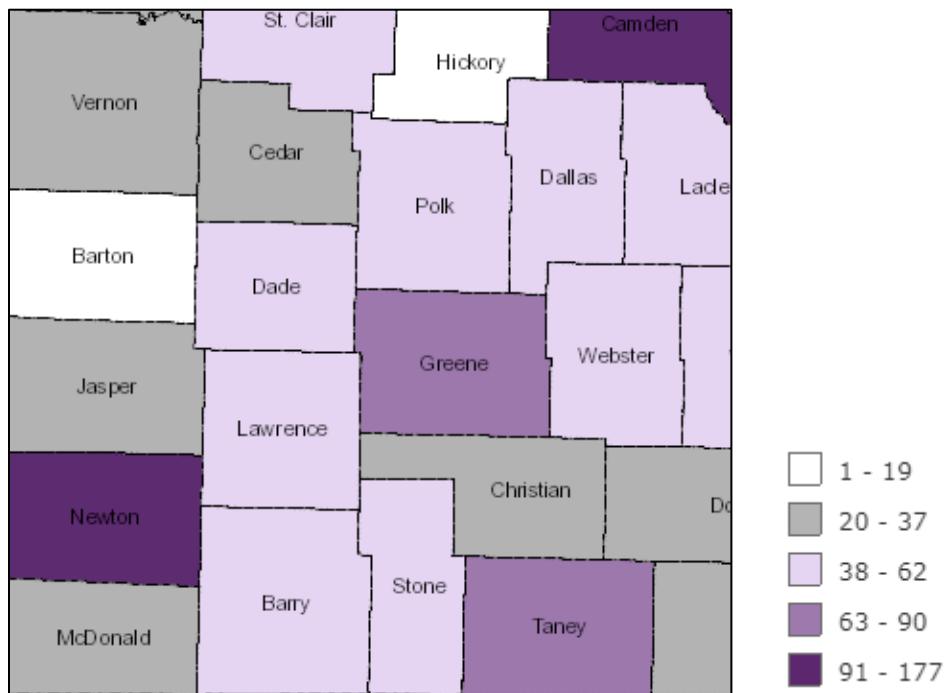
Vulnerability Overview

According to the 14 million acres, Missouri ranks seventh in the northeast region of the U.S. in forest land area. The U.S Fire Administration states that there are factors contributing to wildfire vulnerability. In order for communities to be successful they need to plan for the following:

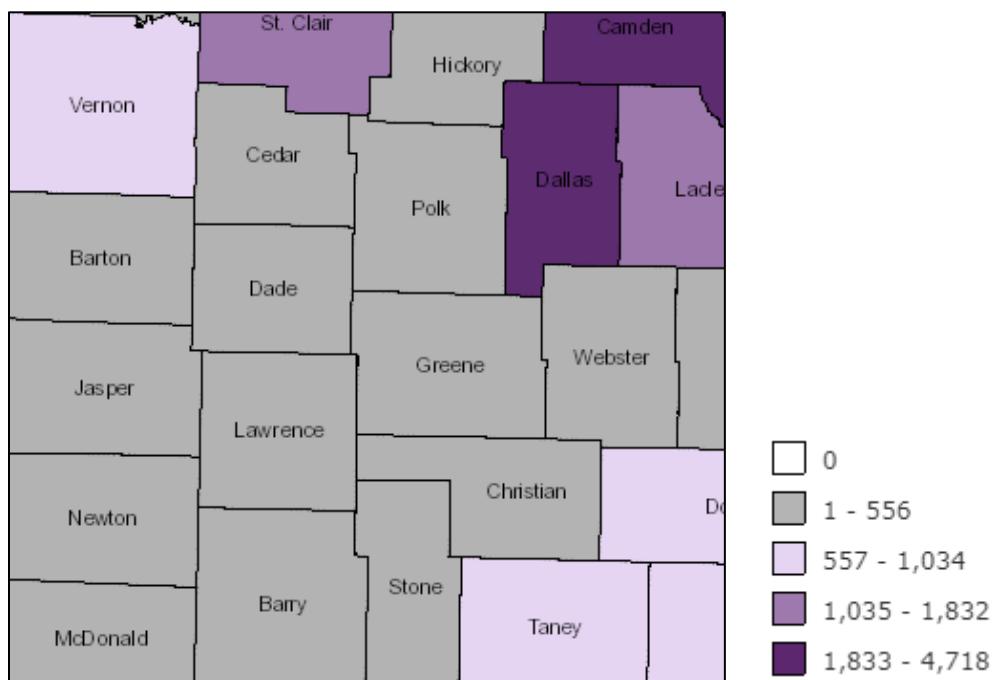
- Exposure vulnerability-What are the fuel conditions in the area? A program to reduce the flammability of building materials used in construction and reduce fuel on public and private lands, as well as in the home ignition zone.
- Sensitivity of the exposed community- What the resident's vulnerabilities? A plan needs to determine the risk factors of the population, such as poverty, age, education, language and special needs.
- Adaptive capacity-Can residents prepare fore, respond to and recover from a wildfire based on their available resources?

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Likelihood of Occurrence (percent)



Average Annual Land Burned (In Acres)

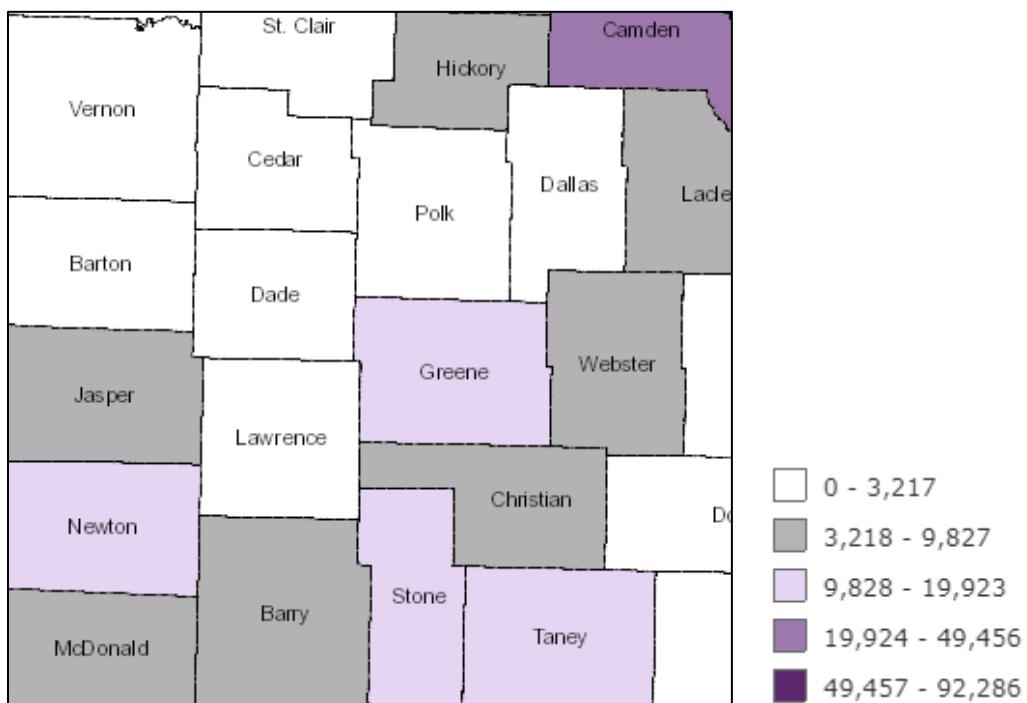


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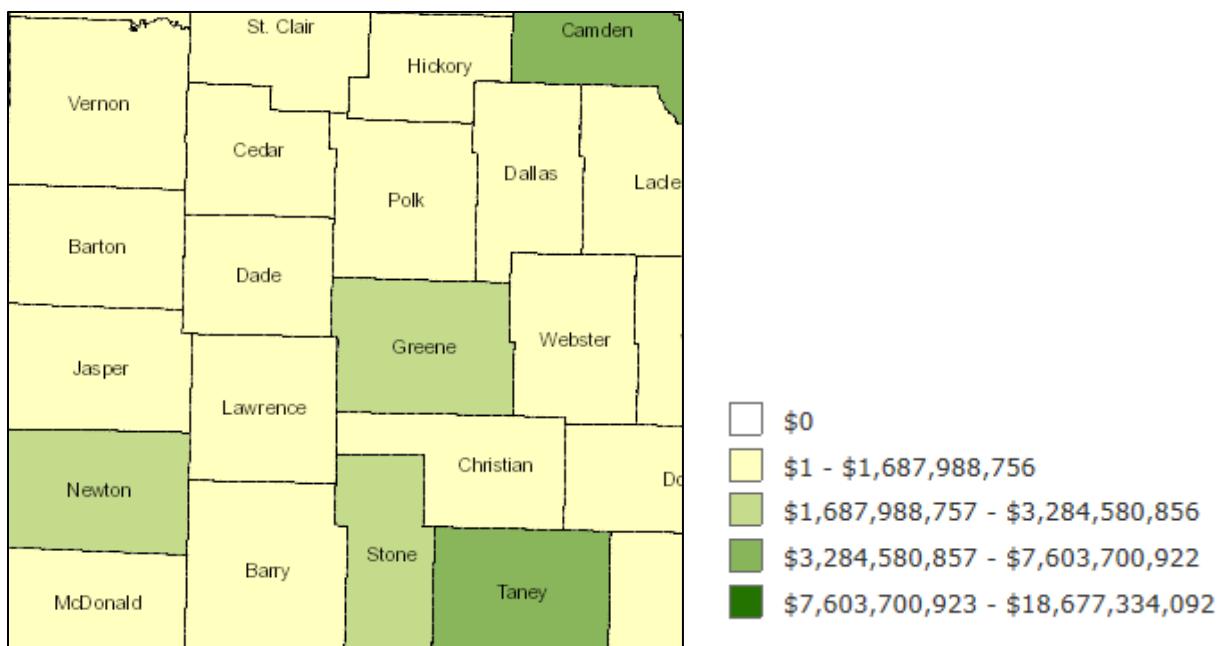
Potential Losses to Existing Development

Though wildfires can be common in Greene County, there is no historical loss information that could be obtained. The following charts were used from Missouri State Emergency Management Agency's Hazard Mitigation Viewer.

Total Number of Structures-WUI Interface/Intermix Area

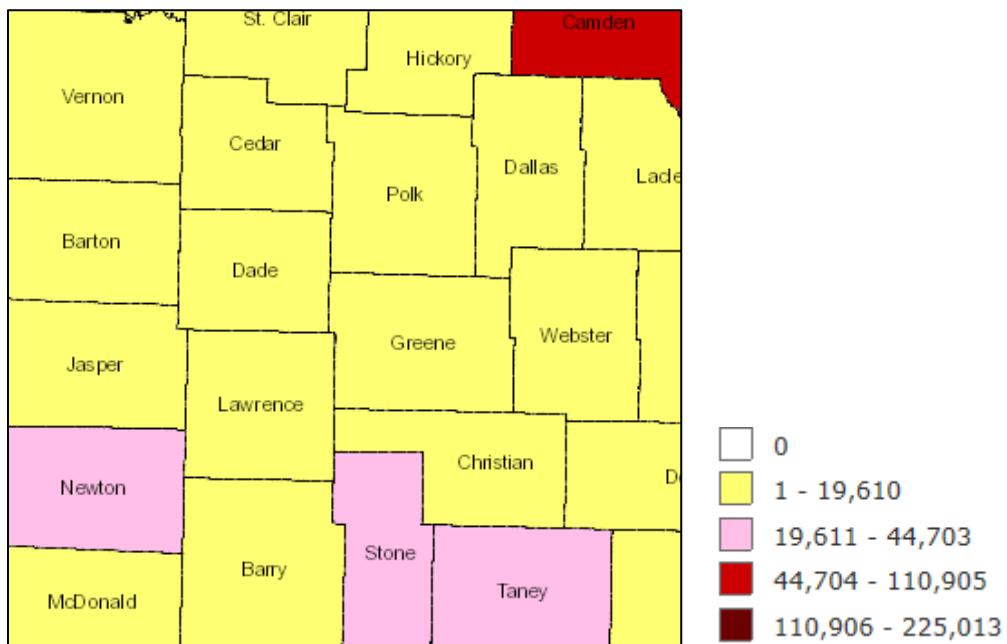


Value of Structures-WUI Interface/Intermix Area

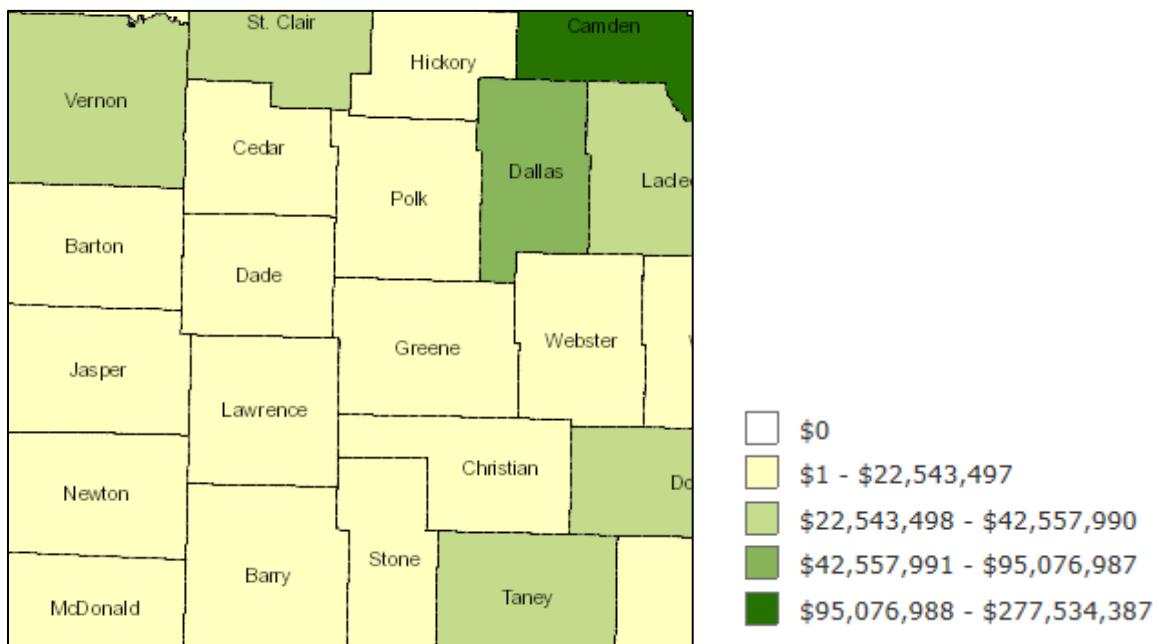


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Population Risk-WUI Interface/Intermix Area



Potential Loss-Average Annual Land Burned



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Impact of Previous and Future Development

As the population of Greene County continues to increase, the chance of development occurring in the Wildland Urban Interface (WUI) areas is possible. Though there are no plans in place as of right now, in the future there could be. Building in those areas could increase the amount of damage that occurs if/when a wildfire takes place. Development in those areas can also increase the risk of injury or death in the county's population.

EMAP Consequence Analysis

EMAP Impact Analysis: Wildfires

SUBJECT	DETERRIMENTAL IMPACTS
Public	Wildfires create multiple isolated instances of safety concerns. Death or injury can occur from wildfire; however this has not been a consequence to Greene County.
Responders	There would be little to no impact on responders and response function in Greene County due to wildfires.
Continuity of Operations	Wildfires have had little to no impact on service operations.
Property, Facilities, and Infrastructure	Greene County has experienced minor isolated instances of property damage due to wildfires. Wildfires can cause minor impact to key infrastructure such as transportation or power, again, depending on the burn path of the fire. Greene County has experienced little to no impact on facilities due to wildfire.
Environment	Wildfires in Greene County can cause multiple instances of damage to the environment depending on what is buried. Wild life is also affected by wildfires.
Economic Condition of Jurisdiction	Wildfires have caused Greene County little to no impact on the economy.
Public Confidence in the Jurisdiction's Governance	Wildfires cause little to no loss of public confidence in governance in Greene County.

*For more details on Consequence Analysis, refer to Appendix B.

Hazard Summary by Jurisdiction

Wildfires is a hazard that the entire planning area is at risk for. Jurisdictions in WUI areas are more vulnerable to wildfires than other jurisdictions. Walnut Grove, Ebenezer and Strafford Fire Protection Districts typically respond the most wildfire calls. This is demonstrated in the "Previous Occurrences" section of this profile. Prosperities in those fire districts are more vulnerable to experiencing damage from wildfires than other jurisdictions in the planning area.

PROBLEM STATEMENT

Wildfires can cause an extreme amount of damage if they are not controlled quickly. Wildfires spread fast and can be hard to control. Wildfires can damage crops, properties, animals and even human life. The cause of wildfires can be widespread from human caused to lightning strikes. Many wildfires go unnoticed to the public, but they can be frequent in Greene County. Development in WUI areas could potentially affect how much damage Greene County sees from wildfires. Wildfires are a county wide hazard that could affect many areas of county and could also cause large amounts of damage. Wildfires can be extremely devastating to the environment, many mitigation actions include quicker response and better equipment for fighting fires. Our Fire Protection Districts created many projects including new fire engines, more staffing, more training and more equipment to mitigate against wildfires.

3 - RISK ASSESSMENT

3.5.1 Technological Hazard: Airplane Crash

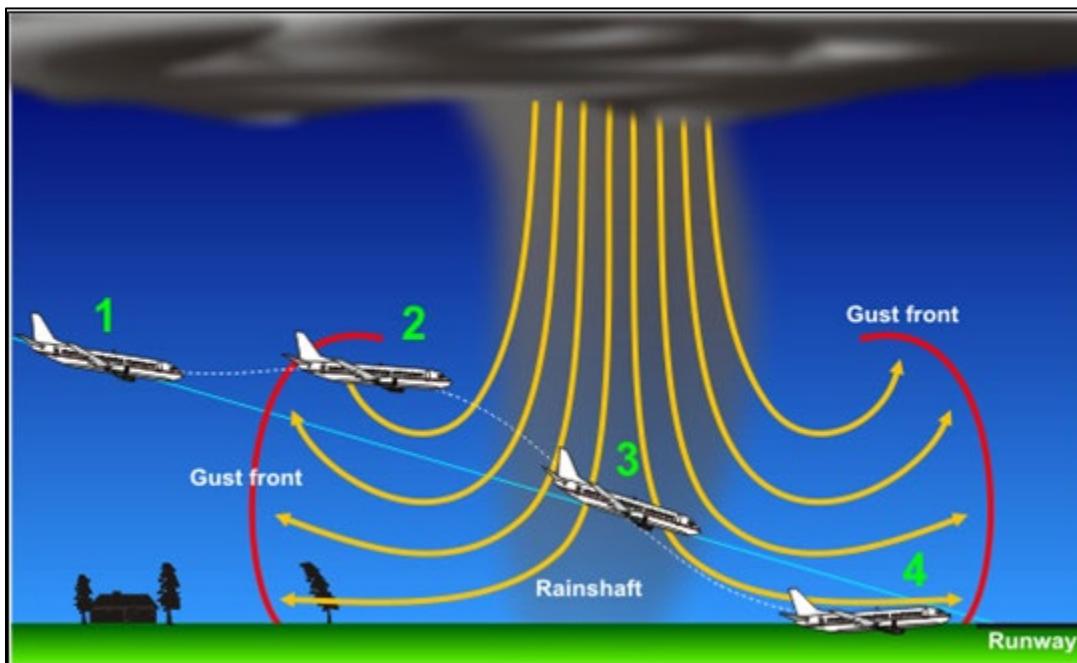
HAZARD PROFILE

Hazard Description

The definition of an airplane crash is an accident in which an aircraft hits land or water and is damaged or destroyed. Airplane crashes can be the result of hijackings, technological malfunctions, and weather or human errors. The result of an airplane crash is usually devastating.

Wind Hazards

As aircraft descend (above) into the airport they follow an imagery line called the "glide slope" (solid light blue line as depicted in the below illustration) to the runway. Upon entering a microburst, the plane encounters a "headwind", an increase in wind speed over the aircraft. The stronger wind creates additional lift causing the plane to rise above the glide slope. To return the plane to the proper position, the pilot lowers the throttle to decrease the plane's speed thereby causing the plane to descend. As the plane flies through to the other side of the microburst, the wind direction shifts and is now a "tailwind" as it is from behind the aircraft. This decreases the wind over the wing reducing lift. The plane sinks below the glide slope. However, the "tailwind" remains strong and even with the pilot applying full throttle trying to increase lift again, there may be little, if any, room to recover from the rapid descent causing the plane to crash short of the runway. Since the discovery of this effect in the early to mid-1980's, pilots are now trained to recognize this event and take appropriate actions to prevent accidents. Also, many airports are now equipped with equipment to detect microbursts and warn aircrafts.



3 - RISK ASSESSMENT

Hijacking

The September 11, 2001 attacks claimed the lives of over 3,000 Americans. This date changed anti-terrorist operations and approaches in the United States and all over the globe. On this day, 19 militants associated with the Islamic extremist group al-Qaeda hijacked four airliners and carried out suicide attacks against targets in the United States. Two of the planes were flown into the towers of the World Trade Center in New York City, a third plane hit the Pentagon just outside Washington, D.C., and the fourth plane crashed in a field in Pennsylvania. Often referred to as 9/11, the attacks resulted in extensive death and destruction, triggering major U.S. initiatives to combat terrorism and defining the presidency of George W. Bush. Over 3,000 people were killed during the attacks in New York City and Washington, D.C., including more than 400 police officers and firefighters. Hijacking can be never dangerous and devastating to both population and property.

Greene County is home to the Springfield-Branson National Airport (SGF). The airport is a small hub airport and currently has 4 airlines including: American, Allegiant, Delta and United. There are 13 non-stop destinations that leave from SGF.

The airport staffs a full-time fire department and every firefighter has Firefighter 1 or Firefighter 2 certification and is a certified EMT. The airport also is protected by Airport Police Department (APD) and has 10 full time commissioned officers who protect the airport 24/7. The APD achieved status as a criminal justice agency in 2002 and it is recognized by Missouri Department of Public Safety as a stand-alone law enforcement agency.

SGF has an Emergency Contingency Plan which meets the guidelines of the FAA Modernization and Reform Act of 2012. This plan is filed with the Department of Transportation because it is a commercial airport, and it may be used by an air carrier for diversions (USC 42301(a)(1)). Springfield-Branson National Airport also has a contingency plan for irregular operations (IROPS). IROPS are events that may be the result of aircraft holdovers, single or multiple aircraft diversions, medical emergencies, pilot/crew error, mechanical problems, weather, national airspace issues and airport closures.

Geographic Location

All of Greene County is susceptible to hazards of an airplane crash, as they can occur anywhere. Depending on the reason behind the crash leaves certain areas at greater risk. If the airplane is hijacked, areas of high population and governmental importance are at the highest risk. If a plane crash were to occur from technological malfunctions or human error, areas around the Springfield-Branson airport become the most at risk.

Strength/Magnitude/Extent

Plane crashes typically are devastating events. The crash itself can cause large amounts of injury and death to the people onboard the aircraft. Depending on where the crash happens, the aircraft can also cause injury and damage to the area that it hits. Airplane crashes typically also cause long-term effects on survivors including survivor's guilt and Post-Traumatic Stress Disorder (PTSD). Airplanes can have a devastating magnitude of impact on the community depending on the size and location of the crash. A large commercial flight could lead to several death, property damages, a decline in public confidence, and potentially many more side effects. A commercial airplane crash would be catastrophic.

3 - RISK ASSESSMENT

Previous Occurrences

Incidents and Accidents in Greene County

DATE	LOCATION	SEVERITY	CAUSE
03/21/2004	Springfield	1 Minor	Pilot Error
06/03/2004	Strafford	None	Mechanical
08/01/2005	Willard	Nonfatal	Pilot Error
10/26/2005	Springfield	2 Fatal, 1 Serious	Pilot Error
10/06/2010	Springfield	1 Fatal, 2 Serious	Pilot Error
01/03/2011	Walnut Grove	1 Fatal	Undetermined
05/21/2012	Rogersville	1 Serious, 1 Minor	Pilot Error
12/05/2013	Willard	5 Fatal	Spatial Disorientation
12/12/2014	Springfield	Nonfatal	Undetermined

January 2014

There have been many instances of close calls with malfunctions and human error in relationship to airplane maneuvers. In January of 2014, a Southwest Airlines jet destined for the Branson Airport, carrying 124 passengers, landed at the wrong airport. "The plane stopped about 500 feet from the end of a runway at M. Graham Clark Downtown Airport, but no one was injured," said Chris Berndt, the Western Taney County Fire District fire chief and emergency management director. The airport's runway is 3,738 feet long, about half the length of the Branson Airport runway, which is 7,140 feet. That forced pilots to act fast and brake hard when the aircraft touched down. If they had not, the plane could have overshot the end of the runway, tumbled down an embankment, and into U.S. Highway 65.

Probability of Future Occurrence

The probability for hazards in Greene County is determined using Calculated Priority Risk Index (CPRI). It is possible for a smaller airplane crash to occur within the next five years in Greene County. A large airplane crash is unlikely in Greene County. For a full description of the CPRI for airplane crash, refer to Appendix B.

Changing Future Conditions and Considerations

As discussed in previous hazard profiles, the climate in Greene County and many other areas is projected to change. The planning area could see an increase of rain and flooding, severe storms including hail, wind and lightning. All of those hazards effect air travel. Changing climate could make it more difficult on pilots when landing and taking off aircrafts. Unfortunately, the risk for hijacking has also become more of a risk for communities nation-wide.

VULNERABILITY

Vulnerability Overview

Airports, including the Springfield-Branson National Airport, have strict plans and protocols in place to ensure the safety and security of their passengers. Even with protocols in place, a major accident could occur at any given time. Airports and airplanes can be targets for terrorism, with high numbers of people congregated in a small space. The Springfield-Branson National Airport is Greene County's busiest airport, but it is not the only airport located in the county. The table below lists the airports (including heliports) both private and public that are in Greene County.

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AIRPORT NAME	LOCATION	USAGE
Eads Ridge Airport	Fair Grove	Private
Medcalf Field Airport	Republic	Private
Childress Airstrip Airport	Springfield	Private
Downtown Airport	Springfield	Private
Flying Bar H Ranch Airport	Springfield	Public
Gardner Airport	Springfield	Private
KTTS Heliport	Springfield	Private
KY-3 Heliport	Springfield	Private
Lester E. Cox Medical Center North Heliport	Springfield	Private
Lester E. Cox Medical Center South Heliport	Springfield	Private
Springfield Community Hospital Heliport	Springfield	Private
Springfield-Branson National Airport	Springfield	Public
Mercy Regional Health Center Heliport	Springfield	Private
Vans Heliport	Springfield	Private
Cuinche Airport	Strafford	Private
Bird Field Airport	Willard	Private
Hogue Farm Airport	Willard	Private
Textor Airport	Willard	Private

Source: Missouri Public Use Airports, 2014

Potential Losses to Existing Development

According to the Missouri State Hazard Mitigation Plan, it is hard to determine the actual risk to Greene County because no studies have been conducted to date. The plan does state that counties in and surround the metropolitan areas of St. Louis, Springfield and Kansas City are at greater risk because of the nature of the population and the transportation hubs within each area. Tourism will also make the Springfield area become at greater risk because of people traveling to see areas in Springfield, including the Bass Pro Attractions. Both economic and human losses can come from airplane crashes.

Impact of Previous and Future Development

As tourism and population increases in the Greene County area, the number of accidents could increase. With population, growth also comes community growth. If development expands around the Springfield-Branson Airport, a larger risk for experiences damages from an airplane crash increases in that area. A lot of airplane crashes or accidents happen around the airport. It is possible that in the future the Springfield-Branson airport could become larger and carry more airlines. Springfield-Branson Airport would have more air traffic also raising the risk for an incident.

3 - RISK ASSESSMENT

EMAP Consequence Analysis

EMAP Impact Analysis: Airplane Crash

SUBJECT	DETERRIMENTAL IMPACTS
Public	Airplane incidents are often fatal to everyone that was in the aircraft. There are also safety to concerns from anyone that is in the immediate area of the crash.
Responders	There would be little to no impact on responders and response functions in Greene County due to an airplane crash.
Continuity of Operations	Airplane incidents have little to no impact on service operations.
Property, Facilities, and Infrastructure	Airplane crashes have little to no property, facility and infrastructure damage in Greene County.
Environment	Airplane incidents result in little to no impact on the environment.
Economic Condition of Jurisdiction	Airplane incidents have little to no impact on the economy.
Public Confidence in the Jurisdiction's Governance	Airplane incidents causes little to no loss of public confidence in governance in Greene County.

*For more details on Consequence Analysis, refer to Appendix B.

Hazard Summary by Jurisdiction

A plane crash could happen in any jurisdiction in the planning area. Jurisdictions that are closer to Springfield-Branson National Airport (Republic, Springfield, and Unincorporated Greene County) would be at higher risk for experiencing an airplane crash. Though Greene County has not experienced a large airplane crash in the past, with facilities high of importance and the population of Greene County, plane crashes are likely to occur in Greene County.

PROBLEM STATEMENT

There are many reasons why an airplane can crash, including hijacking, human error, and mechanical malfunctions. Airplane crashes, especially large ones, can be catastrophic. Greene County has many private and one large airports. The large, public airport sees a lot of traffic 7 days a week. Airplane crashes can be unpredictable and happen anywhere within the county. The main concern for airplane crashes is the loss of human life and destruction of property. Possible solutions to limit the loss of damage is not developing around the airport. Limiting the amount of buildings and property around the airport can limit the destruction created. No participating jurisdiction created a project involving the mitigation of an Airplane Crash in this Mitigation plan.

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3.5.2 Technological Hazard: Cave/Mine Collapse

HAZARD PROFILE

Hazard Description



A cave-in is a collapse of a geologic formation, underground structure or mine. Geologic structures prone to spontaneous cave-ins include many limestone formations, but can also include lava tubes and a variety of other subsurface rock formations. Limestone occurs at the surface and subsurface in 99% of Missouri, inducing Greene County.

In mining, the term roof fall is used to refer to many types of collapses, ranging from the fall of a single flake of shale to collapses that form sink holes that reach to the surface. However, roof falls in mining are not all accidental. In long wall mining and retreat mining, miners systematically remove all support from under large areas of the mine roof, allowing it to settle just beyond the work area. The goal in such mining methods is not to prevent roof fall and the ensuing surface subsidence, but rather to control it.

Caves

There are over 360 documented caves in Greene County. The collapse of an underground geologic formation could kill people by falling rock, trap people inside, and presents a serious danger to people or structures located above ground. Erosion of the walls supporting the cave ceiling creates an increase in the amount of overlying rock being supported. At some point, the weight becomes too great, and the ceiling collapses.

Mines

Abandoned mines are found throughout Missouri. They include both surface pits and underground mines. Older mines typically were abandoned and seldom reclaimed or closed. These mines operated long before permitting laws established requirements for reclamation and closure. Today, these pits, voids, open adits and shafts can pose a public safety hazard. Abandoned mine sites appear attractive to explore, but are unsafe to walk, climb or ride in. Embankments or high walls may be unstable or not visible behind piled material. High walls that appear to be stable can collapse. Piles of waste material called "tailings" or "slime" may be unstable and can slide and bury someone climbing on them.

Quarries

Abandoned quarries or other surface mines often are appealing swimming holes. However, from the surface it is impossible to tell how deep the mine is or if shallow ledges left from mining remain but cannot be seen. Abandoned underground mines can have poor air quality. Active underground mines are ventilated to bring fresh air to miners. Abandoned mines, however, may have dangerous levels of carbon monoxide or methane.

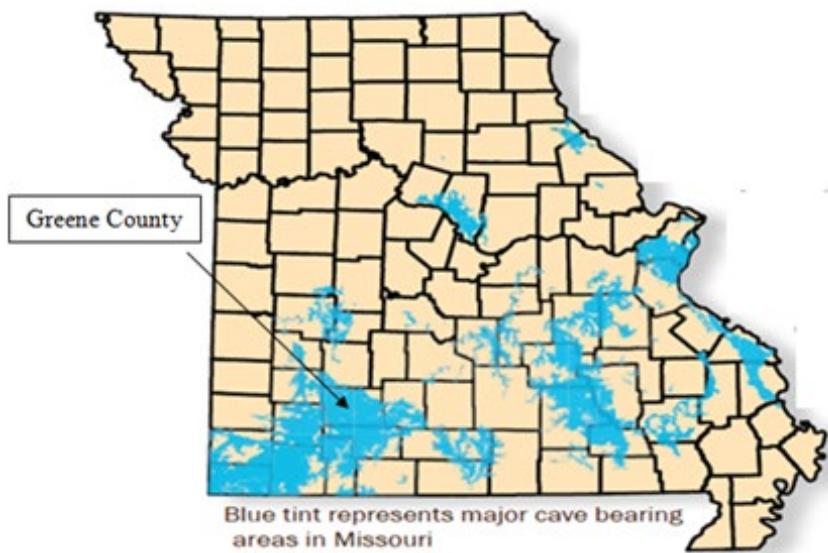
Geographic Location

Greene County has over 360 documented caves sprawled across the region. The Springfield Underground is a 2.4 million square foot underground facility located 100 feet below Springfield Missouri. The majority of these caves are located on private property. Greene County has several public show caves including Fantastic Caverns, Smallin Civil War Cave, Riverbluff Cave, and Crystal Cave.

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There are several operating mines throughout Greene County inducing 5 limestone and zinc mines in Springfield jurisdiction. Quite a bit of lead and zinc mining happened in the Springfield Area from about the 1870s to the 1920s. When the mines stopped producing, they were filled in and then abandoned. The actual number of abandoned mines is unknown.

Major Cave Bearing Areas in Missouri



Strength/Magnitude/Extent

Cave/Mine collapse can cause large amounts of damage. There is no scale for measuring the severity of a cave/mine collapse. However, geological and mining parameters can affect the magnitude and extent.

Previous Occurrences

January 2013

January 29, 2013, a subsidence occurred in east Springfield, Missouri. 31 feet long, 14 feet wide, and 15 feet deep this crater opened up above an abandoned mine shaft. The subsidence opened up beneath the corner of a house. No lives were lost, but \$50,000 in damages was the cost of the incident.

Probability of Future Hazard Events

The probability for hazards in Greene County is determined using Calculated Priority Risk Index (CPRI). It is unlikely for a cave/mine collapse to occur within the next 10 years in Greene County. For a full description of the CPRI for cave/mine collapse, refer to Appendix B.

Changing Future Conditions and Considerations

Climate changes will not necessarily effect cave and mine collapse. Development on areas with cave or mines can cause collapse because of the extra weight on top of them. Earthquakes can also cause caves or mines to collapse. Increase in earthquakes can also cause more cave/mine collapse. Please see Section 3.4.2 for more information about earthquakes.

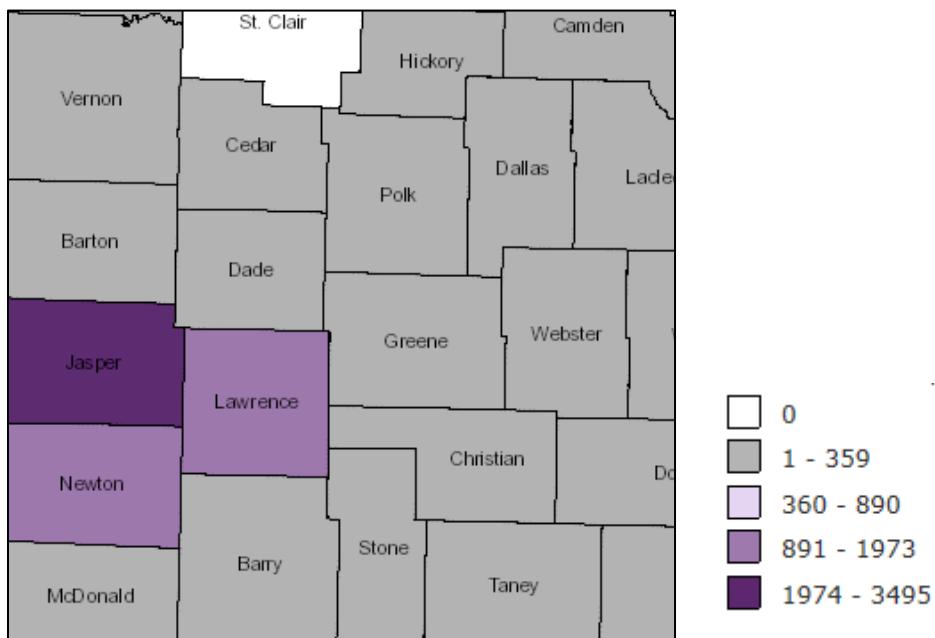
3 - RISK ASSESSMENT

VULNERABILITY

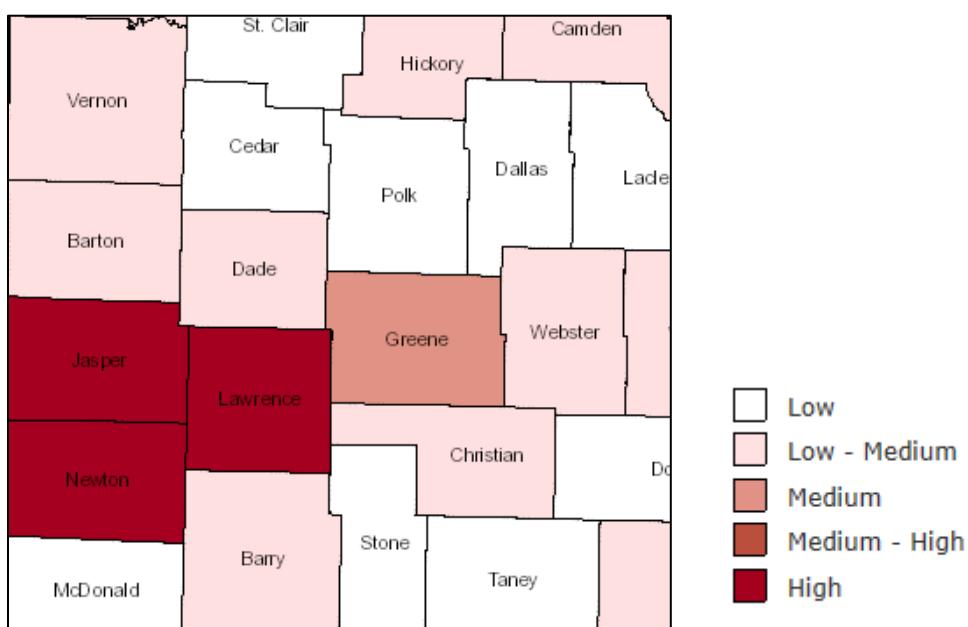
Vulnerability Overview

With increasing regulations and safety procedures, the risk of a cave in due to human error or accident is low, especially in popular show caves in Greene County. In addition, the probability of an earthquake affecting the area is low but still present. As shown by the recent subsidence cause by the mine shaft in Springfield, there is still present risk of other mine shaft collapsing or subsiding beneath unaware people and buildings.

Number of Mines



Vulnerability-Mines



3 - RISK ASSESSMENT

Potential Losses to Existing Development

Fantastic Caverns hosts over 100,000 visitors a year and the other show caves bring in thousands of more people. While the show caves are carefully maintained, the sheer amount of people exposed to the dangers of earthquakes, erosion, and sabotage poses a serious public safety threat.

Springfield Underground, a massive underground storage facility in Springfield, is home to warehousing, laboratories, food storages, records storage and data centers. A collapse in the Springfield Underground could kill or trap hundreds of workers, contaminate millions of pounds of food, and destroy important data and records.

Many undocumented mines are scattered underneath Greene County and many public spaces and private homes have unknowingly been built above abandoned shafts. Public and private properties are vulnerable to the risk of an unknown mine shaft collapsing below.

Impact of Previous and Future Development

Greene County will continue to see development across the planning area. Development has already occurred on areas above abandoned shafts. As more development continues, it is highly likely that more development will occur above mines and caves. Places like Fantastic Caverns bring many people to the area. As tourism continues to expand in Greene County, more population is at risk if a cave or mine does collapse.

EMAP Consequence Analysis

EMAP Impact Analysis: Cave/Mine Collapse

SUBJECT	DETՐIMENTAL IMPACTS
Public	Greene County has never experienced a cave/mine collapse. The most likely type of collapse would be an old mine shaft. These are abandoned and would not create much of a safety impact if there was a collapse.
Responders	If responders are called to the scene of a collapse, there are life safety issues if they must enter an unsafe structure. There may be another collapse.
Continuity of Operations	A cave or mine collapse would cause little to no impact on service operations.
Property, Facilities, and Infrastructure	The collapse of an abandoned mine or save would create little to no property damage. It would also create little to no facility or infrastructure damage.
Environment	A cave or mine collapse could create isolated instances of environmental damage if the collapse occurs in a used water source.
Economic Condition of Jurisdiction	A collapse would cause little to no impact on the economy.
Public Confidence in the Jurisdiction's Governance	The collapse of a cave or mine would cause little to no lose in public confidence in governance.

*For more details on Consequence Analysis, refer to Appendix B.

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Hazard Summary by Jurisdiction

There are many caves and mines placed throughout the planning area. Many have been identified, but many have not. The entire planning area is at risk from experiencing a cave or mine collapse. The planning area has not experienced a large cave/mine collapse, but it is still possible for the future.

PROBLEM STATEMENT

Cave and mine collapses can be very dangerous and cause large amounts of damage to both property and human loss. Caves and mines can also go unnoticed for long periods of time; sometimes they are not noticed until they are completely collapsed. As development continues around the planning area, it is important for communities to stay educated about what a cave/mine collapse is and how to mitigate against it. Cave collapse can cause large amounts of damage. It can be damaging to the environment as well. Mitigation solutions include not developing in or around large caves and education. No participating jurisdiction created mitigation projects involving cave collapse.

3 - RISK ASSESSMENT

3.5.3 Technological Hazard: Dam Failure

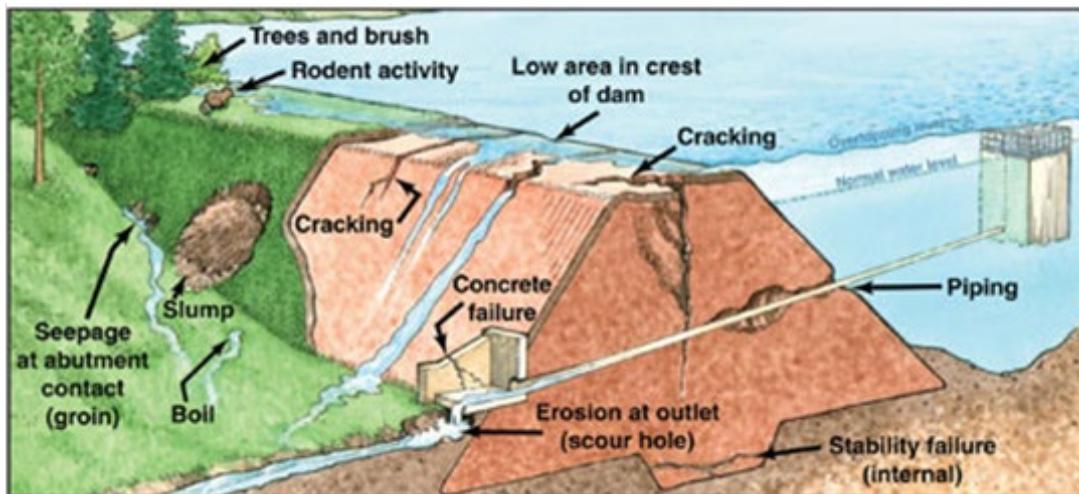
HAZARD PROFILE

Hazard Description

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

Causes of Dam Failures

- Overtopping: Caused by water spilling over the top of a dam. Overtopping of a dam is often a precursor of dam failure. National statistics show that overtopping due to inadequate spillway design, debris blockage of spillways, or settlement of the dam crest account for approximately 34% of all U.S. dam failures.
- Foundation Defects: foundation defects including settlement and slope stability cause about 30% of all dam failures.
- Cracking: mostly caused by movements like the natural settling of a dam.
- Inadequate maintenance and upkeep
- Piping: when seepage through a dam is not properly filtered and soil particles continue to progress form sinkholes in the dam. Another 20% of U.S dam failures have been cause by piping. Seepage often occurs around hydraulic structures, such as pipes and spillways; through animal burrows; around roots of woody vegetation; and through cracks in dams, dam appurtenances and dam foundations.



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Missouri Department of Natural Resource (MoDNR) Dam Hazard Classification Definitions

HAZARD CLASS	DEFINITION
Class I	The area downstream from the dam that would be affected by inundation contains 10 or more permanent dwellings or any public building. Inspection of these dams must occur every 2 years.
Class II	The area downstream from the dam that would be affected by inundation contains 1 to 9 permanent dwellings, or 1 or more campgrounds with permanent water, sewer and electrical services or 1 or more industrial buildings. Inspection of these dams must occur once every 3 years.
Class III	The area downstream from the dam that would be affected by inundation does not contain any of the structures identified for Class 1 or Class 2 dams. Inspection of these dams must occur once every 5 years.

Source: Missouri Department of Natural Resources

National Inventory of Dams (NID) Dam Hazard Classification Definitions

HAZARD CLASS	DEFINITION
Low Hazard	Dams assigned the low hazard potential classification are those where failure or mis-operation results in no probable loss of human life and low economic and/or environmental losses. Losses are principally limited to the owner's property.
Significant Hazard	Dams assigned the significant hazard potential classification are those dams where failure or mis-operation results in no probable loss of human life but can cause economic loss, environmental damage, disruption of lifeline facilities, or can impact other concerns. Significant hazard potential classification dams are often located in predominantly rural or agricultural areas but could be located in areas with population and significant infrastructure.
High Hazard	Dams assigned the high hazard potential classification are those where failure or mis-operation will probably cause loss of human life.

Source: Damsafety.org

3 - RISK ASSESSMENT

Geographic Location

Dams Located Within the Planning Area

Dam Name	Year Complete	Length	Height	ResArea	Drainage Area (Acres)	State Regulated	Hazard Class	Permit Number
Barnard Lake Dam	1963	0	22	2	830	No	3	-
Lake Springfield	1956	1,950	45	360	193,920	Yes	1	R-116
Valley Water Mills Dam	1890	0	21	17	3,200	No	1	-
Fellows Lake Dam	1955	1,500	100	812	12,858	Yes	1	R-012
McDaniel Lake Dam	1929	700	48	300	25,000	Yes	3	R-215
Salisbury Lake Dam	1963	0	25	8	1000	No	3	-
Rainbow Lake Dam	1974	500	42	13	227	Yes	2	R-500
Leo Journagan Lake Dam	1975	1100	20	8	284	No	3	-
D&R Pipeline Construct. Co Lake Dam	1975	0	25	7	560	No	1	-
McLean, Lee and Hammons, John Q Lake	1962	0	15	9	635	No	1	-
Mueller Lake Dam	1971	300	25	2	173	No	3	-
Hilliard Estates Lake Dam	1977	0	27	4	50	No	1	-
Lake James Dam	2000	0	30	6	210	No	3	-
Ford lake Dam	1978	0	25	9	99	NO	2	-
Hardeke Lake Dam	1964	0	22	8	190	No	1	-
Hagewood Lake Dam	1970	0	25	3	80	NO	2	-
Allen Dale Subdivision Dam	2000	0	18	8	6660	No	3	-
Stonegate Dam	1999	250	45	2.1	30	Yes	3	S-092

Source: <https://dnr.mo.gov/geology/wrc/dam-safety/damsinmissouri.htm>

3 - RISK ASSESSMENT

High Hazard Dams in Greene County

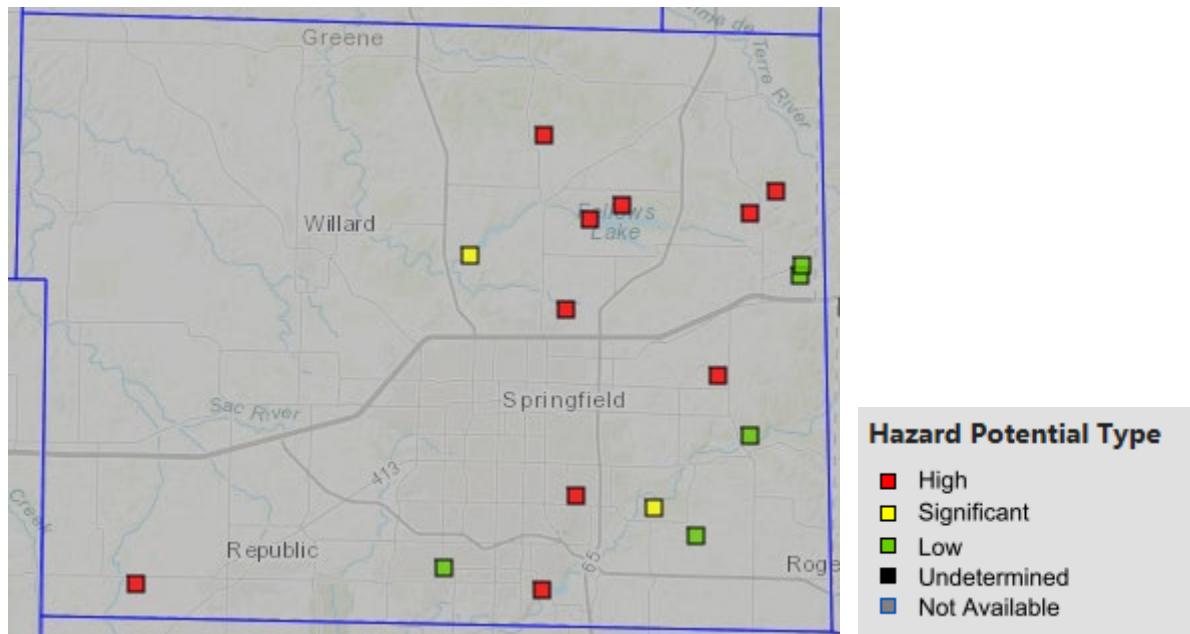
DAM NAME	EMERGENCY ACTION PLAN (EAP) AP	DAM HEIGHT (FT)	NORMAL STORAGE (ACRE-FT)	LAST INSPECTION DATE	RIVER	NEAREST DOWNSTREAM CITY	DISTANCE TO NEAREST CITY	DAM OWNER
Hagewood Lake Dam	Not Required	25ft	40	N/A	TR-Pickerel Creek			R B Hagewood
Lake Springfield Dam	Yes	45ft	20,077	11/22/2016	James River	Springfield	0	Springfield City Utilities
McLean, Lee & Hammons John Q kale #3	Not Required	15ft	72	05/15/1979	Tributary to James River	Springfield	0	L Mclean & J Q Hammons
Ford Lake Dam	Not Required	25ft	120	N/A	TR-Pierson Creek	Unin. Greene County	0	Edel Ford Tractor CO
Valley Water Mills Dam	Not Required	21ft	191	06/06/1979	TR-South Dry Sac River	Springfield	0	Springfield Utilities
Fellows Lake Dam	Yes	102	36,368	05/30/2017	Little Sac River	Springfield	7	City of Springfield
D&R Pipeline Construct	Not Required	25ft	94	05/15/1979	TR-Little Sac River	Springfield	7	D&R Pipeline Construction CO
Rainbow Lake Dam	Yes	42ft	240	02/25/2016	TR-Sims BR N Dry Sac River	Unin. Greene County	0	Paul Olive
Hilliard Estates Lake dam	Not Required	27ft	58	11/19/1980	TR-Little Pomme De Terre River	Strafford	4	John Norman
Hardeke Lake Dam	Not Required	22ft	94	07/17/1980	Trib-Pomme De Terre	Unin. Greene County	0	Carl Hardeke Jr.

Source: Missouri Department of Natural Resources National Inventory of Dams

Inundation Maps are included in Appendix C. These maps give details on areas in danger for a dam breech. These maps also show flow direction of the water.

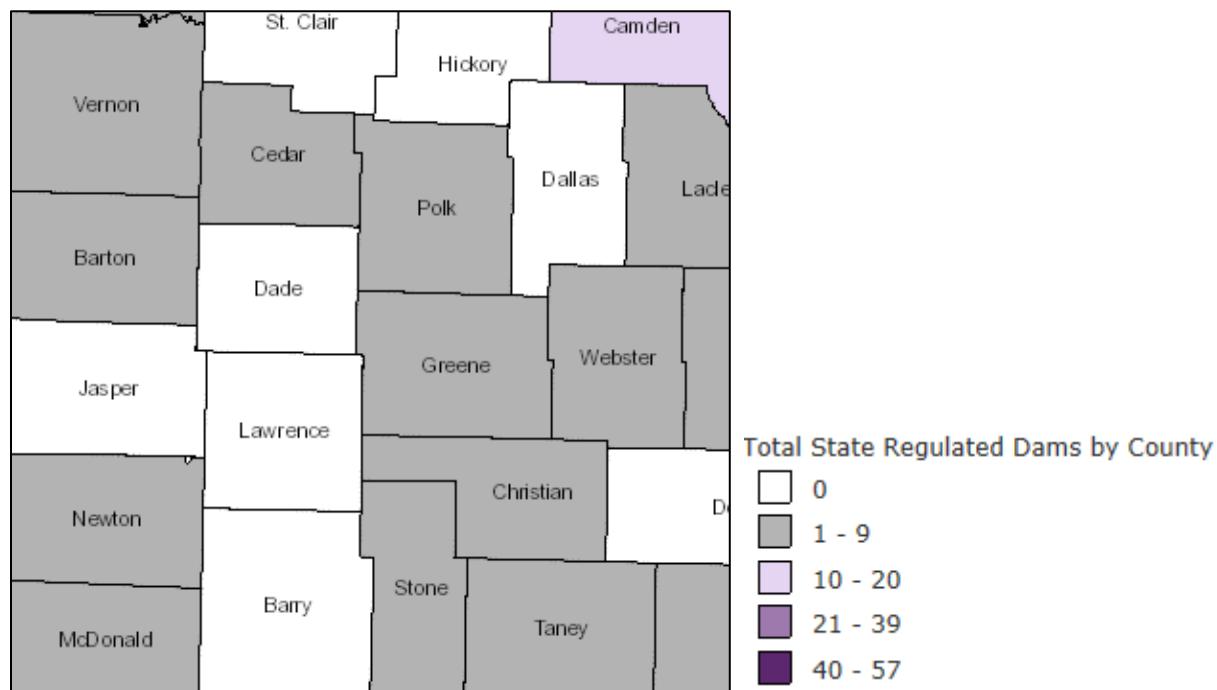
3 - RISK ASSESSMENT

Dam Locations in Greene County



Source: National Inventory of Dams

Total State Regulated Dams-Greene County



3 - RISK ASSESSMENT

Strength/Magnitude/Extent

The strength/magnitude of dam failure would be similar in some cases to flood events (see section 3.4.4). 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. Not that for this reason, dam failures could flood area outside of mapped flood hazards. The State of Missouri has 5,356 dams in the state, 33 of those dams have failed.

Flooding can also result in overtopping of the dam when they spillway and reservoir storage capacity are exceeded by the excess water. Complete structural collapse can occur as a result of an earthquake or severe tremors. When a dam fails, the pent-up water can be suddenly released and have catastrophic effects on life and property downstream. Homes, bridges and roads can be demolished in minutes.

Actual dam failure does not only result in loss of life, but also considerable loss of capital investment, loss of income and property damage. Loss of a reservoir (drinking water source) can cause considerable hardship for the community that relied on it for its water supply. Loss of a reservoir can lead to an upset in the ecological balance of the area as well.

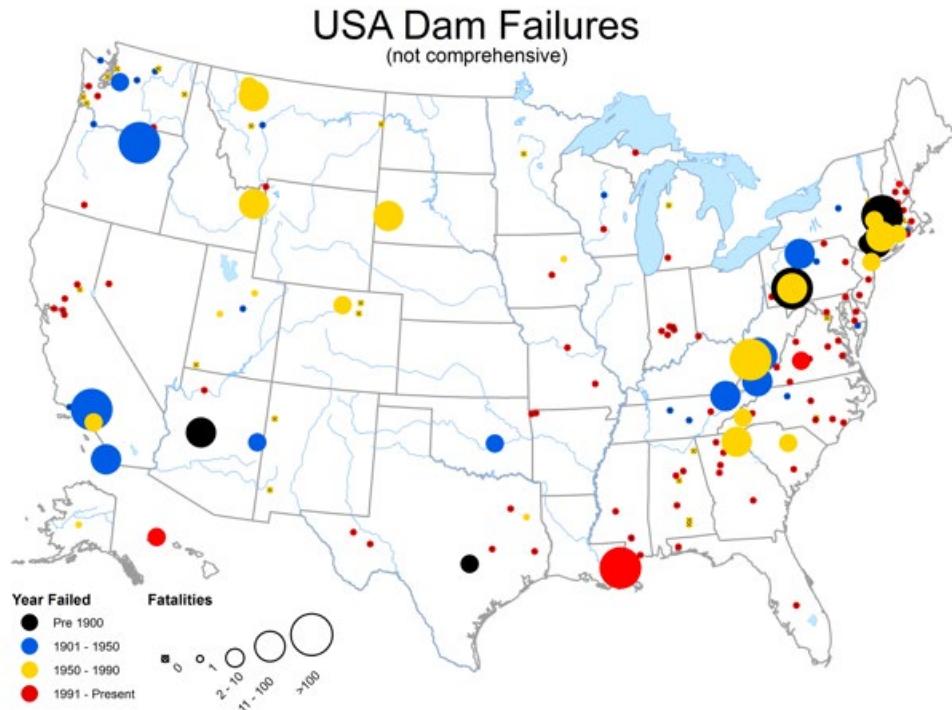
If a failure were to occur with the non-regulated dams, agriculture could be affected for the immediate area, otherwise no loss of life and little property damage would be expected. Failure of one of the regulated dams, especially one of the two lakes established for drinking water purposes, would affect the ability of Springfield City Utilities to supply potable drinking water to residents, in addition to water for schools, businesses and manufacturing. This could cause significant widespread property damage, and shut down of critical facilities.

Within the State of Missouri, to ensure that dams are safely constructed, operated, and maintained, the Legislature enacted Chapter 236 RSMo. Under the law, a dam must be 35 feet or higher to be state regulated. These dams are required to be surveyed every three to five years. The Department of Natural Resources maintains a Water Resources Program within the Division of Geology and Land Survey based in Rolla. In 2004, the program stopped doing dam inspections for permit renewals. The owners are now required to provide inspection documentation for permit renewal. New dam construction will be inspected prior to initial permits being used. Dams under the 35 foot minimum do not require state inspection; the State has for many years encouraged dam owners to do inspections on their own. However, the condition of many of these dams continues to deteriorate. Two of the five lakes provided by the dams are used for potable drinking water for the City of Springfield. One of the lakes provides cooling water for a power facility.

Previous Occurrences

Over the year, dam failures have injured or killed thousands of people, and caused billions of dollars of property damage in the United States. Among the most catastrophic were the failures of the Teton Dam in Colorado in 1976, which killed 14 people and caused more than \$1 billion in damages, and the Kelly-Barnes Dam in Georgia which left 39 dead and \$30 million in property damage. The problem with unsafe dams in Missouri was underscored by dam failures at Lawrenceton in 1968, Washington County in 1975, Fredericktown in 1977 and a near dam failure in Franklin County in 1979. Flash Flooding in October 1998 compromised a dozen small unregulated dams in the Kansas City area. Greene County has not experienced a dam failure yet.

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Source: Association of Dam Safety

Map Showing the Location of Dam Failures Involving Fatalities in the U.S



Probability of Future Occurrence

The probability for hazards in Greene County is determined using Calculated Priority Risk Index (CPRI). It is unlikely for a dam failure event to occur within the next 10 years in Greene County. For a full description of the CPRI for dam failure, refer to Appendix B.

3 - RISK ASSESSMENT

Changing Future Conditions and Considerations

According to the Missouri State Hazard Mitigation Plan, studies have been conducted to investigate the impact of climate change scenarios on dam safety. Dam failure is already tied to flooding and the increased pressure flooding placed on dams. The impacts of changing future conditions on dam failure will most likely be those related to a change in precipitation and flooding. 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

The downstream hazard classification system utilized by the National Inventory of Dams (NID) provides the Hazard Classification system as a means to determine overall vulnerability in the event of dam failure. According to the NID, of the 17 dams in Greene County, 10 dams are high hazard (58.8%), 2 are significant hazard (11.8%) and 5 are low hazard (29.4%). The hazard classification system is a means to classify dam according to what impacts could occur in downstream inundation areas. But, 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.

Emergency Action Planning/ Inundation Mapping

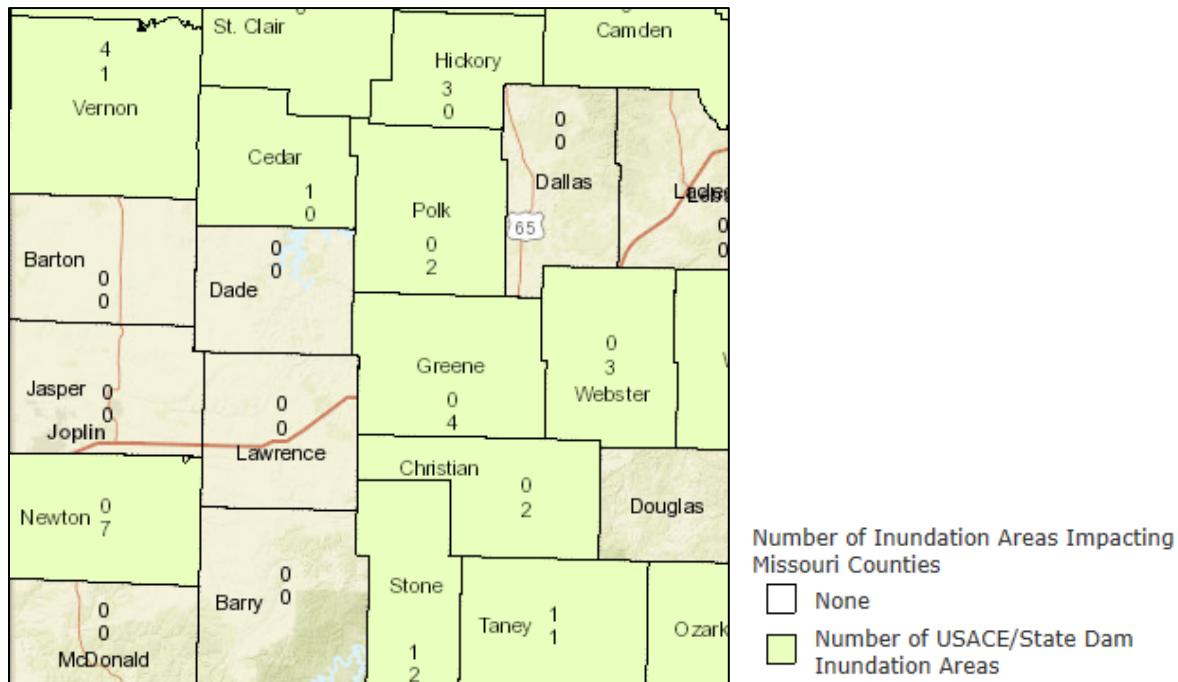
An Emergency Action Plan (EAP) helps emergency managers know the structures that are at risk as well as the roads that will be flooded so that evacuation routes and emergency management efforts can be developed accordingly. Since 2009, the Missouri Department of Natural Resources has been working with dam owners and emergency personnel to develop Emergency Action Plans. A dam inundation map is an important part of the EAP for all state-regulated high-hazard potential dams in Missouri. The EAP template that was developed by the Missouri Department of Natural Resources can be found on the Dam and Reservoir Safety Program Emergency Action Planning Website. To date, over 400 Emergency Action Plans with inundation maps have been completed by dam owners with the assistance of their county emergency management directors (EMD).

Each US Army Corps of Engineers (USACE) dam also has an emergency action plan and inundation map. These EAPs are updated generally on an annual basis. Inundation maps for all USACE dams are in various stages of development. The USACE Modeling, Mapping, and Consequences (MMC) Production Center, which is part of the USACE Risk Management Center, are tasked with producing these maps. When a dam fails, the stored water can be suddenly released and have catastrophic effects on life and property downstream. Homes, bridges, and roads can be demolished in minutes. Residents near High Hazard or Significant Hazard dams should become familiar with the dam's emergency action plans, if available.

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Emergency plans written for dams include procedures for notification and coordination with local law enforcement and other governmental agencies, information on the potential inundation area, plans for warning and evacuation, and procedures for making emergency repairs. Persons at risk in inundation areas may include farm workers, hunters, anglers, hikers, campers and other recreationists. Livestock may also be endangered and crops may be damaged. To complete a quantitative analysis of people and property vulnerable to dam failure in Missouri as well as estimate potential losses, this risk assessment relied on available inundation maps for state and federally-regulated dams. While this analysis does not capture vulnerability to failure of all dams in the state, it is the most comprehensive analysis possible at this time with the available data.

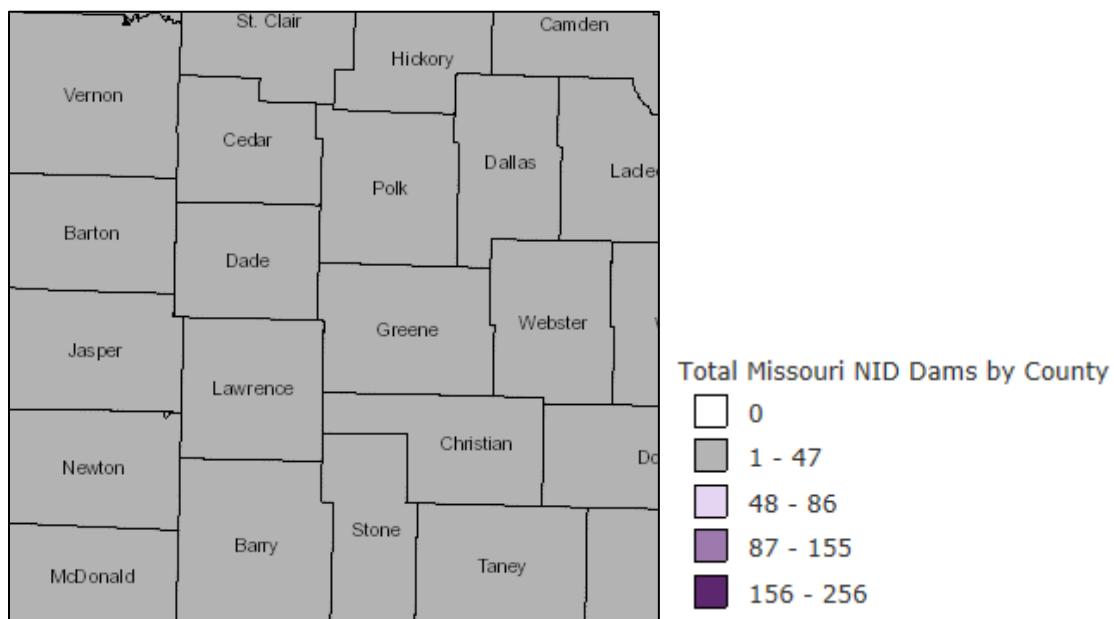
State and Federally-Regulated Dams with Provided Inundation Areas



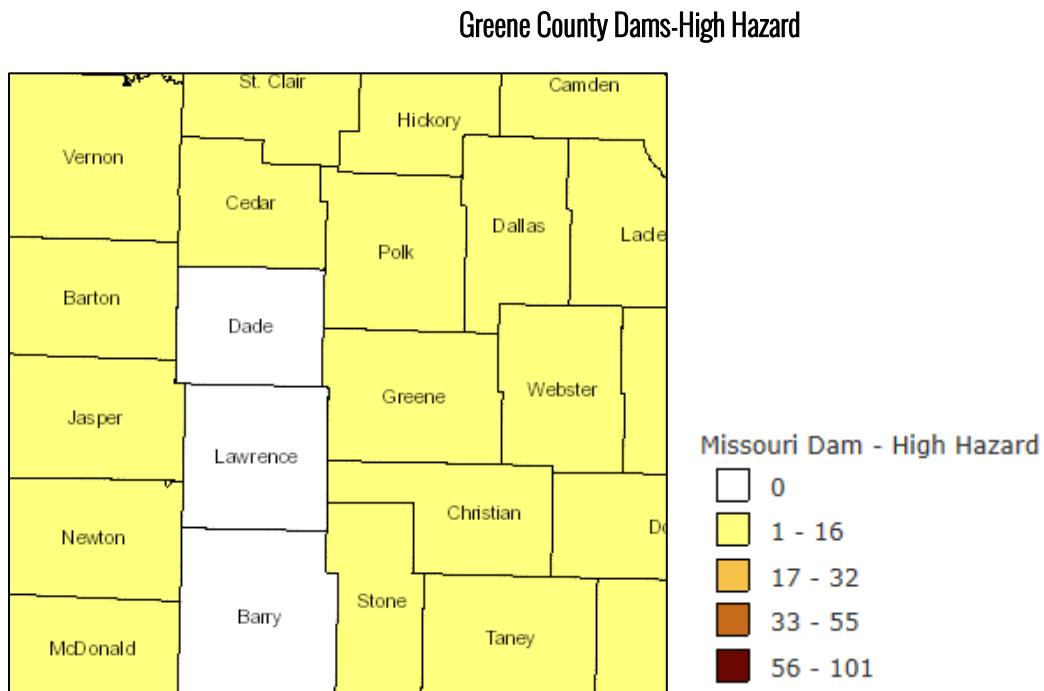
Inundation maps are included in the Maps section of the plan in the maps section of the plan.

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Total NID Dams by County



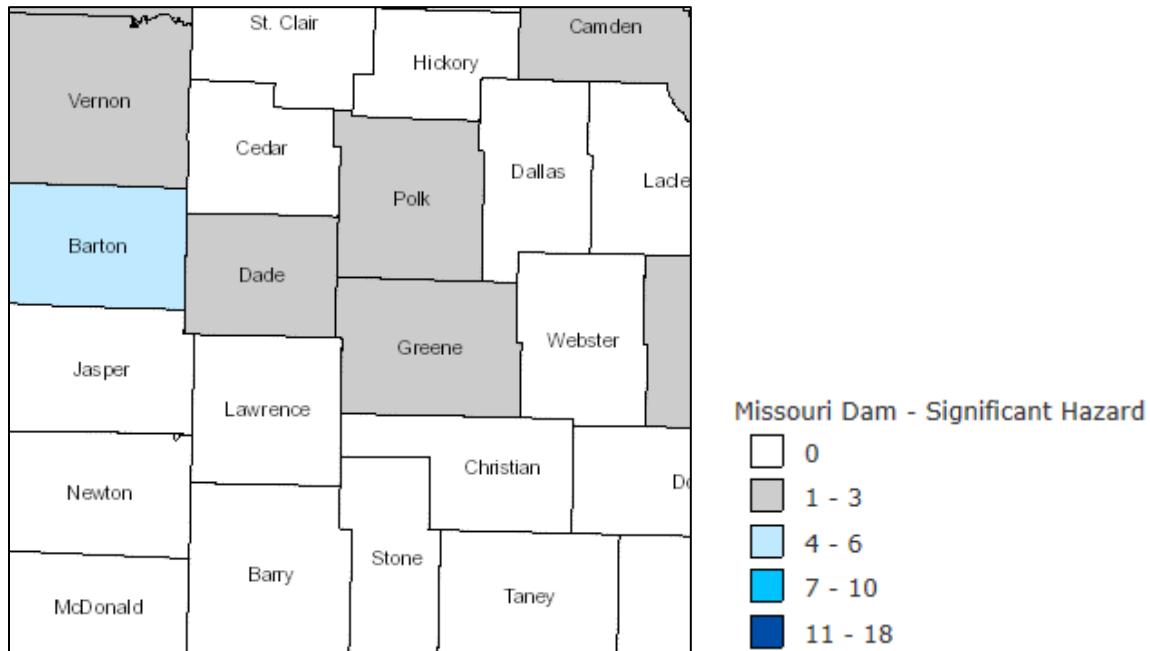
Total Missouri NID Dams by County



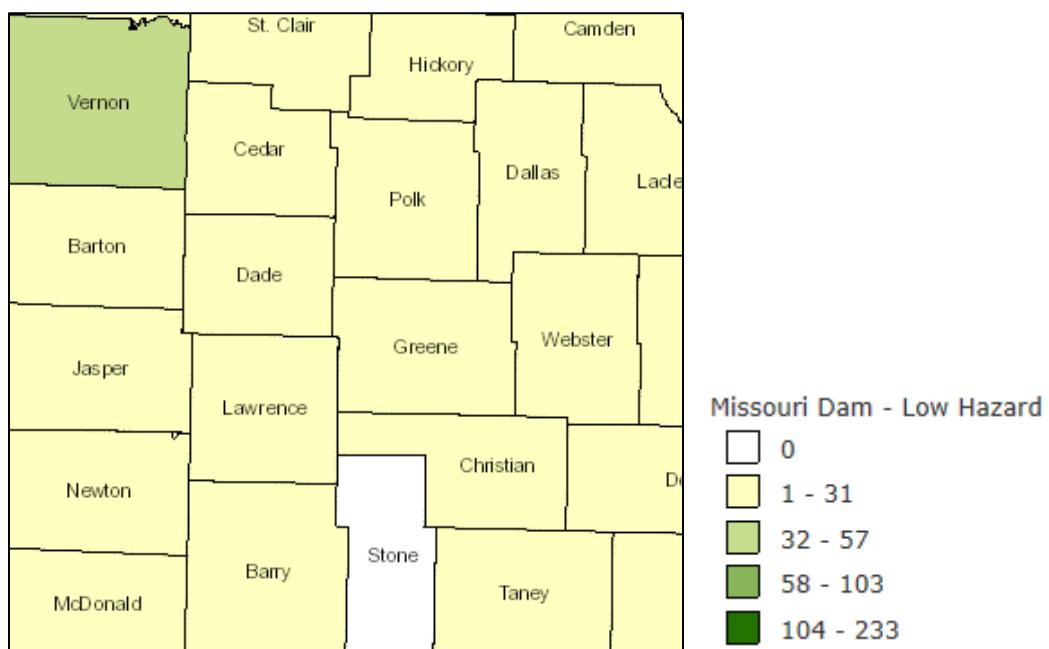
Missouri Dam - High Hazard

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Greene County Dams-Significant Hazard

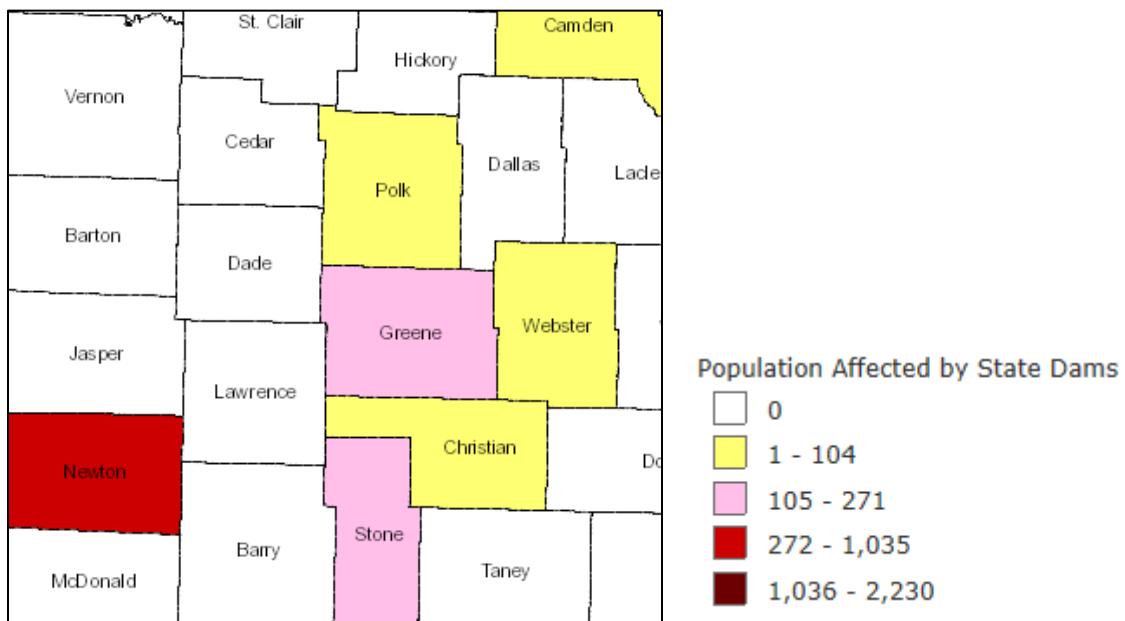


Greene County Dams-Low Hazard



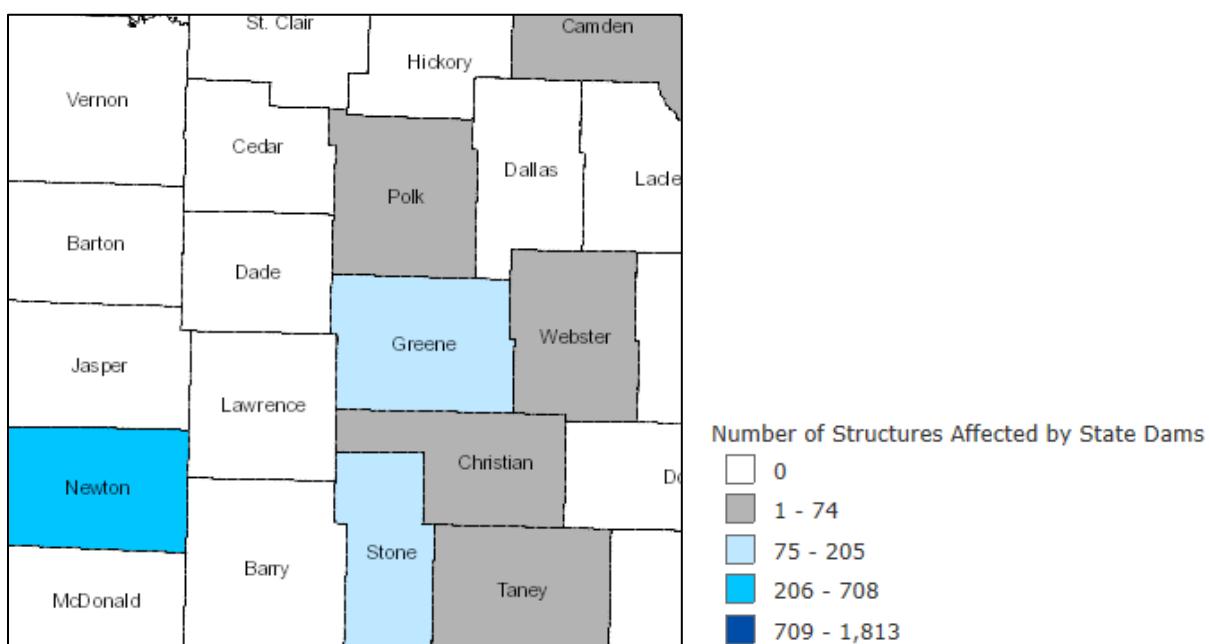
3 - RISK ASSESSMENT

Population Affected by State Dams



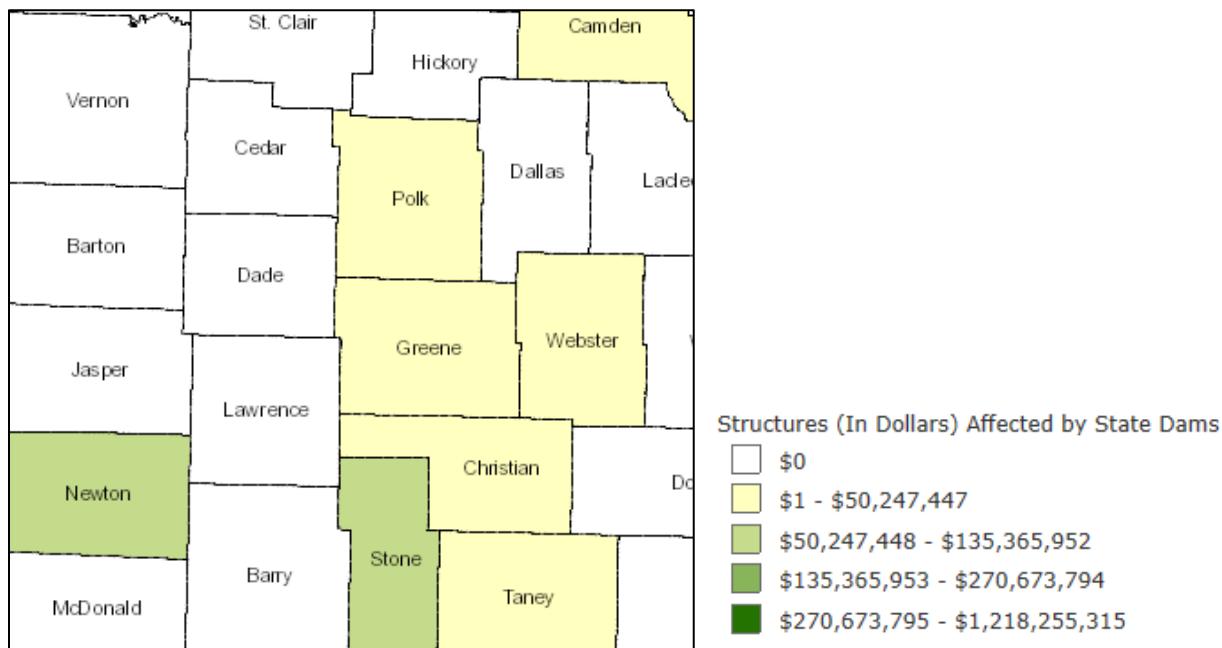
Potential Losses to Existing Development

Number of Structures Affected by State Dams



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Structures (In Dollars) Affected by State Dams



Other Potential Losses

Any dam failures can cause large amounts of damage to the community. These graphics above show the affects of state dams in Greene County but there are many other dams that can cause damage. One of the major risks of dam failure is environmental risks. The soil loss from erosion and scouring could be significantly greater, because of a large amount of fast-moving water affecting a small area. Large amounts of sediment from erosion can alter the landscape and change the ecosystem.

Impact of Previous and Future Development

As development continues in the Greene County area, the risk for many of our hazards increase. There is not much area to develop around Lake Springfield Dam, but there is space around Fellows Lake Dam. With these two dams being the largest dams in the county, they pose the most risk if there was a failure. There are many other smaller dams located around the planning area, any development close to those dams would also be at risk for experiencing damage from a dam failure.

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EMAP Consequence Analysis

EMAP Impact Analysis: Dam Failure

SUBJECT	DETՐIMENTAL IMPACTS
Public	A dam failure in Greene County could result in the loss or severe limitation of drinking water. Health and safety concerns associated with dehydration could cause major widespread safety concerns, and possible illness and death.
Responders	Responder safety and response functions would be impacted due to a lack of water. This would become even more of a safety issue if the dam failure occurred in times of extreme heat or drought.
Continuity of Operations	A shortage of water from a dam failure would create interruptions from some services, and others may be delayed.
Property, Facilities, and Infrastructure	A dam failure in Greene County would cause little to no property damage. Utilities and essential facilities such as hospitals would not be able to operate efficiently without water. Facilities would experience little damage however; they would be impacted in a water shortage situation.
Environment	The environment would experience multiple instances of significant damage in the event of a water shortage.
Economic Condition of Jurisdiction	A dam failure would greatly impact the economic condition throughout the jurisdiction in areas affected by the dam failure.
Public Confidence in the Jurisdiction's Governance	A water shortage from a dam failure would cause minor isolated instances of loss of public confidence in governance.

*For more details on Consequence Analysis, refer to Appendix B.

Hazard Summary by Jurisdiction

There are two main dams in Springfield that could potentially cause a large amount of damage to the city if the dam would fail. Those two dams are Lake Springfield and Fellow Lake. If those dams would fail, the City of Springfield could experience large amounts of damage. There are many neighborhoods around the Lake Springfield Dam that could be affected. There is also the James River Power Station located right on the dam. Fellows Lake Dam does not have as much development around it as Lake Springfield, but there are some houses around the dam that could be affected if there was a failure. Most of the other dams around Greene County are small and would only affect a small amount of land/homes if there was a failure.

PROBLEM STATEMENT

Greene County has many dams spread around the planning area. Many of the dams are smaller and located in undeveloped parts of Greene County. The two main dams that could cause large amounts of damage if there was a failure are Lake Springfield Dam and Fellow Lake Dam. Dam failure can cause property damage, injuries and even death to the population affected. Dam Failure can also cause environmental and soil issues within the planning area. Many of the effects of dam failure are the same as flooding which is discussed in Section 3.4.4. Even though there have not been any dam failures in Greene County, there is a risk for one of the 17 dams in Greene County to fail. According to the Missouri State Hazard Mitigation Plan Greene County is in the top five counties for potential residential losses due to dam failure. Mitigation projects include relocating the dam to a less populated area if possible, improve safety around the dam and other dam structure improvements. The participating jurisdictions did not include any dam improvement projects in this Hazard Mitigation Plan.

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3.5.4 Technological Hazard: Hazardous Materials

HAZARD PROFILE

Hazard Description

The Department of transportation (DOT) has defined a hazardous material as any substance or material that can cause harm to safety of the public, handlers or carriers during transportation. Hazardous materials are essential to the economy of the United States were more than 3 billion tons of regulated hazardous material is transported in the country a year.

Hazard Materials by Class

Class 1: Explosives	<ul style="list-style-type: none">• Mass Explosion Hazard• Projectile Hazard• Predominantly a Fire Hazard• No Significant Blast Hazard• Very Insensitive Explosives with a Mass Explosion Hazard• Extremely Insensitive Explosives
Class 2: Compressed Gases	<ul style="list-style-type: none">• Flammable Gases• Non Flammable, Non-Toxic Gases• Toxic Gases
Class 3: Flammable Liquids	<ul style="list-style-type: none">• Flammable (Combustible)
Class 4: Flammable Solids	<ul style="list-style-type: none">• Flammable Solids• Spontaneously combustible• Water-Reactive Substances/ Dangerous when Wet Material
Class 5: Oxidizing Agents and Organic Peroxides	<ul style="list-style-type: none">• Oxidizing Substances• Organic Peroxide
Class 6: Toxic Materials	<ul style="list-style-type: none">• Toxic Substances• Infectious Substances
Class 7: Radioactive Materials	<ul style="list-style-type: none">• Radioactive Substances/Materials
Class 8: Corrosive Materials	<ul style="list-style-type: none">• Corrosive Materials
Class 9: Miscellaneous	<ul style="list-style-type: none">• Risk of Spontaneous Violent Reaction

Source: U.S. Department of Transportation

The Emergency Response Guide (ERG) states that there are suggested distances to be used with helping to keep the public safe from vapors and other hazards from spills when they happen. There is the initial isolation zone that defines the area surrounding the incident in which the person exposed upwind is dangerous and downwind is life threatening. The protective action zone is the area downwind of the incident in which a person may become incapacitated. Depending on the hazardous material the distance zone for safety will vary and a Safety Data Sheet (SDS) is required with every chemical per OSHA and has to be presented in a consistent and user-friendly format. The SDS will include information on the properties, physical, health and environmental hazards, protective measures, and safety precautions for handling, storing and transporting the material.

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Geographic Location

The entire planning area is susceptible to hazardous materials. Areas around modes of transportation are especially vulnerable due to the number of hazardous materials that go through the Greene County area. A Tier II facility is a facility that reports storing hazardous material. In Greene County, there are 378 Tier II facilities and 105 Tier II facilities with extremely hazardous substances (EHS).

The environmental Protection Agency (EPA) also maintains a National Priority List (NPL) which serves primarily for informational purposes, identifying for the States and the public for those known releases or threatened releases of hazardous substances, pollutants, or contaminants throughout the United States and its territories. The NPL is intended primarily to guide the EPA in determining which sites warrant further investigation. Inclusion of a site on the NPL does not in itself reflect a judgement of the activities of its owner or operator, it does not require those persons to undertake any actions, nor does it assign liability to any person. In Greene County, there are 3 active NPL sites: Compass Plaza Well TCE, Fulbright Landfill and Solid State Circuits, Inc.

Strength/Magnitude/Extent

The magnitude of a hazardous materials release incident will vary in every case depending on the amount spilled or released, type of chemical, method of release, location of release, time of day, and weather conditions. Close coordination between the Missouri Department of Natural resources, the U.S Environmental Protection Agency (EPA), the local jurisdiction, and the spiller will be required to minimize the potential impacts to public health and the environment. A hazardous material incident could cause widespread and/or significant property damage, and create injuries or illnesses if human life.

Previous Occurrences

Probability of Future Occurrences

The probability for hazards in Greene County is determined using Calculated Priority Risk Index (CPRI). It is very likely for an accidental hazardous material event occur within the next year in Greene County. For a full description of the CPRI for hazardous materials, refer to Appendix B.

Changing Future Considerations

According to the Missouri State Hazard Mitigation Plan, accidental or incidental releases of hazardous materials are non-natural incidents and therefore, there are no implications for impacts from climate change. However, there is growing evidence that hazardous material releases triggered by natural hazards can pose significant risks. In these incidences, the impact of climate changes is of a secondary nature. It may exacerbate the natural hazard event by triggering release of hazardous materials.

VULNERABILITY

Vulnerability Overview

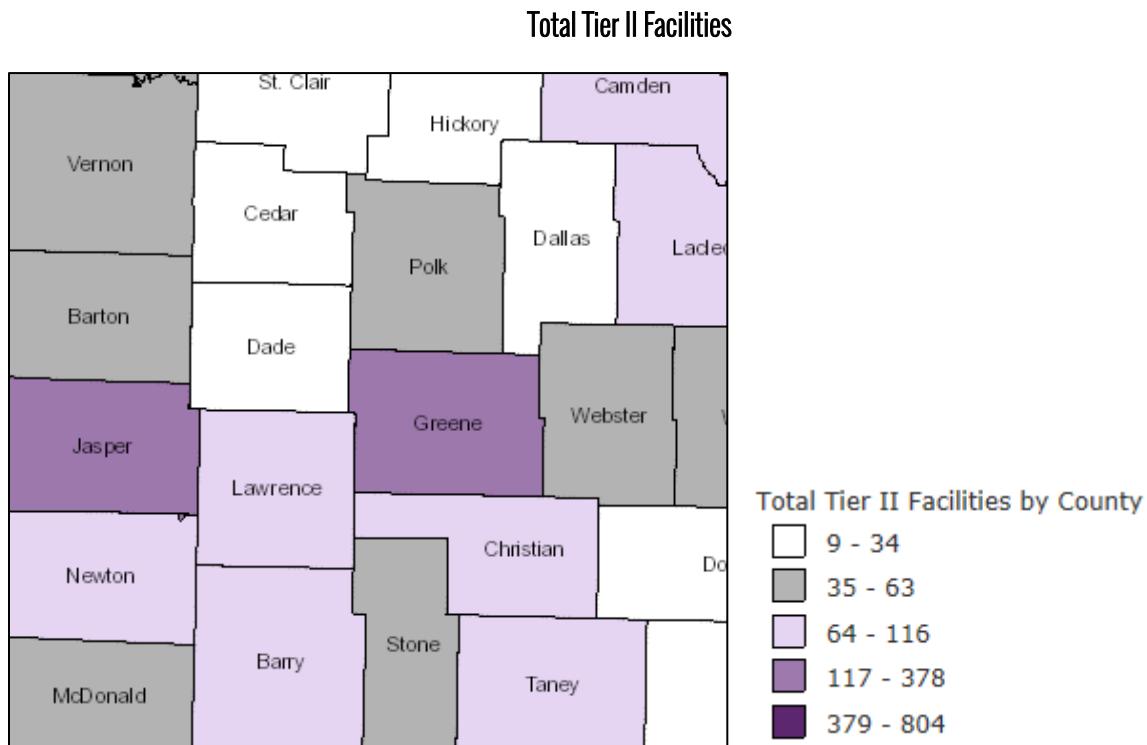
The entire county is susceptible to a hazardous materials incident. This hazard could have significant impact on the public health, the environment, private property, and the economy. The impact of this type of disaster will likely be localized to the immediate area surrounding the incident. The initial concern will be for people, then the environment. If contamination occurs, the spiller is responsible for the cleanup actions and will work closely with the Missouri Department of Natural Resources, EPA, and the local jurisdiction to ensure that cleanup is done safely and in accordance with federal and state laws.

Local responders are generally the first on scene for any incident. They are responsible for treating any injured victims and transporting them to a hospital for more complete medical care. First responders have the initial

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responsibility for controlling exposure of emergency workers and the public to any radioactive materials. While cleanup of any actual spill of radioactive materials rests with the shipper (in most cases), local responders may be required to provide site control for several hours until the responsible parties arrive on the scene.

Every day, hundreds of trucks with chemical tanks travel through Greene County on Interstate 44 (I-44) and other highways/interstates. Hazardous materials also frequently travel through the county by train. These trucks and railcars constitute potential hazards on wheels. In addition, fixed facilities that store and use chemicals have the potential for accidents. During an accidental release of toxic chemicals or other emergencies where air quality is threatened, the toxins heavier than air settle on the ground and the people in proximity can breathe these toxins and be affected. The toxins lighter than air spread for several miles and impact distant people.



Potential Losses to Existing Development

In most cases, the impact of this type of disaster will likely be localized to the immediate area surrounding the incident. The initial concern will be for people, then the environment. It is difficult to determine the potential losses to existing development because of the variable natures of a hazardous materials spill. If there was a hazardous spill in a heavy populated area, it would have a great potential for loss of life. If a spill happened in an agricultural area, it would be less costly.

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Potential Cost Estimate for HAZ-MAT Spill Remediation

ASSOCIATED COSTS	COST PER HOUR/UNIT	NUMBER OF HOURS/UNITS	TOTAL COST
Project Manager	\$92.65	8	\$741.20
Equipment Operator	\$95.76	8	\$766.08
Response Vehicle	\$30.66	8	\$245.28
Track Hoe	\$81.75	8	\$654.00
Environmental Tech	\$76.95	8	\$615.60
Duct Tap	\$7.63	6	\$45.78
Sampling Containers	\$13.08	20	\$261.60
PPE-Level B Protection	\$267.05	3 Staff @ 1 Day	\$801.15
Vermiculite (19lb Bag)	\$32.70	4	\$130.80
55 Gallon Drum	\$87.20	20	\$1,744.00
85 Gallon Overpack Drum	\$272.50	20	\$5,450.00
Total			\$11,455.49

Source: Missouri State Hazard Mitigation Plan

The total of \$11,455.49 is the cost per incident. Because the nature of this hazard is so variable, it is difficult to create a potential dollar loss estimate for Greene County. The damage that would be expected would be based on the type of chemical release, weather conditions, location of the spill, size of the spill, etc.

Impact of Previous and Future Development

As the population continues to increase along with the industries and the number and type of hazardous chemical stored and transported through Greene County, the amount of potential losses will also increase. According to the Missouri State Hazard Mitigation Plan, increased use and transport of materials across the country also creates serious problems for emergency services personnel. Many factors can increase the magnitude of an otherwise simple transportation accident into an incident of potential hazard to high number to people. The following are potential factors to be considered.

- Over 14,000 different chemicals are estimated as being shipped by the various transportation modes. Some types of highly toxic chemicals do not require placarding if shipped in quantities of less than 1,000 pounds, even though lesser quantities could devastate a small town.
- Only a few emergency response organizations in the larger cities and counties near the more metropolitan areas have had training for handling peacetime radiological problems. With recent federal grants and programs in place to provide funding for training, exercises and equipment for state Homeland Security response Teams and local responders, the general capabilities of hazardous materials response personnel and teams statewide is expected to improve.

3 - RISK ASSESSMENT

EMAP Consequence Analysis

EMAP Impact Analysis: Hazardous Materials

SUBJECT	DETՐIMENTAL IMPACTS
Public	Hazardous materials have caused documented injuries in Greene County. Fatalities have not occurred, however are very possible.
Responders	Depending on the type of hazardous materials that are involved, there could be significant safety risks for responders. Response functions may also be impacted.
Continuity of Operations	Hazardous materials have had little to no impact on service operations.
Property, Facilities, and Infrastructure	Areas around modes of transportation are especially vulnerable due to the number of hazardous materials that go through the Greene County area. Hazardous materials in various forms can cause damage to buildings, homes and other property. Many products containing hazardous chemicals are used and stored in homes routinely. These products are also shipped daily on the nation's highways, railroads, waterways and pipelines. Some infrastructure functions such as transportation may have minor impact, especially if the incident occurs on a highway. Greene County has experienced little to no impact on facilities due to hazardous materials.
Environment	Hazardous materials in Greene County can cause multiple instances of damage to the environment if the spill creates a runoff off the roadway.
Economic Condition of Jurisdiction	Hazardous materials could have a minor impact on the economy in Greene County.
Public Confidence in the Jurisdiction's Governance	Hazardous materials incidents cause little to no loss of public confidence in governance.

*For more details on Consequence Analysis, refer to Appendix B.

Hazard Summary by Jurisdiction

Though the entire planning area is susceptible to experiencing hazardous materials risk, there are some jurisdictions that are more likely to see an incident. Jurisdictions along I-44 are closer to chemicals that are traveling through Greene County. Two major jurisdictions that are along I-44 are Springfield and Strafford. Strafford school district is located right off the I-44 exit, making them more vulnerable. Other jurisdictions that are more at risk are cities or communities with railroads traveling through them. The main jurisdictions that experience rail travel are Springfield, Strafford, Ash Grove, Rogersville, and Republic. Many hazardous materials travel by railroad and a train derailment could lead to a large exposure. The railroad in Strafford actually travels through the middle of town and could be potentially dangerous if hazardous materials were to derail.

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PROBLEM STATEMENT

Greene County has a large amount of Tier II facilities, with many of those facilities housing extremely hazardous substances. Greene County also has a major interstate, I-44, that runs through the middle of two jurisdictions. Many hazardous material incidents can occur because of a motor vehicle accident or train derailment. Hazardous material incidents pose a large threat to public and responder health and can be very expensive to clean up. Hazardous material incidents also need immediate clean up and responder action to contain. It is very likely that Greene County will continue to experience hazardous material waste incidents. Some examples of Mitigation solutions for hazardous materials include creating a Hazardous Materials Response Team, training more fire staff to handle these incidents, purchasing better equipment and public education. Many fire protection districts in the planning area requested more training or more staff for their districts as mitigation projects. These are located in the Mitigation Strategy section of this plan.

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3.5.5 Technological Hazard: Power Failure

HAZARD PROFILE

Hazard Description

A power failure is any interruption or loss of electrical service due to disruption of power transmission caused by accident, sabotage, natural hazards or equipment failure. There are many ways that a power failure can happen to an area such as: issues at power stations, damage to the power lines, substation or distribution system, short circuit or even overloading of the mains. Many systems require power that is critical to city and human life. These sites have automatic backup generators that will startup when the electrical power is lost.

- Transient fault: A transient fault is when there is just a few seconds of power loss to a line and the power is restored quickly.
- Brownout: A brownout is an intentional or unintentional drop in voltage in an electrical power supply system. A voltage reduction may be an effect of disruption of an electrical grid, or may occasionally be imposed in an effort to reduce load and prevent a power outage known as a black out.
- Blackout: A blackout is the total loss of power to a certain area of which this is the most severe form of power outage. These can last from minute to weeks depending on the nature and complexity.

Geographic Location

Power failure can affect any private or public property supplied with power. However, the source of the hazard is at the source of the power. Springfield City Utilities supplies both gas and electric to its customers in Springfield. The rest of Greene County is supplied by four electric service providers: Empire Electric, Southwest Electric, Ozark Electric and Webster Electric.

Strength/Magnitude/Extent

Electric companies have multiple transmission and distribution lines serving a community so that if a line goes down there is an alternative line to provide power to the community. Therefore, electricity is lost to as limited an area and for as limited time as possible. Many water companies have some type of back-up, alternative or redundant systems, such as water impoundments, other deep wells, storage tanks or interconnection arrangements with other water companies. Similar switching and rerouting capabilities may exist with communications, while damage to natural gas utilities can often be isolated leaving customers without service for some period of time. Many utilities utilize emergency batteries or generators to provide back-up power for high priority equipment.

Power failures usually last between a few minutes and a few hours. Little danger is present at this short of time, even in the heat of summer or cold of winter. On the other hand, if power went out for a day or more, serious problems could be had. Power failures during extreme temperatures put people at risk for heat stroke or hypothermia.

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Short-Term Power Failure Severity

Refrigerated foods are at risk of contamination after a few hours and should not be consumed. Water is also at risk of contamination due to supplier's water filters losing power. The longer a power failure lasts, the more danger is presented to the public. A lack of food and water and a lack of heating or cooling can result in serious health problems and even death.

Downed power lines can also be hazardous. Overhead and buried power lines are especially hazardous because they carry extremely high voltage. Fatal electrocution is the main risk, but burns and falls are also a hazard.

Long-Term Power Failure Severity

Power failures can cause secondary hazards and have an effect on the health of residents. One potential secondary hazard is chemical accidents that occur after power is restored to industrial facilities. Chemical spills in turn can have significant health and environmental impacts. Another secondary hazard that can result from power failure is a loss of communications capability by first responders, which may in turn have negative impacts on public safety. Backup systems such as amateur radio operators may be required during disaster to augment communications capabilities. Power outages can also lead to instances of civil disturbance, including looting. Wastewater and potable water utility interruption may occur as a result of a power failure. These critical utilities are essential to community continuity and recovery. Their interruption of service may have cascading economic and environmental impacts. Retail and wholesale gas suppliers cannot access gas in underground tanks nor have the electricity to pump it into the tanker trucks for delivery. While hospitals usually have backup generators, a long power outage could cause irreparable harm in a hospital.

Power outages can last anywhere from one minute to a few days. Usually power outages last no longer than a few hours. However, in some circumstances people have been without power for over a week. Greene County normally experiences mild and limited power outages. Therefore, the severity is generally limited with little property damage, and no injuries, or shutdown of critical facilities for greater than 24 hours.

Previous Occurrences

The following incidents that are listed are those that impacted 1,000 people or more. There are power outages that occur around the county all the time according to the City Utility website. City Utilities has an outage map on their website that lists current outages. This can be viewed at: <https://www.cityutilities.net/outage/map-status/>.

January 12-14, 2007

During the days of January 12-14, 2007, a historic ice storm hit Greene County. Approximately 1-2" of freezing rain accumulated over the 3 days, leaving over 200,000 southwestern Missouri residents without power. The heavy ice downed power lines and snapped tree branches. The Missouri National Guard was activated to patrol the rural areas. It took days to weeks for some areas to regain power because of the ice accumulations of the trees and power lines.

September 21, 2010

On September 21 2012, thunderstorms knocked out power all over Springfield. City Utilities of Springfield reported approximately 1,000 customers lost electricity. It knocked out traffic signals on Kansas Expressway at Sunshine Street, where drivers treated it as a four-way stop. No injuries or damages were reported.

September 27, 2010

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On September 27, 2012 a line failure at an electric substation in south central Springfield resulted in 2,500 people being without power. City Utility restored power back to Cox Health and majority of its customer within 45 minutes with about the remaining 800 people having power restored an hour later.

July 12, 2018

Overloaded substations caused over 7,000 Liberty Utilities Empire District customers were without power on July 12, 2018. It took over an hour to get power restored to the city of Republic. A message was pushed out to the Empire District customers to raise the temperature in their homes to relieve some of the stress on the power stations.

March 2019

Over 5,000 customers were without power, including Mercy Hospital Campus when a contractor crew damaged a line near Seminole and Kings Ave. The power outage caused a few major traffic lights to go out including the one on National and Sunshine.

June 2019

Missouri State University had an incident with a bird effecting a power grid. The University had to shut down power for a large portion of the campus for one hour while the systems were being repaired. Many classroom halls and dorms were effected.

Probability of Future Occurrence

The probability for hazards in Greene County is determined using Calculated Priority Risk Index (CPRI). It is very likely for a power failure event to occur within the next one year in Greene County. For a full description of the CPRI for power failure, refer to Appendix B.

Changing Future Conditions and Considerations

According to the Missouri State Hazard Mitigation Plan, Deteriorating infrastructure is a current nationwide problem that is likely to be exacerbated by changing future conditions. Higher future temperatures, for example, would increase the demand for cooling homes, businesses, and public buildings, placing greater stress on power systems. Other storms including severe storms (high wind and tornados) can also have an effect on power outages. If the amount of severe storms increase in the county, the risk for experiencing power outages also increases.

VULNERABILITY

Vulnerability Overview

All utilities, including power, are vulnerable to damage from many natural hazards. Public health and safety and potential impacts on the economy are primary concerns with this hazard. Power is the most vulnerable utility infrastructure. Typically, the most damage comes from damaging wind, lightning, winter storms or tornadoes. The electrical grid is vulnerable in periods of extreme heat when air conditioning use peaks. Underground utilities can also be damaged by expansive soils, erosion, earthquake and intentional or unintentional human actions. The Missouri Underground Facility Safety and damage Prevention Act helps prevent accidental damage of underground facilities. This statute makes it illegal to excavate without first giving notice and obtaining information concerning the possible locations of underground facilities.

Potential Losses to Existing Development

Electrical blackouts and power surges can damage high tech equipment but generally do not cause structural damage. Electrical utilities in Missouri prepare for disaster and power outages by developing written plans to

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follow when events cause outages to customers. Power outages caused by severe weather have prompted the creation of tree trimming plans to ensure above ground power liens are free of potential limbs that could fall on power liens and cause interruptions of power if knocked down.

Typically the damage that will occur from a power outage is damage to the equipment running the power.

Impact of Previous and Future Development

As many of the other hazards, increasing population can put more strain on our power systems leading to power failure. As seen in the Previous Occurrences portion of this hazard profile, the City of Republic and many other customers saw this in July 2018. Utility and infrastructure development and expansion should be minimized or mitigated in known hazard areas to ensure the vulnerability to this hazard is not increases as a secondary impact to the other hazards.

EMAP Consequence Analysis

EMAP Impact Analysis: Power Failure

SUBJECT	DETERRIMENTAL IMPACTS
Public	Power failure can cause minor injuries or illnesses and a few safety concerns. A power failure in Greene County can cause illnesses if spoiled food is consumed, and lack of power can be a safety concern in weather extremes such as heat or cold.
Responders	Response functions are slightly impacted during a power failure. There are no life safety issues for responders.
Continuity of Operations	Power failure can cause many severe operations to be delayed or even suspended.
Property, Facilities, and Infrastructure	Power failure in Greene County has caused little property damage. Infrastructure is very depending on power. Fire alarms and water sprinklers that cease to function, inability to communicate via phone or email with emergency services. Major critical infrastructure is impacted in all key sectors in power failure. Power failure in Greene County has caused little facility damage.
Environment	Power failure in Greene County has caused little to no impact to the county's environment.
Economic Condition of Jurisdiction	A power failure would greatly impact the economic condition for the industrial and business operations.
Public Confidence in the Jurisdiction's Governance	Power failure would cause minor isolated instances of loss of public confidence in governance.

*For more details on Consequence Analysis, refer to Appendix B.

Hazard Summary by Jurisdiction

The entire planning area is at risk for experiencing power outages at any given point throughout the year. The utility companies are generally prepared to deal with day-to-day outages. All jurisdictions, including school districts and universities are at risk for experiencing large power outages that could affect the jurisdictions for days. Cities and communities that have more damage from high winds or severe storms may experience more power outages than other communities may. Jurisdictions that have power cables that are buried underground may be at a lower risk as well.

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PROBLEM STATEMENT

Power outages are a hazard that the planning area will continue to see. Power outages happen on a daily basis throughout the county but are normally fixed in a timely manner. An increase in severe weather can put the county at a greater risk for experiencing power outages. Power outages that last a long period of time can affect the health and well-being of Greene County Citizens. Power outages are a hazard that the county should expect to see frequently in the area. The major mitigation solution for power outages is supply generators to critical facilities across the planning area. Many jurisdictions chose to projects that included purchasing at least one generator for multiple critical facilities including, EOC, fire houses, shelters and schools. These projects can be found in the Mitigation Strategy section of this plan.

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3.5.6 Technological Hazard: Train Derailment

HAZARD PROFILE

Hazard Description

A train derailment is when a train runs off its track. Although many derailments are minor, all result in temporary disruption of the proper operation of the railway system, and they are potentially seriously hazardous to human health and safety. In Missouri, there are approximately 4,400 miles of main track, 2,500 miles of yard track and about 7,000 public and private crossings. There are many reasons why a train may derail; some of the reasons are listed below.

- The primary mechanical failure of a track component. (For example: Broken rails, gauge spread due to tie failure)
- The primary mechanical failure of a component of the running gear of a vehicle (For example: axle box failure, wheel breakage)
- A fault in the geometry of the track components or the running gear that results in a quasistatic failure in running. (For example: rail climbing due to excessive wear of wheels or rails, earthworks slip)
- A dynamic effect of the track-vehicle interaction (For example, vertical bounce, track shift, under a train, excessive speed)
- Improper operation of points, or improper observance of signals protecting them.
- As a secondary event following collision with other trains, road vehicles, or other obstructions.
- Train handling (For example, snatches due to sudden traction of braking forces)

Geographic Location

Passenger trains no longer serve Springfield; however, more than 65 freight trains travel to, from and through the city each day. The Burlington Northern Santa Fe (BNSF) Railway is the largest. BNSF has three switch yards in Springfield. Mainlines to and from Kansas City, St. Louis, Memphis and Tulsa converge at the railroad's yard facility in the north part of the city. The Missouri and Northern Arkansas Railroad also operate several miles of industrial track within the city. Many of our jurisdictions have railroads that travel through them including Springfield, Strafford, Ash Grove, Rogersville, and Republic. Those jurisdictions are at risk for experiencing train derailment.

Greene County, MO Railroad Lines from BNSF



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Strength/Magnitude/Extent

Train derailment poses several threats to Greene County. A derailment could cause loss of life, an explosion and subsequent fire, chemical/gas spill, and damage to the natural and man-made environment. A derailment could impact the surrounding area upwards of a mile or more if a hazardous chemical is spilled. A fire in an urban area could spread quickly, posing significant risk to the high population in the area. With several potential causes for a derailment and little warning time, the public is very vulnerable to any accident that could happen.

Previous Occurrences

Greene County does not have a large history of train derailments. Though Greene County does not have many incidents, the State of Missouri has had over 36 incidents and the U.S has seen over 1,200.

January 2019

Five train cars and a locomotive derailed at BNSF rail yard just north of Division Street in Springfield and came off their tracks. Three of the cars were carrying a hazardous material, Anhydrous Ammonia. Another car was carrying another hazardous material called Ethylene Oxide. The Springfield Fire Department investigated the scene to make sure none of the cars were leaking the hazardous materials. Fortunately, there were no leaks discovered and the rail cars were lifted without incident. If fire crews did find a leak, evacuations would take place immediately.

February 2013

Lilbourne, MO- Over a dozen rail cars flipped over when a faulty wheel broke on a train. No one was injured even though the train derailment blocked off an entire street.

May 2013

Rockview, MO- Two trains collided causing a derailment and the collapse of a highway overpass. Several people were injured including the train crew and two people driving under the overpass.

June 2012

Portageville, MO- Twenty rail cars tipped over spilling coal following a derailment. No one was injured in the derailment.

Probability of Future Occurrence

The probability for hazards in Greene County is determined using Calculated Priority Risk Index (CPRI). It is unlikely for a major train derailment to occur within the next 10 years in Greene County. For a full description of the CPRI for train derailment, refer to Appendix B.

Changing Future Conditions Considerations

Weather hazards can be a potential cause for derailment. This includes ice and snow, tornadoes, and damaging winds. As those weather related hazards increase there is a possibility that train derailment could increase as well. Most of train derailments are caused by equipment failure or mechanical issues.

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VULNERABILITY

Vulnerability Overview

Large train derailments or train derailments that involve hazardous materials can be very dangerous and cause large amounts of damage. Damages from a derailment that involve hazardous materials can lead to public health issues and public evacuations for miles of where the derailment happened. Despite the limited number of incidents that occur each year, the danger is significant. Train rails cars go through towns daily carrying everything from explosives to class-nine miscellaneous chemicals. Train derailments can also lead to urban or wild fires.

Potential Losses to Existing Development

Train derailments can be extremely expensive depending on the magnitude and extent of the derailment. If the train was carrying hazardous materials, it could involve a hazmat clean up. See Section 3.5.4 for more information on hazardous material cleanup cost. Typically, the damages from a train derailment are localized to a specific area.

Impact of Previous and Future Development

Population increase could cause the amount of people affected by a train derailment to increase, but typically, train derailments are localized hazards. Any new development that is close to a railroad would be at higher risk for experiencing damages from a derailment. When population grows, so does development.

EMAP Consequence Analysis

EMAP Impact Analysis: Train Derailment

SUBJECT	DETERRIMENTAL IMPACTS
Public	A recent train derailment that happened in Springfield could have caused a large public safety risk if the rail cars that tipped would have leaked. There is a possibility for injuries and there are definite safety concerns with train derailment and hazardous materials.
Responders	Responders and response functions may be impacted depending on what the train was carrying (hazardous materials) and the severity of the derailment.
Continuity of Operations	Minor service operations may be interrupted and there may be some delay of service depending on the train load, location of the incident, and the situation.
Property, Facilities, and Infrastructure	A train derailment could cause multiple instances of significant property damage in Greene County. Minor impacts to some key infrastructure sectors may occur from a train derailment incident depending on the rail load, the location of the incident, and situation. A train derailment would result in little to no facility damages.
Environment	A train derailment could cause minor instances of environmental damage depending on what type of chemicals are involved and amount of the environment contaminated.
Economic Condition of Jurisdiction	A train derailment may have a minor economic impact depending on the train load, location of the incident and the situation.
Public Confidence in the Jurisdiction's Governance	There is little to no effect on public confidence in governance from a train derailment incident.

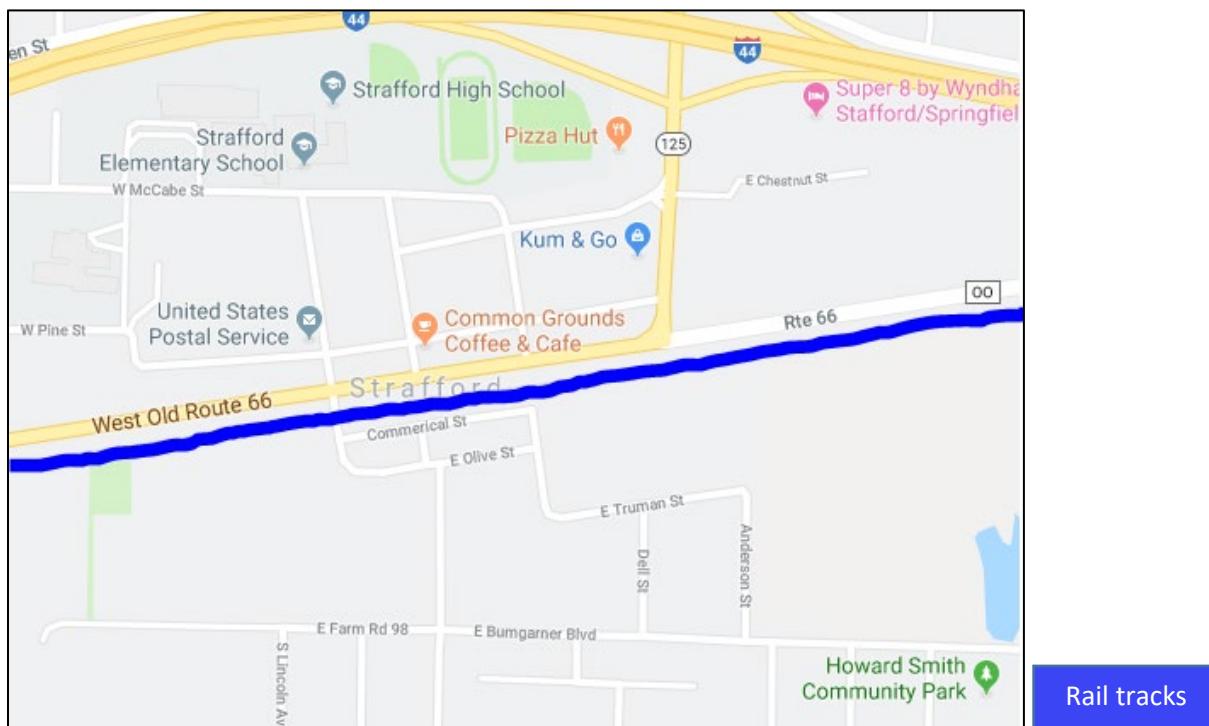
*For more details on Consequence Analysis, refer to Appendix B.

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Hazard Summary by Jurisdiction

Train derailments are a hazard that some of our jurisdictions are at a higher risk for experiencing. The jurisdictions that have trains that run through the cities are Springfield, Strafford, Ash Grove, Rogersville, and Republic. The City of Strafford actually has a train track that runs through the middle of town. The train track is very close to businesses and the school district. If there was a derailment of hazardous materials in the city of Strafford, it is likely that the schools would have to evacuate.

City of Strafford



As you can see in the map above, the schools district is on one side of the tracks and on the other side is a community park and residential housing.

PROBLEM STATEMENT

Though train derailments do not happen very often in Greene County, they still have a large risk in the planning area. A train derailment carrying hazardous materials can cause a huge public health risk and can be very expensive to clean up. A train derailment in a populated area, like Strafford, can also cause a large amount of damage and injury to people around the derailment. Train derailments are hard to mitigate, but some solutions include education, quicker response, and relocation of critical facilities around the railroad. No participating jurisdiction chose to create a project mitigating train derailment in this Hazard Mitigation Plan.

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3.5.7 Technological Hazard: Urban Fire

HAZARD PROFILE

Hazard Description

An urban fire describes an uncontrolled fire within an urban area. Protection from an urban fire is based largely on amount of firefighters, built-in fire protection and building techniques. An urban conflagration is the term used to describe a catastrophic urban fire. An urban conflagration is a large, destructive fire that spreads beyond natural or artificial barriers; it can be expected to result in large monetary loss and may or may not include fatalities. These fires can occur for a variety of reasons. They can come secondary to another event such as a ruptured gas line or a flood. Urban fires can also be caused from open flames and accidental fire. Heating sources within homes or industrial processes are a part of everyday life that can cause a fire to start and spread rapidly.

Causes of Urban Fires:

- Storms
- Droughts
- Transportation Accidents
- Hazardous Material Spills
- Arson
- Terrorism

Urban fires can be maintained and limited by creating natural breaks in buildings, including sprinkler systems into buildings, ensuring adequate water pressures and volumes, ensuring secondary water sources, and maintaining an adequate number of firefighters to reduce chances of a fire growing into an urban fire.

Geographic Location

An urban fire can occur anywhere in the planning area, but the fire needs fuel supply and room to grow. Large urban fires are most likely to occur in areas of dense population, crowded buildings with little or no open spaces, or in buildings that do not meet building code requirements. Urban fires can occur within towns and cities, in buildings or structures, in mines, or on transportation routes such as bus, train, or other vehicles on the road.

Strength/Magnitude/Extent

Urban or structural fires can cause large amounts of damage. Many single structural fires carry large amount of loss to the individual structure. If the fire continues to spread, it can cause more damage to other property, it can also be harder to contain and even cause loss of life or injury to animals and people. Depending on how old buildings are and if they are up to code makes a huge difference on how much damage could be caused.

The extent of damage relies mostly on insurance coverage. Some fires can cause large amounts of damage and if the home or building is not insured, that could mean a huge loss for the owner. Insurance does not always cover everything that was in the home or building that was destroyed either.

Previous Occurrences

Individual structure urban fires occur frequently in Greene County. It can occur weekly or even daily at certain times of the year. Greene County has not experienced a large occurrence that effected multiple buildings or urban areas.

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Probability of Future Occurrences

The probability for hazards in Greene County is determined using Calculated Priority Risk Index (CPRI). It is unlikely for an urban fire to occur within the next 10 years in Greene County. For a full description of the CPRI for urban fire, refer to Appendix B.

Changing Future Conditions and Considerations

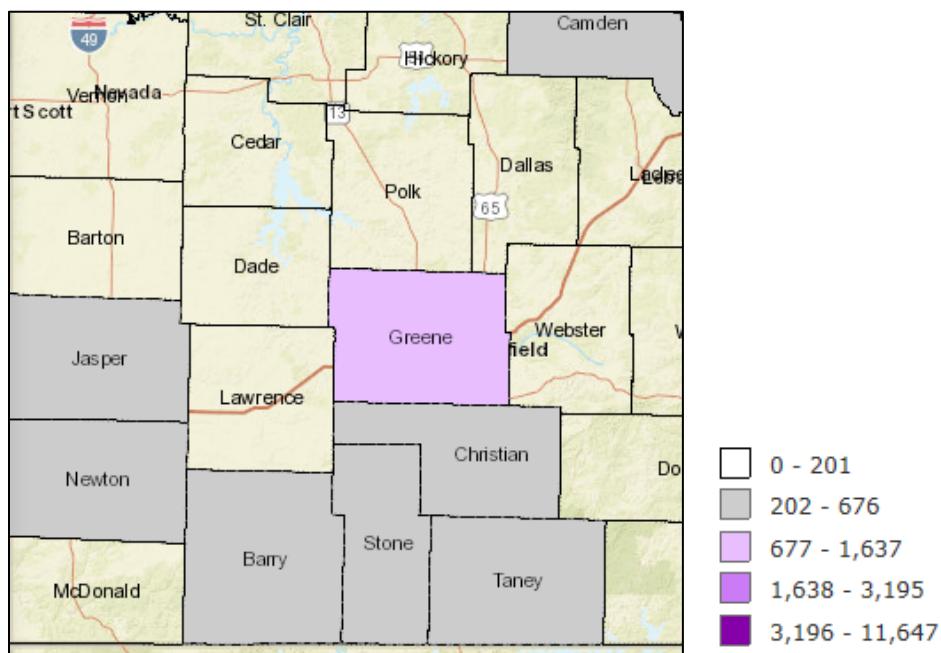
As mentioned in the hazard description sections, urban fires can be caused by weather events. Storms and droughts are two of the main causes. As discussed in sections 3.4.1 and 3.4.6, it is possible for Greene County to experience more severe storms and droughts with climate change. Droughts make things dry out and can make it easier for fires to spread. When flooding occurs, it increases the chances of water causing an electrical fire which can lead to structural fires. Large floods can lead to catastrophic urban fires. This was demonstrated with Hurricane Sandy caused flooding in Queens, New York. Fires destroyed 122 homes in a neighborhood, the fires started from sea water hitting electrical systems.

VULNERABILITY

Vulnerability Overview

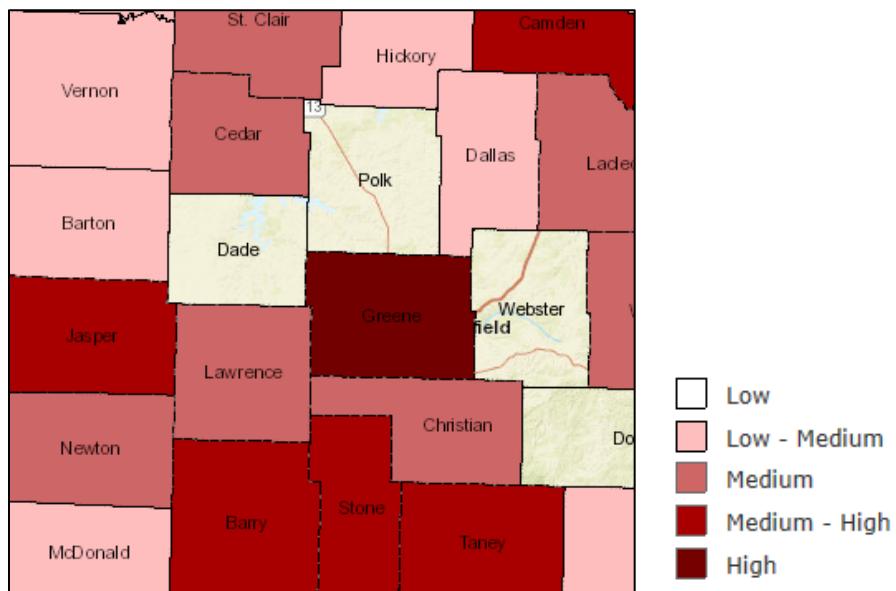
Urban fires can be extremely dangerous and cause large amounts of property loss if not controlled quickly. The entire planning area is at risk for experiencing damages from an urban fire, but more densely populated areas are more likely to experience large urban fires. The elderly population tend to be more vulnerable to fires than any other age group. They also experience the highest number of deaths per fire. The second most vulnerable age group are children. Older homes are also more at risk in experiencing urban fires. Urban fires often occur in heavily populated areas and developed areas.

Structure/Urban Fire Average Annual Occurrence

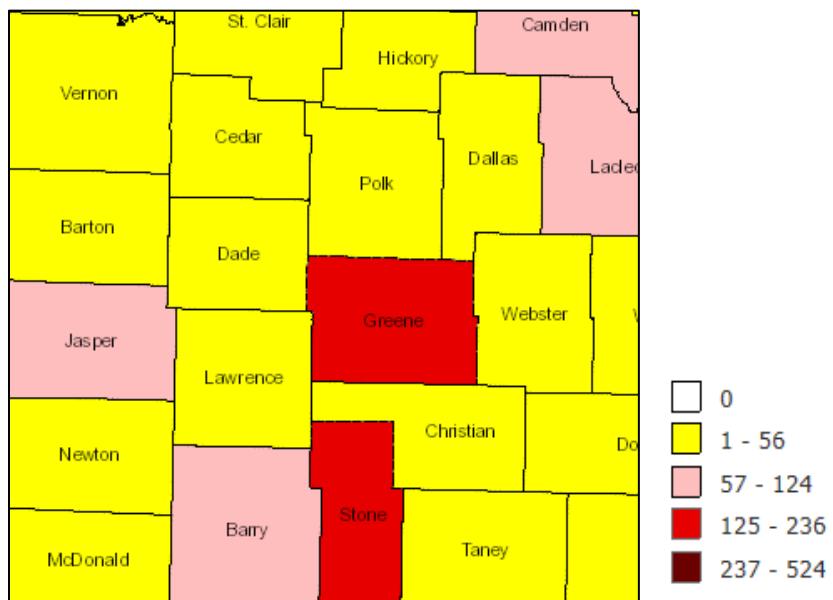


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Vulnerability of Occurrence

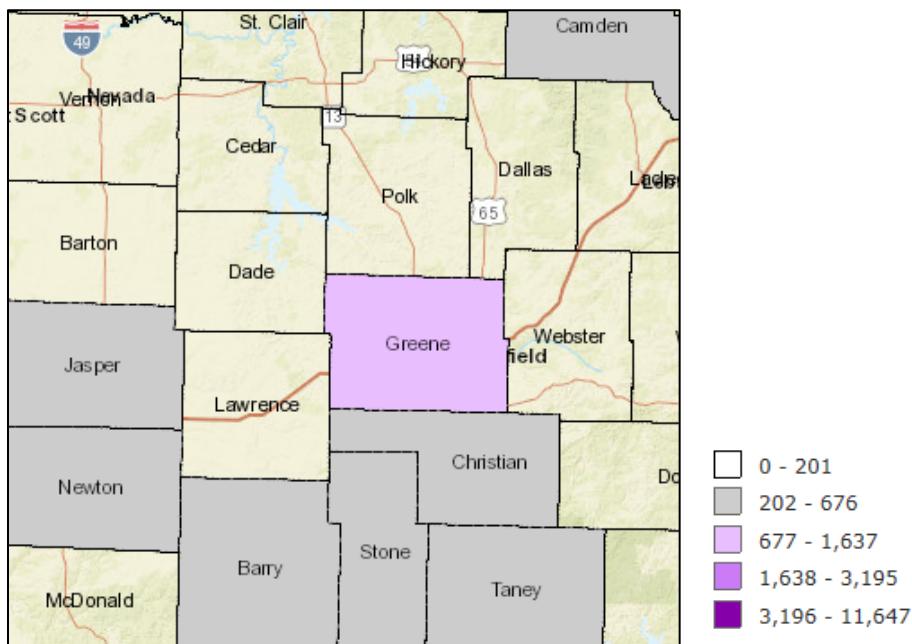


Historical Number of Deaths and Injuries



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Average Annual Occurrence



Potential Losses to Existing Development

As mentioned above, urban fires can cause large amounts of damage and cost the owner and insurance companies a lot of money. If a fire is not controlled quickly, potential loss for more structures is at risk. Older homes are more at risk for experiencing large amounts of damage because of an urban fire. Many of our jurisdictions have older homes and buildings.

Impact of Previous and Future Development

The probability of a fire occurring does increase with population increase. This is due mostly to human error and carelessness, which are other factors contributing to urban fires. More people in the county can also lead to more people making their own source of heat using wood burning, space heaters, etc. Population increase also means more development, newer homes can be built closer together to make room for more homes. This can cause an increase in risk of a larger urban fire to occur.

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EMAP Consequence Analysis

EMAP Impact Analysis: Urban Fire

SUBJECT	DETՐIMENTAL IMPACTS
Public	The safety of the public is of significant concern if an urban fire were to take place. Older neighborhoods in Greene County could create a large number of injuries or fatalities.
Responders	An urban fire in Greene County could present life threatening issues and challenges for response functions.
Continuity of Operations	An urban fire would have little to no impact on service operations in Greene County.
Property, Facilities, and Infrastructure	An urban fire could cause widespread significant property damages. Large urban fires are most likely to occur in areas of dense population, crowded building with little or no open spaces, or in building that do not meet building code requirements. An urban fire could cause multiple critical infrastructure sectors to be impacted such as bank and finance, emergency responders, etc. An urban fire could also cause widespread or multiple instances of facility damage.
Environment	An urban fire would have a very limited effect on the environment, because it is located in an urban areas. There may be minor isolated instances of damage to the environment.
Economic Condition of Jurisdiction	An urban fire could greatly impact the economic system due to damage in Greene County.
Public Confidence in the Jurisdiction's Governance	An urban fire would cause little to no loss of public confidence in governance in Greene County.

*For more details on Consequence Analysis, refer to Appendix B.

Hazard Summary by Jurisdiction

Urban fires is a hazard that the entire planning area is at risk for. There are certain areas in the county that could experience more damages than others. Springfield is the most densely populated community within Greene County. Springfield has many older homes and homes/buildings that are built in close proximity to one another. This puts Springfield at a greater risk for experiencing urban fires. Springfield has many fire stations placed around the Springfield area, which helps reduce the risk of experiencing large amounts of damage. Ash Grove has many old homes and buildings that are more at risk in experiencing damage because of urban fires. Locations in the planning area that are in poverty may also experience more urban fires because alternative heating sources used in the winter.

PROBLEM STATEMENT

Urban fires have the potential to become extremely dangerous in the planning area. Urban fires can cause large amounts of property damage if not controlled quickly. They can also cause loss of life to both people and animals. Though Greene County has not experienced a large urban fire event, many small structural fires happen frequently in the area. Small structural fires can often lead to larger urban fire events. Other hazards like storms and droughts can also can an increase in urban fires. Mitigation solutions for urban fires include training for fire personnel, more fire protection district locations, public education and development planning within the local governments. No participating jurisdiction created mitigation projects for urban fires in this Hazard Mitigation Plan.

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3.6.1 Human Caused Hazard: Biological

HAZARD PROFILE

Hazard Description

This hazard profile focuses on deliberate attacks using biological weapons. For more information on naturally occurring diseases, please see the Communicable Disease Hazard Profile.



Biological Terrorism

Biological Terrorism (Bio-terrorism) is the deliberate release of agents (viruses, bacteria or other germs) to cause illness or death in people, animals and plants. The agents are usually found in nature, but may be modified to increase the severity of the attack (e.g. making the agent resistant to medication). Biological agents may be spread through air, water or food. Some biological agents may be spread human to human (e.g. small pox), while others cannot (e.g. anthrax).

Agricultural Terrorism

The Congressional Research Service explains that agriculture terrorism, or agro-terrorism, is the deliberate introduction of animal or plant disease with the goal of generating fear, causing economic losses and/or undermining social stability. The goal of agro-terrorism is not to kill animals or plants; agro- terrorism is an outlet for terrorists to cause public panic.

Biological Agent

AGENT	POPULATIONS/SPECIES MOST LIKELY AFFECTED
Anthrax	Wild and domestic lower vertebrates (Cattle, sheep, goats, camels, antelopes and other herbivores). Humans may also become infected if exposed to infected animals. Anthrax outbreaks occur on an annual basis in livestock and wild game animals (e.g. deer)
Botulism	Humans are most likely to be exposed and experience botulism-related events; humans are typically infected due to inadequate in-home canning practices.
Brucellosis	Sheep, goats, cattle, deer, elk, pigs, dogs and humans
Plague	Fleas, small rodents and humans
Smallpox	Humans are the only natural hosts.
Tularemia	Frequently found in rodents, rabbits and hares; humans are also affected.

Source: Greene County Multi-Jurisdictional Hazard Mitigation Plan 2015-2020

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Transmission

As with many man-made hazards, biological agents may be used intentionally or unintentionally. Thus, the agents listed below articulate modes of transmission. An intentional transmission implies a malicious intent or the use of a biological agent as a weapon. An unintentional transmission involves unknown or accidental contact with infected humans, animals and objects.

AGENT	TRANSMISSION
Anthrax	Anthrax may be deliberately spread by contaminating items that humans come in contact with.
Botulism	Food supplies may be contaminated, passing the agent to a large population across a large region.
Plague	An aerosol attack could distribute the agent and infected individuals would develop pneumonic plague. This can be spread to anyone who is in close contact with the infected. Because of the delay from exposure, the agent may cover a wide geographical area as people travel.
Smallpox	After September 11 th , the U.S. government has become increasingly concerned that smallpox will be used as a biological agent because citizens have not been regularly vaccinated for smallpox since 1980.
Tularemia	The mechanisms for intentionally spreading Tularemia would occur by using natural carriers of the disease.

Source: Greene County Multi-Jurisdictional Hazard Mitigation Plan 2015-2020

Geographic Location

All areas of Greene County are equally susceptible to a biological hazard whether that is directly or indirectly.

Strength/Magnitude/Extent

Biological weapons can be extremely dangerous to the Greene County population. Biological weapons can bring serious health risks to our citizens.

The use of biological weapons is not only a threat to humans; it is also a serious threat to agricultural ecosystems, wildlife faunas and their habitats. A bio-terrorist attack on a nation's livestock would have a devastating effect on that nation's agricultural industry in terms of economic loss. Moreover, it could have harmful spill-over effects on other susceptible wildlife species: introduced diseases affecting domesticated animals or humans could be particularly harmful for native species that are naturally rare and species whose numbers have been depleted due to habitat degradation.

Agro-terrorism

Agro-terrorism is particularly disconcerting because of the ease in which the industry may be attacked. Farms are geographically disbursed in unsecured environments. Agriculture diseases can be easily obtained, handled and distributed. Further, many veterinarians and farmers are unfamiliar with foreign animal diseases because most diseases have been eradicated domestically. Thus, terrorists are given a low-cost but highly effective way to disrupt the United States economy and cause a public panic.

Economics

The agriculture industry is vital to the U.S. economy, yet it would be easy to infect animals and humans. A concern is the effect an agriculture disease would have on crops and animals. The demand for produce would rapidly increase, but the supply would rapidly decrease. This may result in a famine.

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Previous Occurrences

Greene County and our surrounding areas have not experienced a terrorist attack in the past. Though there has not been an event that has occurred, Greene County is still a strong contributor to the cattle/beef production industry.

Probability of Future Occurrence

The probability for hazards in Greene County is determined using Calculated Priority Risk Index (CPRI). It is unlikely for a biological event to occur within the next ten years in Greene County. For a full description of the CPRI for biological events, refer to Appendix B.

Changing Future Conditions Considerations

Climate change will not affect the chances of Greene County experiencing a biological attack.

VULNERABILITY

Vulnerability Overview

The fear of an attack from biological weapons is greater than ever because, of all weapons of mass destruction, they are the easiest and cheapest to produce. At the most basic level, bio-terrorist attacks against people only require access to natural diseases that can cause disastrous epidemics – laboratory cultures or specialized disease strains are not necessary. Natural diseases are common, widely distributed and easily acquired and transported.

Biological weapons are sometimes the hardest to detect, especially with today's ease and rapidity of international transport, and the increase human and animal resistance to antibiotics enhances the spread of disease. There is a chance that there could be no warning time for an attack. Biological terrorism attacks have the chances of producing large loss to Greene County's agriculture. Biological attacks can also put large amounts of our population at risk.

Potential Losses to Existing Development

The greatest loss that Greene County could experience from a bioterrorism attack would be agricultural loss. As discussed, many diseases are passed through animals. Greene County has a large amount of cows that are used for the beef industry. Farmers would see a huge loss if cattle was affected by Anthrax. The economy could also see a huge loss and the supply demand for crops, produce and meat would increase and supply would decrease.

Impact of Previous and Future Development

As the population increases, it is likely that Greene County could see an increased risk to experience a biological attack. Greene County, more specifically Springfield, is becoming more of a tourist place because of Bass Pro Shops. Springfield is also located fairly close to Branson, which is a larger tourist town. More traffic of people in Greene County can raise the risk of bioterrorism attacks.

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EMAP Consequence Analysis

EMAP Impact Analysis: Biological

SUBJECT	DETՐIMENTAL IMPACTS
Public	A biological attack can deliver any of a large range of safety and health consequences. A biological attack would create a severe number of illnesses, and possibly death.
Responders	Responders will become overwhelmed in a biological incident. There will also be potential fire safety issues for responders as well. Response functions will be impacted.
Continuity of Operations	Minor service operations may be interrupted (anything to do with food and water), and many may be delayed.
Property, Facilities, and Infrastructure	A biological attack would result in minor isolated instances of property and facility damage (where it was detonated or released). Multiple critical infrastructure sectors will be impacted by a biological hazard. Hospitals and emergency response will be overwhelmed.
Environment	The environment would experience widespread significant damage from a biological incident.
Economic Condition of Jurisdiction	A biological incident would be catastrophic for the economy. The agriculture sector would be in ruins, and non-contaminated food and water will be scarce possibility for very long distances.
Public Confidence in the Jurisdiction's Governance	Lack of food and water after a biological attack could result in major widespread loss of public confidence in governance.

*For more details on Consequence Analysis, refer to Appendix B.

Hazard Summary by Jurisdiction

The entire planning area could be affected by bioterrorism attacks. Greene County's agriculture is most at risk for being targets. Greene County does contribute to the cattle/beef industry. Our jurisdictions with crops and cattle would be at higher risk than other jurisdictions. Greene County has a pretty low risk of experiencing a bioterrorism attack.

PROBLEM STATEMENT

Biological terrorism has been around for many of years. The fear of an attack grew more after the attacks on September 11, 2001. Bioterrorism can affect many different aspects of Greene County, including public health and agriculture. Though our risk for experiencing a biological attack is low, a risk is still present. Mitigation solutions for bioterrorism include detailed planning from the local, state and federal governments. The planning should include responses, idea of multiple events, first responder safety, public health safety and many other aspects. Other solutions include public education. No participating jurisdiction chose a project for bioterrorism in this Hazard Mitigation Plan.

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3.6.2 Human Caused Hazard: Chemical

HAZARD PROFILE

Hazard Description

The chemical industry is the center of the modern world economy, converting raw materials (e.g. oil, natural gas, water, metals and minerals) into more than 70,000 different products. Chemical manufacturing is a nearly \$3 trillion global enterprise with companies from the EU and the USA being the world's largest producers.

Chemical hazards, however, encompass any chemical that has the capability to cause an unreasonable risk to human health and safety or the environment when transported in commerce, used incorrectly or not properly stored and contained.



Forms of Exposure

- Inhalation: Absorption through the respiratory tract by inhalation. This is probably the easier way for chemicals to enter the body.
- Ingestion: Absorption through the digestive tract by eating or smoking with contaminated hands or in contaminated work areas. Depending on particle or droplet size, aerosols may be ingested.
- Skin or Eye Contact: Absorption through the skin or eyes. Skin contact is the most common cause of the widespread occupational disease dermatitis. The eyes are very porous and can easily absorb toxic vapors that cause permanent eye damage.
- Injection: Percutaneous injection through the skin. This can occur through misuse of sharp items, especially hypodermic needles.

Intentional Release

Though most chemical hazards are caused by accidental release of a material, the possibility of intentional release cannot be ruled out when planning for response to chemical threats. Given that some chemicals toxic to people and the environment are both colorless and odorless it would not be difficult, for example, to covertly expose the public to such chemical hazards via release from a moving vehicle. The Federal Emergency Management Agency (FEMA) explains that delivery of chemical hazards in lethal dosages is difficult, especially in an outdoor environment where they dissipate rapidly. Nevertheless, the ready availability of toxic chemicals makes intentional release a threat not to be ignored. A more complex and coordinated release of chemical hazards via explosives laced with toxic agents or introduction into the public drinking water system even has the potential to create a major public health emergency in addition to creating unrest among the people.

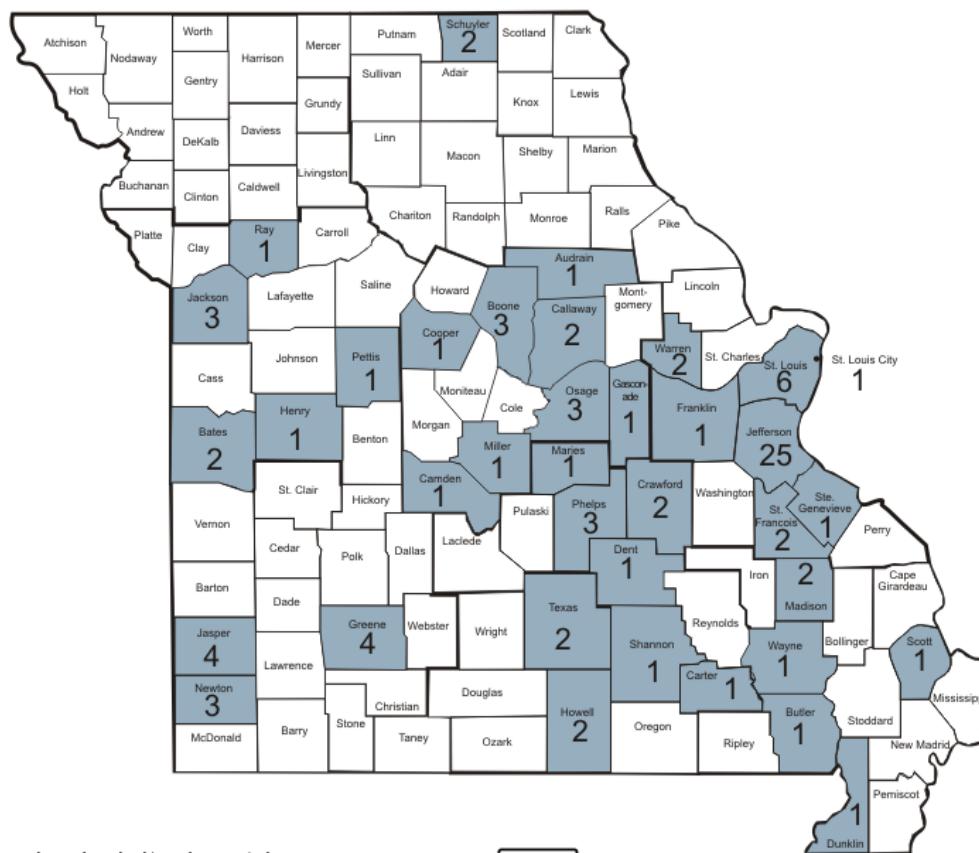
Clandestine Laboratory

Clandestine laboratories found in this area primarily produce methamphetamine, most commonly referred to as: meth, crank, crystal, ice, speed, go fast, and go. These laboratories range from highly sophisticated to makeshift operations, more and more of which are mobile being set up anywhere. They are commonly located in private residences, hotels, trailers, cemeteries, abandoned farms, rural lands and all types of vehicles.

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Methamphetamine addiction varies from person to person. Meth initially sends the brain a feeling of pleasure but through prolonged use the pleasurable feeling is lessened or lost. The meth addict suffers the same cycle of drug cravings as crack cocaine addicts. The biggest difference of the drugs is that the highs of meth last far longer than crack cocaine and binges differ greatly. In crack cocaine, a binge rarely lasts more than 72 hours, while meth binges can last up to 2 weeks.

Number of Missouri Methamphetamine Incidents-2017



Map includes Laboratories, Chemical/Equipment/Glassware seizures, and Dumpsites. These numbers reflect the incidents as reported to EPIC NSS. Report ran by MSHP on 01-04-2018.

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2017 had a lower amount of incidents compared to the previous years. In 2014 there were 26 incidents in Greene County, 2015 there were 22 incidents and in 2016 there were 10.

Geographic Location

The entire county is at risk for experiencing chemical related hazards.

Strength/Magnitude/Extent

Health of individuals and the environment is a risk with chemical hazards. There is a possibility of injury, minor isolated instances of property damage.

3 - RISK ASSESSMENT

Health Hazard

The United States Department of Labor Occupational Safety and Health Administration (OSHA) defines a chemical hazard as any chemical that is a health or physical hazard. A chemical known to cause acute or chronic health effects causes a health hazard. This includes carcinogens, toxic or highly toxic agents, reproductive toxins, irritants, corrosives, sensitizers, hepatotoxins, nephrotoxins, neurotoxins, agents that act on the hematopoietic system and agents that damage the lungs, skin, eyes or mucous membranes.

Health Problems

Acute Toxicity: Symptoms caused by exposure become severe quickly. Acute effects are often results of short-term exposure and are often short in duration. Examples of acutely toxic chemicals include hydrogen cyanide and ammonia.

Chronic Toxicity: Symptoms caused by exposure that develop slowly over a long period of time as a result of frequent exposure. The amount of exposure may be so small that no effects are noticed at the time of exposure. Cumulative poisons are the chemicals that build up in the body as a result of numerous chronic exposures and lead to chronic toxicity. These effects are not seen until a critical burden for a body is reached.

Carcinogenicity: A carcinogen is a chemical that causes malignant (cancerous) tumors.

Reproductive Toxins: Chemicals can affect both adult male and female reproductive systems. Chemicals may also affect a developing fertilized ovum, embryo or fetus through exposure to mother (teratogenic effect).

Reproductive hazards affect people in a number of ways, including mental disorders, loss of sexual drive, impotence, infertility, sterility, mutagenic effects on cells, teratogenic effects on the fetus and transplacental carcinogenesis.

Physical Hazard

A physical hazard is a chemical that is known to be a combustible liquid, a compressed gas, explosive, flammable, organic peroxide, an oxidizer, pyrophoric, unstable or reactive, or water-reactive. Hazardous chemicals may also include paints, cleaning compounds, inks, dyes and many other substances.

Clandestine Laboratories

Clandestine laboratories present many forms of health risks. Explosions, caustic fumes, and deadly gases are very common. Anyone who lives or works nearby or comes into contact with the materials used in its operation are subjected to health risks. Byproducts of meth production are often discarded or disposed of indiscriminately to avoid detection, posing a significant human health and environment hazard. Chemicals spilled or dumped as waste into bathtubs, sinks, toilets, on the ground, along roadways, and waterways are common practices.

3 - RISK ASSESSMENT

Previous Occurrences

Greene County Methamphetamine Incidents-2004-2018

YEAR	INCIDENTS
2004	189
2005	145
2006	36
2007	32
2008	69
2009	78
2010	87
2011	124
2012	96
2013	67
2014	26
2015	22
2016	10
2017	4
2018	3

Source: Missouri State Highway Patrol

Probability of Future Occurrence

The probability for hazards in Greene County is determined using Calculated Priority Risk Index (CPRI). It is probable for a small chemical event to occur within the next three years in Greene County. A larger chemical incident that would cause catastrophic damage, is unlikely for Greene County. For a full description of the CPRI for chemical events, refer to Appendix B.

Changing Future Considerations

Climate change will not affect chemical incidents in Greene County.

VULNERABILITY

Vulnerability Overview

Most incidents occur at the interfaces between transport, storage, processing, use and disposal of hazardous chemicals, where these systems are more vulnerable to fail, error or manipulation. Factors that affect the vulnerability of responders and the public include: the nature of hazard, the level of exposure, availability and quality of shelter, availability of personal protective equipment (PPE), access into and out of the site, the degree to which employees and responders and possibly the public are prepared and trained to deal with a chemical release and the amount of training provided.

People who are at most risk for experiencing illness from chemical related hazards are people who live or work about hazardous chemicals. People who live around meth labs are more vulnerable to experience illness. Common symptoms of toxic exposure to the chemicals involved in methamphetamine production include headaches, nausea, fatigue, lethargy, and dizziness. More acute exposures can result in similar symptoms, as well as difficulty breathing, chest pain and cough, loss of physical coordination, and irritation and chemical burns on the skin, eyes, nose and mouth. Exposure can even be lethal. There is also a long-term risk of cancer, liver, brain and kidney damage, miscarriage and birth defects.

3 - RISK ASSESSMENT

The toxic chemicals that are used to manufacture meth are:

- Hydrochloric Acid
- Methylamine
- Mercuric Chloride
- Anhydrous Ammonia
- Freon
- Methanol
- Red Phosphorus

Potential Losses to Existing Development

Chemical incidents are typically localized to the location where the incident happens. There are times where evacuation would be needed and property damage could happen. If a meth lab were to blow up, extensive damage could happen. Meth labs are highly flammable and can cause explosions. This could cause damage to surrounding properties as well.

Impact of Previous and Future Development

As the population of the county increases, the risk of people being exposed to toxic chemicals also increases. There is also a risk that as the population increases, the chance of people who are making drugs also increases.

EMAP Consequence Analysis

EMAP Impact Analysis: Chemical

SUBJECT	DETERRIMENTAL IMPACTS
Public	Chemical incident in Greene County could cause significant safety concerns. There have been reported injuries, but no deaths in Greene County.
Responders	Responders would face some safety concerns in a chemical incident and there may be minor impact to response functions.
Continuity of Operations	Greene County has not experienced no impact on delivery of service due to a chemical incident.
Property, Facilities, and Infrastructure	Chemical incidents in Greene County have resulted in significant property damage. Greene County has experienced no damages to infrastructure due to a chemical incident. However there could be impact to the transportation sector if an incident occurs on railway, roadways, airport, etc.
Environment	There is no record of a chemical incident affecting the environment in Greene County. However, this could possibly cause isolated instances of agricultural damage.
Economic Condition of Jurisdiction	Greene County has experienced minor economic impact from chemical incidents.
Public Confidence in the Jurisdiction's Governance	Greene County has experienced no impact on the public confidence in governance due to a chemical incident.

*For more details on Consequence Analysis, refer to Appendix B.

3 - RISK ASSESSMENT

Hazard Summary by Jurisdiction

The entire planning area is at risk for experiencing a chemical incident. There is not one jurisdiction that is more vulnerable to a chemical incident. Greene County has a high volume of traffic, especially along I-44, it is highly likely that a chemical event could happen. Due to the number of companies in the area that house large quantities of hazardous materials on site, it is likely that a spill or accident may happen.

PROBLEM STATEMENT

Chemical events can be accidental or intentional. They can be extremely dangerous to the people around the chemicals. If the chemicals cause an explosion, it can be even more devastating to public health and property around the explosion. Chemicals can be a health hazard and physical hazard. Chemical hazards will continue to be a hazard in Greene County and around the United States. Mitigation solutions for chemical attacks include preparedness actions from the local emergency management office and planning. The planning should be detailed and cover multiple different aspects of the disaster. Other solutions involve public education and awareness and purchase of PPE for responders and citizens. No participating jurisdiction chose to create a mitigation project involving chemical events in this Hazard Mitigation Plan.

3 - RISK ASSESSMENT

3.6.3 HUMAN CAUSED HAZARD: CIVIL UNREST

HAZARD PROFILE

Hazard Description



Civil unrest, previously referred to as civil disorder, is a broad term used to describe varying disturbances caused by a group of people. A key component of civil unrest is that law enforcement must intervene to establish and maintain public safety. A protest, riot, sit-in or an out of control crowd are a few examples of when civil unrest may occur. It should be noted, however, that citizens not directly involved in an event may have their lives significantly disrupted. Their ability to work, enjoy recreational activities or the ability to obtain necessities (e.g. groceries) may be jeopardized by civil unrest.

Civil Unrest has the potential of becoming a pervasive hazard as more and more citizens face the perils of today's economy as many businesses are downsizing or closing their doors. This creates a dangerous environment whereby disgruntled workers may retaliate against their employers (e.g. workers in France held Caterpillar executives hostage after being let go).

Dr. Michael Carlie, professor at Missouri State University, explains, "The rate of property crimes or crimes for profit has increased substantially as individuals struggle to find a way to cover their basics, but what people often leave out of the discussion are crimes of stress. Upon losing employment, or when the person a household depends on for income loses employment, families get stressed. That's when we see increases in spousal, child and substance abuses, hangings and self-mutilation."

For the purposes of identifying the events that are dangerous in Greene County, it necessary to discuss two areas within civil unrest: crowd management and control and radical groups.

Crowd Management

Crowd management is the systematic planning, supervision, orderly movement and assembly of people. Crowd management often occurs in the event planning stage. This includes providing internal and external security, contacting local government agencies to inform them of the event (e.g. police), ensuring an adequate quantity of restroom facilities are available, as well as making sure exits are unlocked.

On the other hand, crowd control is a defensive tool. This typically occurs when a crowd begins to lose control and the safety of all parties is in jeopardy. Crowd control attempts to restrict inappropriate or dangerous behavior. Unfortunately, many injuries and deaths are caused by ineffective crowd control. The controllers are typically placed near the front of the crowd and unable to effectively communicate with the individuals in the back. As the back of the crowd pushes forward, individuals in the front fall down creating a false perception of moving forward. The back of the crowd keeps pushing forward, ultimately causing more injuries and fatalities. Crowd forces can reach levels that are almost impossible to control. Evidence of bent steel railings after fatal crowd incidents show forces of more than 4500 N (1,000lbs) occurred.

3 - RISK ASSESSMENT

Radical Groups

Radical groups have strong convictions to extreme principles that they follow. Generally, the groups are advocates for fundamental political, economic and social reforms and often promote their desired changes through direct and uncompromising methods. Radical groups exist across the political spectrum; every political party is prone to having extreme followers who want drastic reform.

Radical groups often demonstrate in public manor. Demonstrations may occur in person at community events or through impersonal means such as editorials, commercials and direct mail campaigns. The concern with radical group demonstrations is that it will cause those who disagree to be just as vocal as the radical groups, ultimately escalating the situation into civil unrest.

Geographic Location

Civil unrest could happen anywhere in Greene County at any given time. Depending on the focus on the unrest it could happen at government offices, businesses, or even in the streets. Typically civil unrest is usually preceded by periods of increased tension fueled by questionable social and political events. Government facilities, landmarks, prisons, and universities are popular locations that civil unrest can occur.

Strength/Magnitude/Extent

Civil unrest can include violence and large amounts of property damages. In previous civil unrest incidents, police cars and building were burned and people have been attacked. In Ferguson, the amount of buildings being burned out numbered the amount of firefighters available to control them, leading to more damages across the city. The extent of civil unrest depends on the size of the event and crowd that the unrest happens in. Two types of large gatherings typically are associated with civil disturbances: a crowd and a mob. A crowd can be identified as causal, sighting, agitated or mob-like:



- A casual crowd is identified as individuals or small groups with nothing in common to bind them together. If each has an agenda, it is his/her own. Casual crowds are made up of individuals or small groups occupying the same common place.
- Sighting crowds are similar to casual crowds; however, they gather for an event. People migrating as a crowd to sporting events, a group of people attracted to fires and accidents, and those attending music concerts are all types of sighting crowds. Individuals or small groups gather at these events for the same purpose. It is the event and/or individuals curiosity that compels a crowd to come together
- Agitated crowds add responses based on the elements (people, space, and event). Individuals with strong emotional feelings within a crowd can quickly spread and infect the rest of the crowd. As more people within the crowd become emotionally involved, a sense of unity may develop, causing changes in the overall demeanor of the crowd. Yelling, screaming, and name-calling all are associated with an agitated crowd.
- Mob-like crowds have all the elements of crowd types described above, in addition to aggressive, physical, and sometimes violent actions. Under these conditions, individuals within a crowd will often say or do things they usually would not do. Extreme acts of violence and property damage are often part of mob activities. These consist of, or involve elements of people and groups mixing together and becoming fluid (U.S. Army 2005).

3 - RISK ASSESSMENT

A mob can be defined as a large disorderly crowd or throng. Mobs are usually emotional, loud, violent, and lawless. Similar to crowds, mobs have different levels of commitment, and can be classified in the following four categories:

- Aggressive Mob: An aggressive mob attacks, riots, and terrorizes. The object of violence may be a person, property, or both. An aggressive mob is distinguished from an aggressive crowd only by lawless activity. Examples of aggressive mobs are inmate mobs in prisons and jails, mobs that act out their frustrations after political defeat, or violent mobs at political protests or rallies.
- Escape Mob: An escape mob is attempting to flee from something such as a fire, bomb, flood, or other catastrophe. Members of escape mobs are generally difficult to control and can be characterized by unreasoning terror.
- Acquisitive Mob: An acquisitive mob is one motivated by a desire to acquire something. Riots caused by other factors often turn into looting sprees. This mob exploits an authority's lack of control in safeguarding property.
- Expressive Mob: An expressive mob is one that expresses fervor or revelry following some sporting event, religious activity, or celebration. Members experience a release of pent up emotions in highly charged situations.

Civil unrest events can range from peaceful sit-ins to a full scale riot.

Previous Occurrences

While far from recent, one of the most notable events in Greene County occurred the night before Easter in 1906. After hearing a rumor of a white woman's rape, a mob of 6,000 individuals beat down the jailhouse doors and kidnapped three black men. The mob took the men to the square and hung them. Within a few hours, new rumors spread that the black neighborhoods were going to be destroyed. As a result, hundreds of residents fled before the state militia arrived to restore order. A grand jury indicted more than a dozen people of the hangings and the story of the woman's rape proved to be untrue. One person went to trial, but the jury could not reach a verdict.

Protests and Demonstrations

Greene County frequently has protests and demonstrations that occur throughout the county. Many of these events occur in Springfield, due to the number of employers, elected officials and guests (e.g. Presidential Visits) that occur in the city. However, not all demonstrations are peaceful, which the city was reminded of on April 24, 2001.

April 2001

Joe Hurley, a 51 year old man from Urbana, pulled his pickup truck into a circle drive in front of the U.S. Federal Courthouse located in Springfield, Missouri. He had three dummies, and each dummy was labeled with the name of a federal organization. The organizations were the Federal Bureau of Investigation (FBI), Bureau of Alcohol, Tobacco and Firearms (ATF) and the Department of Justice (DOJ). Police said the dummies were soaked with gasoline, although Hurley had several containers of water and a fire extinguisher in his truck in case things got out of hand. There were several other items in Hurley's pick-up truck. Police reported an empty mortar shell, a crate marked "Explosives" that was filled with newspapers, and many gas containers filled with water. Hurley was an informant for federal and state agencies, but felt his concerns were being ignored about other individuals being involved in the Oklahoma City bombing. Hurley was disabled after being shot with beanbag rounds and was taken into custody for mental evaluation. He was later released and charges were not filed.

3 - RISK ASSESSMENT

May 2019

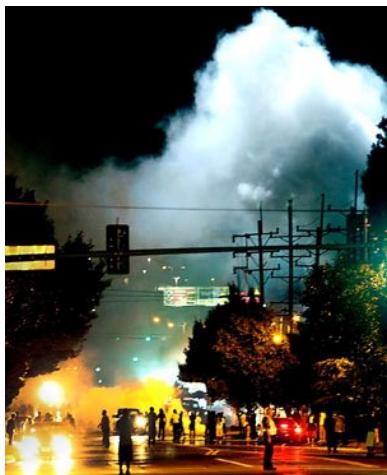
After the State of Missouri decided that no abortions would be allowed in the state, protests began in the square of downtown Springfield. During the protest, things got heated and yelling and shoving began happening towards police officers. Someone was arrested.

June 2019

A pro-choice demonstration that took place in the square in Springfield turned when a group of people started touching and pulling officers. Officers ended up having to take citizens to the ground. One person was arrested but later released from the jail.

National Occurrences

Ferguson, Missouri 2014



Recently, national attention has been focused on Ferguson, Missouri, where the fatal shooting of an unarmed Black teenager by a White police officer on August 9, 2014 has sparked more than three months of continuing protests and civil unrest as of the time of this documentation (November 2014). Although by all accounts the protests have been largely peaceful, there have been instances of shootings, violent clashes with police and property damage, including the burning of a Quik Trip convenience store on August 10. Police and local officials have faced persistent criticism of their incident management efforts from both media and government, particularly over the deployment of military-style equipment and the arrests of journalists. The ongoing dialogue concerning police tactics in Ferguson highlights the necessity for emergency planning that is tailored to the needs and realities of local communities.

Dallas, Texas 2016

A protest was organized in Dallas in response to the killing of two men by police officers in Louisiana and Minnesota. The Dallas protest was one of several held across the United States held on the night of July 7th. Around 800 protestors were involved and around 100 police officers were assigned to protect the event and the surrounding area. A shooter began firing his weapon towards a group of police officers and protestors. 3 police officers were killed in the initial shooting and civilians were injured. The shooter, on his way to Lamar Street, shot and killed another police officer. The shooter fired more shots into the crowd injuring more protestors and killing another police officer before being killed in a multiple hour standoff with police.

Probability of Future Occurrences

The probability for hazards in Greene County is determined using Calculated Priority Risk Index (CPRI). It is probable for a small, isolated civil unrest event to occur within the next three years inn Greene County. For a full description of the CPRI for civil unrest, refer to Appendix B.

Changing Future Considerations

Climate change will not affect Civil Unrest.

3 - RISK ASSESSMENT

VULNERABILITY

Vulnerability Overview

Protests are frequent events that happen in the planning area. Protests can bring large crowds and can lead to civil unrest. Civil unrest may range from a sit in- to a full out riot. Most dangerous incidents escalate over a period of time which provides law enforcement the ability to intervene before the event becomes serious. The more unstable an environment is the more likely civil unrest, albeit in groups or individually, will occur. Crimes and outbursts can be caused by stress, especially stressed caused by a lack of employment.

Civil unrest can include violence and property damages. In previous riots around the United States, police cars, buildings and other property has occurred. Protests can lead to road closures including large interstates and highways. Death and injury has even occurred in some protests. International protests typically have a higher injury and death rate than protests that happen within the United States.

Civil unrest can occur at any time. However, civil unrest is usually preceded by periods of increased tension fueled by questionable social and political events (trials and elections). This can be sudden, or take time to organize. Most are organized directly following the incident provoking the unrest. This helps give police time to plan and help protect the protest.

Potential Losses to Existing Development

Civil Unrest can cause large amount of property damage if not controlled quickly. Typically, civil unrest happens in Downtown Springfield at the Square. They also happen on busy streets around the Springfield areas to attract more people. Critical facilities can be targets for civil unrest. Civil unrest around Greene County does not have a large history of causing large amounts of damage around the planning area.

Previous and Future Development

Increase of population can affect civil unrest. More people in the planning area could lead to larger protests. Protests are trending in the planning area and with the new laws and government changes, more protests can be expected in the area.

3 - RISK ASSESSMENT

EMAP Consequence Analysis

EMAP Impact Analysis: Civil Unrest

SUBJECT	DETՐIMENTAL IMPACTS
Public	Civil unrest could result in a severe number of injuries and minimal deaths. There are also multiple instances of safety concerns.
Responders	Civil unrest creates a potential for life safety issues. Response functions are also greatly impacted and may be delayed due to safety concerns.
Continuity of Operations	Civil unrest can result in service operation interruptions or delays depending on size and duration of unrest.
Property, Facilities, and Infrastructure	Civil unrest could create widespread minor damages or multiple instances of severe damage through riot caused fires and destruction as demonstrated in Ferguson Missouri. Civil unrest can also cause damage to multiple critical infrastructures throughout the entire planning area. It can also cause widespread damage to facilities.
Environment	Civil unrest in Greene County may cause minor isolated instances of damage to the environment.
Economic Condition of Jurisdiction	Civil unrest can cause the economic condition to be greatly impacted throughout the jurisdiction through theft and damages.
Public Confidence in the Jurisdiction's Governance	Civil unrest can greatly impact public confidence in governance throughout the jurisdiction.

*For more details on Consequence Analysis, refer to Appendix B.

Hazard Summary by Jurisdiction

Civil unrest can happen at any given location in the planning area. The City of Springfield is more at risk for experiencing civil unrest because of the larger population. Many protests happen in Downtown Springfield. The City of Springfield also has a larger government plaza. Protests can be created because of court cases, elections and other political reasons. Other popular areas that protests take place are around the large college campuses including Missouri State University.

PROBLEM STATEMENT

Civil unrest can cause large amounts of property damage in the planning area if they are not controlled quickly. Many protests take place in Springfield. There is not a large destructive history of civil unrest in Greene County but many protests take place year round. Around the world, civil unrest causes death and injury to people and large property damage. With the political world constantly changing and people having the right to protest and express their opinion, civil unrest is a risk for the planning area. Mitigation solutions for civil unrest include more presence of police, more training for first responders, higher level of security at schools, more officers at schools and riot equipment for police officers. Several school districts created projects enhancing their security, these projects can be used for civil unrest or targeted violence.

3 - RISK ASSESSMENT

3.6.4 Human Caused Hazard: Cyber

HAZARD PROFILE

Hazard Description



Cyber security is protecting the infrastructure by preventing, detecting and responding to cyber incidents. Physical threats prompt immediate action but unlike cyber incidents it is often hard or difficult to identify these dangers happening. The spectrum of risks are limitless as the threats can be more serious or sophisticated than others and can have a wide range of varying effects on an individual, community, organization or even the national level. Below is a table showing an example of different types of dangers and risks.

Classifications

Financial Fraud Crimes

Computer fraud is any dishonest misrepresentation of fact intended to let another to do or refrain from doing something which causes loss. In this context, the fraud will result in obtaining a benefit by:

- Altering in an unauthorized way. This requires little technical expertise and is a common form of theft by employees altering the data before entry or entering false data, or by entering unauthorized instructions or using unauthorized processes.
- Altering, destroying, suppressing, or stealing output, usually to conceal unauthorized transactions. This is difficult to detect.
- Altering or deleting stored data.

Other forms of fraud may be facilitated using computer systems including, bank fraud, carding, identity theft, extortion, and theft of classified information.

Cyber Terrorism

Government official and information technology security specialist shave documented a significant increase in internet problems and sever scans since early 2001. Bu there is a growing concern among government agencies such as the FBI and CIA that such intrusions are part of an organized effort by cyberterrorists, foreign intelligence services, or other groups to map potential security holes in critical systems. A cyberterrorist is someone who intimidates or coerces a government or an organization to advance his or her political or social objectives by launching a computer-based attack against computers, networks, or the information stored on them.

Cyberextortion

Cyberextortion occurs when a website, email server, or computer system is subjected to or threatened with repeated denial of service or other attacks by malicious hackers. These hackers demand money in return for promising to stop the attacks and to offer "protection". According to the FBI, cybercrime extortionists are increasingly attacking corporate websites and networks, crippling their ability to operate and demanding payments to restore their service

3 - RISK ASSESSMENT

Computer as a Target

These crimes are committed by a selected group of criminals. Unlike crimes using the computer as a tool, these crimes require the technical knowledge of the perpetrators. As technology evolves, so too does the nature of the crime. These crimes are relatively new, having been in existence for only as long as computers have—which explains how unprepared society and the world, in general, is towards combating these crimes. These are numerous crimes of this nature committed daily on the internet.

Crimes that primarily target computer networks or devices include:

- Computer viruses
- Denial-of-service attacks
- Malware

Computer as a Tool

When the individual is the main target of cybercrime, the computer can be considered as the tool rather than the target. These crimes generally involve less technical expertise. Human weaknesses are generally exploited. The damage dealt is largely psychological and intangible, making legal action against the variants more difficult. These are the crimes which have existed for centuries in the offline world. Scams, theft, and the likes have existed even before the development in high tech equipment. The same criminal has simply been given a tool which increases their potential pool of victims and makes them all the harder to trace and apprehend.

Crimes that use computer networks or devices to enhance other ends include:

- Fraud and Identity Theft
- Information Warfare
- Phishing Scams
- Spam

Security Practices

Between 2004 & 2011 much of the data lost was due to poor security practices, inside jobs and lost computers/removable media (CDs, flash drives, etc.). After 2011, the trend indicates more data loss from companies & government agencies being targeted by very intelligent hackers with specific information they are looking for. There has also been a recent trend to encrypt information to make it inaccessible and then demand a ransom for it to be unencrypted. Many of the worst breaches began by employee account information being stolen which allowed access into the network of a company that was later exploited to get the information they wanted...mostly credit cards, personal identification information like social security numbers, addresses, email addresses, etc.

Geographic Location

Cyber attacks have no geographical boundaries. Cyber attacks can be targeted at individuals, governmental areas, businesses or any other location that uses a form of technology.

3 - RISK ASSESSMENT

Strength/Magnitude/Extent

The severity of a cyber-attack depends on what information is hacked and how quickly the system can be restored. Detecting a cyber attack can sometimes be challenging. The longer the crime goes undetected, the larger the impact is. Most cyber attacks have little to no warning time and can last weeks to years. Cyber crimes on businesses can be catastrophic and can lead to the following:

- Loss of intellectual property and sensitive data
- Opportunity costs
- Damage to the brand image and company reputation
- Penalties and compensatory payments to customers
- Cost of countermeasures
- Loss of trade
- Distortion of trade
- Job loss

Cyber Risks and Dangers

RISKS	DANGERS
Organized cybercrime, state-sponsored hackers, cyber espionage	Viruses, viruses that erases entire systems
Transportation, power, and other services breached	Systems being broken into and filed altered
Data breach and increased loss of an organizations network	Your computer being used to attack other devices
Individually owned devices that are connected to in the internet are vulnerable to intrusion: personal information at risk	Stealing of confidential information

Previous Occurrences

February 2009

In February, 2009 the City of Springfield was hit by a computer virus that corrupted the operating system on over 1000 machines. The recovery effort took 2 months while the entire Information Systems staff, with assistance from other departments and City Utilities, tackled the job. All of the computers on the City network were reimaged and Internet access was unavailable for days after the virus was detected.

February 2012

In February, 2012 the City's website was hacked using an SQL injection attack and more than 2000 SSNs were retrieved from a database that contained HR records and posted to a website. The City website was offline temporarily and all of the online applications were rewritten to remove the vulnerability in order to prevent another breach. The FBI was involved with the tracking of the malicious actor and was able to successfully prosecute him and obtain a plea agreement to repay the City for its cost to recover from the incident.

December 2014

On December 25, 2014 a "hacktivist" successfully made the City's website unavailable by utilized a Distributed Denial of Service (DDOS) attack against the CivicPlus hosting company's Internet connection. CivicPlus was able to prevent the DDOS attack and have the website back online soon after the attack. The hacktivist posted to their Twitter account that they attacked the City's website for retaliation against cruel treatment of a pit-bull by the City.

3 - RISK ASSESSMENT

July 2018

The City of Springfield experienced a large and critical outage to main servers in July 2018. The servers that authenticated employee usernames and passwords were down slowly many daily work processes. The outage did not affect 911 or other emergency responses, but police officers in the field had to do hand written reports.

Many cyber incidents go unreported or cannot be released to the public.

Probability of Future Occurrence

The probability for hazards in Greene County is determined using Calculated Priority Risk Index (CPRI). It is highly likely for a cyber incident to occur within the next year in Greene County. For a full description of the CPRI for cyber events, refer to Appendix B.

Changing Future Conditions and Considerations

Climate change will not affect cybercrimes.

VULNERABILITY

Vulnerability Overview

Most of the planning area is vulnerable to cybercrime if technology, like computers, are used in either personal life or for business. Children using technology can be more vulnerable to cyber crimes because they are not as educated as adults on the risks of surfing the web. Larger businesses, government facilities, education facilities and other large facilities are at risk for experiencing cybercrimes. According to the FBI, these are the things that can be done to reduce vulnerability to cybercrime.

- Keep firewalls turned on
- Install or update antivirus software
- Install or update antispyware technology
- Keep operation system up to date
- Be careful downloading
- Turn off computer

Potential Losses to Existing Development

Cybercrimes can cause a large amount of data loss to a business or government facility if the crime is not caught quickly. Cyber-attacks can go unnoticed for long periods of time. Cybercrimes can lead to critical facility shutdown across the planning area. Most of cybercrimes do not cause large amount of money loss, but more data and sensitive information. There are incidents where banks or individual accounts are targeted which can cause financial loss.

Impact of Previous and Future Development

Development of more technology can lead to more cybercrimes around the planning area. More and more of people's personal information and business work is going electronic putting this information at risk for cybercrimes. As the City of Springfield continues to grow, the government buildings become more at risk for being targeted.

3 - RISK ASSESSMENT

EMAP Consequence Analysis

EMAP Impact Analysis: Cyber

SUBJECT	DETՐIMENTAL IMPACTS
Public	A cyber incident would have few safety concerns, including bank account information, medical records and availability of prescription if system is destroyed.
Responders	There are no potential life safety issues for responders; however the impact to response functions could be critical.
Continuity of Operations	Cyber incident can lead to critical services that are hampered or even suspended across the jurisdiction.
Property, Facilities, and Infrastructure	A cyber incident could cause minor isolated instances of property damage if malfunctions occur in electronic systems. Major critical infrastructures sectors can be impacted through-out the jurisdiction because of the dependence on information technology. A cyber incident could cause minor isolated instances of facility damage if malfunction occur in electronic systems.
Environment	Cyber incidents would have little to no impact on Greene County's Environment.
Economic Condition of Jurisdiction	A cyber incident could cause major economic impact on the economy. Especially cyber threats to information about money, accounts, or company information.
Public Confidence in the Jurisdiction's Governance	A cyber-attack could cause a catastrophic impact on public confidence in governance. Major widespread significant loss will occur when personal information and company information is lost or compromised.

*For more details on Consequence Analysis, refer to Appendix B.

Hazard Summary by Jurisdiction

The entire planning area is at risk for experiencing cybercrimes. Larger businesses and government facilities are more vulnerable to experiencing cybercrimes. The City of Springfield has the most large businesses and government facilities located within the city limits. The city of Springfield is at a higher risk for experiencing cyber attacks and crimes, but all areas and citizens are at risk.

PROBLEM STATEMENT

Cybercrimes and issues are on the rise nationwide. Cybercrimes can cause loss of sensitive information and data that could be damaging to a government facility or business. Cybercrimes can be extremely expensive to the targeted location. The entire planning area is at risk for experiencing cyber issues at all times of the year with sometimes no warning times. Cybercrimes can go unnoticed and last for weeks, even years. Individuals and businesses should protect themselves from cybercrimes as much as possible to avoid large losses of personal data and information. Some solutions to Cybercrimes include updating their software's to include many different programs like two factor authentication, strict firewalls, more difficult passwords, etc. Several jurisdictions picked projects that are related to cybercrimes. These can be found in the Mitigation Strategy section of this plan.

3 - RISK ASSESSMENT

3.6.5 Human Caused Hazard: Explosives

HAZARD PROFILE

Hazard Description



An explosion is the sudden expansion of material accompanied by the production of heat and large changes in pressure caused by chemically or energetically unstable products. An explosive charge measures the quantity of explosive material. Explosions may be intentional (e.g. IEDs) or unintentional.

There are two general classifications for explosives: high and low. A high explosive is characterized by how quickly decomposition, or detonation, occurs. Decomposition will be nearly instantaneous when it is initiated by a blow or a shock. A low explosive is made of mostly solid combustible materials that decompose rapidly and don't normally explode. While low explosives do not typically propagate a detonation, they could easily act like a high explosive and detonate. A low explosive will burn rapidly while a high explosive will detonate.

Composition Mixture

Within the high and low classifications, explosives are classified by their composition. An explosive may be a mixture, composed of distinct substances that are carefully prepared and mechanically combined in varying proportions (e.g. black powder).

Composition Compound

An explosive may also be a compound. The compound has homogenous substances, and the substances have molecules that contain oxygen, carbon and hydrogen necessary for combustion (e.g. nitroglycerin).

The single most important property in rating an explosive is its detonation velocity (the speed the detonation wave travels through the explosive). The detonation is a signal that the reaction is moving through the explosive faster than the speed of sound. Deflagration indicates a slower reaction (e.g. burning). A high explosive will detonate; a low explosive will deflagrate. All commercial explosives are high explosives, with the exception of black powder.

Improvised Explosive Devices

An improvised explosive device (IED) is a bomb that is constructed and deployed using unconventional techniques and materials. An IED may be partially composed of conventional military explosives (e.g. an artillery round attached to a detonating mechanism). These devices are designed to destroy or incapacitate personnel and vehicles.

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Types of IED's

NAME	DESCRIPTION
Improvised Explosive Device (IED)	A device placed or fabricated in an improvised manner incorporating destructive, lethal, noxious, pyrotechnic or incendiary chemicals. Designed to destroy, incapacitate, harass or distract.
Improvised Nuclear Device (IND)	A device incorporating radioactive materials designed to disperse radioactive material or form a nuclear-yield action.
Improvised Chemical Device (ICD)	A device incorporating the toxic attributes of chemical materials designed to result in the dispersal of toxic chemical materials.
Improvised Biological Device (IBD)	A device incorporating biological materials designed to disperse vector borne biological materials.
Improvised Radioactive Device/Radiological Dispersion Device (RDD); Dirty Bomb	A device incorporating radioactive materials designed to disperse radioactive materials to cause death, fear and behavior modification.
Improvised Incendiary Device	A device that uses exothermic chemical reactions to rapidly spread fire (e.g. Molotov Cocktail).

Source: The Dictionary of Military and Associated Terms and CBRNe World

IED Delivery Methods

DELIVERY MECHANISM	DESCRIPTION
Car Bomb/Vehicle-Borne (VBIED)	Vehicles may be laden with explosives, set to explode by remote control or by passenger/driver. VBIEDS can carry thousands of pounds of explosives.
Boat-Borne	Boats laden with explosives can be used against ships and areas connected to water.
Collar Bombs	IEDS strapped to the neck of individuals.
Homicide Bombers	An individual may wear and detonate explosives in order to kill others, including himself or herself.
Platter Charges	Rectangular or circular pieces of flat metal with explosives pressed into one of the sides of the platter.
Improvised Rocket Assisted Munitions (IRAM)	Propane tanks packed with explosives and powered by 107mm rockets.

Source: Greene County Multi-Jurisdictional Hazard Mitigation Plan 2015-2020

Electromagnetic Pulse Bomb

An Electromagnetic Pulse Bomb (EMP) is designed to overwhelm electrical circuitry with an intense electromagnetic field. Due to the growing dependency on technology for day to day functions, an EMP attack would be devastating. The EMP would destroy most machines that use electricity. Generators would be useless, cars wouldn't run and the ability to make phone calls would be gone. Emergency response would be severely hindered, companies could lose millions of dollars due to loss of productivity, food in residential and commercial facilities would spoil and the electronic networks that keep government and military operations functioning would be gone. These are just some of the many examples of how an EMP may cripple a military unit or set a city back hundreds of years.

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Geographic Location

Explosives can be used/detonated anywhere in Greene County.

Strength/Magnitude/Extent

The magnitude of an explosive event in Greene County largely depends on what type of explosive is used and where the explosion happens. Explosion events can cause large amounts of property damage and death or injury to people.

Explosive materials may be categorized by the speed at which they expand. Materials that detonate (the front of the chemical reaction moves faster through the material than the speed of sound) are said to be "high explosives" and materials that deflagrate are said to be "low explosives". Explosives may also be categorized by their sensitivity. Sensitive materials that can be initiated by a relatively small amount of heat or pressure are primary explosives and materials that are relatively insensitive are secondary or tertiary explosives.

High Explosives

High explosives detonate under the influence of the shock of the explosion of a suitable primary explosive. They do not function by burning; in fact, not all of them are combustible, but most of them can be ignited by a flame and in small amount generally burn tranquilly and can be extinguished easily. If heated to a high temperature by external heat or by their own combustion, they sometimes explode. They differ from primary explosives in not being exploded readily by heat or by shock, and generally in being more brisant and powerful. They exert a mechanical effect upon whatever is near them when they explode, whether they are confined or not. A high explosive compound detonates at rates ranging from 1,000 to 9,000 meters per second, and are, conventionally, subdivided into two explosives classes, differentiated by sensitivity:

- Primary high explosives are extremely sensitive to mechanical shock, friction, and heat, to which they will respond by burning rapidly or detonating.
- Secondary high explosives, also called base explosives, are relatively insensitive to shock, friction, and heat. They may burn when exposed to heat or flame in small, unconfined quantities, but detonation can occur. These are sometimes added in small amounts to blasting caps to boost their power.

Previous Occurrences

October 1970

In early October, 1970, two union truck drivers, who were on strike, shot a semi-truck hauling dynamite approximately 9 miles west Springfield. The bullet caused the truck to explode which created a 40-foot crater in the east bound lanes of I-44. The effects were felt all over Springfield including the downtown area where many windows were blown out.

June 2003

An Ozark Empire Fairgrounds employee was killed in an explosion on June 18, 2003. Springfield Fire Department and City Utilities officials confirmed the explosion was caused when the deceased attempted to illuminate some breakers in the wall with a lighter in a facility that had a gas leak.

June 2008

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On June 19th, 2008, a homemade bomb was thrown at a Springfield home. Fire investigators found a Molotov Cocktail outside of a residence. There was a juvenile in the home at the time of the attack. Had the bomb entered the home, firefighters would have had a major house fire on their hands.

February 2015

Bomb Technicians were called to Gas Trip on Kearney, as a driver had observed a possible hand grenade in the gas station's parking lot. Upon arrival, bomb technicians investigated and followed procedures to deal with a potential threat.

November 2018

A home explosion happened at Shady Acres Mobile Home Park after someone was working on a propane heater inside. A man escaped with only burns on his face and arms. The home was a total loss.

February 2019

Two contract workers were injured after an explosion and fire at the Southwest Wastewater Treatment Plant in Springfield. The incident was a low order explosion with flash fire. A digester tank at the facility received damages and partially collapsed.

May 2019

Greene County Deputies were dispatched to the 10,000 block of West Farm Road 194, regarding suspicious activity. Deputies discovered numerous vehicles, trailers and equipment that was stolen. Deputies also located commercial grade explosives "that could have caused seriously bodily harm or death" says the Springfield Fire Department.

Probability of Future Occurrence

The probability for hazards in Greene County is determined using Calculated Priority Risk Index (CPRI). It is somewhat likely for an explosive event to occur within the next five years in Greene County. For a full description of the CPRI for explosives, refer to Appendix B.

Changing Future Conditions and Considerations

Climate change will not affect explosive incidents in Greene County.

VULNERABILITY

Potential Losses to Existing Development

Explosives can cause large amounts of destruction to property if the explosion is large. The degree of impact would be directly related to the type of incident. Potential losses would include cost of repair or replacement of damaged facilities, lost economic opportunities for businesses, loss of human life and injuries to persons. Secondary effects of infrastructure failure could include public safety hazards, like public panic.

Impact of Previous and Future Development

Areas of dense population and large public venues may make attractive targets for an explosive attack. More and more large events like concerts and festivals are coming to the Greene County area. Tourist attractions, like Wonders of Wildlife and Bass Pro can also bring large amounts of people together in one small place.

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EMAP Consequence Analysis

EMAP Impact Analysis: Explosives

SUBJECT	DETՐIMENTAL IMPACTS
Public	An explosive has the potential to cause multiple injuries and fatalities. There has only been one recorded fatality due to an explosion in Greene County. Explosives can also cause significant safety concerns.
Responders	Functionality and safety of responders has not been impacted in Greene County due to an explosive. There is a potential for life threatening issues if structural integrity is compromised or another explosive device is present that has not been detonated. This would also greatly impact response functions.
Continuity of Operations	Explosive in Greene County have caused little to no impact of the delivery of services.
Property, Facilities, and Infrastructure	Greene County has experienced limited property damage from explosives. An explosive could possibly create multiple instances of property damage, but this has not occurred at this time within Greene County. Explosives in Greene County have caused little to no damage to infrastructure and facilities. Depending on where the explosive were to detonate, there is a chance that damage could occur at critical facilities and infrastructure.
Environment	Explosives in Greene county have caused little to no impact on the environment.
Economic Condition of Jurisdiction	Explosives in Greene County have caused little to no impact of the economy.
Public Confidence in the Jurisdiction's Governance	Explosives in Greene County have caused little to no impact on public confidence in governance if the situation is handled appropriately.

*For more details on Consequence Analysis, refer to Appendix B.

Hazard Summary by Jurisdiction

All areas of Greene County are at risk for experiencing an explosion event or attack. Areas with a dense population are more at risk like the City of Springfield. All jurisdictions host events throughout the year like Fourth of July Festivals, Christmas Parades, Halloween events, and many other festivals year round. These large events can be targets for explosive attacks. It is difficult to say that one jurisdiction is more at risk than another.

PROBLEM STATEMENT

Explosive attacks or events can happen at any given moment, anywhere in the county. Many of these events come with no warning time. Explosives can cause large amounts of property destruction and can even cause injury and death to people. The magnitude of an explosion depends on the location and type of explosion. Though Greene County has not seen a devastating explosion, the nation has seen many. Explosions can be a targeted threat to dense populations and events across the planning area. Mitigation Solutions for explosions include enhanced first responder training, hospital training, public event planning and other detailed planning. No participating jurisdiction chose to create a mitigation project for explosions in this Hazard Mitigation Plan.

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3.6.6 Human Caused Hazards: Nuclear

HAZARD PROFILE

Hazard Description

Depleted uranium, radiation, x-rays, nuclear power and nuclear waste are examples of nuclear materials. The science behind nuclear energy and weapons is complex and the damage sustained would be devastating.



Atoms

Everything is made of atoms. Atoms bind together to make molecules (e.g. water, or H₂O, is a molecule made of two hydrogen atoms and one oxygen atom). Each atom has three subatomic parts: protons, neutrons and electrons.

An atom can have a variety of these subatomic parts in varying proportions, which is how the atoms differentiate themselves on the periodic table. Because the proportion of subatomic parts varies, many atoms have different forms or compositions. The

different forms are called isotopes. An isotope may be stable; this means the composition will not change over time. Other isotopes are unstable, which means they change composition over time. The process of changing composition is called radioactive decay. An atom may have many isotopes.

When the atom loses energy (via emitting ionizing particles and radiation), decay changes the base atom. The base atom is a parent nuclide, and when it's changed into a different atom, it's renamed. So, a parent nuclide may change into a daughter nuclide.

The process of changing may cause an atom to go through alpha decay, beta decay or spontaneous fission. Alpha and beta decay cause an atom to lose subatomic parts. Spontaneous fission means the atom splits. This creates more energy and is often common with gamma rays.

Types of Rays

After going through the process of radioactive decay, an atom may emit different types of rays. The image on the left shows four types of rays and their strength. From top to bottom, alpha rays can be stopped by a sheet of paper. Beta rays can be stopped by an aluminum plate. Gamma rays are very strong and must be stopped by a strong substance, like lead. Neutron particles/rays can be stopped by a thick wall of water

For more information on rays, please see the Radiological Hazard Profile

Fusion

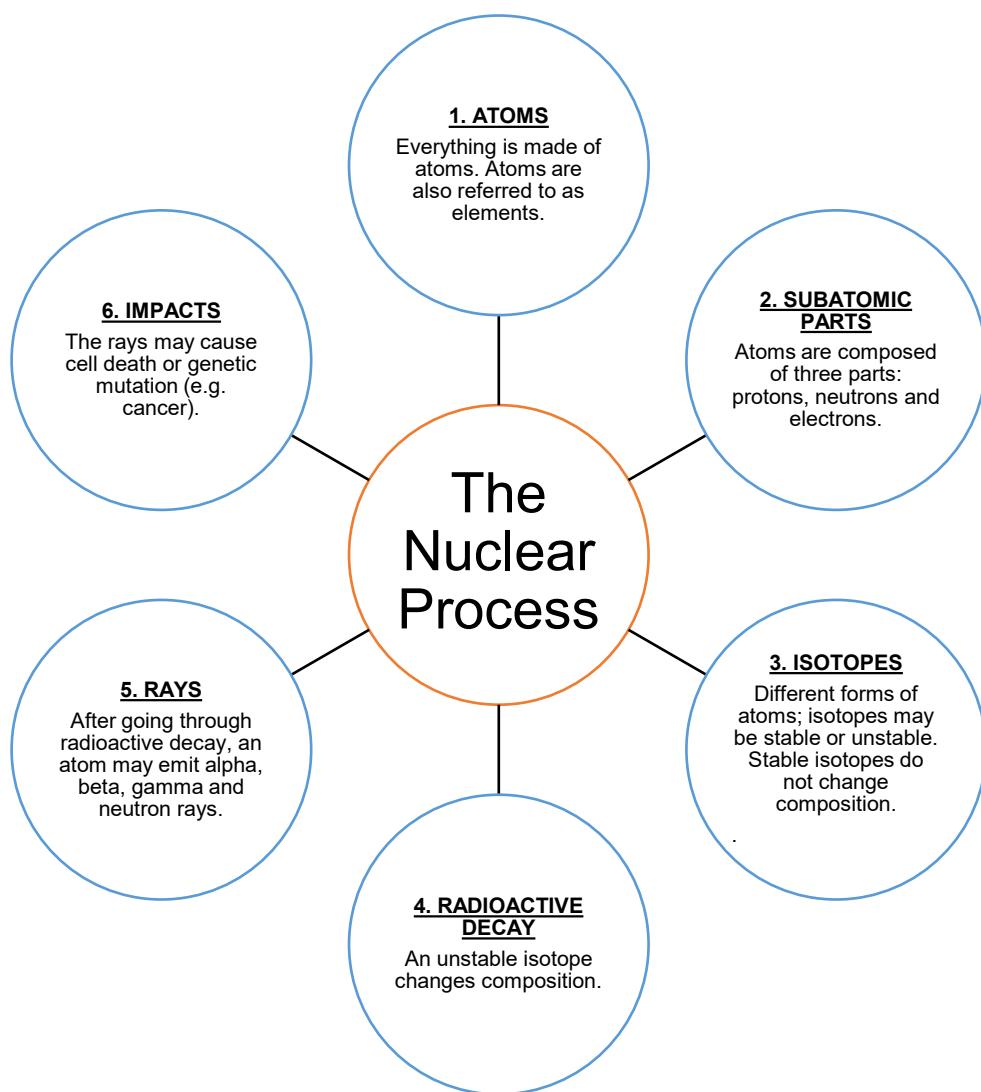
When two light nuclei combine to form a single heavier nucleus, it is referred to as fusion.

Fusion reactions are used to develop thermonuclear weapons and nuclear reactors (e.g. two hydrogen isotopes fused to form an isotope of helium). Fusion is difficult to do because the two nuclei want to repel; only a great force can unite them and create the large burst of energy. Fusion is a process used by the sun to produce heat. An early fusion induced supernova explosion caused debris like lead, gold and silver to be distributed across the Earth.

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Fission

When a heavy nucleus splits into two smaller nuclei it is called fission. This is similar to bowling, because a large isotope (bowling ball) is used to split or reduce other elements (the number of pins). When you compare the sum of the mass of the atoms you started with and the mass of the atoms you ended with, the mass will be less than when you started. The missing mass is converted into energy and is called the mass defect. However, the energy will be greater, even though the numbers appear to be telling a different story. This can be explained by Einstein's famous $E=MC^2$. The amount of mass missing is multiplied by the speed of light squared. This is the amount of energy produced through the fission process.



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Geographic Location

If a nuclear device was detonated, it would be difficult to predict which areas would be affected. Radioactive fallout paths depend on weather, which is, of course, unpredictable. No locality in the United States, Greene County included, is free from risk of receiving dead radiation levels after an attack.

Strength/Magnitude/Extent

A nuclear detonation would cause substantial damage and several casualties. A nuclear attack has the potential to affect the total population in the vicinity of the impacted area. While portions of the area would experience the direct effects (blast, heat and initial radiation), areas further away from the impacted area would experience indirect effects, which would primarily be radioactive fallout. Some areas may experience non-life-threatening levels of radiation while other areas may experience lethal levels of exposure. A transportation incident is far more likely in Greene County. If nuclear waste were spilled in Greene County travelling down any of the roadways or railroads, it would be a serious incident.

Weapons

A nuclear weapon is an explosive device that obtains its destructive force from nuclear reactions using fission and/or fusion. Weapons are typed based upon the type of nuclear energy used.

Fission reactions produce weapons commonly referred to as atomic bombs or atom bombs (A-Bombs).

The amount of energy released by a fission bomb equates 1 kiloton of Nuclear weapon to 1 kiloton of TNT. Most weapons, including those that use fusion, derive the majority of their energy from fission

Fusion reactions produce weapons that are generally referred to as thermonuclear weapons or hydrogen bombs. They derive their energy from fusion reactions between isotopes of hydrogen (deuterium and tritium). While fission weapons have a limit or range of energy release, fusion weapons do not; there is no limit to the amount of energy a fusion weapon can release. The United States, Russia, the United Kingdom, China, France and India are the only six countries that have conducted thermonuclear weapon tests.

Modes of Transportation

Developing and maintaining the delivery of a nuclear weapon is one of the most resource-intensive components. It is estimated that approximately 57% of the United States total financial resources used for nuclear weapons has been spent on deployment since the 1940's. The preferred mode of transportation for a nuclear weapon is to mount it on a missile. The missile may be short range, which allows a warhead to be delivered over the horizon. While these missiles allow for a faster delivery, intercontinental ballistic missiles (ICMBs) and submarine-launched ballistic missiles (SLBMs) allow for global delivery with a high chance of success.

Transportation

The Missouri State Mitigation Plan (2013) identifies Missouri as a crossroads for rail and truck transport of nuclear waste to the Yucca Mountain, Nevada, testing site. One of the most commonly traveled interstates, I-44, runs through Greene County. Further, the United States Department of Energy is shipping radioactive waste by truck to repositories in Texas and Utah. The trucks cross portions of Missouri, including Springfield, on I-44.

MAD

Mutually Assured Destruction (MAD) used to provide enough assurance and deterrence that nation states would not use nuclear weapons in an attack. This device was a concept during the Johnson administration. According to

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the Army the concept has declined and the Bush administration has withdrawn its Anti-Ballistic Missile Treaty based on the MAD. The desire to develop smaller nuclear devices that would be more accurate and reduce the number of innocent civilians killed in the process.

Previous Occurrences

World War II

During World War II, the United States dropped two atomic bombs on Japan; one was in Hiroshima and one was in Nagasaki. The City of Hiroshima was obliterated, killing approximately 66,000 people. Approximately one half of the City of Nagasaki was destroyed, killing approximately 39,000 people. Since WWII, nuclear weapons have been detonated over two thousand times for testing and demonstration purposes. Countries known to have detonated nuclear weapons include the United States, Russia, the United Kingdom, France, China, India, Pakistan and North Korea.

According to the Missouri State Mitigation Plan (2013) seven nations have declared their nuclear capability and five additional nations are suspected of having developed nuclear weapon technology, including North Korea and Iran. Fifteen other nation states have either had weapons or programs to develop nuclear weapons, and have allegedly abandoned their efforts.

A nuclear event has not occurred in Greene County therefore, there are no historical incidents to report.

Probability of Future Occurrence

The probability for hazards in Greene County is determined using Calculated Priority Risk Index (CPRI). It is unlikely that a nuclear event will occur within the next ten years in Greene County. For a full description of the CPRI for nuclear events, refer to Appendix B.

Changing Future Conditions and Considerations

Climate change will not affect nuclear attacks or incidents on Greene County.

VULNERABILITY

Vulnerability Overview

A strategic nuclear attack on the United States could have the most devastating and far-reaching consequences. The use of these weapons against the United States is unlikely. Unfortunately, however, as long as such weapons exist, there is always a chance that they could be used. The potential for traditional war-related attacks, using conventional weapons, is a scenario that is more likely to occur, based on currently available information. Nuclear attacks or a nuclear transportation incident would come with no warning time for the county. The clean up work could take days or weeks in transportation incidents.

According to the Missouri State Hazard Mitigation Plan, direct effects from a nuclear incident include intense heat, blast energy, and high intensity nuclear radiation. These effects generally will be limited to the immediate area of the detonation (up to 22 miles), depending on the size of the weapon, altitude of burst and atmospheric conditions. The indirect effects are much more catastrophic. When a nuclear weapon detonates, intense heat, blast, and overpressure will cause severe injuries and fatalities in the surrounding area and radiation poisoning at more distant locations. A detonation near or on the ground draws up large quantities of earth and debris into a mushroom cloud. This material becomes radioactive, and the particles can be carried by wind hundreds of miles before they drop back to earth as "fallout." In an attack, many areas of the United States would probably escape fallout altogether or experience non-life-threatening levels of radiation. However, because weather that determines where fallout will land is so unpredictable, no locality in the United States is free from the risk of

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receiving deadly radiation levels after a strategic attack. Less than lethal exposures will result in longer-term effects on health and contamination of food, water, and food production.

Potential Losses to Existing Development

Potential losses to a large nuclear incident include losses to infrastructure, critical facilities and lifelines, humans and animals. The degree of impact would largely depend on the size of the incident. A transportation spill would not cause as much damage as a nuclear weapon incident.

Impact of Previous and Future Development

According to the Missouri State Hazard Mitigation Plan, As time passes, relationships between countries across the globe evolve from adversarial conditions to friendship and back; these relationships can be strained by a variety of factors, including energy shortages, water availability and changing weather patterns. No matter the cause, increasing volatility of relations on the national stage can increase the risk of attacks on the homeland.

EMAP Consequence Analysis

EMAP Impact Analysis: Nuclear

SUBJECT	DETՐIMENTAL IMPACTS
Public	There are no reported nuclear incidents in Greene County. Therefore, there are no recorded injuries or deaths. A nuclear spill would have significant safety concerns. A nuclear attack however, would easily prove catastrophic.
Responders	Responders would face some safety concerns in a nuclear incident, but are protected if they possess proper personal protective equipment.
Continuity of Operations	Delivery of services would be catastrophic in a large-scale incident. Greene County has not experienced no impact on delivery of services.
Property, Facilities, and Infrastructure	There are no records of property damage due to a nuclear incident in Greene County. A nuclear spill on the highway would result in minor isolated damaged. A large-scale nuclear attack could be catastrophic. Damage to infrastructure and facilities would be catastrophic in large-scales incidents. Greene County has not experienced damages from nuclear incidents for facilities or infrastructure.
Environment	The environment would be destroyed in the event of an attack; however, Greene County has no records of damage to the environment due to a nuclear incident.
Economic Condition of Jurisdiction	The economy would have catastrophic damage in a large-scale nuclear incident. Greene County has experienced no impact on the economy.
Public Confidence in the Jurisdiction's Governance	The public confidence in Governance would be catastrophic in large-scale incidents. Greene Count has not experienced impact on the public confidence in governance.

*For more details on Consequence Analysis, refer to Appendix B.

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Hazard Summary by Jurisdiction

The entire planning area is at risk for experiencing nuclear attacks and incidents. Nuclear waste does travel through Greene County on both railroad and interstate. Jurisdictions that are at risk for train derailment (Section 3.5.6) could be more at risk to experience a nuclear waste spill in their jurisdiction. Also areas along I-44 could also be more at risk due to the travel of nuclear waste on the interstate as well. Though these events would be unlikely, they are still a risk.

PROBLEM STATEMENT

Nuclear incidents or attack have the possibility of causing devastating damage and major health effects on human and animal life. Nuclear incidents can come from a weapon or they can be caused from a nuclear waste accident. Though there have not been an incident in Greene County, as long as nuclear weapons and materials exist, it will be a hazard for the planning area. Nuclear events are hard to mitigate. One of the best solutions is detailed planning and training. Relocating critical facilities farther from railroads could be a solution, but difficult to do. In this Hazard Mitigation Plan, no participating jurisdictions created mitigation projects for nuclear events.

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3.6.7 Human Caused Hazard: Radiological

HAZARD PROFILE

Hazard Description

Radiological materials are used every day; many people encounter items that are made of radioactive material and do not even know it. Laboratories, medical centers, food irradiation plants and industrial companies routinely use these materials. While limited exposure to low levels of radioactive material may not be harmful, exposure to

material with high levels of radiation could endanger the health and wellbeing of animals, humans and the environment.



Types of Radiation

Radioactive material is emitted and classified by the type of ray (or energy) produced. There are four types: alpha, beta, gamma and x radiation. The image on the right demonstrates the different strengths of each ray and their ability to break through an object.

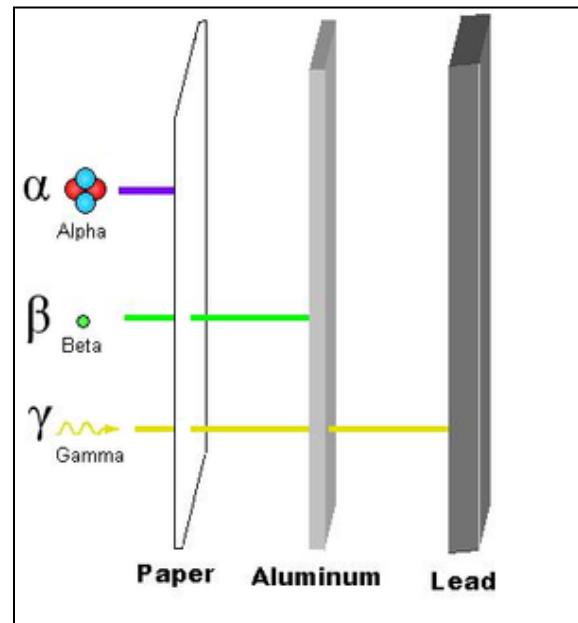
Neutron radiation is also encountered in nuclear power plants and high-altitude flight and emitted from some industrial radioactive sources. For more information please see the nuclear hazards profile and vulnerability.

Alpha Radiation

Alpha radiation is a heavy, very short-range particle and is actually an ejected helium nucleus. Most alpha radiation is not able to penetrate human skin but some alpha-emitting materials can be harmful to humans if the materials are inhaled, swallowed, or absorbed through open wounds. Instruments cannot detect alpha radiation through even a thin layer of water, dust, paper, or other material, because alpha radiation is not penetrating. Alpha radiation travels only a short distance (a few inches) in air, but is not an external hazard. Alpha radiation includes radium, radon, uranium, and thorium.

Beta Radiation

Beta radiation is a light, short-range particle and is actually an ejected electron. Beta radiation may travel several feet in air and is moderately penetrating. Beta radiation can penetrate human skin to the "germinal layer," where new skin cells are produced. If high levels of beta-emitting contaminants are allowed to remain on the skin for a prolonged period of time, they may cause skin injury. Beta-emitting contaminants may be harmful if deposited internally. Beta radiation examples include hydrogen-3 (tritium), carbon-14, sulfur-35, and strontium-90.



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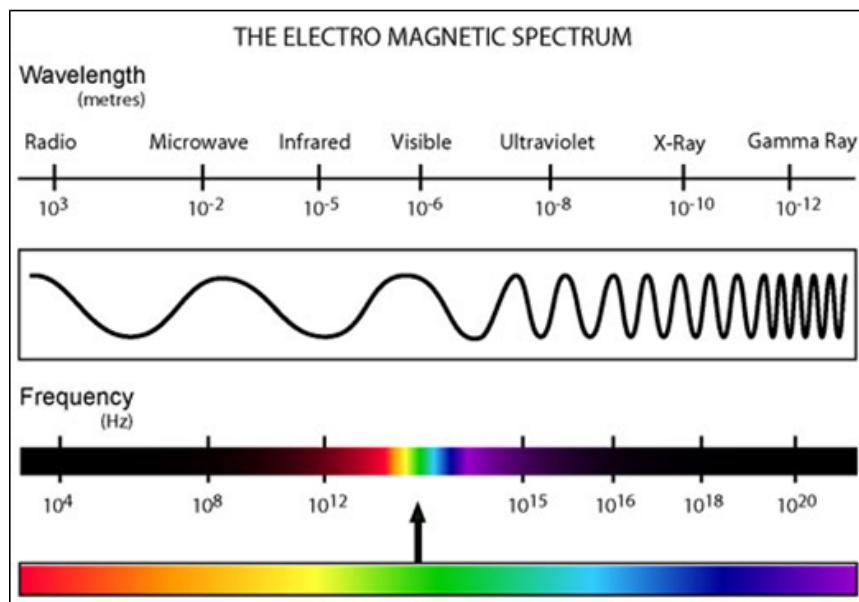
Gamma Radiation

Gamma radiation is highly penetrating electromagnetic radiation. Gamma radiation is able to travel many feet in air and many inches in human tissue. They readily penetrate most materials and are sometimes called "penetrating" radiation. Gamma radiation examples include iodine-131, cesium-137, cobalt-60, radium-226, and technetium-99m.

X-Ray Radiation

X-rays are like gamma rays. X-rays, too, are penetrating radiation. Sealed radioactive sources and machines that emit gamma radiation and x-rays respectively constitute mainly an external hazard to humans.

Gamma radiation and x-rays are electromagnetic radiation like visible light, radio waves, and ultraviolet light. These electromagnetic radiations differ only in the amount of energy they have. Gamma rays and x-rays are the most energetic of these.



Geographic Location

Universities and laboratories use radiation to conduct scientific research. Medical and veterinary hospitals and clinics use radiation to diagnose and treat humans and animals. Nuclear pharmacies use radiation manufacture and distribute radiopharmaceuticals. Blood banks use it to sterilize blood. Companies that provide services, such as sterilization of medical supplies, facility decontamination, and waste processing use radiation.

The closest nuclear radiation sites to Greene County are in St. Louis, Missouri, Lawrence, Kansas, and Jonesboro, Arkansas.

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Strength/Magnitude/Extent

The amount of damage that exposure to radiation can cause depends on several factors, including:

- Type of radiation
- The dose (amount) of radiation
- How the body was exposed, such as through skin contact, swallowing or breathing it in, or having rays pass through your body
- Where the radiation concentrates in the body and how long it stays there
- How sensitive the body is to radiation

Being exposed to a lot of radiation over a short period of time can cause skin burns. It may also lead to Acute Radiation Syndrome (ARS). The symptoms of ARS include headache and diarrhea.

Intentional Release

An intentional release is defined as a radiological attack. A radiological attack is the spreading of radioactive material with the intent to do harm. A Radiological Dispersal Device (RDD), also known as a dirty bomb, disperses radiological material over a targeted area using conventional explosives. This is different from a nuclear bomb that has radioactive fallout. A dirty bomb that explodes would disperse radioactive particles within a few city blocks or miles of the explosion. A nuclear bomb would disburse radioactive material over tens to hundreds of square miles. Another way of intentionally using radioactive materials includes using small dosages to poison a small population.

Unintentional Release

An unintentional release may include a spill, improperly disposing of hazardous waste or obtaining material from a waste site and using it without proper knowledge of the material and its effects.

Naturally Occurring Radiological Hazards

Naturally Occurring Radioactive Material (NORM) is found in virtually all rocks, minerals and soils. The Health Physics Society explains they naturally contain small amounts of uranium, thorium and a radioactive isotope of potassium. Plants and animals are naturally radioactive because they contain small (but measurable) levels of radioactive potassium, radioactive carbon (C-14) and hydrogen (tritium or H-3). The radioactive levels are formed by cosmic ray interactions in the atmosphere.

Commonly Encountered Radionuclides

The Environmental Protection Agency (EPA) explains there are 12 commonly encountered radioactive nuclides, also called radionuclides. A radionuclide is an atom with an unstable nucleus that has excessive energy. The energy may go to a newly-created radiation particle within the nucleus or to an atomic electron. Through moving process the radionuclide undergoes radioactive decay and emits radioactive energy in the form of the aforementioned rays.

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NAME	TYPE	USES
Americium-241	Alpha Gamma	Smoke detectors; diagnostic device; gauges
Cesium-137	Beta Gamma	Density gauges; leveling gauges
Cobalt-60	Beta Gamma	Leveling devices; radiotherapy, sterilization for spices and foods
Iodine-129 & 131	Beta Gamma	Tracks the metabolism of drug compounds; helps diagnose and treat thyroid problems
Plutonium	Alpha Beta Gamma	Nuclear weapons; power source
Radium	Alpha Gamma	Radiography devices; tips of lightning rods
Radon	Alpha	Radon has very little practical use
Strontium-90	Beta	Radioactive tracer in medical and agricultural studies; can be converted into energy for long-lived portable power supplies
Technetium-99	Beta Gamma	Found in radioactive wastes from defense-related facilities, nuclear reactor and fuel cycle facilities, academic institutions, hospitals and research establishments.
Tritium	Beta	Used as a component for a trigger mechanism in thermonuclear weapons; produced commercially in reactors; used in self-luminescent devices
Thorium	Alpha Gamma	Has coloring properties used in ceramic glazes; widely used in lantern mantles for brightness; metals in the aerospace industry
Uranium	Alpha Gamma	Depleted uranium is used as shielding to protect army tanks; parts of bullets and missiles; to propel Navy ships and submarines; nuclear weapons

Source: Commonly Encountered Radionuclides

The previously-listed radionuclides are important for understanding how hazardous material interacts with communities on a regular basis. These materials could be released intentionally or unintentionally.

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Previous Occurrences

In 2008, an accidental exposure occurred in Greene County Missouri. A construction worker operating a motor grader accidentally hit a soil compression gauge. The gauge uses alpha and gamma rays to determine the depth and composition of soil. When the motor grader ran over the gauge, it broke the alpha source and locked the gamma source in a position outside of the cast iron box. The gamma source is kept in the cast iron box to protect workers from unsafe levels of radiation. The construction worker manually hammered the gamma source back into the cast iron box. The entire device was then placed in a larger cast iron box and transported to a safe facility. Throughout this process, the construction worker's exposure was monitored and was within a "safe" range of exposure. Additionally, the emissions from the gauge were also measured as it was transported, and did not pose a risk to the public.

Probability of Future Occurrence

The probability for hazards in Greene County is determined using Calculated Priority Risk Index (CPRI). It is unlikely for a radiological event to occur within the next ten years in Greene County. For a full description of the CPRI for radiological events, refer to Appendix B.

Changing Future Conditions and Considerations

Climate change will not affect radiological events in Greene County.

VULNERABILITY

Vulnerability Overview

Radiation exposure can cause potential health risk to all the population depending on the amount and type of radiation exposure. Children and fetuses are especially sensitive to radiation exposure. The cells in children and fetuses divide rapidly, providing more opportunity for radiation to disrupt the process and cause cell damage. There are several sites that house radioactive materials in the area, like hospitals with x-ray machines or construction sites with gauges. Because of this, some citizens may encounter radioactive materials at varying levels.

The risk of a dirty bomb or a large release of radioactive material in the county is unlikely. A large radioactive material incident would be devastating to Greene County. A small bomb could explode in the center of a small community and cause significant property and health damage.

Radiation is especially frightening to the public because it is something people cannot see or feel; it is an unknown source of danger.

Potential Losses to Existing Development

The major potential losses of radiological incidents are humans, animals and critical facilities. The degree of impact would be directly related to the type of incident. Potential losses would also include the cost of repaired or replacement on damaged facilities, lost economic opportunities for businesses, loss of human life, and injuries to person. Radiological incidents are rare and specific amounts of estimated losses for previous occurrences are not available.

Impact of Previous and Future Development

Population growth could affect how many people could be affected by a large radiation attack. Springfield is a growing city and is most at risk in the planning area for a radiological attack. Though this attack would be unlikely, if the population continues to grow, so could the risk.

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EMAP Consequence Analysis

EMAP Impact Analysis: Radiological

SUBJECT	DETՐIMENTAL IMPACTS
Public	The only recorded radiological incident resulted in no injuries or deaths. An attack however, could have catastrophic damages.
Responders	Responders face some safety concerns, but are protected if they possess proper personal protective equipment.
Continuity of Operations	Delivery of services would be catastrophic in a large-scale incident. Greene County has not experienced an impact of delivery of services.
Property, Facilities, and Infrastructure	The only radiological incident in Greene County left no property, facility or infrastructure damage. A large-scale attack could be catastrophic to property, facilities and infrastructure.
Environment	The environment would be destroyed in the event of a large-scale radiological attack; however history shows radiological incidents have caused no damage to the environment.
Economic Condition of Jurisdiction	The economy would have catastrophic impacts in a large scale incident. Greene County has not experienced impact to the economy.
Public Confidence in the Jurisdiction's Governance	The public confidence in Governance could be catastrophic in a large-scale incident. Greene Count has not experienced an impact on public confidence in governance because of a radiological incident.

*For more details on Consequence Analysis, refer to Appendix B.

Hazard Summary by Jurisdiction

Radiation could be a risk for the entire planning area if it was used as an intentional release or as an attack. These would be used to target a specific location. In the planning area, the City of Springfield would be at higher risk for a planned attack because of large amount of population in condensed areas. An unintentional release could come from a spill or improperly disposing of hazardous waste. A spill would put areas along I-44 at risk. Those areas would include Strafford, including the Strafford School District, and the City of Springfield. Other jurisdictions that would be at risk would be areas along railroad tracks in the planning area. The map below shows the different locations of railroads in the planning area.

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PROBLEM STATEMENT

Radiation is a common thing that the planning area may come into contact with day to day activities. Large amounts of radiation exposure can cause serious harm to human and animal health. Though a large radiation incident is unlikely in Greene County, it is still a possibility. A radiation attack in the planning area, though unlikely, would be devastating. The impact of radiation depends greatly on the type, location and amount of radiation that is exposed. Mitigation solutions for Radiological events are scarce, some solutions could involve keeping large groups of people to a minimum. No participating jurisdiction created a project involving radiological events.

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3.6.8 Human Caused Hazard: Targeted Violence

HAZARD PROFILE

Hazard Description

Targeted violence is an act to harm or kill someone due to an act of that person. The secret service has stated that with targeted violence the perpetrator and target(s) are identifiable prior to the incident. There are several different types of targeted violence.



Types of Targeted Violence

- Schools: Over the last decade there have been many incidents where schools from elementary to college that students have planned to cause harm or killed many students.
- Bombing: Bombing of American embassies from terrorist groups. (See sections 3.6.2, 3.6.5, 3.6.8 for more information)
- Hijacking of airlines: See technological hazard (3.5.1)

The problem with this human-made hazard is that it is unpredictable. There is almost never warning time, or knowledge of where this tragedy could take place. Targeted violence can occur in a public space or a private home. Workplaces, schools, religious and government buildings are the most targeted spaces in public. However, the threat can come from anywhere and strike anywhere. Efforts to prevent and mitigate targeted violence stumble upon difficult obstacles. Debates about gun rights and invasion of privacy hobble these efforts. Navigating the intricacies of privacy laws, preserving academic freedoms, complying with civil rights laws, and simultaneously ensuring a safe campus and workplace environment are tasks not easily accomplished.

Some targeted attacks are launched by people who claim to adhere to a cause or violent ideology, some have a more personal grievance, and in other cases the attacker seems to regard the act as an end unto itself. This is a list of the most common reasons for targeted violence.

- Related to an intimate relationship
- Retaliation for specific actions
- Refused advances or obsession with target response to academic stress/failure
- Acquaintance/stranger based sexual violence
- Psychotic actions
- Workplace dismissal/sanction
- Need to kill/specific victimology
- Draw attention to self/issue
- Bias related

Sabotage

Sabotage is taking a deliberate action to destroy, damage, or incapacitate someone or something else. This can happen for political purposes, military advantage, or in the workplace.

According to the FBI, previous workers are taking revenge on their employers by using their access to the company computers to destroy data, steal customer information, make unauthorized charges to company accounts and steal trade secrets. The financial damage varies with some being more than \$3 million.

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Public offices, centers of government and government depots are easy targets for sabotage.

Workplace sabotage can come in many different forms. Organizations do not frequently like discussing previous occurrences in fear of copycat actions or bad publicity. Employee saboteurs inflict damage to the property, reputation, product or service of an organization. Some of the different forms of sabotage are: equipment destruction, computer viruses, poisoning, working slowly, stealing or purposely treating a customer rudely. Sometimes acts of sabotage are harder to recognize, like viruses. Security or police can catch more serious sabotage acts like fire.

The severity of sabotage can change depending on the type of sabotage and how widespread the incident is.

Geographic Location

The entire planning area is at risk for experiencing targeted violence. Targeted violence is known in busy or popular locations such as schools, universities, churches, malls, movie theatres, etc. There are over 17 colleges and universities located in Greene County, Missouri. Missouri State University has the highest enrollment of 22,000 followed by OTC with 15,000, and Drury with a student population of 5,000. Greene County has one of the highest K-12 populations in Missouri. There are roughly 92 public schools for students in grades K-12. In addition, there are over 19 private and alternative schools. Major religious sites in Greene County: Temple Israel (synagogue) Rogersville and Islamic Center of Springfield (mosque).

Strength/Magnitude/Extent

The effects of targeted violence can vary depending on the type of targeted violence and what method is used. Violence cannot be attributed to a single factor. Its causes are complex and occur at different levels. To represent this complexity, the ecological, or social ecological model is often used. The following four-level version of the ecological model is often used in the study of violence:

1. The first level identifies biological and personal factors that influence how individuals behave and increase their likelihood of becoming a victim or perpetrator of violence: demographic characteristics (age, education, and income), genetics, brain lesions, personality disorders, substance abuse, and a history of experiencing, witnessing, or engaging in violent behavior.
2. The second level focuses on close relationships, such as those with family and friends.
3. The third level explores the community context—i.e., schools, workplaces, and neighborhoods.
4. The fourth level looks at the broad societal factors that help to create a climate in which violence is encouraged or inhibited: the responsiveness of the criminal justice system, social and cultural norms regarding gender roles or parent-child relationships, income inequality, the strength of the social welfare system, the social acceptability of violence, the availability of weapons, the exposure to violence in mass media, and political instability.

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Mass Shooting

Unfortunately, in the last 5 years, mass shooting have become more popular around the nation. A mass shooting is an act of violence with a firearm involving the killing of 4 or more victims. A targeted violence shooting event is any act of violence in which a perpetrator attacks a particular individual or group with a firearm regardless of the number of causalities. Some reasons why a mass shooter may decide to act are:

- Low capability for coping with rejection/criticism
- Interprets criticism as a form of bullying or an attack
- Belief they are the victim and should protect themselves
- Sees murder as justifiable homicide/self defense
- Supports the notion of justice through the death penalty
- Belief they are judge, jury or executioner
- Connects their depression to the target
- Refuses to seek out mental health help
- They take comfort in the violent endgame

In the years 2000-2013, 160 national mass shooting events occurred in the United States. There were 486 dead and 557 wounded.

Previous Occurrences

Greene County has not experienced a large targeted attack within the planning area. The amount of targeted attacks across the nation are continuing to increase.

Historical Education Mass Shootings/Killings

SCHOOL NAME	DATE	NUMBER KILLED
Enoch Brown School	July 1764	10
Charles Town, W. Virginia	December 1898	6
Plain Dealing High School	March 1893	4
South Pasadena Junior High	May 1940	5
University of Texas	August 1966	17
Rose-Mar College of Beauty	November 1966	5
Cal State Fullerton	July 1976	7
Cleveland Elementary School	January 1989	6
University of Iowa	November 1991	6
Westside Middle School	March 1998	5
Thurston High School	May 1998	4
Columbine High School	April 1999	15
University of Arizona	October 2002	4
Red Lake Sr. High School	March 2005	10
Virginia Tech	April 2007	33
Northern Illinois University	February 2008	6
Sandy Hook Elementary	December 2012	28
Marysville Pilchuk High School	October 2014	5
Umpqua Community College	October 2015	10
Stoneman Douglas High School	February 2018	17
Santa Fe High School	May 2018	10

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September 11th 2001

9/11 is one of the United States worst targeted violence event in history. There were nineteen al Qaeda terrorists that hijacked four airplanes that day crashing two of them into the north and south towers of the World Trade Center while the third plane crashed into the Pentagon. The fourth plane was crashed into a field after the crew and passengers attempted to regain control after learning what happened to the other planes. That day resulted in almost 3,000 people losing their lives.

September 2010

On September 21, 2010 a power substation was deliberately destroyed causing a power outage in the Willard, Ash Grove and Bois D'Arc area. This resulted in over 2,900 people losing power and traffic lights being impacted at the I-44 and West Bypass interchange.

Probability of Future Occurrence

The probability for hazards in Greene County is determined using Calculated Priority Risk Index (CPRI). It is probable for acts of targeted violence to occur within the next five years in Greene County. For a full description of the CPRI for targeted violence, refer to Appendix B.

Changes in Future Conditions and Considerations

Climate change will not affect targeted violence in the planning area.

VULNERABILITY

Vulnerability Overview

The entire planning area is vulnerable to targeted violence. Most targeted violence attacks have no warning time and are unpredictable. In some cases, the perpetrator will tell someone or announce over social media their intentions; however, this rarely happens. Many institutions and security officials are attempting to profile at-risk people. While this can identify potential threats, it provides little information on when and where an attack can occur. Greene County is the fourth most populated county in Missouri and has one of the highest student populations. When rioting does break out, it generally proves extremely difficult for first-responder law enforcement authorities to quell the mob promptly. In some cases, police presence is there from the beginning, but in other situations, police may be dispatched to a specific location giving the incident more time to escalate.

Potential Losses to Existing Development

Acts of targeted violence can be extremely costly both in loss of life and in money. During mass shooting attacks some cost factors include:

- | | |
|--|---|
| <ul style="list-style-type: none">• Loss of life• Injured workers• Hospital trauma resources | <ul style="list-style-type: none">• EOC• Labor Costs• Property Loss |
|--|---|

After a mass shooting attack, post event factors include:

- | | |
|--|---|
| <ul style="list-style-type: none">• Psychological Impact• Resiliency of Faculty• Insurance Premiums• Uninsured Losses• Investigation Costs | <ul style="list-style-type: none">• Funeral Costs• Health Care Premium Costs• Credit Impact• Counseling Expense• Supplies |
|--|---|

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Estimated Costs of Active Shooter Events

Name of Event	Cost (Estimated)
Las Vegas Mass Shooting Attack	\$600 Million
Orlando Terror Attack	\$390 Million
San Bernardino Terror Attack	\$125 Million
Century Theatre (Aurora, Colorado)	\$100 Million
Sandy Hook Elementary	\$100 Million
Columbine High School Shooting	\$50 Million
Virginia Tech Shooting	\$48.2 Million

Source: <https://www.acbo.org/files/Conference/2017%20Conference/10-23%20201130a%20GS.pdf>

Impact of Previous or Future Development

As mentioned above, Greene County has one of the largest school districts in America. As the population of the county grows, so does the school population. School shootings are not a new threat, but an increasing threat for areas all around the nation. Many schools participate in active shooter drills, but they are still vulnerable to targeted threats. Greene County also has many popular Universities which are also vulnerable to an attack. As the population and recognition of Greene County grows, the threat of experiencing an attack also grows.

EMAP Consequence Analysis

EMAP Impact Analysis: Targeted Violence

SUBJECT	DETINIMENTAL IMPACTS
Public	Targeted violence can result in injuries and fatalities. The number of people injured or deceased depends on the situation. However, history has shown targeted violence typically ends in a severe number of injuries and minimal deaths.
Responders	There may be a potential for life safety issues for responders depending on the situation. Response functions may also be impacted depends on number of attackers, amount of public at risk, types and amounts of weapons, etc.
Continuity of Operations	Targeted violence would have little to no impact on the delivery of services.
Property, Facilities, and Infrastructure	Targeted violence could have isolated instances of property damage, depending on location and the type of attack experienced. Targeted violence could have isolated instances of facility damage and infrastructure damage.
Environment	The environment would experience little to no impact from targeted violence.
Economic Condition of Jurisdiction	Targeted violence would have little to no impact on the economy.
Public Confidence in the Jurisdiction's Governance	Targeted violence would have a limited effect on public confidence in governance. The public can lose this confidence if it believed responders did not arrive quickly enough or take appropriate actions to prevent, contain, or end violence.

*For more details on Consequence Analysis, refer to Appendix B.

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Hazard Summary by Jurisdiction

All areas in Greene County are at risk for experiencing targeted violence. Our most vulnerable jurisdictions are our school districts and our universities. Though Greene County does not have a history of experiencing large threats, school shootings are occurring more frequently across the Nation. Other areas at risk are areas of dense population or popular areas in the county. Examples would be: movie theatres, malls, government facilities, court house, etc. Most of these places reside in the City of Springfield.

PROBLEM STATEMENT

Targeted threats can come in many forms including mass shootings, high jacking's, bombings etc. Depending on the form of attack and location, targeted threats can cause large amounts of property and human life loss. Targeted Violence can also cause public panic. Targeted threats are unpredictable and come with little too no warning. Though no major events have happened in Greene County, they are happening all over the nation and will continue to be a threat for the planning area. Mitigation solutions include trainings for staff who work in schools or large workplaces, secure entrances in schools and exercises for staff and students in schools. Many school districts created projects mitigating targeted violence. These projects can be found in the Mitigation Strategy Section of this Mitigation Plan.

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3.6.9 Human Caused Hazard: Waste

HAZARD PROFILE

Hazard Description

More than 40 million tons of hazardous waste is produced in the United States each year. It may be produced by large industrial facilities (e.g. chemical manufacturers) or small businesses (e.g. dry cleaners). It is estimated that a city with a population of 100,000 will discharge the following quantities into city drains each month:

- 23.5 tons of toilet bowl cleaner;
- 13.5 tons of liquid household cleaner; and
- 3.5 tons of motor oil.



These substances will eventually enter the local water systems. Because waste can easily infiltrate and harm the environment, the Environmental Protection Agency (EPA) closely work with local agencies to ensure the wastes are properly treated and disposed of. Hazardous waste has the potential to irreversibly damage the environment.

The EPA defines waste as an unwanted substance or material. Before waste can be classified as hazardous, it must be defined as a solid waste. A solid waste includes any discarded material that is abandoned by being disposed of, burned or incinerated, recycled or considered "waste-like". A solid waste can physically be a solid, liquid, semi-solid or container of gaseous material.

There are three common sources of hazardous waste:

1. Agriculture: Pesticides and herbicides; fluoride wastes (by-products of phosphate fertilizer production); and soluble nitrates from manure may dissolve into groundwater and contaminate groundwater drinking wells and cause health problems.
2. Medical: "Sharps" or needles, scalpels and glassware; outdated and unused drugs; testing laboratories' chemical waste; and radioactive isotopes.
3. Household: Toxic paints; flammable solvents; caustic cleaners; toxic batteries; pesticides; drugs; and mercury from broken fever thermometers.

Categories of Waste

There are three official categories of known hazardous waste. They are:

- The F-List (Non-Specific Source Wastes): Wastes from common manufacturing and industrial processes, like solvents, that are used in cleaning or degreasing operations. They're listed as non-specific sources because they can occur in different sectors of industry.
- The K-List (Source-Specific Wastes): Wastes from specific industries, like petroleum refining or pesticide manufacturing. Sludge and wastewater from treatment and production processes are examples of source-specific wastes.

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- The P-List and U-List (Discarded Commercial Chemical Products): These lists include specific commercial chemical products in an unused form. For example, some pesticides and pharmaceutical products become hazardous wastes when discarded.

Properties of Waste

Waste that is not specifically listed on the above-referenced categories may still be considered a hazardous waste if it exhibits one of the following four characteristics:

- Ignitability: Wastes that can create fire under specific conditions, are spontaneously combustible or have a flash point less than 60°C (140°F).
- Corrosivity: Wastes that are acids or bases and are capable of corroding metal containers like storage tanks, drums and barrels (e.g. battery acid).
- Reactivity: Unstable under “normal” conditions. They may cause explosions, toxic fumes, gases or vapors when heated, compressed, or mixed with water (e.g. lithium-sulfur batteries and explosives).
- Toxicity: Wastes that are harmful or fatal when ingested or absorbed (e.g. contains mercury or lead). When land-disposed, waste may reach and pollute groundwater.

Mixed Waste

In addition to solid waste being hazardous, the waste may also be classified as mixed waste, which means it includes radioactive components. The treatment of mixed waste is complex. Most commercially mixed waste is classified as low-level mixed waste, which means it has low-levels of radioactivity and low-levels of hazardous substances. The United States Department of Energy identifies three types of mixed waste:

- Low-Level Mixed Waste (LLMW): Waste generated from research, development and production of nuclear weapons.
- High-Level Mixed Waste (HLW): Waste generated from reprocessing spent nuclear fuel and irradiated targets from reactors. This waste often includes highly-corrosive components, organics or heavy metals regulated by the RCRA.
- Mixed-Transuranic (MTRU): Contains radioactive elements heavier than uranium and a hazardous waste component.

Classification of Waste Disposal Sites

CLASS	DESCRIPTION
1	Sites that are causing or presenting an imminent danger of causing irreversible or irreparable damage to the public health or environment – immediate action required.
2	Sites that are a significant threat to the environment – action required.
3	Sites that do not present a significant threat to the public health or environment – action may be deferred.
4	Sites that have been properly closed – require continued management.
5	Sites that have been properly closed with no evidence of present or potential adverse impact – no further action required. (Any site listed as Class 5 will be removed from the registry according to state law).

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Geographic Location

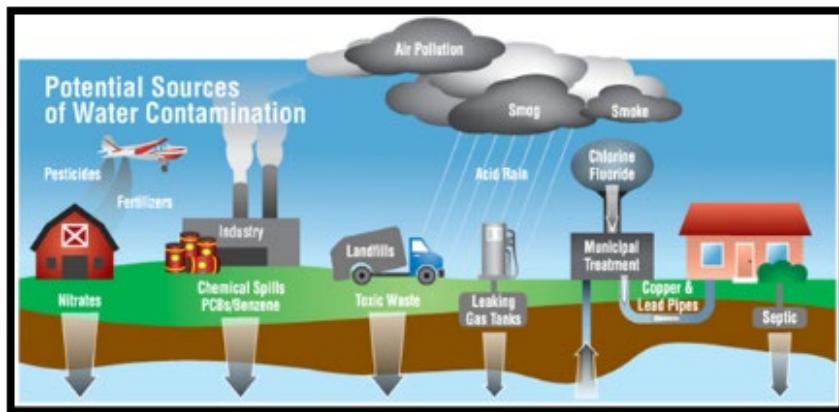
There are multiple waste sites throughout Greene County including: Ash Grove, Springfield, Strafford and Willard. Please see the critical facility appendix for specific locations.

Strength/Magnitude/Extent

Missouri homes, businesses and industry generate millions of tons of solid waste annually. While landfill disposal continues to be an option, new disposal facilities face strong public examination and are costly to site, build and operate. The department is constantly seeking alternatives to landfill disposal that are both environmentally protective and cost-effective for the consumer. Solid waste management permitting, monitoring and enforcement efforts can prevent illegal dumping and other factors that may cause long-term social, economic and environmental problems.

Environmental

Groundwater and soil are the most frequently affected pathways that facilitate the general public's interaction with hazardous waste. The Groundwater Foundation explains that groundwater contamination occurs when man-made products (e.g. gasoline, oil, road salts, etc) get into the groundwater making it unsafe or unfit for human use. Some major sources of these products/contaminants include storage tanks, septic systems, hazardous waste sites, landfills and the use of road salts, fertilizers, pesticides and other chemicals. Soil contamination is the presence of man-made chemicals or other alterations to the natural soil environment. The primary concern regarding soil contamination is health risks either directly (e.g. residences, parks or schools) or indirectly (via water contamination) facilitated. Once the water or soil is contaminated, there is a greater chance that the environment and habitats, both animal and human, may experience the detrimental effects associated with hazardous waste.



Health

Health effects caused by exposure to hazardous waste may be acute or chronic. Acute effects are felt within 24 hours of exposure and include skin burns and disfigurement from substances (e.g. contact with battery acid). Chronic effects are gradual and occur from a repeated exposure over an extended period of time. Carbon monoxide leakage may cause headaches and concentration problems, allergic reactions may occur from cleaning productions; most of the chronic health effects are liver and/or kidney damage, central nervous system damage, cancer and birth defects.

Previous Occurrences

In 1983, Times Beach, Missouri, was completely evacuated due to a dioxin scare that made national headlines; it was the largest civilian exposure to dioxin in the United States. The town was plagued with dust problems throughout the 1970's because it lacked funding to pave the 23 miles of dirt roads. The town hired a waste hauler to oil the roads to reduce the volume of dust. The oil contained high levels of dioxin; soil samples identified dioxin levels 100 times higher than one part per billion that is considered hazardous to humans. Dioxin can cause many

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health problems including but not limited to: chlorine, sarcoma, thyroid disorders, diabetes and endometriosis. The government bought out the town for \$32 million. The total cost for clean-up of the area, which included incinerating debris and soil from the town and surrounding areas, was \$110 million. The government paid \$100 million and \$10 million was supplemented by a company responsible for the contaminated oil.

Probability of Future Occurrence

The probability for hazards in Greene County is determined using Calculated Priority Risk Index (CPRI). It is unlikely for a large waste event to occur within the next ten years in Greene County. For a full description of the CPRI for waste, refer to Appendix B.

Changing Future Conditions and Considerations

Climate change will not affect waste disposal in Greene County.

VULNERABILITY

Vulnerability Overview

A hazardous materials waste incident could cause health and environmental damage to Greene County. The severity of the incident could cause small amounts of property damage. There is typically no warning time with this hazard and it could take days to clean up depending on how large the incident was.

In Springfield, there are two licensed infectious waste transporter facilities, Stericycle Inc. and Sunbelt Environmental Services. Many other licensed waste transporters may be pass through Greene County to reach their destination.

Waste Disposal Sites in Greene County

SITE NAME	SITE LOCATION	CLASSIFICATION	AGENCY INVOLVED	SITE DESCRIPTION
HCI Chemtech	Springfield	Class 2	EPA	A chemical distribution facility has operated at the site since 1975.
Syntex	Springfield	Class 3	EPA/DNR	An active chemical manufacturing facility.
Solid State Circuits	Republic	Class4	DNR	Solid State Circuits Site (SSC) .5 acres in downtown Republic
Sac River Landfill	Springfield	Class 4	EPA	An inactive landfill adjacent to the Fulbright Lanfill; industrial waste containing hazardous materials and heavy metals were deposited during the landfill's operation.
Fulbright Landfill	Springfield	Class 4	EPA	Located in the South Dry Sac River flood plain, north of Springfield.

Former manufactured Gas Plants

Industrial gas plants generate coal tar as the gas is manufactured from coal. Coal tar is composed of thousands of different chemicals, but coal tar is composed of potentially carcinogenic polycyclic hydrocarbons and volatile

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organic compounds. Cyanide and other metals may also be on site. There is one former manufactured gas plant site located in Greene County, the Springfield Gas & Electric Company.

Smelter Sites

Smelting is a process that is used to produce a metal from its ore. Smelting uses heat and a chemical reducing agent to change the oxidation state of the metal ore. The chemical agent removes the oxygen from the ore to leave the metal. For the past 150 years, the state of Missouri has been one of the world's largest producers of lead and zinc metals. The lead and zinc ores were mined, milled by crushing and separation, and then transferred to smelters to be processed into raw materials. The most common contaminants found at smelter sites include lead, zinc, cadmium, barium, nickel and chromium. The contamination is most frequently caused by dust escaping from the furnace in the smokestacks during the production process. The Slogdill & Wilson Furnace in Brookline, Missouri, is the only site listed in Greene County by the Missouri Department of Natural Resources.

Wood Treatment Inventory

Wood preserving is used to extend the life of wood products, especially if the products are used in the construction, railroad and utilities industries. The preservation provides long-term protection from weather, fungi, insects and marine borders. Mismanagement of wood preservation chemicals has caused significant contamination of soil and groundwater at various locations. There are two wood treatment sites in Greene County. The Kerr-McGee Chemical Corporation and the Robert E. Lee Lumber Site are both located in Springfield.

Brownfields

Like most communities, Springfield has properties that are abandoned or under-used. These properties are called Brownfields, and are located in both rural and urban areas. From former lumberyards to old, abandoned feed mills, Brownfields can be found across Greene County. Brownfields are cause for concern because there may be the presence, or potential presence, of a hazardous substance, pollutant or contaminant. Environmental testing is conducted to determine if an environmental threat is present.

One of Greene County's greatest success stories is Jordan Valley Park located in Springfield. Prior to developing the park, there was a 300-acre former industrial area in downtown Springfield. Now, instead of vacant factories and used-car dealerships, there is a 12-acre public park and an ice area, including an arts center, an Exposition Center and a minor league baseball stadium.

Potential Losses to Existing Development

According to the Missouri State Hazard Mitigation Plan, cost information pertaining to water quality improvement and protection efforts is difficult to calculate exactly, but can be estimated to some degree. While the Department tracks its own programmatic costs, those representatives of municipal, private, and industrial treatment facility operations, and in some cases, the implementation of BMPs, are typically not readily available. Economic benefits, in monetary terms, resulting from water protection efforts are even more difficult to calculate. An overview of the amount of funding the department spends on various aspects of water pollution control and prevention includes the following:

- USGS ambient water quality monitoring network: \$1.2 million annually. Annual costs for permit issuance averaged approximately \$2.96 million for fiscal years 2014 and 2015. On average, approximately \$7.6 million is spent each year for other facets of water pollution control and administrative support.
- Non-Point Source (NPS): \$3.9 and \$3.8 million was spent on NPS projects in state fiscal years (SFYs) 2014 and 2015, respectively. Approximately \$200,000 is awarded annually for planning such projects.
- Soil and Water Conservation Program: an average of \$24.1 million each year is distributed directly to landowners to address agricultural NPS pollution and to conserve and protect the quality of water resources in agricultural landscapes. Over FFYs 2014 to 2015, a total of \$48.3 million was spent on SWCP conservation practices aimed at reducing soil runoff from farmland.

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- Missouri's Clean Water State Revolving Fund (CWSRF) makes low interest loans available to eligible recipients for designing and constructing publicly-owned wastewater systems and other eligible projects including, but not limited to, stormwater infrastructure, non-point source projects, and water conservation or reuse.

Impact of Previous and Future Development

As the population and growth continues in Greene County, so does the amount of waste that is produced. According to the Missouri State Hazard Mitigation Plan, Throughout the State, continuing suburban development impacts streams in several ways. Shortening and culverting of channels leads to the direct loss of streams and riparian areas. The increase in impervious surface area in the surrounding watershed leads to unnatural hydrograph patterns, with lower baseflow and higher stormflow. The altered channel and higher peak flows can increase erosion, while the runoff from the impervious surface carries increased levels of sediment and various chemicals from the urban environment. Elevated nutrient levels or bacterial contamination is also likely if individual or community domestic sewage systems are not well maintained.

EMAP Consequence Analysis

EMAP Impact Analysis: Waste

SUBJECT	DETERRIMENTAL IMPACTS
Public	A waste incident creates many safety concerns for the public. Injuries and illnesses are likely, and possibly death if exposed to hazardous waste.
Responders	First responders will have proper equipment and training to handle a waste incident. The safety measures may create a delay of some response functions.
Continuity of Operations	Waste incidents would have little to no impact on the delivery of services in Greene County.
Property, Facilities, and Infrastructure	Greene County would experience minor isolated instances of property damages in the event of a hazardous waste incident. Waste incidents would have little to no impact on facilities and infrastructure damages.
Environment	Hazardous waste is very harmful to the environment. Water contamination also occurs from this type of incident.
Economic Condition of Jurisdiction	Waste incidents would have little to no impact on the economy.
Public Confidence in the Jurisdiction's Governance	Waste incidents could have a minor effect of loss in public confidence, depending on the situation; and if the government is at fault.

*For more details on Consequence Analysis, refer to Appendix B.

Hazard Summary by Jurisdiction

There are many waste facilities located within the planning area. As listed above, many of the waste facilities are located in Springfield. Springfield also has a denser population that could be affected if a major waste incident would occur. Jurisdiction along I-44 would also be at risk if a waste spill were to happen during transportation.

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PROBLEM STATEMENT

There are many instances where hazardous waste can affect the environment with considerable consequences to either air or water. Waste incidents can also affect public health. Waste incidents come with no warning time and can be difficult to clean up. Though Greene County has not experienced a disaster involving waste, it still is a potential threat to our area. Mitigation solutions for waste are difficult but include, identifying strategies to expedite the removal of disaster related waste, evaluate the community's recycling programs, and finding opportunities for source reduction. No participating community chose a waste related mitigation solution in this hazard mitigation plan.

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3.7.1 Other Hazard: Animal Disease

HAZARD PROFILE

Hazard Description

Animal diseases are diseases that do not typically affect human beings directly. They do, however, have very negative effects on food supplies and the economy. Transboundary animal diseases (TADs) are defined as epidemic diseases which are highly contagious or transmissible and have the potential for very rapid spread, irrespective of national borders, causing serious socio-economic and possibly public health consequences. TADs are a serious threat to the livelihood of livestock farmers and the economy in general. They can threaten food security, result in major production losses, increase the cost of livestock due to costly disease control measures, inhibit trade, and cause serious environmental consequences. A characteristic of transboundary animal diseases (TADs) is that they themselves can be the cause of national emergencies and, as this manual demonstrates, their significance often transcends national boundaries. It is imperative therefore, wherever possible, to limit the socio-economic disruptions resulting from outbreaks of TADs.

Cattle (Bovine)



Cattle bred for meat production are commonly referred to as beef cattle. Beef is a meat product that is high in protein, iron, zinc and B-vitamins. Cattle bred for milk production are referred to as dairy cattle. Dairy products fall into two major categories, fluid milk and manufactured products, such as cheese, yogurt and butter. Cattle and calves are considered to be one of the most valuable agriculture commodity produced by Missouri. In addition, Missouri has traditionally ranked second nationally in relation to number of cattle operations. Missouri also ranks

second in the nation in beef production with 4.25 million head of cattle on 59,000 operations and 15th in milk production with over 1.6 billion pounds of milk produced. In Greene County alone, there are approximately 68,606 cattle and calves on 1,225 farms as inventoried by the Census of Agriculture in 2017. There are approximately 37,691 beef cows on 1,073 farms and 664 milk cows on 29 farms.

Cattle Diseases

Anaplasmosis, also known as yellow bag or yellow fever, is an infectious parasitic disease caused by *Anaplasma phagocytophiliun*. This parasite infects the red blood cells in cattle and results in severe anemia, weakness, fever, decreased appetite, depression, constipation, decreased milk production, jaundice, abortion, and death. Adult animals are most susceptible to this disease; symptoms become progressively severe and death often occurs. Transmission of this disease occurs primarily through vectors (including ticks, horseflies, and mosquitoes), but can also occur through contaminated farming tools (such as ear tagging). Once an animal becomes infected with anaplasmosis, they become a carrier of the disease for life and become a source of infection to vulnerable cattle. Because vectors carry the disease, it can also be transmitted to humans through tick bites. Symptoms usually occur 1-2 weeks after infection and are characterized by fever, headache, muscle pain, malaise, chills, nausea, abdominal pain, cough, confusion, and rash. The number of anaplasmosis cases reported to the CDC has increased steadily since the disease became reportable from 348 cases nationwide in 2000, to 1761 cases in 2010. The fatality rate in humans has remained low, at less than 1%. Although information was not found regarding prevalence in animals, increased prevalence in humans indicates a high probability for increased incidence in animals. The impact of anaplasmosis on the community is great. It can lead to human infection and economic losses due to decreased milk production, severe weight loss, poor reproductive ability, abortion, and death.

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Bovine Leukosis Virus (BLV) is a virus that targets lymphocytes in beef and dairy cattle and leads to Bovine lymphosarcoma. Infection is often present without any manifestations, but lymphocytosis (an abnormal increase in white blood cells in the blood) may occur. Bovine Leukosis Virus impairs the immune system and leaves animals vulnerable to other infectious diseases. Malignant tumors are present in 1-5% of all infected cows which may result in protruding eyeballs, weight loss, enlarged lymph nodes, gastrointestinal obstructions, paralysis in the hind limbs, and/or infertility. BLV is typically transmitted in the blood of infected cattle, but can also be transmitted in saliva, semen, and milk. Common needles, blood contaminated syringes, rectal palpation, and drug vials may all be causes of infection. Diagnosis of BLV is performed by testing serum for virus-specific antibodies. Prevalence studies by the National Animal Health Monitoring System (NAHMS) revealed that in 1996, at least one BLV infected cow was found in 89% of the 1,000 farms who participated in the study and an average of 40% of tested cows were infected in the Midwest. The study also showed that larger herds were more likely to both test positive for infection and have a higher percentage of infected cattle. In 2007, a NAHMS prevalence report indicated that BLV may be present in at least 70-80% of Michigan dairy cattle and 83.9% of U.S. dairy operations. BLV can cause significant losses to farmers including increased replacement costs, loss of income from condemned carcasses of full cows, reduced reproductive efficiency, and decreased milk production. The NAHMS study determined that BLV infected herds produce \$59 less in annual production per cow, which equates to 3% less milk. These losses can be substantially more with a higher prevalence of infection within a herd. For example, the average annual cost in a 100 cow herd with a 50% prevalence rate was nearly \$6,400. The Bovine Leukosis Virus Free Program exists in Missouri to help reduce economic losses by decreasing the prevalence of BLV in Missouri's cattle.

Brucellosis (a.k.a. Bang's disease or contagious abortion) is an infectious disease of cattle caused by the *Brucella abortus* bacteria. Although it can also be found in sheep, goats, rams, dogs, rodents, and pigs, it causes the biggest threat to cattle. This disease causes abortions, sterility, reduced milk production, placenta retention, and weak calves. It can also cause epididymitis, seminal vesiculitis, orchitis, and testicular abscesses in bulls. Chronic Brucellosis can result in recurrent fever, arthritis, or udder infection. Death is rare except in the fetus or newborn, and pregnancies are generally normal after the first abortion; thus, the main impact of this disease is economic. Transmission of *Brucella abortus* occurs due to contact with infected birth tissue (such as aborted fetuses or fetal fluid/membranes) or fluids (such as vaginal discharges, semen, urine, and milk). It can also be transmitted by ingestion, direct contact with mucous membranes or breaks in the skin, or fomites (contact with an infected object such as equipment, hay, feed, or water). Brucellosis is also infectious to humans through ingesting contaminated milk products or through direct contact with an infected animal. Indications of Brucellosis in humans include flu-like symptoms (fever, night sweats, headache, and back pain), arthritis, and recurrent fever. The economic impact of this disease can be seen through cost of medications and vaccines, production costs (mandatory testing, reduced milk production, increased abortions, decreased fertility, and non-viable or slow growing calves), replacement costs if a herd is infected, delay in the sale of animals, reduced population (due to abortions), and potential food safety issues. Cattle are required to be tested for Brucellosis upon change of ownership, on the farm and at livestock markets, and at slaughter and exhibitions. Brucellosis is close to being eradicated from the United States, with the exception being bison and elk in the Greater Yellowstone Area. Missouri was classified as a Brucellosis Free state in March 2004.

Johne's disease is a chronic, contagious bacterial disease that affects the small intestines of ruminants such as cattle, sheep, goats, deer, antelope, and bison. It is caused by *Mycobacterium paratuberculosis*. Infection occurs when the bacterium embeds itself into the ileum of the ruminant and an immune response occurs leading to thickened intestinal tissue and decreased absorption of nutrients. Clinical manifestations include weight loss despite a normal appetite, diarrhea, decreased milk production, increased incidence of mastitis, prolonged calving interval, emaciation, and eventual death. Several weeks after the onset of diarrhea, intermandibular edema (bottle jaw) may occur due to protein loss from the bloodstream into the digestive tract. Death is imminent at this point. Transmission occurs through the fecal-oral route via infected manure, through bacteria passed in milk/colostrums, or in utero. The incubation period for this bacterium is long; symptoms of the disease are rarely evident until two or more years after infection. Most animals are exposed to the bacterium shortly after birth, when they are most

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vulnerable to infection. Because Johne's disease can be a herd problem, a Johne's Voluntary Control Program exists to help lower prevalence of the disease. A 2007 NAHMS study of 82.5% of U.S. dairy cows found that 17.4% of small operations (less than 100 cows), 35% of medium operations (100-499 cows), and 34.1% of large operations (500 or more cows) confirmed Johne's disease in their herd during the previous 12 months. The impact of Johne's disease includes decreased milk production (of approximately 675 pounds in 305 days), production losses up to 10% for each affected animal, premature culling, reduced fertility, and reduced slaughter value. This can account for losses of approximately \$1,062 per infected 50-head herd.

Trichomoniasis is a venereal disease of cattle caused by a protozoan parasite called *Tritrichomonas foetus*. While it was virtually unheard of before 2005, it is now becoming a common problem in the Midwest. *Tritrichomonas foetus* is found in the reproductive tract of bulls and cows and is transmitted during breeding from the bull to the cow. Infected cows will experience infertility and early embryonic death, causing the cow to return to heat and subsequently leading to poor pregnancy rates and an extended breeding season. Transmission of this organism during breeding can decrease the calf crop by as much as 50% during the breeding season. The disease is often asymptomatic in bulls while a mild vaginal discharge 1-3 weeks after becoming infected can be seen in cows. The majority of infected cows will clear the disease given 120-150 days of sexual rest. However, immunity is short-lived and re-infection is common because bulls frequently remain carriers for life. Currently, there is no immunization or treatment for Trichomoniasis. This disease can have a severe impact on an agrarian culture due to the devastating financial impact of poor calf crops, infertility, low pregnancy rates, an extended calving season, occasional abortions in cows, and expenses associated with cleaning up an infected herd. This disease began to be a problem in Missouri in 2010 and by 2012, 172 bulls tested positive for Trichomoniasis. In 2013, due to mandated testing for Trichomoniasis in Missouri, only 13 bulls tested positive which equates to a 70% reduction in infection. Missouri is now considered a leading state in Trichomoniasis management due to their scientific approach to identifying, controlling, and eradicating the disease. Regulations require that all non virgin bulls and bulls over the age of 24 months be tested for Trichomoniasis. Positive bulls are sent to slaughter and the herd of origin for the Trichomoniasis positive bull will be quarantined or sent to slaughter. This disease should continue to be monitored due to increased numbers of infected cattle in surrounding states (Kansas) and the severe impact it could have in Missouri.

Tuberculosis (TB) is a contagious disease caused by *Mycobacterium bovis* (*M. Bovis*) that affects cattle, bison, elk, and deer. Tuberculosis by *Mycobacterium bovis* can be transmitted to humans by eating or drinking contaminated, unpasteurized dairy products; through direct contact with a wound; or by inhaling the bacteria in air exhaled by animals infected with *M. bovis*. Symptoms of human infection by *M. bovis* include fever, night sweats, and weight loss. Individuals who work in close contact with cattle, bison, or cervids are at increased risk for developing TB by *M. bovis*. However, this only accounts for approximately 2% of confirmed cases of TB in the United States. There have been several incidences of *M. bovis* causing TB in humans in Southern California, and it has been determined that this is likely originating from infected cattle in Mexico. The Cooperative State-Federal Tuberculosis Eradication Program has nearly eliminated *M. bovis* in livestock in the United States. However, it can still be found in wild animals, such as bison, elk, and deer. Missouri has been considered tuberculosis free in cattle since 1986. However, tuberculosis will remain a potential threat to Missouri's cattle population until it is completely eradicated.

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Hogs



Hogs are a source of high quality animal protein in the form of common meat products such as ham, pork chops, pork sausage and bacon. By-products from hogs play a vital role in maintaining the quality of human life. For example, insulin from hogs is used to treat human diabetes; heart valves are used to replace damaged human heart valves; and hog skin is used to treat severe burn victims. Hogs and pigs constitute one of Missouri's top 5 most valuable agriculture commodities and pork is one of Missouri's top 5 agriculture exports. In fact, Missouri is the 6th largest hog-producing state in the nation with an inventory of nearly three million hogs and pigs. In Greene County there are approximately 382 hogs and pigs on 50 farms.

Hog Diseases

Porcine Epidemic Diarrhea Virus (PEDV) is a coronavirus that affects swine. It causes diarrhea, vomiting, dehydration, and death in 50-100% of infected piglets (especially pigs younger than 10-14 days old). While adult pigs can become infected, death typically doesn't result. Transmission occurs through direct and indirect fecal-oral route. It can be transferred via feces from infected pigs, trucks, boots, clothing, and other contaminated fomites. Incubation only last 12-24 hours and the virus can be shed for 7-10 days. Although this disease

is a serious threat to swine, transmission to humans has not been seen and there are no associated food safety concerns. This is a very serious disease that has been found around the world for more than 30 years. However, the first case was seen in the United States on May 17, 2013. From April 1, 2013 to July 29, 2013, 254 pigs tested positive for PEDV. Positive cases were found in 14 states including Iowa, Minnesota, Illinois, Oklahoma, Ohio, Kansas, Missouri, North Carolina, New York, and Michigan. Infection has been increasing since it was introduced to the United States. On February 15, 2014, a study showed that there were over 300 new cases occurring per week in the United States. This disease could cause major implications for Missouri including decreased hog production, increased morbidity and mortality in piglets, and increased price of pork products for consumers. In the past two years, nearly 8 million piglets died from this disease, which equals approximately 10% of the nation's hog population. While this disease caused major economic implications last year (pork cost \$154.45/cwt), spread of the virus is finally starting to be controlled and pork prices are expected to drop (back to an average of \$99/cwt)

Pseudorabies (PRV), also known as Aujeszky's disease, is a swine disease that can also affect cattle, horses, dogs, cats, sheep and goats. The disease is caused by an extremely contagious herpes virus that causes reproductive problems, including abortion, and stillbirths, and even occasional deaths in breeding and finishing hogs. Missouri has been recognized as pseudorabies free since May 1999, thanks to the cooperation and support of Missouri's swine producers and industry leaders.

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Poultry

Poultry includes domesticated fowl such as chickens, turkeys, ducks, and geese. They are typically valued for their meat and eggs. Turkey constitutes one of Missouri's top 5 agricultural commodities. Greene County alone has over 250 poultry farms and sells over 12,000 broiler and other meat-type chickens each year.



Poultry Diseases

Avian influenza is a disease caused by the Avian Influenza A virus that occurs in poultry (such as chickens, turkeys, pheasants, quail, domestic ducks, geese, and guinea fowl). It is transmitted by infected birds through saliva, nasal secretions, feces, or contact with surfaces/materials that have been contaminated by the virus. Avian influenza can be either "low pathogenic" and spread without any noticeable signs or symptoms, or be "highly pathogenic" and spread rapidly throughout an avian population. In fact, this form could cause mortality rates of 90-100% within 48 hours. On March 10, 2015, the United States Department of Agriculture's Animal and Plant Health Inspection Service confirmed the presence of highly pathogenic H5N2 in two different commercial turkey flocks in Missouri. Although Avian Influenza can be transmitted to humans, the CDC considers the risk to be low; no human infections by H5N1 have been detected at this time. While risk of virulence to humans is low, Avian Influenza could pose a huge threat to poultry farms in southwest Missouri in regards to both economy and food supply.

Pullorum Disease is an infectious disease in poultry caused by *Salmonella pullorum*. It is an acute systemic disease of young chicks and poultts that results in a very high mortality (potentially approaching 100%) within the first 2-3 weeks of age. Transmission occurs by direct or indirect contact with infected birds, through infected parents to young birds via the egg, or through contaminated feed, water, or litter. Although the disease may be seen in all birds, birds younger than four weeks old are most commonly affected. Affected birds huddle near a heat source, are anorectic, appear weak, experience labored breathing, and have a white diarrhea pasted around the vent. Most birds die shortly after hatching. Antibiotic treatment is not recommended because birds may become carriers; control is usually by testing and the removal of infected birds. While this disease was once common, it has now been eradicated from most commercial chicken stock in the USA. However, a risk for infection still exists because it may be seen in other avian species and backyard or hobby flock. The commercial poultry industry is free of pullorum disease after years of dedicated efforts by the states and poultry producers. However, outbreaks of pullorum disease occasionally occur and these outbreaks re-enforce the need for ongoing pullorum surveillance to maintain Missouri's federally granted Pullorum-Typhoid Clean State status. The last outbreak in Missouri was in 2004 and resulted in the direct depopulation of all poultry on 5 Missouri farms and 2 farms in Kansas. Infected poultry were shipped to 11 other states. These shipments resulted in testing and eradication costs for the customers and state agencies and may have potentially resulted in spreading Pullorum disease to clean poultry farms.

Other Diseases

Campylobacteriosis is a contagious disease caused by *Campylobacter* spp. found in both humans and animals that can cause enteritis, abortions, and infertility. It is commonly seen in cattle, sheep, poultry (broiler chickens), cats, dogs, mink, ferrets, and pigs. Transmission occurs via direct contact with infected animals, ingestion of fecally contaminated feed/water (fecal oral route), or by licking/chewing on objects contaminated with feces from infected animals (fomites). It can also be spread to other animals/humans by vectors (rodents or flies). Sheep and cattle may become infected after contact with infected animal feces, vaginal discharge, aborted fetuses, or fetal membranes. Human consumption of contaminated or undercooked poultry and other meats, raw milk or other

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dairy products, contaminated vegetables, or contaminated water can cause transmission to humans. It can also be spread person-to-person. *Campylobacter* can be shed in stool for 2-7 weeks if left untreated and can survive for weeks in water and up to 20 days in soil. Symptoms of the disease can be seen within 3 days of transmission such as diarrhea, decreased appetite, vomiting, fever, and death in severe cases. In cattle, *Campylobacter fetus* can cause bovine genital campylobacteriosis which is indicated by infertility, early embryonic death, and prolonged calving season. *Campylobacter jejuni* can cause late term abortions, stillbirths, and weak offspring in sheep, goats, and cattle. When transmitted to humans, *Campylobacter jejuni* causes diarrhea, fever, nausea, vomiting, abdominal pain, headache, and muscle pain. In 2011, 919 counts of Campylobacteriosis were documented in humans.

Rabies is a severe viral disease that can affect all mammals and can be transmitted to humans. This disease affects the central nervous system and almost always leads to death once symptoms develop. Although all mammals may become infected by the disease, only a few (including dogs, coyotes, wolves, foxes, raccoons, jackals, skunks, and bats) act as reservoirs. Rabies is usually transmitted through saliva when an infected animal bites another animal. However, any contact with infected saliva or neurological tissues through mucous membranes or breaks in the skin can lead to infection (such as consuming infected animals). Transmission can occur from an infected animal before symptoms are present; skunks can spread the virus for up to 14 days before symptoms are present. Signs and symptoms of rabies include fearfulness, restlessness, anorexia or increased appetite, vomiting, diarrhea, low-grade fever, pupil dilation, hyperreactivity to stimuli, and excessive salivation. Infection in a vaccinated animal can be seen by lameness in the vaccinated leg. Animals also often have temperament changes where they either become unusually aggressive or unusually affectionate. After 2-5 days, the paralytic or furious form of rabies is evident. Paralytic rabies is characterized by progressive paralysis, including the throat and masseter muscles. Symptoms include profuse salivation, inability to swallow, hoarse howling, facial paralysis, ataxia, and incoordination or paralysis. Death usually occurs after 2-6 days from respiratory failure. Furious rabies is characterized by restlessness, wandering, howling, polypnea, drooling, and attacks on other animals or people. Death usually occurs during a seizure 4-8 days after appearance of symptoms. Vaccinations are available for both animals and humans to prevent rabies transmission.

Reportable Animal Diseases

The following table includes reportable diseases that must be reported to the state or federal officials within 24 hours of suspicion or diagnosis. Although this information is required to be reported, records have not been able to be obtained showing incidences of the various diseases in Missouri.

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Reportable Communicable Diseases

Aquaculture (Fish)	Avian (Poultry, chickens, turkeys, birds)	Bovine (Cattle and Bison)	Caprine (Goat) - Ovine (Sheep)
Infectious salmon anemia	Avian infectious encephalomyelitis	Bovine babesiosis (Texas Fever, piroplasmosis)	Foot-and-mouth disease
Spring viremia of carp	Infectious laryngotracheitis	Foot-and-mouth disease	Goat and sheep pox
	Avian influenza (High pathogenic, H5, H7)	Rinderpest (cattle plague)	Heartwater
	Newcastle disease (VVND)	Bluetongue	Peste des petits ruminants (kata)
		Bovine spongiform encephalopathy (BSE)	Rift Valley fever
		Contagious bovine pleurpneumonia	Scabies
		Heartwater	Scrapie
		Rift valley fever	
		Trichomoniasis	
Cervidae (Elk and Deer)	Equine (Horses)	Porcine (Swine, pigs and feral swine)	All Species
Chronic Wasting Disease (CWD)	African Horse sickness	African swine fever	Anthrax
Foot-and-mouth disease	Babesiosis (piroplasmosis)	Classical swine fever (Hog cholera)	Brucellosis
	Contagious equine metritis	Foot-and-mouth disease	Pseudorabies
	Dourine (equine trypanosomiasis)	Swine vesicular disease	Rabies
	Eastern equine encephalomyelitis		Screwworm
	Equine infectious anemia (EIA)		Tuberculosis
	Equine piroplasmosis		Vesicular stomatitis
	Equine rhinopneumonitis		
	Equine viral arteritis		
	Glanders		
	Venezuelan equine encephalomyelitis		
	Western equine encephalomyelitis		
		Missouri Department of Agriculture http://agriculture.mo.gov/animals/health/disease/comdisease.php	

Geographic Location

All agricultural and urban areas in Greene County are susceptible. Diseases are not typically bound by geographic distributions, so any animal can be affected by proximity to another infected animal.

Strength/Magnitude/Extent

Animal diseases have the potential to affect both the economy and public health.

Economics

An animal disease outbreak could be devastating to our economy. In 2012, Greene County had a livestock inventory of 55,424 cattle and calves and a market value of agriculture products valued at \$41,468,000. In 2008, Missouri ranked second in the nation in beef production with 4.25 million head of cattle on 59,000 farms and 15th in milk production with over 1.6 billion pounds of milk produced. Hogs, pigs, and turkeys also constitute one of Missouri's top 5 most valuable agriculture commodities, and pork is one of Missouri's top 5 agriculture exports. Missouri is the 6th largest hog-producing state in the nation with an inventory of nearly three million hogs and pigs. The U.S. Census of Agriculture shows that in Greene County alone as of 2012, there are approximately 55,242 cattle on 1,124 farms, 291 hogs and pigs on 18 farms, and over 172 poultry farms which sells over 6,154 broiler and other meat-type chickens each year.

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Health

Impact from an animal disease outbreak could lead to the following:

- The compromise of food security through serious loss of animal protein and/or loss of draught animal power for cropping.
- Cause major production losses for livestock products such as meat, milk and other dairy products, wool and other fibers and skins and hides.
- Cause losses of valuable livestock of high genetic potential.
- Restrict opportunities for upgrading the production potential of local livestock industries by making it difficult to import exotic high-producing breeds that are extremely susceptible to TADs.
- Add significantly to the cost of livestock production since costly disease control measures need to be applied.
- Seriously disrupt or inhibit trade in livestock, germplasm and livestock products, either within a country or internationally. Their occurrence may cause public health consequences where diseases can be transmitted to humans (i.e. zoonoses); cause environmental consequences when wildlife populations die out; and cause unnecessary pain and suffering for many animals.

This type of incident could cause multiple deaths in animals and humans as well as cause major economic losses. However, because most animal infectious diseases have associated screening and control processes, the potential severity can be diminished. Although many animals may still become infected, protocols regarding control and prevention of spread can limit the number of exposed animals. While a wide-spread animal disease outbreak in Greene County Missouri would be catastrophic, a small scale outbreak would be manageable and result in minimal losses when compared to a large scale spread.

Knowing where diseased, exposed, and at-risk animals are located; where they've been; and when they may have been in contact with others is very important for ensuring a quick, effective response in the event of an animal disease event. Animal disease traceability helps reduce the impact of disease investigations to both animals and producers. Depending on the relative location of the first case of disease, it is very possible to get warning time. If an infectious disease is nearby geographically, measures can be taken to prevent the spread of the disease, look for signs and symptoms of disease transmission, and prevent adverse effects. However, it is also possible to receive no warning time at all. Many diseases are only discovered after they have killed a large portion of animals or resulted in severe adverse effects within an animal population.

Previous Occurrences

Midwest Region 1996

Bovine Leukosis Virus (BLV) is a virus that targets lymphocytes in beef and dairy cattle impairing the immune system and leaving the animal vulnerable to other infectious diseases. BLV can cause significant losses to farmers including increased replacement costs, loss of income from condemned carcasses, reduced reproductive efficiency, and decreased milk production. In 1996, 40% of cattle were infected with this disease in the Midwest. In 2007, a NAHMS prevalence report indicated that BLV may be present in at least 70-80% of Michigan dairy cattle and 83.9% of U.S. dairy operations. The Bovine Leukosis Virus Free Program exists in Missouri to help reduce economic losses by decreasing the prevalence of BLV in Missouri's cattle.

Missouri 2004

Brucellosis is an infectious disease that affects cattle, sheep, goats, rams, dogs, rodents, and pigs. It results in abortions, sterility, reduced milk production, placenta retention, weak calves, problems with reproductive organs, recurrent fever, arthritis, and udder infection. This disease is zoonotic and can be transmitted to humans by ingesting contaminated milk products or through direct contact with an infected animal. The impact of this disease includes the economic burden associated with the cost of medications and vaccines, production costs,

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replacement costs if a herd becomes infected, delay in sale of animals, reduced population of animals, and potential food safety issues. Missouri was classified as a Brucellosis Free state in March 2004, but a small risk continues to exist due to existence of Brucellosis in wild bison and elk in the Greater Yellowstone Area.

Pullorum disease is an acute systemic disease of young chicks and pouls that results in a very high mortality (potentially reaching 100%) within the first 2-3 weeks of age. The commercial poultry industry is free of pullorum disease after years of dedicated efforts by the states and poultry producers. However, the disease may still exist in other avian species and backyard or hobby flock. The last outbreak in Missouri was in 2004 and resulted in the direct depopulation of all poultry on 5 Missouri farms and 2 farms in Kansas. Infected poultry were shipped to 11 other states. These shipments resulted in testing and eradication costs for the customers and state agencies and may have potentially resulted in spreading Pullorum disease to clean poultry farms.

Missouri 2007

Anaplasmosis is an infectious parasitic disease of cattle that results in severe anemia, weakness, fever, decreased appetite, depression, constipation, decreased milk production, jaundice, abortion, and death. This is a zoonotic disease that can be transmitted to humans. In 2010, 1761 cases of Anaplasmosis were reported nationwide. In 2007, five Missouri residents died from Anaplasmosis. Missouri's rates of Anaplasmosis have been consistently higher than the national rates since 1998. The impact of this disease on the community includes human infection and economic losses due to decreased milk production, severe weight loss, poor reproductive ability, abortion, and death.

Missouri 2008

Johne's Disease is a chronic, contagious bacterial disease that affects the small intestines of ruminants such as cattle, sheep, goats, deer, antelope, and bison. Manifestations of this disease include weight loss despite a normal appetite, diarrhea, decreased milk production, increased incidence of mastitis, prolonged calving interval, emaciation, and eventual death. A 2007 NAHMS study of 82.5% of U.S. dairy cows found that 17.4% of small operations (less than 100 cows), 35% of medium operations (100-499 cows), and 34.1% of large operations (500 or more cows) confirmed Johne's disease in their herd during the previous 12 months. The impact of Johne's disease includes decreased milk production (of approximately 675 pounds in 305 days), production losses up to 10% for each affected animal, premature culling, reduced fertility, and reduced slaughter value. This can account for losses of approximately \$1,062 per infected 50-head herd. The Johne's Voluntary Control Program exists in Missouri to help reduce prevalence of the disease. In 2008, the Missouri Department of Agriculture's Animal Health Division reported that 12,177 cows, representing 360 cattle herds in Missouri, were tested for Johne's disease and 99 animals tested positive.

Missouri 2011

Campylobacteriosis is a contagious disease found in both humans and animals that can cause enteritis, abortions, and infertility. It is commonly seen in cattle, sheep, poultry, cats, dogs, mink, ferrets, and pigs. In 2011, 919 counts of Campylobacteriosis were documented in humans. This is the most up-to-date information that is available at this time. No information has been found regarding number of incidences of Campylobacteriosis in animals.

Missouri 2013

Trichomoniasis is a disease caused by a protozoan parasite that affects the reproductive ability of cattle (infertility and embryonic death result from infection). This disease results in poor calf crops, infertility, low pregnancy rates, an extended calving season, occasional abortions in cows, and increased expenses associated with cleaning up an infected herd. This disease began to be a problem in Missouri in 2010, and by 2012, 172 bulls tested positive for Trichomoniasis. In 2013, due to mandated testing, only 13 bulls tested positive, which equates to a 70% reduction in infection.

Missouri 2014

Porcine Epidemic Diarrhea Virus (PEDV) is a coronavirus that affects swine. It causes diarrhea, vomiting,

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dehydration, and death in 50-100% of infected piglets. The first case was seen in the United States on May 17, 2013. From April 1, 2013 to July 29, 2013, 254 pigs tested positive for PEDV. Positive cases were found in 14 states including Iowa, Minnesota, Illinois, Oklahoma, Ohio, Kansas, Missouri, North Carolina, New York, and Michigan. Infection has been increasing since it was introduced to the United States. On February 15, 2014, a study showed that there were over 300 new cases occurring per week in the United States. In the past two years, nearly 8 million piglets died from this disease, which equals approximately 10% of the nation's hog population. While this disease caused major economic implications last year (pork cost \$154.45/cwt), spread of the virus is finally starting to be controlled and pork prices are expected to drop (back to an average of

Missouri-Christian County 2015

Rabies is a severe viral disease that can affect all mammals and can be transmitted to humans. This disease affects the central nervous system and almost always leads to death once symptoms develop. In 2011, there were 29 instances of animal Rabies in Missouri, the lowest prevalence recorded in the last 15 years. In 2014, that number decreased even further with 27 confirmed cases. On March 31, 2015, a dead skunk in Christian County, Missouri tested positive for Rabies. Due to possible transmission through a bite, two household dogs were euthanized as a precaution.

Rabies Incidents-Missouri

Year	Total Rabies
2018	20
2017	20
2016	20
2015	31
2014	27
2013	39
2012	28

Source: Missouri Department of Health and Senior Services

Probability of Future Occurrence

The probability for hazards in Greene County is determined using Calculated Priority Risk Index (CPRI). It is likely for a small animal disease incident to occur within the next three years in Greene County. For a full description of the CPRI for animal disease, refer to Appendix B.

Changing Future Conditions and Considerations

Climate change, in particular global warming, is likely to greatly affect the health of animals, both directly and indirectly. Direct effects include temperature-related illness and death and the morbidity of animals during extreme weather events. Indirect impacts follow more intricate pathways and includes those deriving from the attempt of animals to adapt to thermal environment or from the influence of climate on microbial populations, distribution of vector-borne diseases, host resistance to infectious agents, feed and water shortages, or food-borne illness. Climate change may also affect the abundance and/or distribution of the competitors, predators, and parasites of vectors themselves, thus influencing patterns of disease.

Health stress can increase mortality and cause metabolic diseases in production animals. It can also reduce fertility, feed intake and immunological response. These cases tend to result in decreased production of pigs and chickens, which are especially vulnerable to raised temperatures, as increased mortality may result if supplemental cooling is not provided.

The impacts of climate change on livestock disease may be very complex and studying them needs to go well beyond any simple assessment of rainfall and temperature effects on distribution.

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VULNERABILITY

Vulnerability Overview

Transboundary animal diseases are highly contagious and easily transmitted within and between livestock populations. They therefore threaten the economic health of the livestock sector, the livelihood of farmers, and ultimately food security.

According to Jens F. Sundstrom, Microbial pollution is defined as pollution with pathogens, including bacteria, viruses and parasites. The pathogens may be zoonotic, i.e., affecting both humans and animals, or species specific and may enter agricultural systems in various ways. They can be borne by polluted water or by organic material that is used as fertilizer. Pathogens of animal origin can accumulate in the environment following an outbreak of disease of the kind resulting in large amounts of pathogen-contaminated animal waste (e.g. manure or carcasses). Such waste might contaminate water sources, or the land on which the waste is collected, stored, buried or subsequently spread as fertilizer. Hence, microbial pollution of an agricultural environment can pose health risks to both humans and animals and may render agricultural activity impossible.

All animals and humans within Greene County are vulnerable to experiencing the health or economic effects that animal diseases could cause if not resolved quickly.

Potential Losses to Existing Development

Animal Disease could cause large economic loss to Greene County if not controlled quickly. As of 2017, Greene County had 1,225 livestock and poultry farms, totaling over 68,000 animals. A large animal disease outbreak could cause devastating loss to one or multiple farms within the planning area. According to Drovers, one beef cow can sell from \$600-\$800 each. If five beef cows were to be infected with an animal disease, one farm could lose up to \$4,000 in profit.

Impact of Previous and Future Development

Land degradation is a long-term loss of ecosystem function and services caused by disturbances from which the system cannot recover unaided. The degradation can be caused either by natural phenomena or by human activities, and of course land degradation of natural origin can be reinforced by the action of man.

Greene County has a large amount of livestock production which continues to grow. As farms continue to grow and expand their inventory, the risk of experiencing animal diseases also increases. Much of the land in Greene County has not been developed yet and has the potential to be used for additional farming.

3 - RISK ASSESSMENT

EMAP Consequence Analysis

EMAP Impact Analysis: Animal Disease

SUBJECT	DETՐIMENTAL IMPACTS
Public	An animal disease could cause illness and death if the disease is transmitted to humans. However, deaths from animal disease are rare. This would cause multiple safety concerns when around animals, or potential infected produce.
Responders	An animal disease outbreak would cause potential life threatening safety issues to responders. Diseases that can spread from animal-to-person may be passed on to a responder. Additionally, if responders become ill response function will be impacted greatly.
Continuity of Operations	Delivery of services has had no reports of animal diseased impact operations or delivery of services.
Property, Facilities, and Infrastructure	Minor property damage may occur on farms if equipment becomes contaminated. Hospitals, veterinary clinic, and first responders would be overwhelmed. Grocery stores that get food from a local farm or butcher will also be greatly impacted in a large-scale event. Multiple infrastructure sectors will be impacted through-out the planning area. Animal diseases would have little to no impact on facilities.
Environment	The wildlife in the area can be affected by animal diseased in many ways. Illness, infertility and death can cause extinction or a large decline in populations. The could become widespread. Animal diseases can cause widespread significant damage to agriculture. Animal diseases create a loss of livestock, animal power and pain and suffering to animals.
Economic Condition of Jurisdiction	An animal disease could have a major economic impact with widespread loss due to the fact that Greene County's economy is so dependent on agriculture. Diseased animals would cause a great loss in profits, and it would be expensive to replenish livestock, euthanize the ill, and dispose of the diseased properly.
Public Confidence in the Jurisdiction's Governance	The government is seen as a responsible for providing food and medical opportunities to the community. Lack of food and availability of hospitals would create a significant loss in public confidence of the government.

* For more details on Consequence Analysis, refer to Appendix B.

Hazard Summary by Jurisdiction

All jurisdictions within Greene County have livestock present. The entire planning area is at risk for experiencing effects from animal diseases. The effects could either be health or economic. Farm owners are more vulnerable in experiencing direct effects from a localized animal disease issue. Larger contaminations would have a greater effect on the county and surrounding areas.

3 - RISK ASSESSMENT

PROBLEM STATEMENT

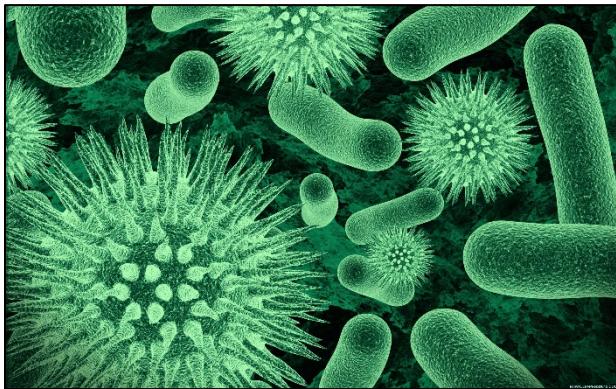
Though Greene County has not experienced a large animal disease incident, the county has large amount of livestock population that is a risk for being infected. Animal diseases can have effects on human health if not controlled and caught quickly. Large incidents could cause large financial loss to individual farms and Greene County's economy. Animal diseases come with no warning time and can last months. They can also take the lives of both animals and humans. Mitigation solutions for Animal disease could be difficult, but focusing on mitigating the transmission could be beneficial. Other solutions could be, ensuring large farms have adequate hygiene, training on symptoms of diseases and vaccination of animals. No participating jurisdiction created a project for mitigating animal disease.

3 - RISK ASSESSMENT

3.7.2 Other Hazards: Communicable Disease

HAZARD PROFILE

Hazard Description



Communicable diseases are spread from person to person or animal to person. It can be spread via airborne, bacteria, blood or other bodily fluid. In some cases zoonotic infections (infections in humans acquired from an animal source) result in severe disease or even death in humans, but often these infections result in only a mild illness or appear to cause no illness at all. All human infections with animal influenza viruses are of concern, not only because of the cases of disease and deaths in individual people, but also because if these viruses become able to spread from human to human they could spark a pandemic. All

of the past four pandemic influenza viruses have contained gene components originating in animals. An outbreak is a sudden rise in the incidence of disease or persons infected within the same community within a short period of time, typically 3 months. This hazard encompasses endemics, epidemics, and pandemics.

- **Endemic-** An endemic is a disease or illness that is contained to one town or geographical area.
- **Epidemic-** An epidemic is the spread of disease or illness within the community/surrounding areas or country that could range several hundreds of miles.
- **Pandemic-** A pandemic is the spread of disease or illness between two or more countries.

Low and High Pathogenic

The difference between low pathogenic and high pathogenic influenza viruses is their ability to cause mortality. Most strains are classified as low pathogenic avian influenza (LPAI) and cause few clinical signs in infected birds. High pathogenic avian influenza (HPAI) causes severe and extremely contagious illness and death among infected birds. While LPAI does not pose health threats to humans, some HPAI strains can be infectious to people. While LPAI does not pose known health risks to humans, it does have the potential of mutating into an HPAI strain.

Ebola

The Fruit bats of the Pteropodidae family are natural Ebola hosts. Transmission is obtained through contact with bodily fluids of infected animals (eg. ill or dead). Although transmission begins as animal to human, once a human begins showing symptoms of the illness, human to human transmission is possible. The human to human transmission is via direct contact (eg. through broken skin or mucus membranes) with blood, secretions, organs or other bodily fluids of infected individuals present with symptoms. It can take from 2 to 21 days once a person has been exposed to an infected person to present with symptoms themselves. Symptoms are sudden onset of fever, fatigue, muscle pain, headache, sore throat, vomiting, diarrhea, rash, impaired liver and kidney function, and possible internal and external bleeding. The average fatality rate for Ebola is 50% and has varied in the past from 25% to 90% depending on the outbreak. There is currently no cure for this disease according to World Health Organization (WHO) and the only way of controlling the spread is by community engagement through management, surveillance, contact tracing, good laboratory service, proper and safe burials, and social mobilization.

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Tuberculosis

Tuberculosis (TB) is caused by a bacterium known as *Mycobacterium tuberculosis*. This bacterium typically attacks the lungs but can affect any part of the body such as the brain, spinal cord, and kidney. If it is not treated properly it can lead to death. Tuberculosis was once the leading cause of death in the United States. Tuberculosis is airborne and is spread from one person to another through coughing, sneezing, speaking and singing. Tuberculosis can be a Latent TB Infection or TB disease. The latent form means that the person has the bacterium living within their lungs but does not actively present with any symptoms. This form may at any point go from latent to active when a person's immune system is weakened, the bacterium multiplies, and the person starts to present with symptoms. People actively have the TB infection when their immune system cannot make the bacterium stop growing and they become sick within weeks. Treatment for Tuberculosis is currently a six to nine month process with a varying range of antibiotic regimen.

Mycobacterium bovis (Bovine Tuberculosis) is a type of bacterium that can cause tuberculosis in humans but is most commonly found in bison, elk and deer. Further details are provided on the animal disease hazard.

Seasonal Influenza

Influenza is a contagious respiratory illness caused by influenza viruses. It can cause mild to severe illness. Respiratory illness spread from person to person. Seasonal Influenza typically occurs between October and April in 5-20% of the U.S. Population.

Pandemic Influenza

A global outbreak caused by a new strand of virus never seen before by the human population; rarely happens; would significantly impact the global economy. Pandemic Influenza would likely cause millions of deaths globally due to individuals not being immune to the strand, unavailable vaccinations, and a limited supply of medicine.

Meningitis

Meningitis is a disease that causes infection of the meninges, membranes that cover the brain and spinal cord. There are five types of meningitis: bacterial, viral, parasitic, fungal and non-infectious. The severity of the illness and treatment differs depending on the cause.

TYPE OF MENINGITIS	TRANSMISSION	HOW IT IS TRANSMITTED
Bacterial	Contagious	Through the exchange of respiratory and throat screens
Viral; enteroviruses	Person to Person	Spread through fecal contamination for example: Diaper changes, not properly using hand hygiene techniques, Enteroviruses: can be spread via eye, nose and mouth secretions or blister fluids.
Fungal	Non Contagious	Inhaling fungal spores
Parasitic	Rare form- swimming in lakes or rivers with <i>Nagleria fowleri</i> (Parasite)	
Non-Infectious	Caused by cancers, systemic lupus erythematosus, certain drugs, head injury and brain injury	Not spread from person to person caused by other attributes of person's medical condition that lead to infection of brain and spinal cord.

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Meningitis outbreaks can occur within a community, school, college, prison, or other population. An outbreak happens when several persons become infected over a short period of time, typically three or more individuals with the same strain. There is currently a vaccine for Meningococcal Disease that is recommended for those at high risk of contracting the disease.

Lyme

Lyme disease, or borreliosis, is an infectious disease caused by at least three species of bacteria belonging to the genus *Borrelia*. *Borrelia burgdorferi* is the predominant cause of Lyme disease in the United States. Symptoms include fever, headaches, fatigue, depression, and a target-shaped skin rash known as erythema migrans. If untreated, Lyme disease may affect the joints, heart, and nervous system. Transmission is relatively rare, with only 1% of recognized tick bites resulting in Lyme disease. Experts believe the rate is so low because a tick needs to be attached for at least 24 hours for transmission to occur, and most individuals find the ticks before that time period expires. Lyme disease is difficult to diagnosis, especially in later stages, because the disease has symptoms that mimic other disease. Lyme disease may be misdiagnosed as multiple sclerosis, rheumatoid arthritis, fibromyalgia, chronic fatigue syndrome (FS), or lupus. Lyme diseases may be prevented on a regional level by reducing the deer population that ticks depend on for reproductive purposes. This tactic has been successful in Monhegan, Maine and Mumford Cove, Connecticut. It is recommended to have 8 to 10 deer per square mile, but most populations have 60 deer per square mile. By reducing the number of deer in an area, the tick population may be too low to spread Lyme disease and other tick-borne diseases.

Malaria

Malaria is a serious and potentially fatal disease that is transmitted from mosquito to human. It is a parasite that infects the mosquito is a host to this parasite. When a person is infected, he or she will present with high fevers, chills, and flu-like symptoms. Malaria was first eliminated from the United States in the 1950's and in 2011 it has reached a 40 year high of 1,925 cases. The Center for Disease Control and Prevention (CDC) has estimated that approximately 1,500-2,000 cases are reported every year in the United States.

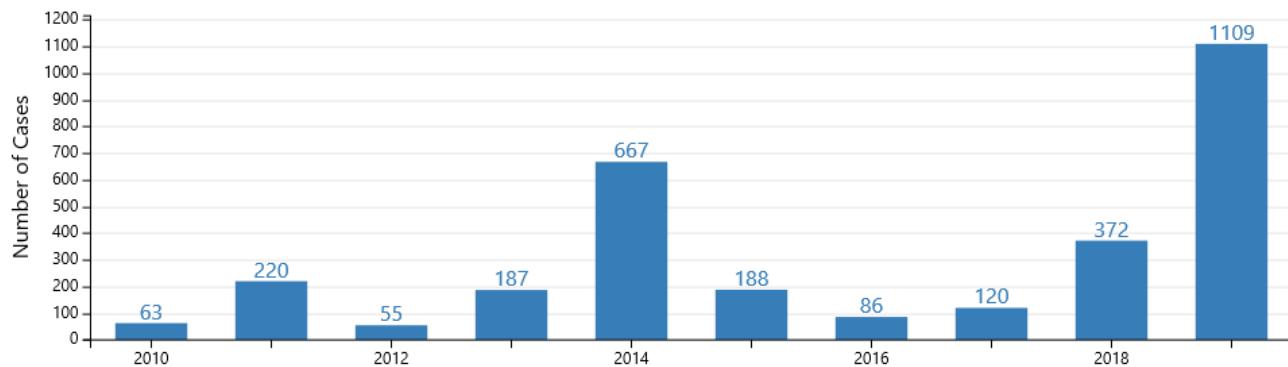
West Nile is transmitted to humans by mosquito according to the CDC. Of those infected with the virus, 70-80% will not become symptomatic. For the people that present with symptoms, 1 out of 5 people will show outward signs of fever, headache, body ache, joint pains, vomiting, diarrhea, or rash. Most people do recovery quickly but symptoms of fatigue can last for several months. In cases that symptoms are more severe is in less than 1% and they will develop a neurologic illness.

Measles

Measles is a highly infectious airborne illness caused by a virus. The disease is spread by coughing and sneezing but can also be transmitted by direct contact with infected nasal or throat secretions. This illness is prevented and often kept under control through the vaccination of children at 12 months and 4 years of age with the MMR vaccine. Those infected usually do not begin showing symptoms until 10 days after exposure. Signs and symptoms of the illness include fever, a severe cough, conjunctivitis, small white spots on the oral mucosa, and a rash lasting 3 or more days. According to the CDC, the United States documented measles as eliminated in 2000. However, in the last 20 years Measles have made a comeback across the nation. Many Measles outbreaks have occurred over the last several years including 17 outbreaks in 2018. Three outbreaks in New York State, New York City, and New Jersey. The cases mostly occurred in unvaccinated people.

3 - RISK ASSESSMENT

Number of Measles Cases reported by Year 2010- July 3rd, 2019



Source: Centers for Disease Control

Foodborne Illnesses

While the United States Food and Drug Administration (FDA) reports the American food supply is among the safest in the world, the United States Federal Government estimates that there are more than 48 million cases of food-borne illness each year that cause approximately 128,000 hospitalizations and 3,000 deaths.

BACILLUS CEREUS	CAMPYLOBACTER
Common Name: B. cereus, food poisoning	Common Name: Campylobacteriosis
Onset Time after Ingestion: 10-16 hours	Onset Time after Ingestion: 2-5 days
Signs and Symptoms: Abdominal cramps, diarrhea, nausea.	Signs and Symptoms: Cramps, fever, vomiting, and diarrhea
Duration: 24-28 hours	Duration: 2-10 days
Food Sources: Meats, stews, gravies, vanilla sauce.	Food Sources: Raw and undercooked poultry, unpasteurized milk, contaminated water.

CLOSTRIDIUM BOTULINUM	CRYPTOSPORIDIUM
Common Name of Illness: Botulism	Common Name of Illness: Intestinal cryptosporidiosis
Onset Time after Ingestion: 12-72 hours	Onset Time after Ingestion: 2-10 days
Signs and Symptoms: Vomiting, diarrhea, blurred vision, double vision, difficulty swallowing, muscle weakness. Can result in respiratory failure and death.	Signs and Symptoms: Diarrhea, stomach cramps, upset stomach, slight fever.
Duration: Variable	Duration: May be remitting and relapsing over weeks to months.
Food Sources: Improperly canned foods, especially home-canned vegetables, fermented fish, baked potatoes in aluminum foil, bottled garlic.	Food Sources: Undercooked food, contaminated water or food contaminated by an ill food handler.

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CYCLOSPORA CAYETANENSIS	E. COLI (ESCHERICHIA COLI)PRODUCING TOXIN
Common Name of Illness: Cyclosporiasis	Common Name of Illness: E. coli infection
Onset Time after Ingestion: 1-14 days, usually at least 1 week.	Onset Time after Ingestion: 1-3 days
Signs and Symptoms: Diarrhea, loss of appetite, substantial loss of weight, stomach cramps, nausea, vomiting, fatigue.	Signs and Symptoms: Diarrhea, abdominal cramps, vomiting.
Duration: May be remitting and relapsing over weeks to months.	Duration: 3-7 or more days
Food Sources: Various types of fresh produce (imported berries, lettuce, basil).	Food Sources: Water or food contaminated with human feces.

E.COLI 0157:H7	HEPATITIS A
Common Name of Illness: Hemorrhagic colitis or E. Coli Infection	Common Name of Illness: Hepatitis
Onset Time after Ingestion: 1-8 Days	Onset Time after Ingestion: 28 days average (10-15 days)
Signs and Symptoms: Severe diarrhea, abdominal pain and vomiting. Can lead to kidney failure.	Signs and Symptoms: Diarrhea, dark urine, jaundice, and flu-like symptoms.
Duration: 5-10 Days	Duration: variable; 2 weeks to 3 months
Food Sources: Undercooked beef (especially hamburger), unpasteurized milk and juice, raw fruits and vegetables and contaminated water.	Food Sources: Raw produce, contaminated drinking water, undercooked foods and cooked foods that are not heated after contact with an infected food handler; shellfish from contaminated water.

LISTERIA MONOCYTOGENES	NOROVIRUSES
Common Name of Illness: Listeriosis	Common Name of Illness: Variously called viral gastroenteritis, winter diarrhea, acute non-bacterial gastroenteritis, food poisoning and food poisoning infection.
Onset Time after Ingestion: 9-48 hours for gastrointestinal symptoms, 2-6 weeks for invasive disease	Onset Time after Ingestion: 12-48 hours
Signs and Symptoms: Fever, muscle aches, and nausea or diarrhea. Pregnant women may have mild flu-like illness, and infection can lead to premature delivery or stillbirth. The elderly or immune compromised patients may develop bacteremia or meningitis.	Signs and Symptoms: Nausea, vomiting, abdominal cramping, diarrhea, fever, headache. Diarrhea is more prevalent in adults, vomiting more common in children.
Duration: Variable	Duration: 12-60 hours
Food Sources: Unpasteurized milk, soft cheeses made with unpasteurized milk, ready to eat deli meats.	Food Sources: Raw produce, contaminated drinking water, uncooked foods and cooked foods that are not reheated after contact with an infected food handler; shellfish from contaminated waters.

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SALMONELLA	SHIGELLA
Common Name of Illness: Salmonellosis	Common Name of Illness: Shigellosis or bacillary dysentery
Onset Time after Ingestion: 6-48 hours	Onset Time after Ingestion: 4-7 days
Signs and Symptoms: Diarrhea, fever, abdominal cramps, vomiting	Signs and Symptoms: Abdominal cramping, fever, bloody diarrhea
Duration: 4-7 Days	Duration: 24-48 Hours
Food Sources: Eggs, Poultry, meat, unpasteurized milk or juice, cheese, contaminated raw fruits and vegetables.	Food Sources: Raw produce, contaminated drinking water, uncooked foods that are not reheated after contact with an infected food handler.

STAPHYLOCOCCUS AUREUS	VIBRIO PARAHAEMOLYTICUS
Common Name of Illness: Staphylococcal food poisoning	Common Name of Illness: V. parahaemolyticus infection
Onset Time after Ingestion: 1-6 hours	Onset Time after Ingestion: 4-96 hours
Signs and Symptoms: Sudden onset of severe nausea and vomiting, abdominal cramps, diarrhea and fever may be present	Signs and Symptoms: Water (occasionally bloody) diarrhea, abdominal cramps, nausea, vomiting and fever.
Duration: 24-48 hours	Duration: 2-5 days
Food Sources: Unrefrigerated or improperly refrigerated meats, potato and egg salads, cream pastries.	Food Sources: Undercooked or raw seafood (shellfish)

VIBRIO VULNIFICUS
Common Name of Illness: V. vulnificus infection
Onset Time after Ingestion: 1-7 days
Signs and Symptoms: Vomiting, diarrhea, abdominal pain, blood-bone infection. Fever, bleeding within the skin, ulcers requiring surgical removal. Can be fatal to persons with liver disease or weakened immune systems.
Duration: 2-8 days
Food Sources: Undercooked or raw seafood (e.g. oysters).

Geographic Location

Communicable diseases can spread throughout the entire planning area, including all of our jurisdictions.

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Strength/Magnitude/Extent

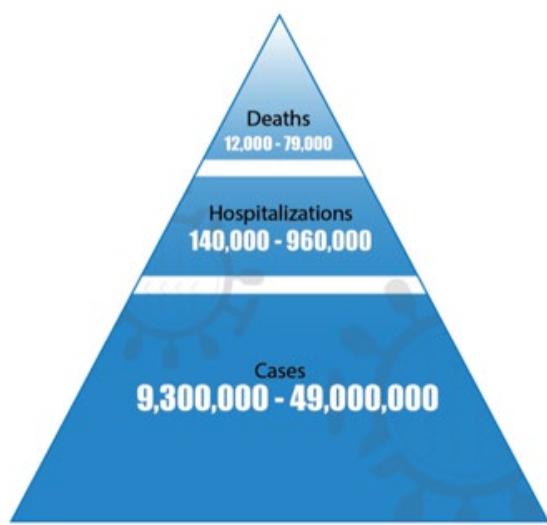
The magnitude and severity of a communicable disease often depends on several factors. The amount of people affected depends on the amount of people exposed to the pathogen and how readily the illness can be passed from one person to another. There is a direct relationship between the degree of infectivity of the pathogen and the amount of people that are affected by the illness.

While some communicable diseases are commonly expected, for example, seasonal influenza, the severity of the illness is usually not known until symptoms present. Viruses and bacteria are able to mutate and adapt over time in order to survive. This means that vaccines that may have been effective a year ago are no longer useful against the current strain.

Burden of Flu in the U.S.

The burden of influenza disease in the United States can vary widely and is determined by a number of factors including the characteristics of circulating viruses, the timing of the season, how well the vaccine is working to protect against illness, and how many people got vaccinated. While the impact of flu varies, it places a substantial burden on the health of people in the United States each year. The Centers for Disease Control estimates that influenza has resulted in between 9.3 million-49.0 million illnesses, between 140,000-960,000 hospitalizations and between 12,000-79,000 deaths annually since 2010. The flu brings fever, cough, sore throat, runny nose, muscle or body aches, headaches, fatigue and sometimes vomiting. The 2017-2018 influenza season was additionally atypical in that it was severe for all ages of the population. The burden of influenza and the rates of influenza associated hospitalization are generally higher for the very young and the very old. In the 2017-18 season alone, 79,400 deaths and over 950,000 hospitalizations.

Influenza Statistics



A global outbreak caused by a new strand of virus never seen before by the human population would significantly impact the global economy. This event would likely cause millions of deaths globally due to individuals not being immune to the strand, unavailable vaccinations and a limited supply of medicine. A pandemic would place everything on hold. Most of the population would be infected, unable to work and may not receive medication due to limited supplies. According to the CDC, several scientists believe a pandemic caused by the Avian Flu is possible. Some estimates suggest the virus could travel around the world in four days. However, scientists have had experience dealing with human infections from the Avian Influenza, thus having more time to prepare for a future global outbreak. A communicable disease

outbreak in Greene County would have many different severities depending on the disease itself. However, if current global communicable diseases were to reach Greene County, the severity would be critical with many illnesses, and shut down of critical facilities for at least 2 weeks.

3 - RISK ASSESSMENT

Estimated Influenza Disease Burden, by Season- United States, 2010-2011-2017-2018 Influenza Seasons

	Symptomatic Illnesses		Medical Visits		Hospitalizations		Deaths	
Season	Estimate	95% Cr I	Estimate	95% Cr I	Estimate	95% Cr I	Estimate	95% Cr I
<u>2010-2011</u>	21,000,000	(20,000,000 - 25,000,000)	10,000,000	(9,300,000 - 12,000,000)	290,000	(270,000 - 350,000)	37,000	(32,000 - 51,000)
<u>2011-2012</u>	9,300,000	(8,700,000 - 12,000,000)	4,300,000	(4,000,000 - 5,600,000)	140,000	(130,000 - 190,000)	12,000	(11,000 - 23,000)
<u>2012-2013</u>	34,000,000	(32,000,000 - 38,000,000)	16,000,000	(15,000,000 - 18,000,000)	570,000	(530,000 - 680,000)	43,000	(37,000 - 57,000)
<u>2013-2014</u>	30,000,000	(28,000,000 - 33,000,000)	13,000,000	(12,000,000 - 15,000,000)	350,000	(320,000 - 390,000)	38,000	(33,000 - 50,000)
<u>2014-2015</u>	30,000,000	(29,000,000 - 33,000,000)	14,000,000	(13,000,000 - 16,000,000)	590,000	(540,000 - 680,000)	51,000	(44,000 - 64,000)
<u>2015-2016 *</u>	25,000,000	(24,000,000 - 28,000,000)	12,000,000	(11,000,000 - 13,000,000)	310,000	(290,000 - 340,000)	25,000	(21,000 - 31,000)
<u>2016-2017 *</u>	30,000,000	(28,000,000 - 32,000,000)	14,000,000	(13,000,000 - 16,000,000)	580,000	(520,000 - 660,000)	51,000	(44,000 - 64,000)
<u>2017-2018 *</u>	49,000,000	(46,000,000 - 53,000,000)	23,000,000	(21,000,000 - 25,000,000)	960,000	(870,000 - 1,100,000)	79,000	(69,000 - 99,000)

Source: Centers for Disease Control

*Note: Estimates from the 2015-2016, 2016-2017, and 2017-2018 seasons are preliminary and may change as data are finalized.

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Previous Occurrences

May 20, 2014

On May 20, 2014, the Springfield-Greene County Health Department was notified that an individual working at the Red Robin restaurant on Glenstone Avenue had tested positive for Hepatitis A. The public was notified of the incident via multiple news media outlets and individuals who ate at the restaurant from May 8 to May 10 were asked to contact their healthcare provider. Vaccination clinics were held and 2,522 vaccines were administered from May 22 to May 27.

December 2014

In 2014, The United States experienced 23 measles outbreaks. During these outbreaks, 383 people were reported to have contracted the illness. A large measles outbreak began in December of 2014 when a case was traced back to an amusement park in California. The outbreak spread across several states and 59 cases were reported. Although vaccination rates are typically higher in the Midwest than either the east or west coast, an outbreak is still possible due to a growing number of unvaccinated children. The last case of measles in Springfield-Greene County occurred in 2010.

Winter 2014-2015

Influenza is a common wintertime illness and the time to get it typically begins at the end of the fall, peaks in January and February, and ends usually with the beginning of spring. In 2014 and continuing in 2015 there has been a large increase in the number of individual flu cases and hospitals have quickly become overwhelmed. During the week of December 7-13, 217 were diagnosed with the flu in Greene County and the following week had 445 cases of influenza. As of February 14, 2015, there have been 2,168 cases reported. Hospitals temporarily had to restrict visitors under that age of 14 from visiting the hospital to help reduce the number of exposures to the influenza virus.

August 2014

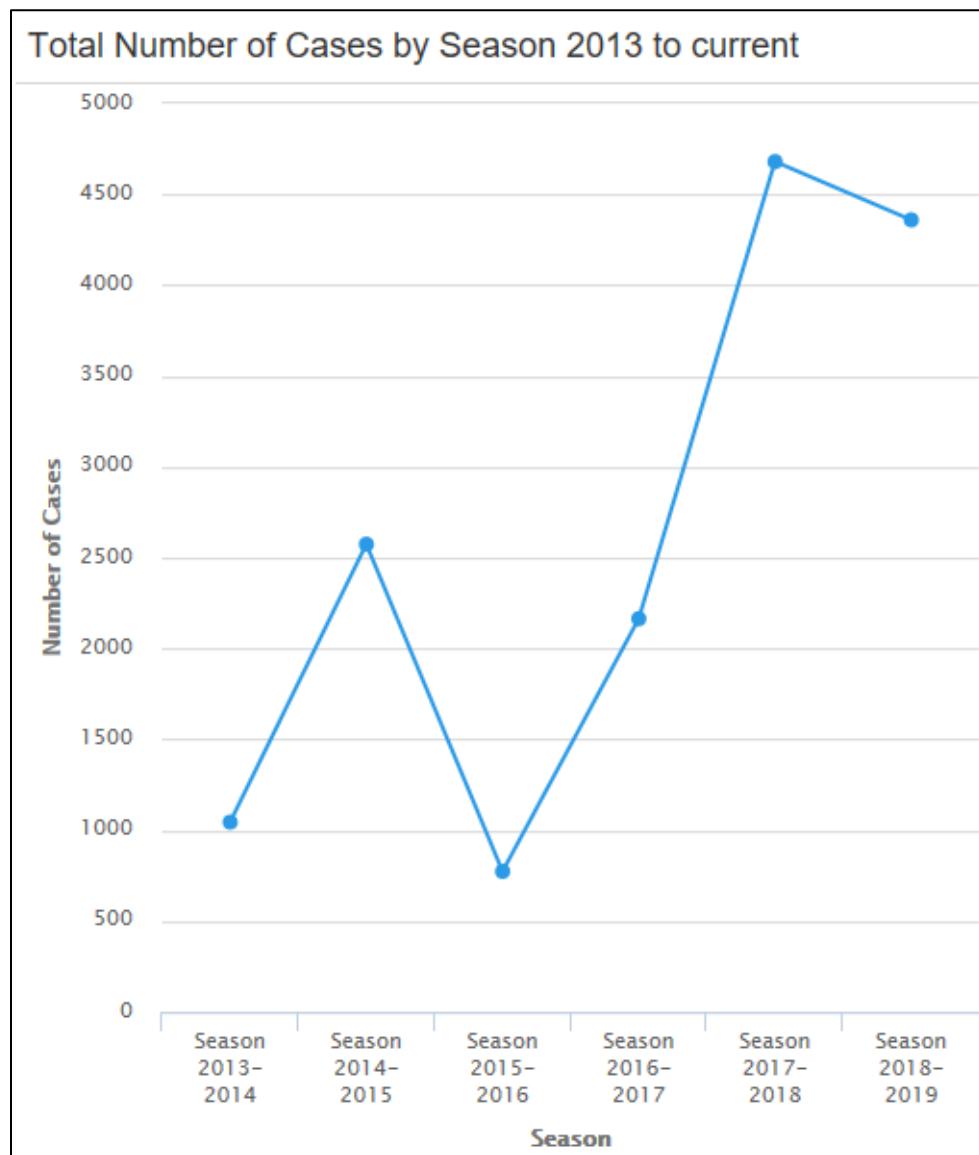
Beginning in mid-August, children across the country began coming down with symptoms of Enterovirus D68. This virus causes respiratory illness that causes fever, runny nose, sneezing, cough, and, if severe, can lead to difficulty breathing. The virus spreads when an infected person coughs or sneezes and infects another individual. Enterovirus D68 has spread across 49 states and has affected 1,153 people. There were over 300 cases of the illness in Missouri. Fourteen patients nationwide died as a result of the virus and currently no antiviral medications are available for people who are diagnosed with this virus.

September 2017-2019

Beginning in September 2017, Missouri Department of Health and Local Public Health Agencies began seeing an increased amount of cases of Hepatitis A within the State. In 2019, Missouri officially was under a Hepatitis A Outbreak. In September of 2019, the State of Missouri had 453 cases of Hepatitis A. 15 of those cases were in Greene County. Of the 453 cases, 255 were hospitalized and there were 2 deaths. No common sources of food, beverages, or drugs have been identified as a potential source of the infection. The transmission appeared to be direct person-to-person contact. Several other states are experiencing Hepatitis A outbreaks as well. Nationwide, as of September 13, 2019 there were 25,783 cases, 15,517 hospitalizations and 259 deaths from this outbreak.

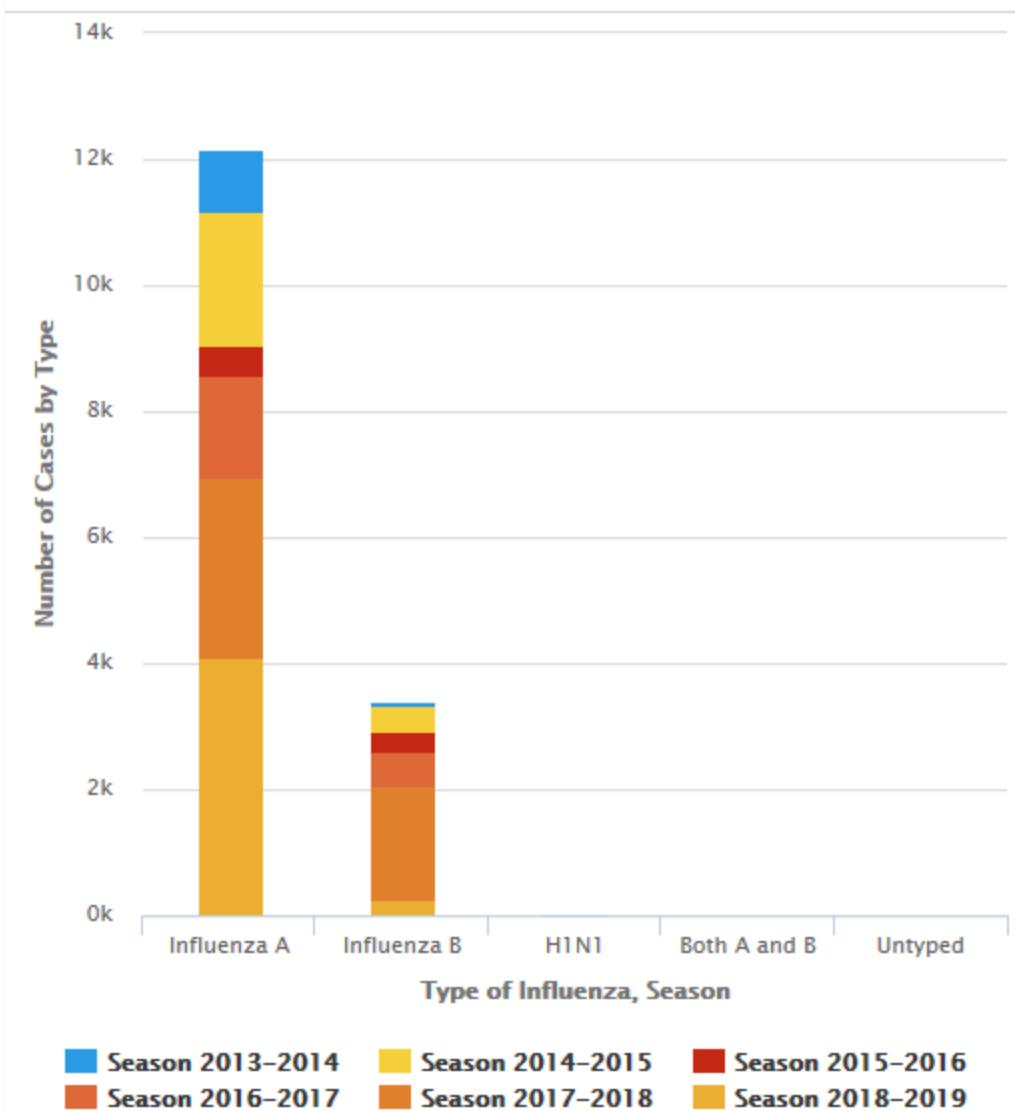
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Flu Cases for Greene County



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Number of Cases by Type of Influenza, Season



Source: Springfield-Greene County Health Department

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Probability of Future Occurrence

The probability for hazards in Greene County is determined using Calculated Priority Risk Index (CPRI). It is highly likely that a communicable disease event will occur within the next year in Greene County. For a full description of the CPRI for droughts, refer to Appendix B.

Changing Future Conditions and Considerations

According to the Missouri State Hazard Mitigation Plan, the influences of climate change on public health is significant and varied. The influences range from the clear threats of temperature extremes and severe storms to less obvious connections related to insects. Climate and weather can also affect water and food quality in particular areas, with implications for public health.

One of the diseases most at risk from climate change is malaria. This bacterial infection kills around 429,000 each year and although that number is on the decline, there are fears that in the future, climate change could help malaria spread. Malaria is transmitted to humans by mosquitoes, which are highly sensitive to climatic variations, generally requiring moist conditions, and a temperature of around 25-28 degrees centigrade to breed. Scientists suspect that rising global temperatures could cause mosquitoes to expand, and thereby increase the spread of malaria to humans.

According to Bob Jordan from Stanford News, Scientists have found that warmer temperatures increase transmission of vector-borne disease up to an optimum temperature or “turn-over point”, above which transmission slows. The good news is that higher global temperatures will decrease the chance of most vector-borne disease spreading in places that are currently relatively warm. The bad news is that warming will increase the chance that all diseases spread in places that are currently relatively cold.

VULNERABILITY

Vulnerability Overview

The entire planning area and population are vulnerable to the communicable diseases. Some of our populations are more vulnerable to experiencing a larger impact of diseases than others. Two of our most vulnerable populations for diseases are children and elderly populations.

Influenza

Populations most vulnerable to experiencing flu complications that can result in hospitalizations and sometimes death are:

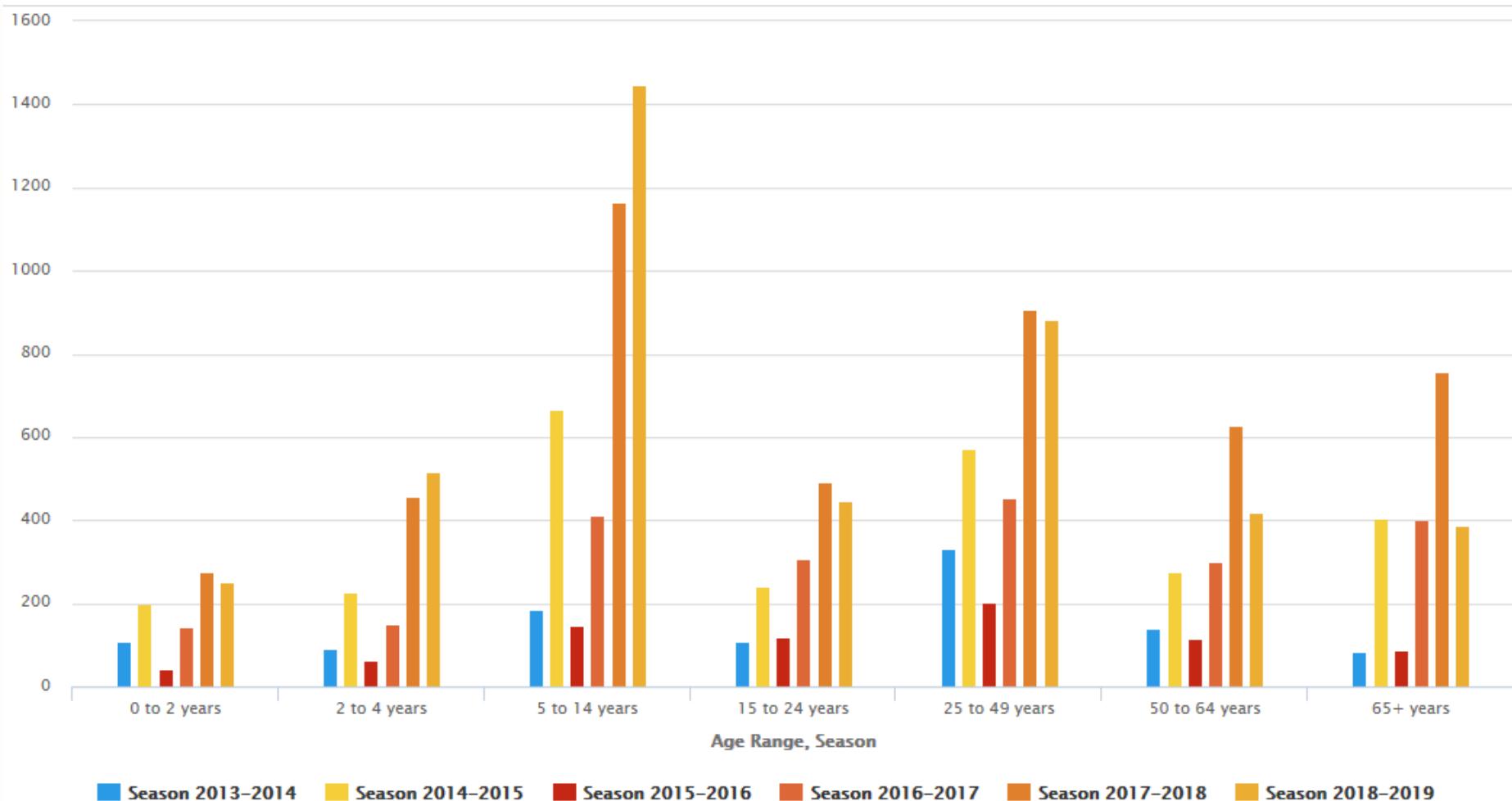
- Adults 65 Years and Older
- Pregnant Women
- Young Children
- Asthmatic Patients
- Heart Disease and Stroke Patients
- Diabetics
- Patients with HIV/AIDS
- Patients with Cancer
- Children with Neurologic Conditions

The best way to protect against flu and its potentially serious complications is to get an annual flu vaccination by the end of October.

3 - RISK ASSESSMENT

Greene County Flu Cases by Age

Number of Cases by Age Range, Season



Source: Springfield-Greene County Health Department

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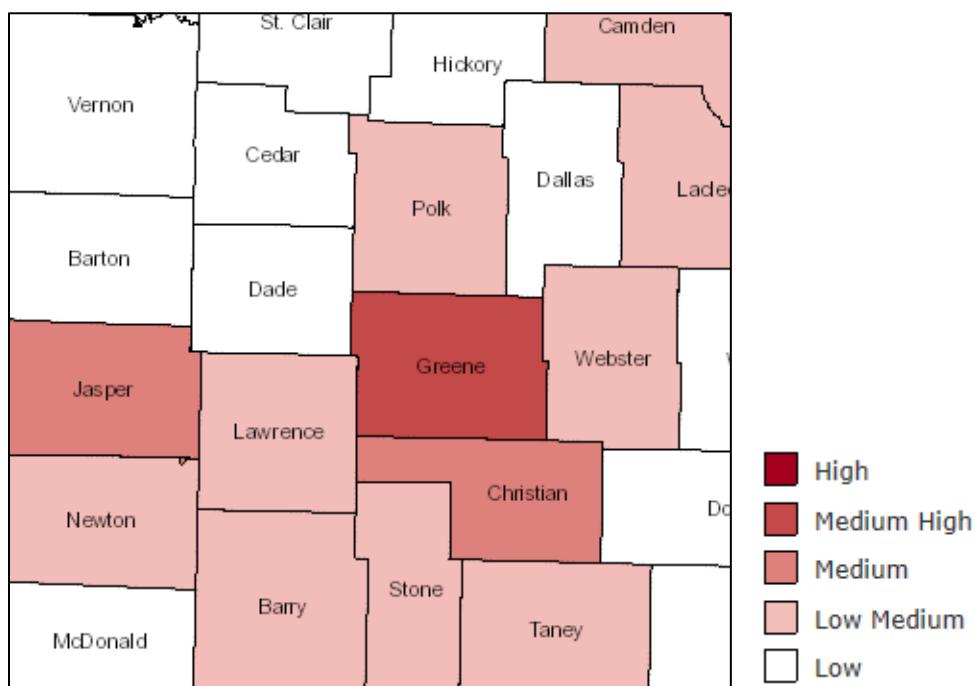
Numbers of Vulnerable Populations-Greene County 2017

Age	Number
Under 5 Years	17,513
10 to 14 years	16,654
65 to 74 Years	24,495
75-84 Years	13,496
85 Years and over	6,406

Source: U.S. Census-2017 Estimates

Currently, the Greene County Jails has 708 beds and staffs approximately 230 officers. Greene County consistently over the years has more than 708 inmates that are housed in other counties. Inmate transports happen daily and happen between multiple different counties and states. Communicable disease could spread quickly throughout the jail and be transmitted to different jail facilities while transports are taking place.

Vulnerability Pandemic Influenza



Potential Losses to Existing Development

Buildings, Infrastructure and critical facilities are not vulnerable to this hazard. It only affects persons susceptible to the illness. Communicable diseases can come with large health impacts but also large financial impacts to the economy as well. The Springfield Business Journal (2009) reported that H1N1 is impacting Missouri's pork producers. Ron Plain, professor of Agriculture Economics at the University of Missouri-Columbia explains that H1N1, after being labeled "Swine Flu" has cost U.S. pork farmers \$10 million dollars each day. Locally, Heritage Acres Foods in Pleasant Hope had to temporarily lay off 40 of its skilled production workers, or 40% of its production staff.

Health related illnesses can impact the reputation of restaurants if an outbreak, like Hepatitis A, were to come from a specific place. Diseases like this can lead to the restaurant closing down and owners taking a huge financial loss because of it.

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The lasting impacts and potential losses are largely economic and are depending on the type, extent, and duration of the illness. "A 2007 study prepared by the Trust for America's Health, a nonprofit organization dedicated to making disease prevention a national priority, developed a model to assess the potential impact of a pandemic flu on each states' workforce and how 20 key industry sectors and trade would be affected. Economic impact to Missouri was estimated to include the following:"

- Projected GDP Loss from Pandemic: \$12.4 billion
- Projected GDP Percentage Loss from Pandemic: 5.74%
- Ranking of Percentage Losses Out of 50 States (Highest = 1): 14
- Projected Impact on the Workforce: \$5.5 billion in losses
- Projected Impact on Industries: \$4.7 billion in losses
- Projected Trade Impact: \$2.2 billion in losses
- Projected Number of Lives Lost: 47,000
- Projected Number of Sick Workers (assuming 3 weeks of work lost (with 50 weeks of work per year) from those who are either ill, fear the risk of infection at work, or need to take care of sick family members): 1,717,000

Impact of Previous and Future Development

As the populations of all our jurisdictions within Greene County continues to grow, potential losses can be expected to rise. A lot of people move to Greene County and surrounding areas to build families. Greene County has excellent school districts which also draws more children to our areas. Children are some of the most vulnerable populations to communicable diseases.

As stated previously in the previous section, incarcerated people are vulnerable to communicable diseases. The Greene County Sheriff's Office is in process of building a larger jail within the county that would house more inmates in one location rather than spreading them throughout different counties. The risk for spreading communicable disease from jail to jail may decrease, but having more incarcerated people in one place also raises the risk of infection among Greene County Inmates and Staff.

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EMAP Consequence Analysis

EMAP Impact Analysis: Communicable Disease

SUBJECT	DETՐIMENTAL IMPACTS
Public	A widespread communicable disease would cause a significant impact depending on which communicable disease is affecting the community, a large number of the population would be ill and death could result to a few or many.
Responders	A communicable disease would bring many safety concerns to first responders. If a large number of the population were ill, the demand for responders would be overwhelming, especially if responders are ill.
Continuity of Operations	Delivery of services would be heavily impacted if a large number of the population becomes ill. Operation may be delayed, suspended, or overwhelmed.
Property, Facilities, and Infrastructure	A communicable disease would cause little to no property damage. Hospitals and first responders would be overwhelmed. Infrastructure owners and operators contracting the disease would impact multiple infrastructure sectors in the jurisdiction. A communicable disease could have little to no impact of facilities.
Environment	A communicable disease would create little to no impact on the environment. If wildlife becomes infected with disease, please refer to the hazard "Animal Disease"
Economic Condition of Jurisdiction	A communicable disease would create major economic impact and widespread loss. Illness would create a small workforce, and demand for many businesses would dissipate with all income going toward hospital bills and medication.
Public Confidence in the Jurisdiction's Governance	The government is seen as responsible for providing medical opportunities to the community and ultimately a cure. Long term illness and deaths would create a significant loss in public confidence of the government.

*For more details on Consequence Analysis, refer to Appendix B.

Hazard Summary by Jurisdiction

The entire planning area is at risk for experiencing communicable diseases. Communicable diseases are common within Greene County because of seasonal influenza. Though the entire planning area is at risk for experiencing communicable diseases, our most vulnerable populations are elderly and children. The jurisdictions with the most children are all of our school districts. Communicable diseases can spread quickly in schools because of the close contact children have with one another. Our jurisdictions that have the most elderly populations are Battlefield and Springfield. As of 2017, Battlefield had 944 people who were 65 and older which is 15.77% of the population. As of 2017, Springfield had 24,646 people who were 65 years and older. This is 14.87% of the population.

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PROBLEM STATEMENT

Communicable diseases can have extensive health impacts including death. Communicable diseases can also have large economic losses if not controlled quickly. Though diseases do not directly cause damage to infrastructure and critical facilities, they can have a huge impact on the planning area. Greene County experiences at least one communicable disease every year, seasonal influenza. Flu can cause the most harm to children and elderly populations but can affect everyone in the planning area. Some mitigation solutions for communicable diseases include public education, training for local government staff and Public Information Officers, strengthening the public health infrastructures, including water and sanitation systems, and increasing public awareness. No participating jurisdiction chose a mitigation project involving communicable disease in this hazard mitigation plan.