Missouri State

Hazard Mitigation Plan

2018

TABLE OF CONTENTS

INTRODUCTION

Across the United States, natural, manmade, and other disasters have led to increasing numbers of deaths, injuries, property damages, and disruptions of business and government services. This can take an immense toll on people, businesses and government, especially in these challenging economic times. The time, money and effort to respond to and recover from disasters divert public resources and attention from other important programs. As of March 2018, Missouri has had a total of 59 federal Presidential Disaster Declarations and 10 Emergency Disaster Declarations since 1957. Missouri recognizes the consequences of disasters and the need to reduce the impacts of natural, human-caused/technological, and other disasters.

Hazard mitigation is defined by the Federal Emergency Management Agency (FEMA) as any action taken to eliminate or reduce the long-term risk to human life and property from hazards and their effects. This is crucial to the residents, businesses, and governments of Missouri. Hazard Mitigation is the only phase of emergency management specifically dedicated to breaking the cycle of damage, reconstruction, and repeated damage.

People and property in Missouri are at risk to a variety of hazards. Among other hazards, Missouri is at risk to tornadoes, floods, drought, earthquakes, severe winter weather, and wildfires. These hazards have the potential to cause widespread loss of life and damage to property, infrastructure, and the environment. Missouri recognizes the potential consequences of disaster events. The need to reduce these impacts through property planning and preventative measures is of great importance to the State and its residents.

This Missouri State Hazard Mitigation Plan update is an important planning component of state-level programs for management of disasters and their impacts. It takes into account years of mitigation experience and a variety of mitigation initiatives. It has also taken advantage of the collective mitigation knowledge of many state, federal, and local officials as well as multiple stakeholders throughout the private sector. As such, implementation of this plan is positioned to significantly contribute to mitigation of negative impacts from future Missouri disasters.

This plan also summarizes the methods the State will use to prioritize cost-effective mitigation measures. The current priorities include local hazard mitigation planning, acquisition of floodprone properties, relocation/retrofitting of floodprone properties, floodplain management, tornado safe rooms, flood and earthquake structural projects, and technical assistance. Both short-term and long-term hazard mitigation measures are identified and prioritized to help all state and local agencies allocate appropriate resources in a responsible manner that will provide for the health, safety, and general welfare of all people in Missouri.

This plan will continue to provide a general blueprint for hazard mitigation activities in Missouri and is structured to serve as the basis for specific hazard mitigation efforts for multiple hazards. It is done so in a manner that meets federal requirements for mitigation planning and that complies with collaboratively developed national standards for emergency management. As such it is approved by FEMA and accredited by the Emergency Management Accreditation Program (EMAP).

Organization

This plan is written in accordance with, and is generally organized according to the guidance set forth in the State Mitigation Plan Review Guide, effective March 2016. The plan is divided into seven chapters briefly summarized below:

- **Chapter 1, Prerequisites** – This chapter includes details of the formal adoption of the plan update as well as a summary of the plan's compliance with Federal and State laws and regulations.
- **Chapter 2, Planning Process** – This chapter explains the planning process that was followed to prepare the plan update, including how it was prepared, who was involved, and how it was integrated with other related planning efforts.
- **Chapter 3, Risk Assessment** – This chapter features the risk assessment which identifies the type and location of hazards that can affect Missouri, analyzes the State's vulnerability to the hazards identified, and serves as the factual basis for the mitigation strategy.
- **Chapter 4, Comprehensive State Hazard Mitigation Program** – This chapter provides the State's mitigation blueprint. Specifically, in includes goals and objectives, State and local capabilities, mitigation activities, and funding sources.
- **Chapter 5, Coordination of Local Mitigation Planning** – This chapter describes the State's role in funding, developing, coordinating, and approving local mitigation plans, and how the state prioritizes funding for local mitigation plans and projects.
- **Chapter 6, Plan Maintenance** – This chapter presents the method the State Risk Management Team (SRMT) uses to monitor, evaluate, and update the plan. It also introduces how the team monitors project implementation and closeouts and reviews progress on achieving goals.
- **Chapter 7, Enhanced Plan** – This chapter is the "enhanced" portion of the plan and documents Missouri's project implementation capabilities and commitment to a comprehensive mitigation program.

Accessibility of Data/Resources

With the 2018 Plan Update, SEMA is pleased to provide online access to the risk assessment data and associated mapping for the 114 counties in the State and the Independent City of St. Louis. Through a web-based Missouri Hazard Mitigation Viewer, local planners or other interested parties can obtain the State Plan datasets behind the maps presented in the 2018 Plan Update.

Data layers developed or provided by SEMA planners and partners (State and Local) are available at one central location. The Missouri Hazard Mitigation Viewer includes a Map Viewer with a legend of clearly labeled features, a north arrow, a base map that is either aerial imagery or a street map, risk assessment data symbolized the same as in the 2018 State Plan for easy reference, search and query capabilities, zoom levels to county level data, and capable of downloadable PDF format maps. A User Guide and Data Dictionary for the Viewer are provided in Appendix A1.

The Missouri Hazard Mitigation Viewer can be accessed here:
http://bit.ly/MoHazardMitigationPlanViewer2018

1 PREREQUISITES

Hazard mitigation has become an increasingly important component of disaster recovery since 1988 when the Disaster Relief Act of 1974, Public Law 93-288, was amended by Public Law 100-707, the Robert T. Stafford Disaster Relief and Emergency Assistance Act. Greater emphasis was placed on hazard mitigation and pre-disaster mitigation (Section 203) with the enactment of another amendment, the Disaster Mitigation Act of 2000. This Missouri State Hazard Mitigation Plan Update is a direct result of the latter amendment to the Stafford Act.

The Disaster Mitigation Act (DMA) of 2000 enacted the following provisions relative to mitigation planning:

Standard State Mitigation Plans (201.4 of the Rule): To receive federal mitigation funds, states must develop and submit for approval to FEMA a Standard Hazard Mitigation Plan that includes details of the State's natural hazards risks, vulnerabilities, and mitigation goals, objectives, and priorities. States with an approved Standard Hazard Mitigation Plan are eligible for Hazard Mitigation Grant Program (HMGP) funding based on 15 percent for disaster assistance not more than $2 billion, 10 percent for disaster assistance of more than $2 billion and not more than $10 billion, and 7.5 percent for disaster assistance more than $10 billion and not more than $35.3 billion of the total estimated eligible Stafford Act disaster assistance as a result of a presidential major disaster declaration.

Enhanced State Mitigation Plans (201.5 of the Rule): States that have an approved Enhanced State Mitigation Plan at the time of a disaster declaration will qualify to receive HMGP funds based on up to 20 percent of the total estimated eligible Stafford Act disaster assistance. This document is the scheduled 2018 update to Missouri's standard and enhanced state hazard mitigation plan, which was initially approved by FEMA in 2004 and previously updated in 2007, 2010, and 2013.

Section 404 (Hazard Mitigation Grant Program (HMGP) allows the federal government to contribute up to 75 percent of the cost of cost-effective hazard mitigation measures that substantially reduce the risk of future damage, hardship, loss, or suffering in any area affected by a major disaster. Such mitigation measures shall be identified following the evaluation of natural hazards under Section 322 of the Disaster Mitigation Act. Section 404 funds may be used for a variety of eligible projects that may or may not be related to the disaster and, if the State allows, in counties that were not in the declared disaster area.

2 PLANNING PROCESS

2.1. Documentation of the Planning Process

Requirement §201.4(c)(1): [The State plan must include] a description of the planning process used to develop the plan, including how it was prepared, who was involved in the process, and how other agencies participated.

The process established for this planning effort is based on the Disaster Mitigation Act of 2000 (DMA 2000) planning and update requirements and FEMA's associated State Mitigation Plan Review Guide, effective March 2016 (FP 302-094-2). In addition, FEMA's Key Topics Bulletin: Planning Process, released in July 2016 was consulted to ensure renewed focus on an effective planning process for the State Hazard Mitigation Plan Update. The primary steps in the planning process included:

1) Updates to the identification and profiles of the types of hazards (natural, human-caused/technological, and other) that affect the State
2) Updates to the assessment of present and future risk and vulnerability of Missouri residents and critical assets to these hazards
3) Updates to the assessment of capabilities of locals, state agencies, federal agencies, and stakeholder groups to mitigate hazards
4) Updates and prioritization of the key issues that should be addressed by mitigation efforts
5) Updates to the goals, objectives, and mitigation action to address key issues to reduce the State's vulnerability to present and future hazards

2.1.1. Evolution of the State Hazard Mitigation Plan

The Missouri State Hazard Mitigation Plan in its current form has evolved over the last 20 years. In 1994, in response to the 1993 Midwest Flood Disaster, and in accordance with the planning regulations in place at the time (Section 409 of the Robert T. Stafford Disaster Relief and Emergency Assistance Act of 1988), the first Missouri Hazard Mitigation Plan was developed. Under Section 409, states were required to prepare and update state hazard mitigation plans within six months of a Presidential Disaster Declaration as a condition for receiving federal disaster assistance.

With the passage of the Disaster Mitigation Act of 2000, the Stafford Act was amended and Section 322 mitigation planning requirements was substituted for the older requirements in Section 409. The first State Hazard Mitigation Plan prepared in accordance with the Disaster Mitigation Act of 2000 was the 2004 Missouri State Hazard Mitigation Plan. This plan was updated in 2007, 2010, and 2013, and 2018 (this plan update).

A State Hazard Mitigation Planning Team (SHMPT) was formed to develop the 2004 State plan and continued for the 2007 and 2010 plan updates. This team evolved to include several federal agencies and additional expanded stakeholder agencies and became known as the State Risk Management Team (SRMT) for the 2013 plan update. Since 2013, the SRMT has met twice each year to discuss issues relevant to risk management and mitigation as well as coordinate across partner agencies to leverage programs and support. For the 2018 plan update, the SRMT was utilized as the advisory body to assist in its development.

Missouri employs a continuous improvement process to ensure that the State's mitigation planning and program efforts are effective. Missouri's planning and program successes to date are demonstrated throughout this document.

2.1.2. 2018 Plan Update Process

In November 2016, Missouri initiated the planning process to update the Missouri State Hazard Mitigation Plan. The Missouri State Emergency Management Agency (SEMA) took the lead role, under direction of the Mitigation Management Section, with the State Hazard Mitigation Officer as the planning lead. For assistance in development of the plan update, SEMA contracted with Wood Environment and Infrastructure Solutions (Wood E&IS), Inc.

Wood E&IS's role included the following 15 tasks:

- **Task 1:** Facilitate and document the process used to develop the plan update, including:
  - Assist in identifying representatives and reconvening the SRMT as defined by the DMA 2000, the March 2016 State Plan Review Guide, and the July 2016 State Mitigation Planning Key Topics Bulletins: Planning Process
  - Ensure compliance with the DMA 2000 requirements as established by federal regulation and the March 2016 State Plan Review Guide for both the Standard and Enhanced Plan
  - Facilitate the entire planning process
  - Identify the data requirements that SRMT participants should provide and conduct research and documentation necessary to augment that data
  - Documentation of how the plan was prepared, the schedule or timeframe, specific milestones and activities, stakeholders that involved in the process, and how other agencies participated.
- **Task 2:** Complete the update to the Risk Assessment for each hazard, including:
  - Incorporation of improvements to the State Risk Assessment Vulnerability Analyses as a result of availability of more current data and process improvements
- **Task 3:** Incorporation of the impacts and considerations for changing future conditions state wide and in each hazard assessment
- **Task 4:** Integration of local level risk assessments through an assessment of local plans to extract data for inclusion in the State assessments
- **Task 5:** Improving vulnerability analyses of state-owned/operated facilities based on the improved State Risk Assessment
- **Task 6:** Provide a summary of the changes in development that have occurred or are projected to occur in hazard prone areas based on the state and local risk assessments.
- **Task 7:** Update the State Mitigation Strategy, including the Repetitive Flood Loss Strategy for repetitive loss and severe repetitive loss properties; in coordination with the Silver Jackets, the state is currently in the process of developing a buyout strategy that includes a number of State and Federal agencies.
- **Task 8:** Update State Mitigation Capabilities to include updated descriptions of existing state pre- and post-disaster hazard management policies, programs, and capabilities to mitigation hazards in the state
- **Task 9:** Review and update the process to monitor, evaluate, and update the plan including the agency responsible for and the schedule for monitoring, evaluating, and updating the plan. This task also describes the system for tracking the implementation of mitigation activities and projects identified in the mitigation strategy, as well as, a system for reviewing progress on achieving the goals of the mitigation strategy, including criteria and process for evaluating progress.
- **Task 10:** Preparation of the Enhanced Plan including:
  - Comprehensive description of integrated planning in the State of Missouri

2 Planning Process

  - Demonstrate the State of Missouri successfully implements programs or projects that reduce exposure to hazards or other mechanisms that show the state has exceeded the requirements of the standard plan.
  - Demonstrate the State of Missouri effectively manages the HMGP as well as other mitigation grant programs
- Develop supplemental Enhanced Plan Elements in coordination with the SRMT to include:
  - **Task 11:** Preparation of loss avoidance studies to demonstrate the effectiveness of two of the State's priority mitigation project types: Flood-prone Property Acquisition and Tornado Safe Room Construction.
  - **Task 12:** Research and Development of a comprehensive multi-year plan to mitigate the risks posed to the existing buildings that have been identified as necessary for post disaster response and recovery operations.
  - **Task 13:** A study of the Public Assistance Program's 406 Mitigation program to determine additional opportunities to utilize this Post-Disaster Recovery program more effectively in future disasters.
  - **Task 14:** Development of an Application for Accessible Risk Assessment Data. The purpose of this Application is to streamline access for local planners to the data obtained and/or created throughout the State Plan process.
- **Task 15:** Produce the draft and final plan documents and coordinate with the FEMA Region VII plan reviewers.

At the November 2016 Kickoff meeting, the SRMT discussed the purpose and requirements of the state plan update, the project scope of work and schedule as well as the role of the SRMT. During the course of the plan update, six additional planning meetings were held after the kickoff meeting. Highlights include:

- Meeting #2 - The proposed approaches for the State Risk Assessment Hazard Vulnerability Analyses were presented to the SRMT for review, discussion, and final concurrence. For each of the natural and human-caused hazards the category of analysis was identified along with a description of the analysis method, the proposed presentation of findings, the associated tables and figures, as well as, a listing of data sources and the data limitations. Additionally, for the State Capability Assessment, a data collection guide was provided to the SRMT to document the mitigation-related capabilities of each agency. The data collection guide included text from the previous State Hazard Mitigation Plan and additional researched text for each agency to review and update, as well as, a set of questions for each agency to complete in regard to mitigation-related programs and initiatives, outreach and partnerships, plans and reports, and funding sources.
- Meeting #3 – The results of the State Risk Assessment Hazard Vulnerability Analyses were presented to the SRMT, as well as, a demonstration of the Missouri Hazard Mitigation Viewer.
- Meeting #4 – The results of the State Risk Assessment Hazard Vulnerability Analyses were presented to the SRMT for levee failure, flood, and earthquake, as well as, a review and update of the mitigation goals, objectives, and actions.
- Meeting #5 – An update of the mitigation planning process was presented to the SRMT.
- Meeting #6 – The SRMT reviewed, updated, and prioritized the mitigation actions.
- Meeting #7 – An overview of the draft 2018 State Hazard Plan document was presented to the SRMT along with the incorporation review comments from the SRMT.

Table 2.1 provides additional details on the meetings held during the plan update process. Agendas, sign-in sheets, meeting handouts and other documentation have been compiled in a planning reference file that is available from SEMA upon request.

Table 2.1. 2018 State Hazard Mitigation Plan Update Planning Meetings

Meeting	Date	Topics Discussed
Kickoff Meeting	11/2/2016	• Introductions • Overview of the Disaster Mitigation Act • Mitigation in Missouri—a History of Planning Put into Practice • Role of the State Hazard Mitigation Team • 2018 Update Strategy—Overview of 15 Main Tasks • Risk Assessment Data Sources • Plan Update Timeline
Meeting #2	1/25/2017	• Introductions • Review Plan Purpose / Role of SRMT • Plan Update Tasks / Meeting Schedule • State Risk Assessment – Recommended Methods • Risk Assessment of State-Owned Facilities • Integration of Local Plans • State Capability Assessment Update • Next Steps • Adjourn
Meeting #3	06/07/2017	• Introductions • Exposure and Analysis of Assets at Risk • Hazard Identification Recap • State Risk Assessment Results • Integration of Local Plans • Risk Assessment of State-Owned Facilities • Mapping Web Application Demonstration • Next Steps • Adjourn
Meeting #4	09/12/2017	• Introductions • Review of Mitigation Planning Process and Current Project Status • State Risk Assessment Results (Levee Failure, Flood, Earthquake) • Review/Update of Mitigation Goals and Objectives • Overview of State Capability Assessment • Update Status of Local Capability Assessment • Review/Update of Mitigation Actions • Overview of Repetitive Flood Loss Strategy • Next Steps • Adjourn
Meeting #5	11/07/2017	• Introductions • Review Plan Purpose / Role of SRMT • Plan Update Tasks / Meeting Schedule • Integration of Local Plans • State Capability Assessment Update • Next Steps • Adjourn
Meeting #6	12/13/2017	• Introductions • Summarize Plan • Mitigation Action Prioritization • Comment Solicitation • Next Steps • Adjourn
Meeting #7	02/21/2018	• Introductions • Summary of Review Comments • Discussion of Final Plan Revisions • Next Steps • Adjourn

While geospatial data has been used in previous plan updates, one of the hallmarks of the 2018 plan update has been the concerted effort to integrate as much available geospatial or geographical information systems (GIS) data as possible and to integrate many of emerging worldwide technologies for data display. This is a theme running throughout the plan update. GIS staff for Wood E&IS assessed the available GIS data statewide through multiple sources which included the Missouri Spatial Data Information Service (MSDIS), the official GIS website for the State maintained by the University of Missouri. GIS was also obtained from various SRMT member agencies in a collaborative partnership with SEMA. In some instances, data available from SRMT member agencies was shared in tabular format and converted to GIS data. A data matrix was created and is included in Appendix A2. A summary of sources for GIS data include:

- MSDIS located at http://msdis.missouri.edu which included datasets for landslide potential, liquefaction potential, landslide potential, inventory of landslide occurrences, higher education institutions, air quality monitoring sites, 303d listed impaired streams and lakes, inventory of mines, inventory of sinkholes,
- U. S. Census located at https://www.census.gov/geo/maps-data/data/tiger provided census data as well as county boundaries
- USACE SRMT members provided Federal Dams locations and inundation areas as well the national levee data from http://nld.usace.army.mil/egis/f?p=471:1:
- EPA HSIP Freedom data from https://hifld-geoplatform.opendata.arcgis.com/ which included facility information on hazardous materials, medical facilities, fire stations, National Bridge Inventory, National Levee Inventory and schools
- NOAA climate data from the NCEI at https://gis.ncdc.noaa.gov/maps/ncei
- FEMA's HAZUS software GIS data was exported to be used in other risk assessments for consistency including earthquake data
- FEMA's NFIP national floodplain data was obtained from https://msc.fema.gov and additionally provided the Repetitive Loss and Severe Repetitive Loss data for the State
- USGS located at https://landcover.usgs.gov/ provided land use data
- FEMA Region VII proved the Regional version of the National Levee Database
- CUSEC provided additional earthquake GIS data
- Missouri Association of Councils of Government http://www.macogonline.org/rpcs.htm
- MODNR SRMT members provided wildland fire data
- SEMA provided Disaster Region data, safe room locations, NFIP participating communities and a large inventory of data from the floodplain mapping update program
- MODHE proved Higher Education facility data
- MDC proved facility locations
- MODOT provided a statewide bridge inventory and state transportation layer
- MODNR proved water intake wells, state dam locations and inundation layers

It is through this data availability matrix that a large wealth of information was able to be integrated into the plan in a meaningful and comprehensive manner.

2.1.3. Plan Review and Update Summary

During the 2018 State Hazard Mitigation Plan Update process, each section of the 2013 plan was reviewed and updated, as appropriate. At each step of the update process, FEMA's *State Mitigation Plan Review Guide*, effective March 2016 as well as applicable key topic bulletins that were released prior to completion of the plan were consulted to ensure conformance with the most recent guidance and planning aides. The Emergency Management Accreditation Program (EMAP) standards for mitigation were also considered to ensure continued accreditation of Missouri's Emergency Management Program. This plan update includes improved organization and formatting of the plan's content where possible.

Table 2.2 provides a summary of the updates made to each section of the plan. Additional detailed documentation on updates made is provided at the beginning of each plan section.

Table 2.2. Summary of Updates for 2018 State Hazard Mitigation Plan

Plan Section	Summary of Updates
Entire Plan	• This document is a user- interfaced, Web-based interactive plan. It has been formatted with active embedded hyperlinks throughout which will direct the user to: o Internal document locations; o External SEMA websites; and o External third-party websites where additional information can be found.
1 Introduction	• Updated language to describe purpose and requirements of the Missouri State Hazard Mitigation Plan update process.
2 Planning Process	• Described planning process for 2018 update, coordination among agencies, and integration with other planning efforts. • A cross-reference table for EMAP mitigation standards was added.
3.0 Risk Assessment	The chapter has been re-organized into Sections 3.1 through 3.6: • Section 3.1 Exposure and Analysis of Assets at Risk and State Development Trends replaces former Section 3.4 Overview Analysis of State Development Trends and Assets at Risk • Section 3.2 Hazard Identification aligns with former Section 3.2 Identifying Hazards • Section 3.3 Hazard Profiles and State Risk Assessment – replaces and combines former Section 3.3 Profiling Hazards; former Section 3.5 Vulnerability Analysis & Estimating Potential Losses by Jurisdiction: State Risk Analysis; and former Section 3.8 Summary and Conclusions • Section 3.4 Integration of Local Plans: Vulnerability and Loss Estimates replaces former Section 3.6 Assessing Vulnerability & Estimating Losses by Jurisdiction: Integration of Local Plans • Section 3.5 State Owned and Operated Facilities: Vulnerability and Loss Estimates replaces former Section 3.7 Assessing Vulnerability & Estimating Losses of State Owned/Operated Facilities • Section 3.6 References replaces former Section 3.9 Bibliography
3.1 Exposure Analysis of Assets at Risk and State Development Trends	• Described changes in growth and development and examined these changes in the context of hazard-prone areas and how the changes affect loss estimates and vulnerability. • Added Section 3.1.3 addressing Changing Future Conditions and the impact on Missouri's hazards.
3.2 Hazard Identification	• This section is divided into 3.2.1 Natural Hazards, 3.2.2 Human-Caused/Technological Hazards, and 3.2.3 Disaster Declarations. • Former fire hazard (Urban/Structural/Wild) divided into two separate hazards: (1) Wildfire and (2) Structural and Urban Fires • Updated declarations table and figure as well as tables providing IA and PA costs by disaster.

Plan Section	Summary of Updates
3.3 Hazard Profiles and State Risk Assessment	• Historically, the Hazard Analysis has been developed by SEMA's Planning and Disaster Recovery Branch, updated each October. SEMA, however, no longer develops this separate State Hazard Analysis. Therefore, the hazard profiles developed for this 2018 Plan Update will serve as the bases for hazard profile needs in other State Plans, promoting continued integration. • Each hazard was profiled to include information on description/location, extent, previous occurrences, probability of future hazard events, and changing future conditions. • Proposed approaches for State Risk Assessment Hazard Vulnerability Analyses were presented and discussed at SRMT Meeting #2. • Each hazard was analyzed for vulnerability and potential loss estimation. Additionally, changes in development for jurisdictions in hazard prone areas, EMAP consequence analysis, and a risk summary was provided for each hazard. • Repetitive Loss / Severe Repetitive Loss: For the Flood Hazard, the Risk Assessment addresses repetitive loss (RL) and severe repetitive loss (SRL) properties. • A summary of the vulnerability analysis/loss estimation updates are presented in Table 3.6.
3.4 Integration of Local Plans: Vulnerability and Loss Estimates	• Reviewed risk assessments from 114 local plans to summarize how local governments ranked hazards in their jurisdictions associated with the natural hazards. • Summarized loss estimates for flood, earthquake, and tornado to present the population and buildings at risk within the hazard areas.
3.5 State Owned or Operated Facilities: Vulnerability and Loss Estimates	• Major improvements were made to available facility and bridge data resulting in an improved dataset from which to base the vulnerability assessments and loss estimations. Table 3.130 presents a summary of the updated state facility inventories. • For the 2018 State Plan Update, the following facilities were inventoried in GIS format and included in the analyses: o Increase from 4,396 to 8,183 geolocated Office of Administration facilities (owned and leased); o Over 10,400 of Missouri State Bridges; o Increase from 175 to 295 geolocated MoDOT facilities; o Increase from 89 to 455 geolocated Department of Higher Education/Public Colleges and Universities; and o Addition of 1,511 geolocated Missouri Department of Conservation facilities. • Vulnerability analysis and loss estimates were provided for all the profiled hazards where data was available. New data allowed for the analysis of vulnerability to sinkholes, wildfire, and hazardous materials fixed facility incidents. Table 3.129 presents a summary of the updated vulnerability and loss estimation methods.
3.6 References	• Updated reference information utilized in the hazard identification, profiles and risk assessments.
4.0 Mitigation Strategy	• Updated 4.0 based on the results of the updated risk assessment, data from the local plans, completed mitigation actions, and implementation obstacles and opportunities since the previously approved plan.
4.1 Hazard Mitigation Goals and Objectives	• Goals and objectives from the 2013 plan were reviewed during SRMT Meeting #4. The SRMT concluded that the goals and objectives continued to be representative of the state's mitigation strategy.

Plan Section	Summary of Updates
4.2 Mitigation Actions	• Formerly Section 4.4, Mitigation Actions was moved to Section 4.2 to follow Goals and Objectives and the State Mitigation Plan Review Guide. • Mitigation actions discussed at SRMT Meeting #4. • Mitigation action categories M1-M11 remain applicable. Three new mitigation action categories were also added to address risk communication, response and recovery facility mitigation projects, and state owned/operated facility mitigation projects. • Progress of actions since 2013 documented and mitigation actions updated and/or revised. • Prioritization of mitigation actions conducted through online survey.
4.3 Repetitive Flood Loss Strategy	• Formerly Section 4.6, Severe Repetitive Flood Loss Strategy was moved to Section 4.3 to follow Mitigation Actions and the State Mitigation Plan Review Guide. • Described the State's current Repetitive Flood Loss Strategy with updated repetitive loss and severe repetitive loss data by community along with new section on Targeted Actions.
4.4 Funding Sources	• Formerly Section 4.5, Funding Sources was moved to Section 4.4 to follow - Repetitive Flood Loss Strategy and the State Mitigation Plan Review Guide. • Identified funding sources used since previously approved plan. • Appendix D provides a list of funding sources updated for this 2018 State Plan update.
4.5 State Capability Assessment	• Formerly Section 4.2, State Capability Assessment was moved to Section 4.5 to follow Funding Sources and the State Mitigation Plan Review Guide. • Evaluated state laws, regulations, policies, and programs related to hazard mitigation, as well as, to development hazard prone areas. • Updated the state capabilities, both pre- and post-disaster, and how these capabilities have changed since the previously approved plan. • Discussed state funding capabilities for hazard mitigation projects and how the state has used FEMA mitigation programs and funding sources. • Discussed obstacles and challenges and changes since the previously approved plan.

4.6 Local Capability Assessment	• Formerly Section 4.3, Local Capability Assessment was moved to Section 4.6 to follow the State Capability Assessment and the State Mitigation Plan Review Guide.
	• Performed local capability assessment through review of:
	  o Planning Capabilities;
	  o Building Codes, Policies, and Ordinances;
	  o Mitigation-related Programs/Partnerships;
	  o Specific Studies;
	  o Staffing Positions; and
	  o Potential Funding Sources
	• Analyzed effectiveness of local capabilities through a survey developed to obtain input from local governments, state, federal, and stakeholder agencies. A summary of the results is provided.

5.0 Coordination of Local Mitigation Planning	• Reviewed process for and progress in coordinating local mitigation planning. • Updated information on the status of local plan completion.
5.1 Local Funding and Technical Assistance	• Described how the State provided funding, technical assistance, and training to local governments since the previously approved plan, including development of new training materials and planning resources. • Summarized current status of counties with completed and approved local plans, those in process, and those without plans. • Added Section 5.1.6 Barriers to Local Mitigation Planning to demonstrate the State's effort to advance local mitigation planning.
5.2 Local Plan Integration	• Described how local risk assessments, goals and objectives, mitigation actions, and capabilities were integrated into the updated state plan. • Assessed the challenges and success of this 2018 integration.

Plan Section	Summary of Updates
5.3 Prioritizing Local Assistance	• Reviewed criteria for prioritizing communities and local jurisdictions that would receive planning and project grants and determined existing criteria including the coordination with mitigation actions identified through the RiskMAP process and entered into FEMA's Mitigation Action Tracker.
6.0–6.2 Plan Maintenance Process	• Reviewed procedures for evaluating and updating the plan and determined that no changes were required. • Updated monitoring information from the most current Administrative Plan. • Added reference to Loss Avoidance Tool, which is fully described in Chapter 7, Enhanced Plan.
7.0–7.6 Enhanced Plan	• Reviewed and revised sections based on FEMA's guidance for enhanced plan updates. • Improved integration of enhanced plan information with other sections of the plan. • Prepared loss avoidance studies to demonstrate the effectiveness of two of the State's priority mitigation project types: Flood-prone Property Acquisition and Tornado Safe Room Construction • Researched and developed a comprehensive multi-year plan to mitigate the risks posed to the existing buildings that have been identified as necessary for post-disaster response and recovery operations. • Performed study of the Public Assistance Program's 406 Mitigation program to determine additional opportunities to utilize this Post-Disaster Recovery program more effectively in future disasters. • Developed a web-application for accessible risk assessment data.

2.2. Coordination among Agencies

Requirement §201.4(b): The [State] mitigation planning process should include coordination with other State agencies, appropriate Federal agencies, and interested groups.

As the agency designated by the Missouri Governor to coordinate statewide emergency preparedness, response, recovery, and hazard mitigation activities, SEMA acted as the coordinator of the SRMT during the planning process. SEMA recognizes the importance of coordinating with local, state, and federal agencies, as well as other interested groups involved in hazard mitigation planning. This coordination is necessary to enhance data collection, mitigation strategy development, plan implementation, and overall investment in Missouri's mitigation program.

For this plan update, the role of the SRMT included the following:

- Attend Planning Meetings
- Assist with Data Collection
- Serve as Advisory Group for State Risk Assessment Methods
- Report on Agency Mitigation Capabilities
- Leverage Funding / Programs to Maximize Benefits
- Provide Input to Mitigation Strategy/Actions
- Review Drafts

The SRMT consists of a broad range of stakeholders from various sectors, agencies, and organizations. The key sectors represented on the SRMT include the following:

- Emergency Management
- Economic Development
- Land Use and Development
- Housing
- Health and Social Services
- Infrastructure
- Natural and Cultural Resources

Table 2.3 provides the entities invited to participate on the SRMT for the plan update process as well as those represented at the planning meetings for the 2018 update of the State Hazard Mitigation Plan.

Table 2.3. SRMT Involvement in the 2018 Plan Update Process

Agency/Division	Sector	Participated in 2018 Plan Update	Kickoff Meeting	Meeting #2	Meeting #3	Meeting #4	Meeting #5	Meeting #6	Meeting #7	Provided Data
Missouri State Agencies										
State Emergency Management Agency (SEMA)	Emergency Management	X	X	X	X	X	X	X	X	X
Department of Agriculture (MDA)	Land Use and Development	X				X				X
Department of Conservation (MDC)	Natural and Cultural Resources	X			X	X				X

Agency/Division	Sector	Participated in 2018 Plan Update	Kickoff Meeting	Meeting #2	Meeting #3	Meeting #4	Meeting #5	Meeting #6	Meeting #7	Provided Data
Department of Corrections (MOC)	Health and Social Services									
Department of Economic Development (DED)	Economic Development; Housing									
Department of Elementary and Secondary Education (DESE)	Health and Social Services	X								X
Department of Health and Senior Services (DHSS)	Health and Social Services	X								X
Department of Higher Education (DHE)	Health and Social Services	X								X
Department of Insurance, Financial Institutions, and Professional Registration (DIFP)	Economic Development	X								X
Department of Labor and Industrial Relations (DOLIR)	Economic Development									
Department of Mental Health (DMH)	Health and Social Services	X	X							X
Department of Natural Resources (MoDNR), Dam Safety	Natural and Cultural Resources	X	X	X	X	X	X	X	X	X
MoDNR, Missouri Geological Survey (MGS)	Natural and Cultural Resources	X								X
MoDNR, Energy Center	Natural and Cultural Resources	X								X
MoDNR, Environmental Services Program	Natural and Cultural Resources	X								X
Department of Public Safety (DPS), Division of Fire Safety (DFS)	Emergency Management	X								X
DPS, State Highway Patrol (MSHP)	Emergency Management									
DPS, State Water Patrol (MSWP)	Emergency Management									
Public Service Commission (PSC)	Economic Development	X								X
Department of Social Services (DSS)	Health and Social Services	X	X	X	X	X			X	X
Department of Transportation (MoDOT)	Infrastructure	X			X			X		X
Division of Tourism	Economic Development									
Office of Administration (OA)	Economic Development	X	X	X	X					X
National Guard (MONG)	Emergency Management	X	X				X			X
National Air Guard (MOANG)	Emergency Management									
Missouri Association of Council of Governments (MACOG) Stakeholders										
Boonslick Regional Planning Commission	Economic Development; Land Use and Development	X								X
Bootheel Regional Planning and Economic Development Commission	Economic Development; Land Use and Development	X								X
East-West Gateway Coordinating Council	Economic Development; Land Use and Development	X								X
Green Hills Regional Planning	Economic Development; Land	X								X

Agency/Division	Sector	Participated in 2018 Plan Update	Kickoff Meeting	Meeting #2	Meeting #3	Meeting #4	Meeting #5	Meeting #6	Meeting #7	Provided Data
Commission	Use and Development									
Harry S Truman Coordinating Council	Economic Development; Land Use and Development	X								X
Kaysinger Basin Regional Planning Commission	Economic Development; Land Use and Development	X								X
Lake of the Ozarks Council of Local Governments	Economic Development; Land Use and Development	X								X
Mark Twain Regional Council of Governments	Economic Development; Land Use and Development	X								X
Meramec Regional Planning Commission	Economic Development; Land Use and Development	X								X
Mid-America Regional Council	Economic Development; Land Use and Development	X								X
Mid-Missouri Regional Planning Commission	Economic Development; Land Use and Development	X								X
Mo-Kan Regional Council	Economic Development; Land Use and Development	X								X
Northeast Missouri Regional Planning Commission	Economic Development; Land Use and Development	X								X
Northwest Missouri Regional Council of Governments	Economic Development; Land Use and Development	X								X
Ozark Foothills Regional Planning Commission	Economic Development; Land Use and Development	X								X
Pioneer Trails Regional Planning Commission	Economic Development; Land Use and Development	X								X
South Central Ozark Council of Governments	Economic Development; Land Use and Development	X								X
Southeast Missouri Regional Planning and Economic Development Commission	Economic Development; Land Use and Development	X								X
Southwest Missouri Council of Governments	Economic Development; Land Use and Development	X								X
Federal Stakeholders										
FEMA Region VII	Emergency Management	X	X	X	X	X	X	X	X	X
National Oceanic and Atmospheric Administration National Weather Service	Natural and Cultural Resources	X	X				X			X
U.S. Army Corps of Engineers (USACE) Kansas City	Infrastructure	X	X	X	X	X	X	X	X	X
USACE Little Rock District	Infrastructure	X								X
USACE St Louis District	Infrastructure	X	X	X	X	X	X			X
USACE Memphis District	Infrastructure	X								X
USACE Rock Island District	Infrastructure	X								X

Agency/Division	Sector	Participated in 2018 Plan Update	Kickoff Meeting	Meeting #2	Meeting #3	Meeting #4	Meeting #5	Meeting #6	Meeting #7	Provided Data
USACE Omaha District	Infrastructure	X								X
USACE Tulsa District	Infrastructure	X								X
U.S. Department of Agriculture (USDA), Forest Service, Mark Twain National Forest	Land Use and Development	X								X
USDA, Natural Resources Conservation Service	Natural and Cultural Resources	X								X
USDA, Rural Development Agency	Land Use and Development	X								X
U.S. Department of Commerce, Economic Development Administration	Economic Development	X								X
U.S. Department of Homeland Security	Emergency Management	X								X
U.S. Department of Housing & Urban Development	Housing	X								X
U.S. Department of Transportation	Infrastructure	X								X
U.S. Environmental Protection Agency	Natural and Cultural Resources	X								X
U.S. Geological Services (USGS)	Natural and Cultural Resources	X	X		X					X
U.S. Small Business Transportation	Infrastructure									
Private Stakeholders										
Adventist Community Services	Health and Social Services									
AmeriCorps	Health and Social Services									
American Red Cross	Health and Social Services									
Association of Missouri Electric Cooperative (AMEC)	Infrastructure	X								X
Callaway Nuclear Power Plant (AUE)	Infrastructure	X								X
Cooper Plant Nebraska Public Power District (NPPD)-Entergy Support	Infrastructure	X								X
Kansas City Power and Light (KCPL)	Infrastructure	X	X							
Missouri Baptist Convention	Health and Social Services									
Missouri Community Service Commission	Health and Social Services	X	X							
Missouri Floodplain and Stormwater Managers Association (MSFMA)	Land Use and Development	X								X
Missouri Hospital Association	Health and Social Services									
Missouri Public Health Association	Health and Social Services	X								X
The Salvation Army	Health and Social Services									

2.3. Integration with Other Planning Efforts

Requirement §201.4(b): The [State mitigation planning process] should be integrated to the extent possible with other ongoing State Planning efforts as well as other FEMA mitigation programs and initiatives.

The Missouri State Hazard Mitigation Plan Update identifies Missouri's hazards, risks, vulnerabilities, goals, objectives, priorities, and strategies for mitigation. This plan is the governing document that SEMA uses to direct and focus mitigation efforts. Through the establishment and continued coordination of the SRMT, this plan and the process to update it have also served as a mechanism to guide mitigation goals and objectives across multiple stakeholder entities, including federal partners, other state agencies, local entities, as well as contributing private-sector stakeholders.

Inclusion of key stakeholder entities has been an ongoing process that has helped inform partner agencies and organizations about the importance of mitigation. This education process has resulted in the ability to leverage other stakeholder programs and planning initiatives to advance mitigation opportunities and concepts.

2.3.1. Integration with Other Ongoing State Planning Efforts

The State of Missouri is fully committed to an effective and comprehensive mitigation program. Missouri is somewhat unique in that the FEMA Hazard Mitigation Assistance (HMA) grant programs, Earthquake Program, and mitigation planning are all the direct responsibility of SEMA. In order for these programs to achieve their full potential as well as to leverage available funding and resources of other mitigation-related programs available in Missouri, integration with other planning efforts is crucial. Some examples as to how the State mitigation planning process is integrated with other ongoing State planning efforts are provided below:

- Mitigation is considered, where possible by Missouri statutes, in the earthquake plans of the Departments of Transportation; Insurance, Financial Institutions, and Professional Registration; Corrections; Natural Resources; Education; the Office of Administration; the Public Service Commission; Missouri Seismic Safety Commission; Missouri Emergency Response Commission; and others.
- The Department of Transportation considers mitigation, especially floodplain management and open-space issues, in their transportation plans.
- The Department of Conservation has partnered with SEMA in developing streambank stabilization planning to help mitigate flooding problems in communities such as Piedmont, Missouri.
- The vulnerability analysis of state-owned facilities continued to be expanded in this 2018 State Plan Update and the results have been provided to the Office of Administration, Department of Higher Education, Department of Transportation, and Missouri Department of Conservation. For those facilities for which GIS data was provided, the State agencies have been provided with the results indicating specific facilities potentially at risk to inundation from failure of state-regulated dams, flooding from a 100-year flood event, and levee failure; location relative to sinkholes and potential wildfires; and damage from an earthquake event with a 2% probability of exceedance in 50 years. Results were provided in both GIS (geodatabase) and Excel spreadsheet formats. Provision of this data is provided specifically so that those State-agencies are made aware of potential risks to determine if mitigation opportunities are necessary and/or feasible. Section 3.5 provides additional details.

During the 2018 State Plan update, the SRMT reviewed the mitigation-related programs and initiatives, mitigation-related outreach and partnerships; mitigation-related plans and reports, and mitigation-related funding sources of other State agencies. The purpose of this review was to identify changes, updates, and/or additions since the 2013 Mitigation Plan to incorporate relevant data and capabilities into the mitigation plan and to better understand areas where mutual responsibilities and policies could be leveraged. Identified mitigation-related capabilities of other State agencies participating on the SRMT are provided in Section 4.5.1.

SEMA also works to implement the components of this plan by being a part of the SRMT and working with state agencies that participate on the Missouri Seismic Safety Commission, state agencies that help develop mitigation measures associated with Public Assistance projects, and state educational institutions that participate in the mitigation program.

In addition to working with FEMA in all aspects of hazard mitigation projects and plans, SEMA has worked with multiple federal mitigation partners to integrate mitigation into projects and plans. Examples include:

- The Natural Resources Conservation Service (NRCS) and U.S. Army Corps of Engineers provided input and advice on several mitigation initiatives in the State regarding retention/detention basins. The successful combination of SEMA buyouts and NRCS retention basins in the City of Neosho, a former Project Impact Community, is an excellent example of the NRCS' support.
- An NRCS feasibility study led the City of Piedmont to develop several flood buyout programs to mitigate flooding over time and Project Impact Disaster Resistant Community status. Piedmont also worked with the Missouri Department of Conservation to reduce flooding through creek cleanup and streambank stabilization activities and plans. In addition, Piedmont and the City of Maryville worked with the Economic Development Agency, using SEMA's hazard mitigation planning process, to develop communitywide business plans for disaster survivability. The City of Hannibal (another former Project Impact community) followed Piedmont's creek cleanup lead and conducted similar activities.

SEMA has also supported efforts to reduce damages from severe winter storms, such as the project undertaken by the City of Independence to bury electric service lines to homes that were damaged by the severe Ice Storm of 2002. Similarly, SEMA worked with the City of Bolivar (also a former Project Impact community) helping the city procure and issue NOAA weather warning radios to local schools, nursing homes, day care centers, and college dormitories.

Approximately 671 Missouri communities participate in the National Flood Insurance Program (NFIP), an increase of 19 jurisdictions since the 2013 Mitigation Plan. Participation in the Community Rating System (CRS) has also increased from 5 to 10 jurisdictions. The SEMA Recovery Division, Floodplain Management Section conducts workshops each year promoting the NFIP to nonparticipating communities. Additional workshops are conducted to promote the CRS. These workshops have been instrumental in increasing the number of communities participating in both programs.

SEMA supports the NWS StormReady program and its many mitigation measures in Missouri. Participation in the program continues to increase since the 2013 Mitigation Plan. Currently Missouri has 30 counties (an additional 10 counties); 51 communities (an additional 10 communities); four universities, two government/military sites, one commercial, and 22 supporters (an increase of 8 supporters) that are recognized as StormReady.

The Missouri Department of Economic Development's Community Development Block Grant Program (CDBG) has complemented the SEMA buyout program in removing homes and businesses from the flood hazard areas throughout the State. The SEMA program has concentrated primarily on family residences, while the CDBG program has included businesses and some residences. Together, these programs have made a significant impact on the overall vulnerability of individuals to flooding as well as reducing the costs of future flooding.

Other partners and projects include the following:

- The U.S. Army Corps of Engineers has worked with SEMA on several levee projects, the Silver Jackets program, and requests for channelization projects.
- The Missouri Department of Conservation has worked with SEMA on endangered species and fish and wildlife management issues associated with flood buyouts and water management and conservation questions.
- The Missouri Department of Agriculture works with SEMA on agriculture and drought issues and planning, including ways to mitigate damage.
- The Missouri Department of Insurance, Financial Institutions, and Professional Registration supports SEMA in promoting flood and earthquake insurance, preparedness, response, and mitigation issues and plans.
- The Missouri Department of Natural Resources has worked with SEMA on flood buyouts, hazardous material planning, earthquake mitigation, and dam safety plans and issues.
- The Missouri Department of Transportation, the U.S. Department of Transportation, and the Federal Highway Administration have worked with SEMA on flood buyouts, open-space restriction issues, and earthquake planning and bridge retrofits.
- In addition to the state and federal transportation agencies, the U.S. Geological Survey; Central U.S. Earthquake Consortium; MoDNR; Missouri Department of Insurance, Financial Institutions, and Professional Registration; Missouri Seismic Safety Commission; Missouri Structural Assessment and Visual Evaluation (SAVE) Coalition (members include the American Council of Engineering Companies/Missouri, American Institute of Architects/Missouri, American Society of Civil Engineers, Missouri Society of Professional Engineers, Structural Engineers Association of Kansas and Missouri, University of Missouri–Rolla School of Civil Engineering and Natural Hazards Mitigation Institute, Saint Louis University Earthquake Center, Washington University, Southern Illinois University–Edwardsville, University of Memphis Center for Earthquake Research and Information, and Earthquake Engineering Research Institute New Madrid Chapter) work with SEMA on earthquake mitigation, including retrofits, public education, soil mapping, and seismic studies.
- SEMA's statewide volunteer coordinator has worked for years to educate local, state, and national voluntary organizations through the Disaster Recovery Partnership, Community Organizations Active in Disaster, and the Missouri Voluntary Organizations Active in disasters about the importance of mitigation.
- SEMA's staff served on the State American Red Cross mitigation committee.

The general information in this plan is intended for use by interested local governments, universities, businesses, and private associations, in addition to state and federal departments and agencies.

2.3.2. Integration with other FEMA Mitigation Programs and Initiatives

Mitigation is woven throughout SEMA's execution of FEMA's Risk Mapping Assessment and Planning (RiskMAP) program. SEMA has developed, and regularly updates, a five-year Combined Strategic and CERC Business Plan which emphasizes its comprehensive and integrated approach to RiskMAP that includes floodplain mapping, risk assessment and mitigation planning unified by risk communication that meets or exceeds FEMA goals and program intent. SEMA has fully committed to engaging communities, stakeholders and project team members throughout the life of the RiskMAP projects through active Community Engagement and Risk Communication (CERC) activities to build risk awareness and understanding at the local level, increase communities' ability to communicate risk at the local level and support local efforts to reduce natural hazard risk within the community through mitigation actions. Examples of these are:

- Workshops on how to use DFIRM products and RiskMAP products are presented annually;
- Quarterly communications on project status are sent to community officials.
- Phone calls with local officials are fielded weekly on a full range of questions regarding floodplain management.
- When communities are not able to attend meetings, SEMA routinely delivers data personally to community officials to ensure it's received and questions are answered.
- An outreach website was created for the life of the projects which stores the Modeling Methods maps, the proposed floodplains, meeting documentation and the ability to comment on the proposed data.

To measure the success of the Risk MAP program, Risk MAP Action Measures have been developed and are tracked in accordance with FEMA Region VII guidance. SEMA works with communities to understand their needs, and educate and engage them to take mitigation actions to minimize their flood risk. As per Region VII guidance, SEMA gathers all the information that is necessary to include in the Mitigation Action Tracker. While most mitigation activity takes place at the local level and is measured at the community level in watersheds where Risk MAP is deployed, SEMA identifies which communities can potentially advance actions utilizing RiskMAP products. SEMA provides literature, how-to-guides and best practices in mitigation actions to promote mitigation action advancement in those identified communities.

2.3.3. Integration with EMAP Standards

During the 2018 plan update, the SRMT considered the State's overall mitigation planning process in the context of the 2016 Emergency Management Accreditation Program's (EMAP) mitigation standards. EMAP is a voluntary assessment and accreditation process for state emergency management programs. Accreditation is granted only following a rigorous peer review of all aspects of a state's emergency management program. **Table 2.4** presents the EMAP mitigation standards and corresponding reference in this 2018 State Plan update:

Table 2.4. EMAP Mitigation Standards Addressed in the 2018 State Plan

2016 EMAP Standard		2018 State Plan
4.1 Hazard Identification, Risk Assessment and Consequence Analysis		
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 assesses the risk and vulnerability of people, property, the environment, and its own operations from these hazards.	Section 3.2 Hazard Identification Section 3.3 Hazard Profiles and State Risk Assessment Section 3.5 State Owned and Operated Facilities: Vulnerability and Loss Estimates
4.1.2	The Emergency Management Program conducts a consequence analysis for the hazards identified in Standard 4.1.1	Within Section 3.3, an EMAP consequence analysis is provided for each natural and human-caused hazard.
4.1.3	The Emergency Management Program has a method and schedule for evaluation, maintenance, and revision of its Hazard Identification, Risk Assessment (HIRA) and Consequence Analysis identified in Standard 4.1.1.	Sections 2.1.2 and 2.1.3 describe the State Plan Update process including the hazard information in Chapter 3. Additionally, SEMA updates its Threat and Hazard Identification and Risk Assessment (THIRA) annually in accordance with the Comprehensive Preparedness Guide 201.
4.2 Hazard Mitigation		
4.2.1	The Emergency Management Program has a plan to implement mitigation projects and sets priorities based upon loss reduction.	Section 4.2.2 Process for Identifying, Evaluating, Prioritizing, and Updating Mitigation Actions
4.2.1 (1)	The plan … is based on the natural and human-caused hazards identified in Standard 4.1.1 and the risk and consequences of those hazards.	Table 4.5 presents how mitigation actions relate to the different hazards, as well as, the associated probability and severity.
4.2.1 (2)	The plan … is developed through formal planning processes involving Emergency Management Program stakeholders; and	Section 2.1.2 and 2.2 describe the planning process and coordination/ participation of stakeholders.
4.2.1 (3)	The plan … establishes interim and long-term strategies, actions, goals and objectives	Section 4.2 Hazard Mitigation Goals and Objectives Section 4.2 Mitigation Actions
4.2.2	The Emergency Management Program documents project ranking based upon the greatest opportunity for loss reduction and documents how specific mitigation actions contribute to overall risk reduction.	Section 4.2.2 Process for Identifying, Evaluating, Prioritizing, and Updating Mitigation Actions
4.2.3	The Emergency Management Program has a process to monitor overall progress of the mitigation activities and documents completed initiatives and their resulting reduction or limitation of hazard impact on the jurisdiction.	Section 4.2.4 Review and Progress of Mitigation Actions
4.2.4 The Emergency Management Program, consistent with the scope of the mitigation program, does the following:		
4.2.4 (1)	… provides technical assistance in implementing applicable mitigation codes and ordinances;	Section 5.1.5 Technical Assistance
4.2.4 (2)	… identifies ongoing opportunities and tracks repetitive loss; and	Section 4.3 Severe Repetitive Loss Strategy
4.2.4 (3)	… participates in applicable jurisdictional, inter-jurisdictional and multi-jurisdictional mitigation efforts.	Section 2.3 Integration with Other Planning Efforts
4.2.5	The Emergency Management Program has a method and schedule for evaluation, maintenance, and revision of the plan identified in Standard 4.2.1.	Chapter 6 Plan Maintenance

2.3.4. Challenges in Planning Integration

Traditionally, the State of Missouri has had great success in integrating with other state planning efforts as well as FEMA mitigation programs and initiatives. Challenges in integration that exist relate to lack of staff, meeting schedule conflicts, lack of travel funds for meetings, and lack of time to focus on other plans and programs in addition to daily work duties.

More information on integration with other planning efforts can be found in Section 4.2 State Capability Assessment; Section 4.4 Mitigation Actions, Table 4.9 Missouri Mitigation Action Categories Strategy Overview; Section 5.2 Local Plan Integration, and Section 7.1 Integration with Other Planning Initiatives

In addition, to the HMGP, other funding mechanisms are available in Missouri with an approved standard state plan. These programs listed below are further described in Chapter 4 of this plan.

- FEMA Public Assistance (Categories C-G)
- Flood Mitigation Assistance Program
- Pre-Disaster Mitigation Program

1.1. Plan Adoption

Requirement for Update §201.4(c)(6): The Plan must be formally adopted by the State prior to submittal to [FEMA] for final review and approval.

The Missouri State Hazard Mitigation Plan is the result of the systematic evaluation of the nature and extent of vulnerability to the effects of all hazards (natural, human-caused/technological, and other) present in Missouri and includes the actions needed to minimize future vulnerability to those hazards. It sets forth the policies, procedures, and philosophies that will be used to establish and implement hazard mitigation activities within the State. Effective and consistent implementation of this plan is crucial to the hazard mitigation program and the State's efforts to reduce or eliminate the threat of future disasters. This plan, initially adopted May 12, 2004, along with subsequent adopted updates, incorporates all changes associated with the implementation of the federal/state hazard mitigation program, including the applicable sections of the DMA 2000 and is in compliance with the following standards for accreditation outlined in the 2016 Emergency Management Standard developed by the Emergency Management Accreditation Program (EMAP).

- Hazard Identification, Risk Assessment and Consequence Analysis
- Hazard Mitigation

Overall administration of the hazard mitigation program is the responsibility of the Missouri State Emergency Management Agency (SEMA) Recovery Division, Mitigation Management Section. The Mitigation Management Section will review the plan annually or as needed if hazard mitigation regulations or guidelines change. The plan will be formally updated, submitted to FEMA Region VII for approval, and adopted every five years, or as required, such as following a presidential disaster declaration if the State's priorities change.

The FEMA State Mitigation Plan Review Guide, effective March 2016, provided additional guidance on plan adoption requirements. This revised guidance requirement states "the state must provide documentation of formal adoption by the highest elected official or designee prior to the final review and approval by FEMA". The intent of this revised guidance requirement is to provide statewide recognition and demonstration of risk reduction as a statewide priority.

This 2018 update of the Missouri State Hazard Mitigation Plan was adopted by the State of Missouri by letter signed by SEMA Director Ernie Rhodes June 27, 2018.

1.2. Compliance with Federal and State Laws and Regulations

Requirement §201.4(c)(7): The plan must include assurances that the State will comply with all applicable Federal statutes and regulations in effect with respect to the periods for which it receives grant funding, in compliance with 44 CFR 13.11(c). The State will amend its plan whenever necessary to reflect changes in State or Federal laws and statutes as required in 44 CFR 13.11(d).

1.2.1. General Compliance Assurance Statement

This plan is prepared to comply with the requirements of the Robert T. Stafford Disaster Relief and Emergency Assistance Act of 1988 (as amended by the DMA); all pertinent presidential directives associated with the U.S. Department of Homeland Security and FEMA; all aspects of 44 CFR pertaining to hazard mitigation planning and grants pertaining to the mitigation of adverse effects of disasters (natural, manmade, and other); interim final rules and final rules pertaining to hazard mitigation planning and grants, as described above; all planning criteria issued by FEMA; and all Office of Management and Budget circulars and other federal government documents, guidelines, and rules.

The State of Missouri agrees to comply with all federal statutes and regulations in effect with respect to mitigation grants it receives, in compliance with 2 CFR parts 200 and 3002. As stated in Section 1.1 Plan Adoption, the plan will be updated every five years or as required and amendments will be made as necessary to address changes in federal or state statutes, regulations, and policies. Such amendments will be submitted to FEMA for approval. Additional information about how the plan will be reviewed and updated is in Section 6.1.1

SEMA intends to comply with all administrative requirements outlined in 2 CFR parts 200 and 3002 in their entirety and to monitor all Sub-recipients supported activities to ensure compliance with 2 CFR parts 200 and 3002 in their entirety.

SEMA also, requires all Sub-recipients receiving $750,000 or more in federal assistance to have an audit conducted in accordance with the Single Audit Act under 44 CFR 14, Administration of Grants: Audits of State and Local Governments. Such reports by an independent certified public accountant will be maintained by SEMA. All general audit requirements in 44 CFR 14 will be adhered to by SEMA as well as Sub-recipients receiving FEMA hazard mitigation grant awards.

1.2.2. Authorities

The Missouri State Hazard Mitigation Plan is an important component of state-level programs for management of disasters and their impacts. As such, the strategy relies on the authorities given to the state agencies and their programs herein incorporated for implementation of its strategies and assignments. Further, the plan is intended to be consistent with and supportive of the policies, plans, and implementation procedures that govern mitigation-related state agency programs. In the event of any inconsistency, state agency policies and programs supersede the provisions of the plan. The State's mitigation strategy relies upon and is intended to be consistent with the following specific state and federal authorities as well as EMAP mitigation standards:

Statutes

State

- Constitution of the State of Missouri, as amended
- Chapter 44, Emergency Management, Revised Statutes of Missouri, as amended
- Chapter 160.451-160.457, Schools—General Provisions, Earthquake Emergency Procedure, Revised Statutes of Missouri, 2003

- Chapter 256, Geology, Water Resources, and Geodetic Survey, Interstate Earthquake Emergency Compact and Geologic Hazard Assessment, Revised Statutes of Missouri, 2003
- Chapter 319, General Safety Requirements, Pipelines, Seismic Building Ordinances, Revised Statutes of Missouri, 2003

Federal*

- Public Law 106-390, Disaster Mitigation Act of 2000 (Amendment to Robert T. Stafford Disaster Relief and Emergency Assistance Act
- The National Security Act of 1947
- Public Law 84-99 (33 USC 701n) for flood emergencies
- Public Law 85-256, Price-Anderson Act
- Public Law 89-665 (16 USC 470 et seq.), National Historic Preservation Act
- Public Law 90-448, National Flood Insurance Act of 1968 (42 USC 4001 et seq.)
- Public Law 91-646, Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970 (42 U.S.C. 4601 et seq.)
- Public Law 93-288, as amended by Public Law 100-707, The Robert T. Stafford Disaster Relief and Emergency Assistance Act (42 U.S.C. 6121 et seq.)
- Public Law 93-234, Flood Disaster Protection Act of 1973
- Public Law 95-124, as amended by Public Laws 96-472 and 99-105, Earthquake Hazards Reduction Act of 1977 (42 USC 7701 and 7704)
- Public Law 96-295, The Nuclear Regulatory Commission Appropriations Authorization Act
- Public Law 96-510, Comprehensive Environmental Response, Compensation, and Liability Act of 1980, Section 104(i),(42 USC 9604(i))
- Public Law 99-499, Superfund Amendments and Reauthorization Act of 1986
- Public Law 101-615, Hazardous Materials Transportation Uniform Safety Act
- Public Law 101-549, Clean Air Amendments of 1990
- Public Law 107-296, Homeland Security Act of 2002

*As amended where applicable

Administrative Rules

Federal

- 2 CFR Part 200, Uniform Administrative Requirements, Cost Principles, and Audit Requirements for Federal Awards
- 2 CFR Part 3002, Uniform Administrative Requirements, Cost Principles, and Audit Requirements for Federal Awards
- 44 CFR Part 9, Floodplain Management and Protection of Wetlands
- 44 CFR Part 10, Environmental Considerations
- 44 CFR Part 13 (The Common Rule), Uniform Administrative Requirements for Grants and Cooperative Agreements
- 44 CFR Part 14, Audits of State and Local Governments
- 44 CFR Parts 59-76, National Flood Insurance Program and related programs
- 44 CFR Part 201, Mitigation Planning
- 44 CFR Part 206, Federal Disaster Assistance for Disasters Declared after November 23, 1988
- 49 CFR Part 24, Uniform Relocation Assistance and Real Property Acquisition for Federal and Federally Assisted Programs

Executive Orders

State

- 82-19, Provisions for the necessary and appropriate state coordination and participation with the Federal Insurance Administration under the National Flood Insurance Act of 1968
- 93-40, Establishes the Task Force on Flood Plain Management
- 94-25, Established the Disaster Recovery Partnership with human services disaster response
- 97-09, Authorizes SEMA to issue floodplain development permits for any state owned or leased development in a special flood hazard area
- 03-23, Reaffirms the endeavors of the Disaster Recovery Partnership and ascribes to it the additional functions of a state citizen council
- 05-20, Establishes the Missouri Homeland Security Advisory Council to review and evaluate current state and local homeland security plans
- 06-10, Creates the Citizen Corps to help coordinate volunteer and individual or family preparedness activities in any emergency situation
- 06-41, Creates the Interdepartmental Coordination Council for Water Quality
- 09-25, Creates and establishes the Governor's Faith-Based and Community Service Partnership for Disaster Recovery

Federal

- Executive Order 11988, Floodplain Management
- Executive Order 11990, Protection of Wetlands
- Executive Order 12656, Assignment of Emergency Preparedness Responsibilities
- Executive Order 12148, Federal Emergency Management
- Executive Order 12699, Seismic Safety of Federal and Federally Assisted or Regulated New Building Construction
- Executive Order 12898, Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations
- Homeland Security Presidential Directive 5, Management of Domestic Incidents, February 28, 2003
- Homeland Security Presidential Directive 8, National Preparedness, December 17, 2003

Other

Emergency Management Accreditation Program, 2016

- 4.1 Hazard Identification, Risk Assessment and Consequence Analysis
- 4.2 Hazard Mitigation Standards

3 RISK ASSESSMENT

3.1. Exposure and Analysis of Assets at Risk and State Development Trends

Requirement for Update §201.4(d): Plan must be reviewed and revised to reflect changes in development.

3.1.1. Assets at Risk

As a starting point for analyzing the State's vulnerability to identified hazards, a variety of data is used to define a baseline against which all disaster impacts can be compared. If a catastrophic disaster was to occur in the Planning Area, this section describes significant assets exposed or at risk which could be damaged or destroyed. Data used in this baseline assessment includes:

- Total assets at risk
- General population data
- Population growth and land use/development trends
- Critical facility and bridge inventory
- Cultural, historical, and natural resources

The inventory of buildings and population that could be vulnerable to each hazard within the State is accompanied by an analysis of growth, including recent trends in population growth and housing unit development at the county level to show impacts the hazards have on both population and building assets.

This data presents an inventory of the total exposure of developed properties within each county. It is important to note that depending on the nature and type of hazard event or disaster, it is the value of the infrastructure or improvements to the land that is of concern or at risk. Generally, the land is not insurable and does not see a measurable reduction in use (except for lands with crops); therefore, the unimproved property should not see a reduction in value. And as such, the asset analysis excludes land value.

Table 3.1 below shows a summary of the estimated population and building exposure (total improved property values) by county. Estimated population was obtained from the US Census Bureau 2015 American Community Survey (ACS). Building exposure information was derived from inventory data associated with FEMA's loss estimation software HAZUS-MH. Content values were also included and were estimated as a percentage of building value based on their property type, using FEMA/HAZUS estimated content replacement values. Those content values are 50% for residential, 100% for commercial and governmental and 150% for industrial. All Values are in thousands of dollars. Structure counts are from the MSDIS structure database described in Chapter 2.

Table 3.1. Population and HAZUS Building Exposure by County

		Building Exposure (HAZUS)								Structure Counts						
County	Estimated Population (ACS 2015)	Agriculture	Commercial	Education	Industrial	Government	Religion	Residential	TOTAL	Total Number of Structures	Agriculture	Commercial	Education	Industrial	Government	Residential
Adair	25,378	$14,320	$350,179	$119,783	$67,886	$14,868	$48,170	$1,984,408	$2,599,614	17,344	7,066	869	60	163	37	9,149
Andrew	17,296	$27,974	$153,203	$15,552	$23,708	$8,766	$26,612	$1,469,004	$1,724,819	11,879	4,736	475	23	53	70	6,522
Atchison	5,306	$22,491	$119,723	$9,409	$16,068	$5,204	$29,563	$604,296	$806,754	10,738	7,801	269	34	207	17	2,410
Audrain	26,096	$36,295	$383,416	$34,748	$157,593	$21,423	$73,133	$1,982,482	$2,689,090	25,592	15,295	765	40	274	55	9,163
Barry	35,829	$15,610	$428,580	$40,027	$506,679	$19,746	$69,524	$2,655,955	$3,736,121	28,963	13,871	1,473	51	99	118	13,351
Barton	11,880	$31,626	$197,447	$24,789	$186,381	$8,737	$28,994	$936,986	$1,414,960	15,729	9,810	544	16	112	24	5,223
Bates	16,446	$28,662	$189,303	$26,920	$43,680	$9,961	$31,504	$1,320,120	$1,650,150	12,513	7,016	591	57	29	45	4,775
Benton	18,670	$12,934	$162,248	$18,053	$39,827	$12,329	$42,407	$2,190,660	$2,478,458	15,393	2,630	1,978	12	22	30	10,721
Bollinger	12,182	$8,696	$66,384	$12,514	$17,817	$6,986	$9,643	$913,089	$1,035,129	12,018	7,314	121	9	4	3	4,567
Boone	174,974	$81,799	$2,902,955	$561,011	$407,438	$147,830	$261,447	$14,110,729	$18,473,209	58,267	8,630	1,229	381	159	125	47,743
Buchanan	89,100	$40,774	$2,097,549	$111,075	$672,528	$64,570	$192,842	$7,399,738	$10,579,076	40,969	7,307	1,651	132	1,194	188	30,497
Butler	42,951	$40,726	$651,043	$69,407	$181,046	$36,726	$72,590	$3,092,572	$4,144,110	23,870	5,273	1,300	84	325	43	16,845
Caldwell	9,014	$19,093	$88,804	$24,652	$13,418	$8,772	$17,597	$811,767	$984,103	13,640	9,912	123	34	9	21	3,541
Callaway	44,834	$30,210	$486,435	$52,907	$129,889	$16,773	$66,542	$3,627,689	$4,410,445	22,893	7,002	420	92	268	130	14,981
Camden	44,237	$9,819	$722,847	$26,694	$170,924	$24,689	$55,988	$7,314,982	$8,325,943	46,570	2,295	16,544	20	240	49	27,422
Cape Girardeau	78,572	$49,963	$1,600,035	$101,425	$339,287	$48,778	$168,180	$6,485,161	$8,792,829	34,872	10,084	841	67	123	11	23,746
Carroll	8,992	$29,081	$144,225	$19,671	$69,344	$39,392	$23,042	$875,184	$1,199,939	13,675	9,280	351	18	90	51	3,885
Carter	6,263	$1,690	$45,684	$7,922	$22,102	$6,364	$12,149	$423,355	$519,266	4,068	1,418	58	25	27	2	2,538
Cass	101,603	$66,021	$838,113	$98,722	$264,077	$32,011	$109,183	$9,514,831	$10,922,958	56,662	18,745	2,026	124	706	128	34,933
Cedar	13,934	$12,369	$171,500	$7,481	$67,424	$9,787	$28,483	$1,010,563	$1,307,607	9,338	5,106	371	53	11	26	3,771
Chariton	7,589	$27,712	$107,536	$25,523	$20,346	$4,808	$18,472	$734,359	$938,756	13,262	8,808	373	11	33	19	4,018
Christian	83,279	$29,086	$641,666	$56,773	$264,117	$18,894	$98,647	$6,638,717	$7,747,900	42,164	8,670	1,413	67	404	130	31,480
Clark	6,801	$13,007	$87,371	$10,412	$19,704	$7,257	$12,688	$559,560	$709,999	10,066	7,162	224	9	59	11	2,601
Clay	235,637	$50,087	$3,917,260	$210,279	$1,100,140	$93,067	$372,590	$21,845,657	$27,589,080	83,419	5,155	3,183	178	698	110	74,095
Clinton	20,609	$17,405	$196,298	$27,549	$54,927	$8,667	$39,975	$1,938,029	$2,282,850	13,864	4,996	596	39	134	27	8,072
Cole	76,720	$32,479	$1,341,236	$98,461	$231,480	$1,709,783	$275,095	$7,035,748	$10,724,282	28,931	5,305	363	91	239	112	22,821
Cooper	17,642	$32,082	$244,119	$31,679	$76,537	$12,620	$40,661	$1,359,383	$1,797,081	13,024	6,249	527	15	52	65	6,116
Crawford	24,526	$14,469	$251,924	$18,789	$142,728	$10,438	$51,972	$1,899,135	$2,389,455	16,223	4,873	974	15	149	38	10,174
Dade	7,595	$13,342	$70,690	$12,931	$40,271	$5,560	$19,157	$576,690	$738,641	9,624	4,814	271	14	42	21	4,462
Dallas	16,393	$10,931	$117,584	$11,400	$35,985	$5,094	$23,092	$1,154,677	$1,358,763	17,865	9,948	390	12	64	48	7,403
Daviess	8,253	$14,695	$96,156	$26,529	$65,580	$5,796	$13,130	$736,716	$958,602	17,736	12,227	965	24	50	40	4,430
DeKalb	12,687	$18,076	$119,662	$8,553	$14,310	$3,644	$14,075	$911,782	$1,090,102	8,340	4,143	371	14	38	67	3,707
Dent	15,593	$7,883	$186,997	$22,341	$52,070	$8,610	$30,532	$1,143,111	$1,451,544	17,221	9,511	700	18	107	49	6,836
Douglas	13,373	$7,034	$91,137	$7,496	$25,891	$5,835	$23,093	$887,363	$1,047,849	13,808	7,489	384	10	52	30	5,843
Dunklin	30,895	$49,964	$563,256	$35,610	$53,454	$16,996	$83,674	$2,173,106	$2,976,060	11,158	2,815	136	26	20	28	8,133
Franklin	102,426	$59,994	$1,403,754	$119,573	$944,377	$57,405	$206,434	$8,625,556	$11,417,093	62,302	18,823	3,049	139	481	120	39,690
Gasconade	14,858	$18,387	$224,384	$33,998	$99,085	$15,192	$37,758	$1,459,826	$1,888,630	12,493	7,000	407	29	60	32	4,965
Gentry	6,692	$18,498	$113,912	$15,351	$18,341	$10,730	$16,218	$496,449	$689,499	8,616	5,082	437	5	53	41	2,998
Greene	288,072	$88,611	$5,314,649	$409,822	$1,237,560	$140,600	$621,065	$24,294,425	$32,106,732	123,403	15,605	7,826	308	651	383	98,630
Grundy	10,097	$19,547	$173,150	$18,439	$36,646	$9,903	$32,910	$884,708	$1,175,303	13,578	8,138	615	21	118	39	4,647
Harrison	8,615	$21,281	$170,654	$16,398	$9,586	$9,918	$28,473	$768,410	$1,024,720	13,676	9,506	323	46	27	20	3,754
Henry	21,737	$38,838	$388,739	$29,757	$178,555	$24,646	$47,084	$1,829,277	$2,536,896	21,520	11,201	879	24	140	64	9,212

County	Estimated Population (ACS 2015)	Building Exposure (HAZUS)								Structure Counts						
		Agriculture	Commercial	Education	Industrial	Government	Religion	Residential	TOTAL	Total Number of Structures	Agriculture	Commercial	Education	Industrial	Government	Residential
Hickory	9,201	$3,705	$53,163	$8,417	$11,141	$5,973	$11,238	$771,943	$865,580	7,533	1,238	686	18	19	37	5,535
Holt	4,484	$25,266	$77,464	$14,386	$21,080	$5,941	$24,853	$453,770	$622,760	9,884	6,628	268	11	96	58	2,823
Howard	10,139	$27,277	$112,386	$20,955	$29,214	$11,134	$31,997	$853,479	$1,086,442	5,649	2,085	244	29	31	11	3,249
Howell	40,117	$25,285	$573,884	$38,614	$176,681	$23,699	$75,677	$2,637,052	$3,550,892	30,415	13,505	1,386	45	474	70	14,935
Iron	10,125	$3,900	$83,383	$5,769	$52,052	$8,121	$36,855	$788,608	$978,688	4,947	2,279	135	25	194	27	2,287
Jackson	687,623	$156,848	$16,123,342	$1,148,835	$4,339,214	$770,713	$1,755,443	$65,015,511	$89,309,906	250,658	3,659	13,666	704	3,026	162	229,441
Jasper	118,596	$65,089	$2,067,173	$194,173	$641,409	$69,298	$243,865	$8,789,476	$12,070,483	65,054	13,942	4,217	193	1,958	254	44,490
Jefferson	224,124	$53,093	$2,053,730	$373,933	$800,580	$77,966	$315,610	$18,574,856	$22,249,768	105,667	6,503	5,099	219	536	107	93,203
Johnson	53,951	$38,206	$595,850	$782,337	$204,201	$33,490	$98,091	$4,292,334	$6,044,509	31,227	12,706	959	145	119	1,085	16,213
Knox	3,910	$16,398	$52,598	$6,751	$6,413	$6,053	$7,692	$342,518	$438,423	8,597	6,161	307	4	46	28	2,051
Laclede	35,473	$27,213	$516,577	$31,485	$191,656	$14,180	$70,143	$2,367,327	$3,218,581	24,443	9,964	810	22	274	26	13,347
Lafayette	32,701	$52,605	$504,103	$75,051	$120,365	$17,178	$81,305	$2,990,786	$3,841,393	29,301	14,235	1,348	85	161	44	13,428
Lawrence	38,180	$39,725	$368,672	$42,837	$200,899	$13,160	$83,906	$2,746,561	$3,495,760	30,865	14,507	1,241	51	158	125	14,783
Lewis	10,207	$19,997	$102,873	$13,069	$41,456	$7,710	$25,948	$784,820	$995,873	20,578	12,607	635	51	155	38	7,092
Lincoln	54,696	$41,794	$459,402	$28,549	$142,096	$27,493	$70,090	$3,950,497	$4,719,921	33,231	15,516	289	48	26	20	17,332
Linn	12,308	$34,542	$210,477	$30,857	$55,071	$16,334	$36,950	$1,167,554	$1,551,785	14,977	8,066	419	9	77	38	6,368
Livingston	15,028	$19,486	$313,606	$21,619	$111,502	$15,484	$34,284	$1,195,139	$1,711,120	12,422	6,334	321	11	11	43	5,702
Macon	15,335	$28,687	$228,826	$25,782	$42,708	$25,601	$38,954	$1,244,279	$1,634,837	16,318	8,922	726	32	78	48	6,512
Madison	12,408	$6,003	$150,263	$10,995	$64,385	$4,669	$35,875	$863,412	$1,135,602	7,159	1,644	456	47	136	52	4,824
Maries	8,963	$13,976	$61,517	$9,966	$55,735	$7,761	$14,185	$792,723	$955,863	9,706	5,400	349	5	45	15	3,892
Marion	28,880	$26,661	$471,676	$49,080	$130,845	$22,222	$70,761	$2,453,396	$3,224,641	16,799	4,451	1,335	50	218	62	10,683
McDonald	22,643	$12,544	$107,167	$21,431	$62,164	$8,141	$26,380	$1,445,793	$1,683,620	14,795	7,224	322	8	48	11	7,182
Mercer	3,694	$5,999	$37,602	$9,673	$4,256	$3,572	$8,478	$331,940	$401,520	6,818	4,718	142	4	39	16	1,899
Miller	25,113	$19,511	$295,032	$30,654	$92,450	$8,840	$42,248	$1,915,737	$2,404,472	20,087	6,142	2,261	38	102	38	11,506
Mississippi	14,036	$27,625	$127,309	$25,409	$19,601	$16,033	$31,525	$867,032	$1,114,534	7,628	2,528	195	26		29	4,850
Moniteau	15,963	$20,771	$139,541	$23,420	$90,281	$17,535	$29,151	$1,187,359	$1,508,058	12,633	7,484	70	39	14	62	4,964
Monroe	8,583	$16,494	$97,141	$22,974	$48,653	$7,031	$24,397	$762,795	$979,485	12,516	7,210	461	19	22	29	4,775
Montgomery	11,703	$26,634	$192,730	$22,592	$104,546	$15,000	$25,807	$1,010,136	$1,397,445	16,650	11,138	205	33	56	22	5,196
Morgan	20,171	$25,418	$300,915	$7,822	$76,526	$14,146	$42,294	$2,405,174	$2,872,295	30,068	10,045	6,631	39	108	8	13,237
New Madrid	18,208	$23,520	$211,322	$37,254	$90,102	$13,557	$29,923	$1,359,611	$1,765,289	14,398	5,946	288	66	193	73	7,832
Newton	58,615	$31,573	$821,493	$121,341	$250,522	$28,249	$114,690	$4,141,636	$5,509,504	35,945	10,796	1,885	105	292	73	22,794
Nodaway	22,810	$36,074	$263,182	$35,283	$109,275	$16,459	$46,587	$1,940,940	$2,447,800	23,183	14,261	618	52	115	75	8,062
Oregon	10,953	$8,246	$96,301	$10,066	$13,599	$8,145	$22,182	$732,498	$891,037	13,375	8,642	500	68	27	20	4,118
Osage	13,628	$18,356	$114,226	$66,208	$107,196	$11,425	$13,014	$1,281,365	$1,611,790	14,148	8,469	350	29	100	24	5,176
Ozark	9,409	$5,644	$68,168	$14,173	$28,799	$11,820	$9,400	$788,354	$926,358	12,398	7,221	483	12	67	22	4,593
Pemiscot	17,482	$17,696	$197,885	$34,165	$74,439	$17,129	$43,608	$1,257,368	$1,642,290	12,568	4,481	352	50	81	65	7,539
Perry	19,183	$38,219	$302,599	$11,355	$212,491	$7,600	$62,018	$1,598,727	$2,233,009	14,796	7,321	230	15	118	19	7,093
Pettis	42,255	$49,925	$816,567	$121,899	$286,237	$29,727	$72,077	$3,091,696	$4,468,128	31,252	14,539	1,728	71	245	100	14,569
Phelps	44,794	$16,661	$772,776	$101,599	$144,551	$42,999	$102,021	$3,562,881	$4,743,488	19,418	3,621	1,049	66	39	70	14,573
Pike	18,348	$24,666	$281,618	$26,030	$76,195	$16,285	$40,689	$1,396,095	$1,861,578	13,573	5,289	796	21	292	72	7,103

County	Estimated Population (ACS 2015)	Building Exposure (HAZUS)								Structure Counts						
		Agriculture	Commercial	Education	Industrial	Government	Religion	Residential	TOTAL	Total Number of Structures	Agriculture	Commercial	Education	Industrial	Government	Residential
Platte	96,096	$34,663	$1,268,806	$93,271	$366,982	$64,085	$136,758	$9,395,603	$11,360,168	34,849	3,909	1,751	71	465	104	28,549
Polk	31,229	$33,744	$329,743	$45,402	$68,241	$12,892	$49,909	$2,168,773	$2,708,704	21,150	8,476	756	61	82	35	11,740
Pulaski	53,221	$11,408	$433,400	$52,782	$73,642	$47,095	$84,685	$4,631,648	$5,334,660	19,605	2,017	538	28	36	5,073	11,913
Putnam	4,858	$13,739	$60,827	$3,054	$12,749	$5,158	$7,812	$428,681	$532,020	8,716	5,933	421	4	72	3	2,283
Ralls	10,196	$17,552	$90,615	$5,232	$115,428	$6,791	$14,982	$905,046	$1,155,646	12,905	6,965	530	12	190	33	5,175
Randolph	25,104	$15,681	$369,932	$43,642	$132,182	$22,503	$51,092	$1,790,133	$2,425,165	16,794	5,221	761	38	214	68	10,492
Ray	22,810	$37,883	$217,356	$34,784	$67,518	$15,283	$41,718	$2,122,513	$2,537,055	16,007	6,600	382	30	68	22	8,905
Reynolds	6,432	$2,381	$50,969	$6,564	$29,571	$6,565	$13,035	$560,562	$669,647	4,482	716	180	23	292	5	3,266
Ripley	13,802	$5,131	$110,346	$21,928	$71,484	$9,079	$22,776	$890,591	$1,131,335	10,129	3,738	226	10	55	18	6,082
Saline	23,258	$28,865	$303,991	$60,626	$104,411	$21,026	$62,570	$1,856,157	$2,437,646	18,058	7,962	555	40	102	35	9,364
Schuyler	4,436	$8,592	$43,660	$2,108	$4,502	$7,997	$8,263	$326,678	$401,800	5,451	3,438	231	18	1	15	1,748
Scotland	4,854	$14,748	$78,880	$7,751	$17,890	$6,257	$6,834	$409,127	$541,487	8,702	6,329	298	11	13	13	2,038
Scott	39,008	$36,363	$669,038	$135,294	$212,662	$24,923	$100,358	$2,857,650	$4,036,288	20,131	5,535	363	34	51	26	14,122
Shannon	8,258	$4,612	$42,559	$7,241	$19,189	$7,568	$9,172	$588,387	$678,728	7,865	3,114	543	53	236	42	3,877
Shelby	6,128	$27,188	$89,869	$14,423	$63,308	$6,263	$31,470	$554,101	$786,622	12,853	9,855	393	15	12	28	2,550
St. Charles	385,590	$85,752	$4,283,344	$457,659	$1,132,861	$137,257	$439,871	$35,308,261	$41,845,005	129,950	5,845	4,972	178	527	89	118,339
St. Clair	9,440	$13,070	$108,644	$16,865	$13,488	$12,189	$18,413	$753,428	$936,097	12,306	7,486	649	20	21	25	4,105
St. Francois	66,520	$19,301	$872,269	$73,649	$262,897	$38,788	$155,358	$4,757,904	$6,180,166	27,392	2,377	2,166	53	264	156	22,376
St. Louis	1,003,362	$302,127	$21,831,143	$1,892,121	$7,188,513	$566,833	$2,006,742	$105,100,371	$138,887,850	490,949	1,761	49,134	1,159	3,228	769	434,898
St. Louis City	315,685	$31,192	$10,747,251	$887,335	$3,482,455	$306,627	$1,251,874	$30,173,479	$46,880,213	104,927	16	7,055	454	2,674	110	94,618
Ste. Genevieve	17,919	$12,526	$229,251	$23,414	$154,462	$16,046	$28,420	$1,699,025	$2,163,144	14,711	5,898	228	4	218	6	8,357
Stoddard	29,862	$43,125	$381,428	$31,005	$128,573	$20,598	$64,808	$2,319,593	$2,989,130	25,156	10,727	473	21	155	19	13,761
Stone	30,943	$10,277	$268,485	$34,158	$58,834	$9,766	$71,456	$3,483,522	$3,936,498	27,851	6,797	3,001	44	132	78	17,799
Sullivan	6,353	$10,795	$68,601	$13,507	$46,017	$9,027	$14,841	$461,815	$624,603	8,018	5,217	157	9	58	7	2,570
Taney	54,592	$13,873	$969,985	$31,816	$107,076	$28,320	$121,929	$4,847,613	$6,120,612	26,884	4,202	3,491	59	136	141	18,855
Texas	25,690	$28,152	$255,079	$22,233	$92,472	$20,128	$83,700	$1,791,662	$2,293,426	25,695	15,128	746	87	114	52	9,568
Vernon	20,826	$19,657	$321,893	$113,754	$89,034	$23,596	$32,729	$1,650,737	$2,251,400	16,865	8,970	581	51	34	75	7,154
Warren	33,513	$16,569	$297,431	$24,310	$178,066	$12,319	$42,918	$2,906,963	$3,478,576	20,539	7,419	250	34	27	49	12,760
Washington	24,788	$3,402	$142,056	$23,264	$28,070	$11,747	$48,682	$1,473,765	$1,730,986	16,291	6,331	652	49	81	45	9,133
Wayne	13,405	$4,139	$95,470	$10,248	$54,877	$6,532	$28,231	$1,057,093	$1,256,590	9,020	3,372	128	19	25	4	5,472
Webster	37,483	$21,865	$267,409	$34,971	$90,840	$10,062	$40,763	$2,316,205	$2,782,115	25,782	13,001	659	39	107	84	11,892
Worth	2,057	$6,777	$20,511	$2,383	$5,599	$5,168	$2,934	$226,160	$269,532	2,903	1,606	106	9	7	17	1,158
Wright	18,268	$24,024	$205,125	$25,876	$48,367	$12,913	$50,095	$1,235,931	$1,602,331	19,205	10,925	496	63	175	18	7,528
Total	6,045,448	**$3,294,066**	**$103,571,712**	**$10,559,903**	**$31,971,65**	**$5,718,449**	**$12,569,797**	**$541,878,610**	**$709,564,189**	16,291	6,331	652	49	81	45	9,133

Building Source: Hazus, U.S. Census Bureau 2015 Population Estimates, www.census.gov
Structure Source: Missouri Spatial Data Information Service (MSDIS) Structures Inventory
*All Values are in thousands of dollars

Population

Based on the 2015 ACS released by the U.S. Census Bureau (July 2017), Missouri ranked 18th among the 50 states in population, 18th in land areas (68,742 square miles), 27th in rate of growth, and 28th in population density. In 1830, the first year of statehood, Missouri had a population of 140,455. Decennial census findings from the last few decades and the most recent estimate illustrate Missouri's growth.

Historical Population Growth

According to the US Census, the state of Missouri had a population of 5,595,211 in 2000. In 2010, the population reached 5,988,927 representing a 7% increase. Counties with more than 15% growth from 2000-2015 include Christian, Lincoln, Warren, Taney, Pulaski, St. Charles, Cass, Platte, Clay, Boone, Camden, St. Francois and Webster Counties.

Table 3.2. Missouri Population Estimates

Census	Total Population	Ten-year % Change	Average Annual % Change
1970	4,677,623	--	--
1980	4,917,444	5.13%	0.051%
1990	5,117,073	4.06%	0.041%
2000	5,595,211	9.34%	0.093%
2010	5,988,927	7.04%*	0.070%
2015 (estimated)	6,045,448	--	0.19%

Table 3.3. Table 3.3 Missouri Population Estimates

Population estimates, July 1, 2016	6,093,000
Population, percent change, April 1, 2010 to July 1, 2016 (V2016)	1.7%
Land Area in Square Miles (2010)	68,741.52
Persons per Square Mile (2010)	87.1
Number of Incorporated Cities, Towns, and Villages	951
Housing Units (2015)	2,746,599
Number of Counties (with St. Louis City*)	115
Counties with a 2010 population estimate; Greater than 500,000	2 (St, Louis, Jackson)
200,000 to 499,000	5 (St Louis City, St. Charles, Greene, Jefferson, Clay)
100,000 to 199,99	3 (Boone, Jasper, Franklin)
50,000 to 99,999	12
25,000 to 49,999	23
15,000 to 24,999	26
10,000 to 14,999	18
1 to 9,999	26

Source: U.S. Census Bureau, 2015 ACS

Figure 3.1 on the following page illustrates Missouri's population by county based upon the 2015 ACS.

Figure 3.1. Counties by Population, 2015

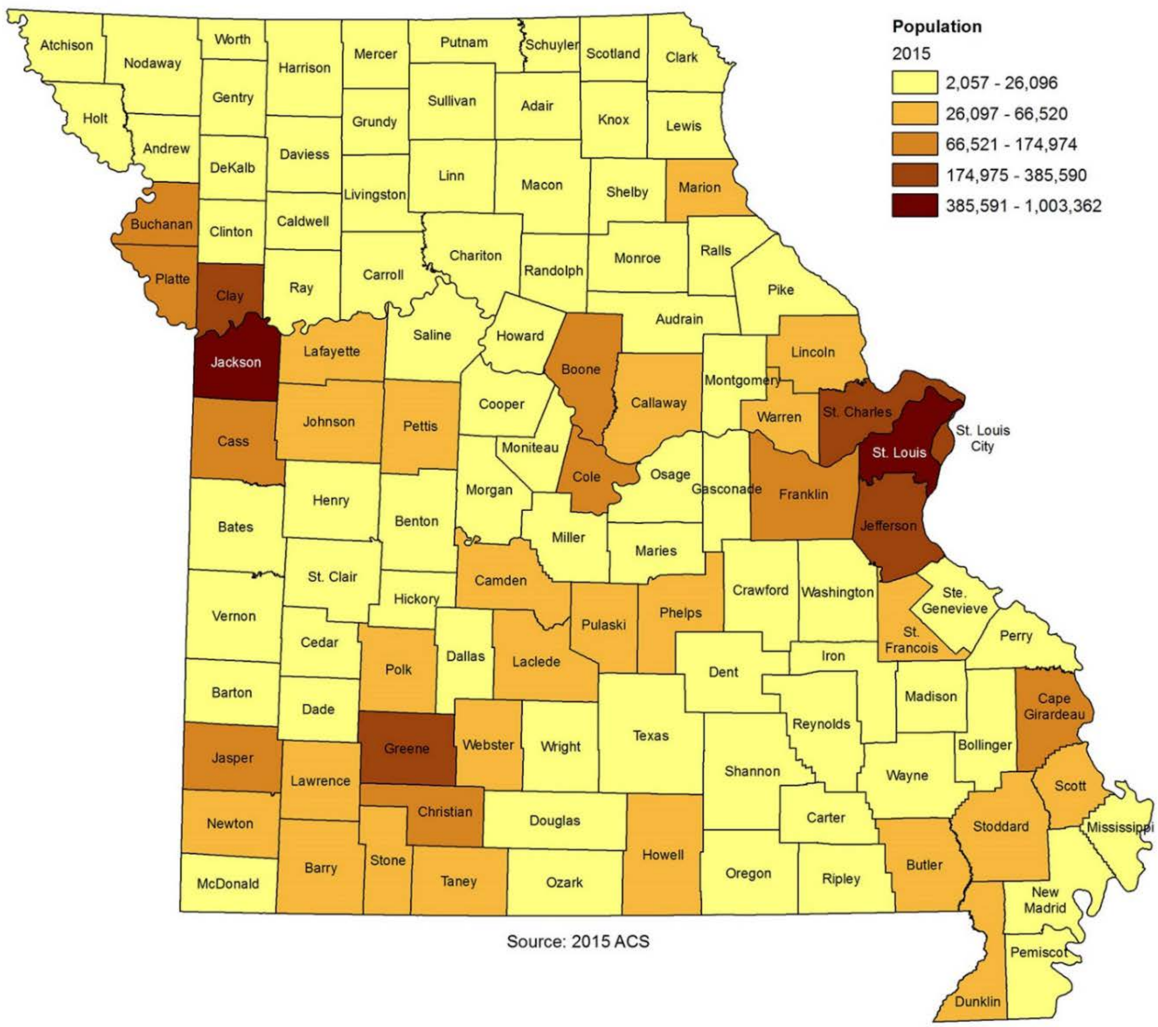


Table 3.5. Missouri Counties Population

County	2000 Census	April 1, 2010 - Census	Growth 2000-2010	ACS 2015 Population	Growth 2010-2015	Growth 2000-2015
Adair	24,977	25,607	3%	25,378	-0.89%	1.61%
Andrew	16,492	17,291	5%	17,296	0.03%	4.88%
Atchison	6,430	5,685	-12%	5,306	-6.67%	-17.48%
Audrain	25,853	25,529	-1%	26,096	2.22%	0.94%
Barry	34,010	35,597	5%	35,829	0.65%	5.35%
Barton	12,541	12,402	-1%	11,880	-4.21%	-5.27%
Bates	16,653	17,049	2%	16,446	-3.54%	-1.24%
Benton	17,180	19,056	11%	18,670	-2.03%	8.67%
Bollinger	12,029	12,363	3%	12,182	-1.46%	1.27%
Boone	135,454	162,642	20%	174,974	7.58%	29.18%
Buchanan	85,998	89,201	4%	89,100	-0.11%	3.61%
Butler	40,867	42,794	5%	42,951	0.37%	5.10%

County	2000 Census	April 1, 2010 - Census	Growth 2000-2010	ACS 2015 Population	Growth 2010-2015	Growth 2000-2015
Caldwell	8,969	9,424	5%	9,014	-4.35%	0.50%
Callaway	40,766	44,332	9%	44,834	1.13%	9.98%
Camden	37,051	44,002	19%	44,237	0.53%	19.39%
Cape Girardeau	68,693	75,674	10%	78,572	3.83%	14.38%
Carroll	10,285	9,295	-10%	8,992	-3.26%	-12.57%
Carter	5,941	6,265	5%	6,263	-0.03%	5.42%
Cass	82,092	99,478	21%	101,603	2.14%	23.77%
Cedar	13,733	13,982	2%	13,934	-0.34%	1.46%
Chariton	8,438	7,831	-7%	7,589	-3.09%	-10.06%
Christian	54,285	77,422	43%	83,279	7.57%	53.41%
Clark	7,416	7,139	-4%	6,801	-4.73%	-8.29%
Clay	184,006	221,939	21%	235,637	6.17%	28.06%
Clinton	18,979	20,743	9%	20,609	-0.65%	8.59%
Cole	71,397	75,990	6%	76,720	0.96%	7.46%
Cooper	16,670	17,601	6%	17,642	0.23%	5.83%
Crawford	22,804	24,696	8%	24,526	-0.69%	7.55%
Dade	7,923	7,883	-1%	7,595	-3.65%	-4.14%
Dallas	15,661	16,777	7%	16,393	-2.29%	4.67%
Daviess	8,016	8,433	5%	8,253	-2.13%	2.96%
DeKalb	11,597	12,892	11%	12,687	-1.59%	9.40%
Dent	14,927	15,657	5%	15,593	-0.41%	4.46%
Douglas	13,084	13,684	5%	13,373	-2.27%	2.21%
Dunklin	33,155	31,953	-4%	30,895	-3.31%	-6.82%
Franklin	93,807	101,492	8%	102,426	0.92%	9.19%
Gasconade	15,342	15,222	-1%	14,858	-2.39%	-3.15%
Gentry	6,861	6,738	-2%	6,692	-0.68%	-2.46%
Greene	240,391	275,174	14%	288,072	4.69%	19.83%
Grundy	10,432	10,261	-2%	10,097	-1.60%	-3.21%
Harrison	8,850	8,957	1%	8,615	-3.82%	-2.66%
Henry	21,997	22,272	1%	21,737	-2.40%	-1.18%
Hickory	8,940	9,627	8%	9,201	-4.43%	2.92%
Holt	5,351	4,912	-8%	4,484	-8.71%	-16.20%
Howard	10,212	10,144	-1%	10,139	-0.05%	-0.71%
Howell	37,238	40,400	8%	40,117	-0.70%	7.73%
Iron	10,697	10,630	-1%	10,125	-4.75%	-5.35%
Jackson	654,880	674,158	3%	687,623	2.00%	5.00%
Jasper	104,686	117,404	12%	118,596	1.02%	13.29%
Jefferson	198,099	218,733	10%	224,124	2.46%	13.14%
Johnson	48,258	52,595	9%	53,951	2.58%	11.80%
Knox	4,361	4,131	-5%	3,910	-5.35%	-10.34%
Laclede	32,513	35,571	9%	35,473	-0.28%	9.10%
Lafayette	32,960	33,381	1%	32,701	-2.04%	-0.79%
Lawrence	35,204	38,634	10%	38,180	-1.18%	8.45%
Lewis	10,494	10,211	-3%	10,207	-0.04%	-2.73%
Lincoln	38,944	52,566	35%	54,696	4.05%	40.45%
Linn	13,754	12,761	-7%	12,308	-3.55%	-10.51%
Livingston	14,558	15,195	4%	15,028	-1.10%	3.23%
Macon	15,762	15,566	-1%	15,335	-1.48%	-2.71%
Madison	11,800	12,226	4%	12,408	1.49%	5.15%
Maries	8,903	9,176	3%	8,963	-2.32%	0.67%

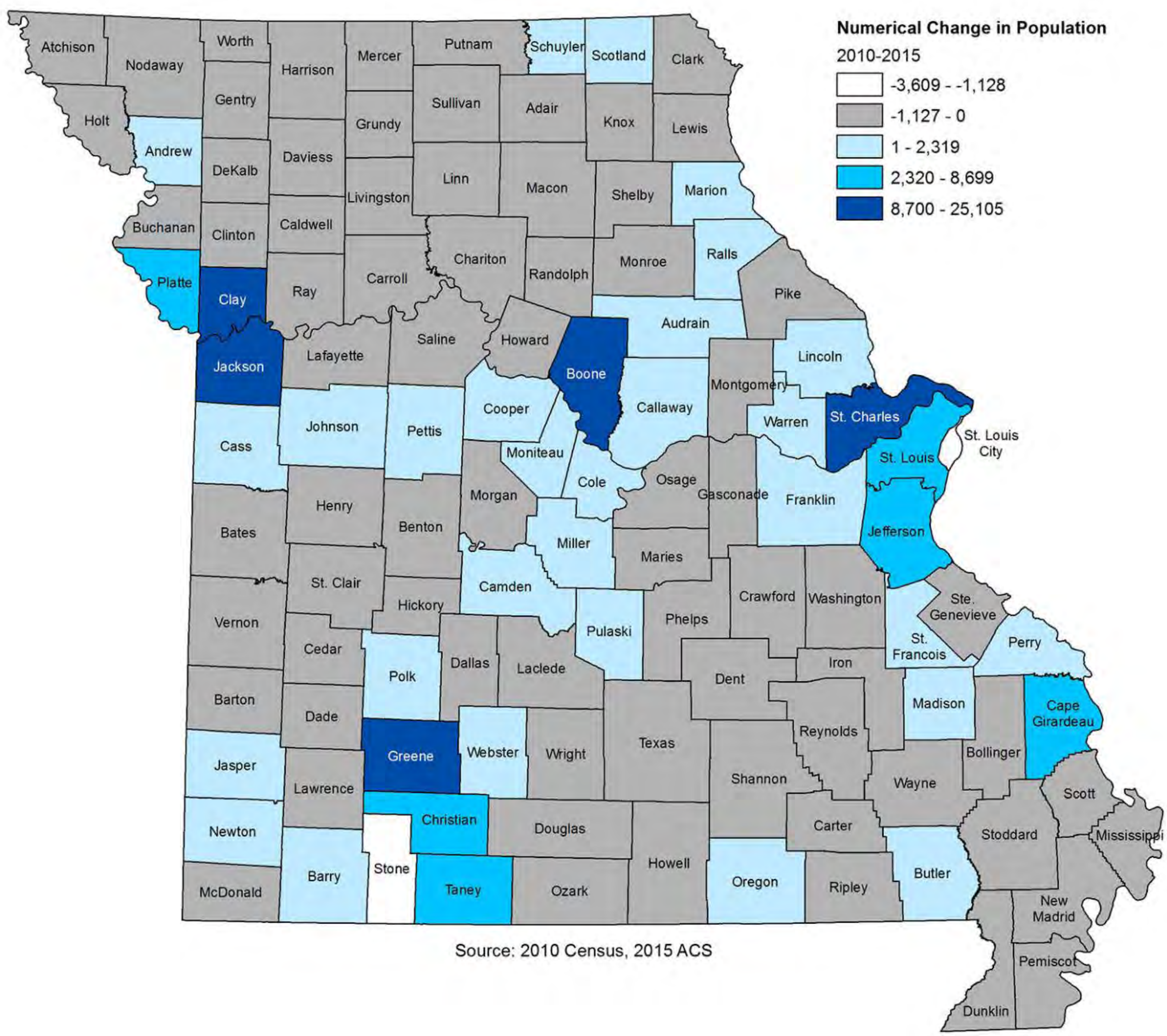
County	2000 Census	April 1, 2010 - Census	Growth 2000-2010	ACS 2015 Population	Growth 2010-2015	Growth 2000-2015
Marion	28,289	28,781	2%	28,880	0.34%	2.09%
McDonald	21,681	23,083	6%	22,643	-1.91%	4.44%
Mercer	3,757	3,785	1%	3,694	-2.40%	-1.68%
Miller	23,564	24,748	5%	25,113	1.47%	6.57%
Mississippi	13,427	14,358	7%	14,036	-2.24%	4.54%
Moniteau	14,827	15,607	5%	15,963	2.28%	7.66%
Monroe	9,311	8,840	-5%	8,583	-2.91%	-7.82%
Montgomery	12,136	12,236	1%	11,703	-4.36%	-3.57%
Morgan	19,309	20,565	7%	20,171	-1.92%	4.46%
New Madrid	19,760	18,956	-4%	18,208	-3.95%	-7.85%
Newton	52,636	58,114	10%	58,615	0.86%	11.36%
Nodaway	21,912	23,370	7%	22,810	-2.40%	4.10%
Oregon	10,344	10,881	5%	10,953	0.66%	5.89%
Osage	13,062	13,878	6%	13,628	-1.80%	4.33%
Ozark	9,542	9,723	2%	9,409	-3.23%	-1.39%
Pemiscot	20,047	18,296	-9%	17,482	-4.45%	-12.79%
Perry	18,132	18,971	5%	19,183	1.12%	5.80%
Pettis	39,403	42,201	7%	42,255	0.13%	7.24%
Phelps	39,825	45,156	13%	44,794	-0.80%	12.48%
Pike	18,351	18,516	1%	18,348	-0.91%	-0.02%
Platte	73,781	89,322	21%	96,096	7.58%	30.24%
Polk	26,992	31,137	15%	31,229	0.30%	15.70%
Pulaski	41,165	52,274	27%	53,221	1.81%	29.29%
Putnam	5,223	4,979	-5%	4,858	-2.43%	-6.99%
Ralls	9,626	10,167	6%	10,196	0.29%	5.92%
Randolph	24,663	25,414	3%	25,104	-1.22%	1.79%
Ray	23,354	23,494	1%	22,810	-2.91%	-2.33%
Reynolds	6,689	6,696	0%	6,432	-3.94%	-3.84%
Ripley	13,509	14,100	4%	13,802	-2.11%	2.17%
Saline	23,756	23,370	-2%	23,258	-0.48%	-2.10%
Schuyler	4,170	4,431	6%	4,436	0.11%	6.38%
Scotland	4,983	4,843	-3%	4,854	0.23%	-2.59%
Scott	40,422	39,191	-3%	39,008	-0.47%	-3.50%
Shannon	8,324	8,441	1%	8,258	-2.17%	-0.79%
Shelby	6,799	6,373	-6%	6,128	-3.84%	-9.87%
St. Charles	283,883	360,485	27%	385,590	6.96%	35.83%
St. Clair	9,652	9,805	2%	9,440	-3.72%	-2.20%
St. Francois	55,641	65,359	17%	66,520	1.78%	19.55%
St. Louis	1,016,315	998,954	-2%	1,003,362	0.44%	-1.27%
St. Louis City	348,189	319,294	-8%	315,685	-1.13%	-9.34%
Ste. Genevieve	17,842	18,145	2%	17,919	-1.25%	0.43%
Stoddard	29,705	29,968	1%	29,862	-0.35%	0.53%
Stone	28,658	32,202	12%	30,943	-3.91%	7.97%
Sullivan	7,219	6,714	-7%	6,353	-5.38%	-12.00%
Taney	39,703	51,675	30%	54,592	5.64%	37.50%
Texas	23,003	26,008	13%	25,690	-1.22%	11.68%
Vernon	20,454	21,159	3%	20,826	-1.57%	1.82%
Warren	24,525	32,513	33%	33,513	3.08%	36.65%
Washington	23,344	25,195	8%	24,788	-1.62%	6.19%
Wayne	13,259	13,521	2%	13,405	-0.86%	1.10%

County	2000 Census	April 1, 2010 - Census	Growth 2000-2010	ACS 2015 Population	Growth 2010-2015	Growth 2000-2015
Webster	31,045	36,202	17%	37,483	3.54%	20.74%
Worth	2,382	2,171	-9%	2,057	-5.25%	-13.64%
Wright	17,955	18,815	5%	18,268	-2.91%	1.74%
Total	5,595,211	5,988,927	7%	6,045,448	0.94%	8.05%

Source: U.S. Census Bureau, 2015 ACS

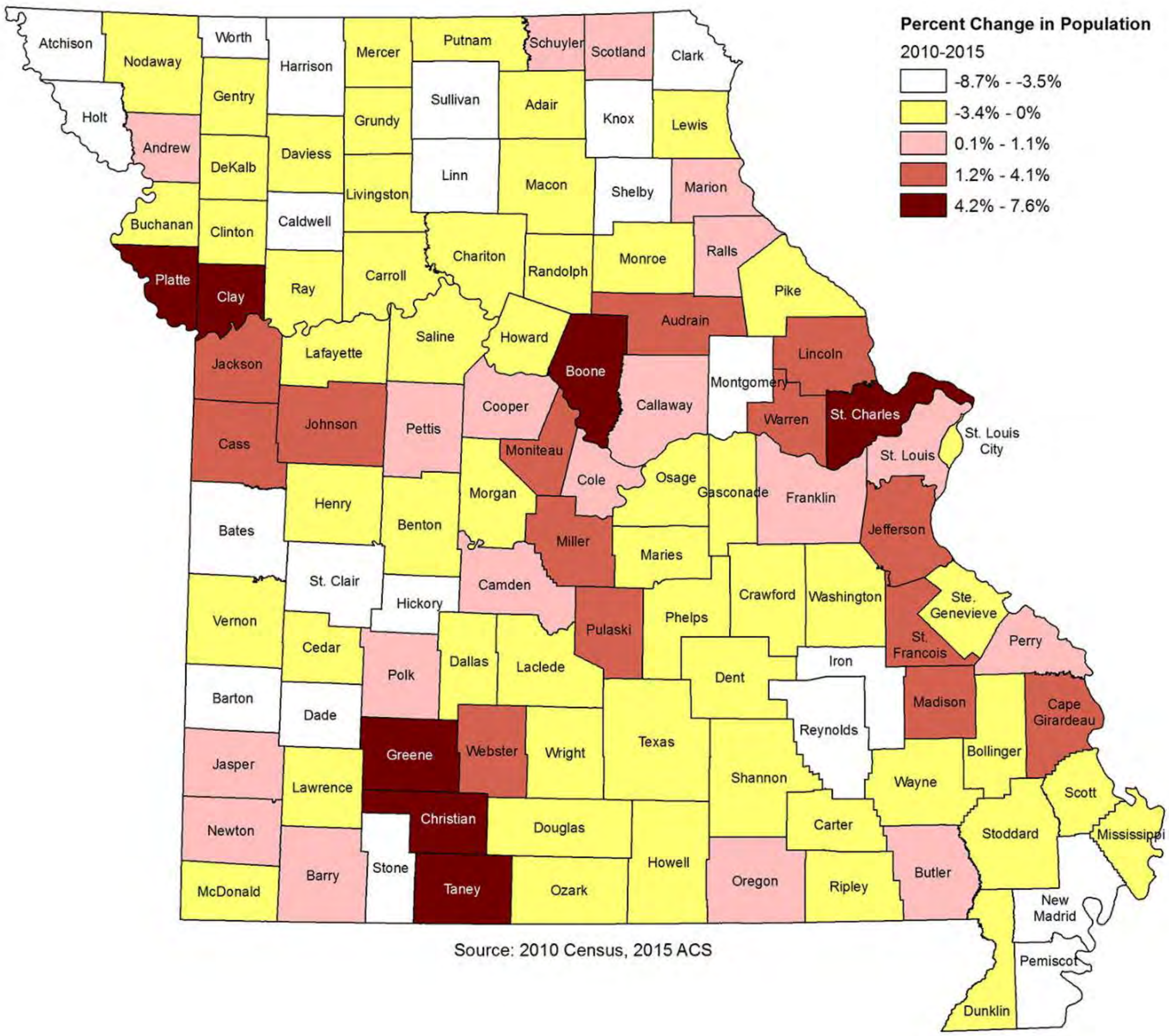
Figure 3.2 and **Figure 3.3** illustrate county population changes from 2010 to 2015 by numerical count and by percent statewide. Between 2010 and 2015, 40 counties increased in population and seven of them grew by more than 5 percent.

Figure 3.2. Estimated Change in Population by County, 2010-2015, Numerical



Source: 2010 Census, 2015 ACS

Figure 3.3. Estimated Change in Population by County, 2010-2015, Percentage



Source: 2010 Census, 2015 ACS

Table 3.6. Top 10 Most Populated Missouri Counties, 2015

County	2010 Population	2015 Population	Percent Change 2010-2015
St. Louis	998,954	1,003,362	0.44%
Jackson	674,158	687,623	2.00%
St. Charles	360,485	385,590	6.96%
St. Louis city	319,294	315,685	-1.13%
Greene	275,174	288,072	4.69%
Clay	221,939	235,637	6.17%
Jefferson	218,733	224,124	2.46%
Boone	162,642	174,974	7.58%
Jasper	117,404	118,596	1.02%
Franklin	101,492	102,426	0.92%

Source: U.S. Census Bureau, 2015 ACS

Growth in Missouri counties over the past decades can be attributed to a robust economy that led to low unemployment and reasonable interest rates. Economic resources include the following:

- The Missouri Department of Economic Development creates an environment that encourages an economic growth by supporting Missouri's businesses by providing data and resources for businesses, industries, and communities to grow and expand. The site provides a list of companies that announced their expansion projects to create jobs throughout the state.
- Missouri Small Business and Technology Development Centers partnered with Missouri Economic Research and Information Center (MERIC) and the Business Research and Information Development Group (BRIDG) University of Missouri to analyze Missouri's fastest growing businesses with a report titled "Chasing Cheetahs." The report explains that a Cheetah Firm has at least doubled its employment in the past five years. Less than four percent of all businesses in the state or 6,252 met this benchmark in the most recent five-year study period. This level of job creation added nearly 130,000 new positions to Missouri payrolls. This job growth exceeded 250 percent when the statewide job growth rate for the same period was just over two percent. Population growth can be correlated to significant job growth.

Although these growth factors (low unemployment and reasonable interest rates) have been dampened by the recent economic slowdown, not every county has been affected to the same extent. A report from the Brookings Institution suggests that Missouri is decentralizing to low population density areas and that this development pattern will exacerbate the fiscal problems of state and local governments by increasing the cost of providing infrastructure and services into rural areas. (Brookings 2002). The report also emphasizes the need for the State to monitor the effect that additional land consumption will have regarding newly developed areas which includes buildings and increased density. In addition, the Missouri Office of Administration Division of Budget & Planning describes population shifts among Missouri regions as having followed similar patterns for many years. Shifts have been from rural agricultural areas to urban areas and to rural areas rich in recreational amenities. Projections show that these patterns will continue, and there will be more movement to urban fringe areas. The demand for infrastructure and resources in the developing areas and urban fringe areas will be accompanied by the need for new hazard mitigation projects. **Table 3.7** and **Table 3.8** lists the ten counties with the greatest population growth from 2010 through 2015.

Table 3.7. Missouri Counties with Greatest Estimated Population Gains (Numerical), 2010-2015

County	2010 Census	2015 ACS	Growth 2010-2015
St. Charles	360,485	385,590	25,105
Clay	221,939	235,637	13,698
Jackson	674,158	687,623	13,465
Greene	275,174	288,072	12,898
Boone	162,642	174,974	12,332
Platte	89,322	96,096	6,774
Christian	77,422	83,279	5,857
Jefferson	218,733	224,124	5,391
St. Louis	998,954	1,003,362	4,408
Taney	51,675	54,592	2,917

Source: U.S. Census Bureau, 2015 ACS

Table 3.8. Missouri Counties with Greatest Estimated Population Gains (Percent), 2010-2015

County	2010 Census	Population Estimate (as of July 1) - 2015	Growth 2010-2015
Platte	73,781	96,096	7.58%
Boone	135,454	174,974	7.58%
Christian	54,285	83,279	7.57%
St. Charles	283,883	385,590	6.96%
Clay	184,006	235,637	6.17%
Taney	39,703	54,592	5.64%
Greene	240,391	288,072	4.69%
Lincoln	38,944	54,696	4.05%
Cape Girardeau	68,693	78,572	3.83%
Webster	31,045	37,483	3.54%

Source: U.S. Census Bureau, 2015 ACS

Not all of Missouri's counties are growing, however (refer to **Table 3.9** and **Table 3.10**). St. Louis City, one of the most populous jurisdictions, lost the greatest number of people.

Table 3.9. Counties with Greatest Estimated Population Loss (Numerical), 2010-2015

County	Population Decrease	Associated Percent Decrease
St. Louis City	(3,609)	-1.13%
Stone	(1,259)	-3.91%
Dunklin	(1,058)	-3.31%
Pemiscot	(814)	-4.45%
New Madrid	(748)	-3.95%
Ray	(684)	-2.91%
Lafayette	(680)	-2.04%
Bates	(603)	-3.54%
Nodaway	(560)	-2.40%
Wright	(547)	-2.91%

Source: U.S. Census Bureau, 2015 ACS

Table 3.10. Counties with Greatest Estimated Population Loss (Percent), 2010-2015

County	Percent Decease	Associated Numeric Decrease
Holt	-8.71%	(428)
Atchison	-6.67%	(379)
Sullivan	-5.38%	(361)
Knox	-5.35%	(221)
Worth	-5.25%	(114)
Iron	-4.75%	(505)
Clark	-4.73%	(338)
Pemiscot	-4.45%	(814)
Hickory	-4.43%	(426)
Montgomery	-4.36%	(533)

Source: U.S. Census Bureau, 2015 ACS

Interim population projections issued by the Missouri Office of Administration in 2008 suggest that Missouri's population will continue to grow, but percentages will drop, over the next three decades (see **Table 3.11**).

Table 3.11. Interim Missouri Population Projections, 2000-2030

Year	Population	Percent Change
2000	5,596,687	--
2005	5,781,293	3.3%
2010	5,979,344	3.4%
2015	6,184,390	3.4%
2020	6,389,850	3.3%
2025	6,580,868	3.0%
2030	6,746,762	2.5%

Source: Missouri Office of Administration, 2008

In addition to these growth projections, the following counties are expected to experience a population decrease of 5 percent or greater by 2030 (see **Table 3.12**).

Table 3.12. Counties Projected to Have Future Population Decreases (In order of percent decline by 2020 and 2030)

Counties	2015	Population Projections					
		2020 (Proj)	2030 (Proj)	# Decline by 2020	# Decline by 2030	% Decline by 2020	% Decline by 2030
New Madrid	15,764	14,621	12,554	1,143	3,210	-7.25%	-20.36%
Iron	9,158	8,605	7,494	553	1,664	-6.04%	-18.17%
Gentry	5,637	5,314	4,759	323	878	-5.73%	-15.58%
Chariton	7,178	6,832	6,172	346	1,006	-4.82%	-14.02%
Holt	4,591	4,428	4,094	163	497	-3.55%	-10.83%
Mississippi	12,784	12,285	11,443	499	1,341	-3.90%	-10.49%
Linn	11,898	11,477	10,696	421	1,202	-3.54%	-10.10%
Wayne	12,378	12,001	11,200	377	1,178	-3.05%	-9.52%
Pemiscot	17,856	17,324	16,447	532	1,409	-2.98%	-7.89%
Atchison	5,715	5,559	5,280	156	435	-2.73%	-7.61%
Worth	1,975	1,917	1,826	58	149	-2.94%	-7.54%
Shelby	6,223	6,067	5,764	156	459	-2.51%	-7.38%
Carroll	9,489	9,232	8,816	257	673	-2.71%	-7.09%
Sullivan	6,253	6,033	5,822	220	431	-3.52%	-6.89%
Putnam	4,680	4,545	4,391	135	289	-2.88%	-6.18%
Dade	7,434	7,294	6,977	140	457	-1.88%	-6.15%
Dunklin	30,575	29,870	28,765	705	1,810	-2.31%	-5.92%
Ozark	8,981	8,804	8,457	177	524	-1.97%	-5.83%
Statewide Total[1]	**6,184,390**	**6,389,850**	**6,746,762**	**+205,460**	**+562,372**	**+3.32%**	**+9.09%**

[1] Statewide populations are expected to increase.

Source: Missouri Office of Administration, 2008

Housing Units

A good indicator of growth is the number of housing units. The census defines a housing unit as a house, an apartment, a mobile home or trailer, a group of rooms, or a single room that is occupied, or, if vacant, is intended for occupancy as separate living quarters. According to the U.S. Census Bureau, the number of estimated housing units in Missouri increased 11.8 percent (287,845 units) between 2000 and 2015; and 1.57 percent (42,252 units) between 2010 and 2015. Taney County, Christian County, and St. Charles County topped the list for percent growth of housing units.

Table 3.13 and **Table 3.14** list the counties that have grown the most in terms of housing units by number and percent respectively. **Figure 3.4** and **Figure 3.5** illustrate these changes statewide.

Table 3.13. Counties with Greatest Estimated Housing Unit Gains (Numerical), 2010-2015

County	Housing Unit Increase	Associated Percent Increase
St. Charles	8,194	5.96%
Greene	5,389	4.39%
Boone	3,591	5.23%
Clay	2,873	3.13%
Taney	2,751	10.10%
Jackson	2,622	0.84%
Jefferson	2,045	2.36%
Christian	1,836	6.02%
Platte	1,580	4.13%
St. Francois	1,333	4.79%

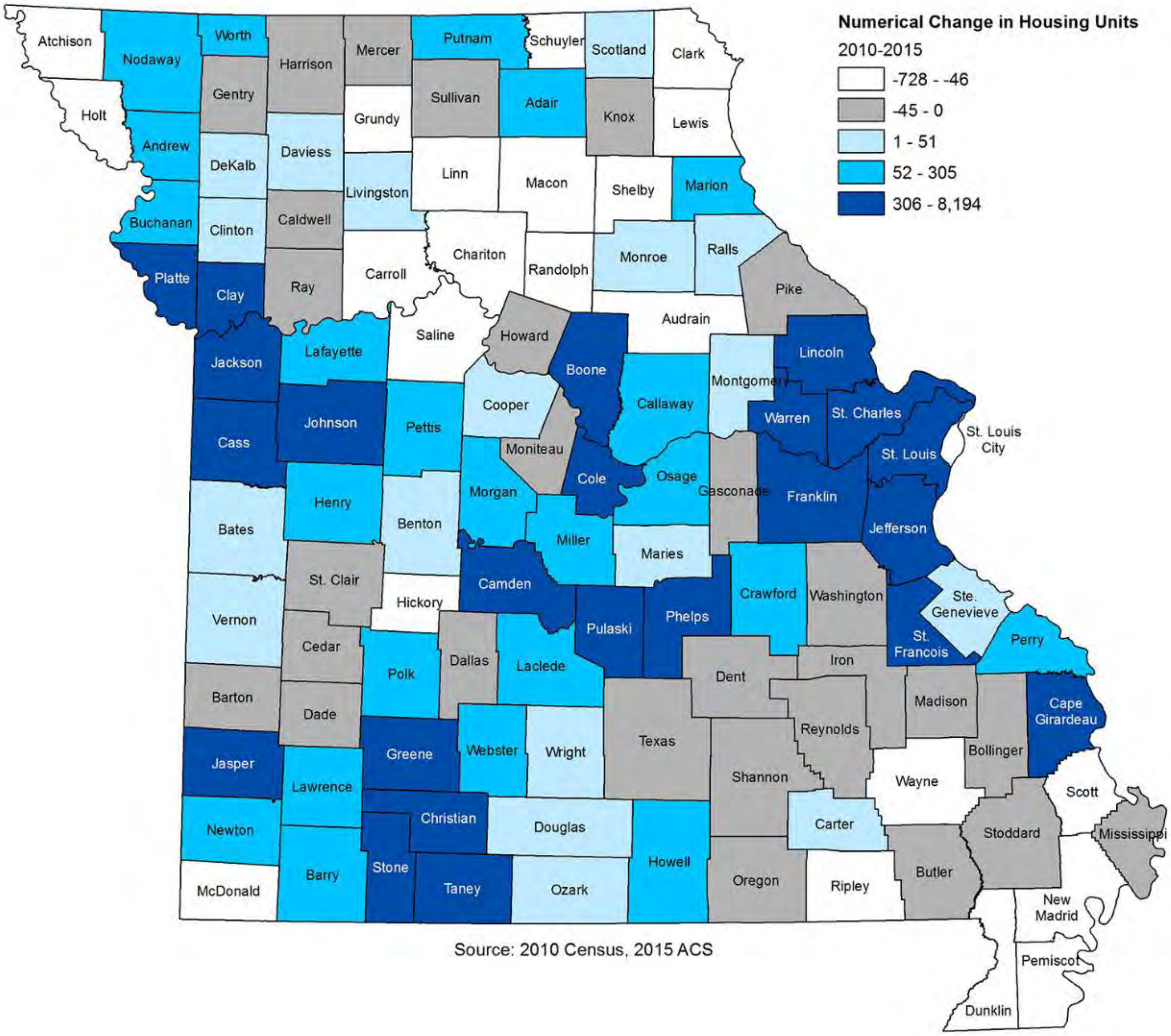
Source: U.S. Census Bureau, 2015 ACS

Table 3.14. Counties with Greatest Estimated Housing Unit Gains (%), 2010-2015

County	Percent Increase Housing Unit	Associated Numerical Increase
Taney	10.10%	2,751
Christian	6.02%	1,836
St. Charles	5.96%	8,194
Worth	5.64%	68
Boone	5.23%	3,591
Stone	5.07%	991
Pulaski	4.85%	850
Putnam	4.81%	136
St. Francois	4.79%	1,333
Lincoln	4.41%	890

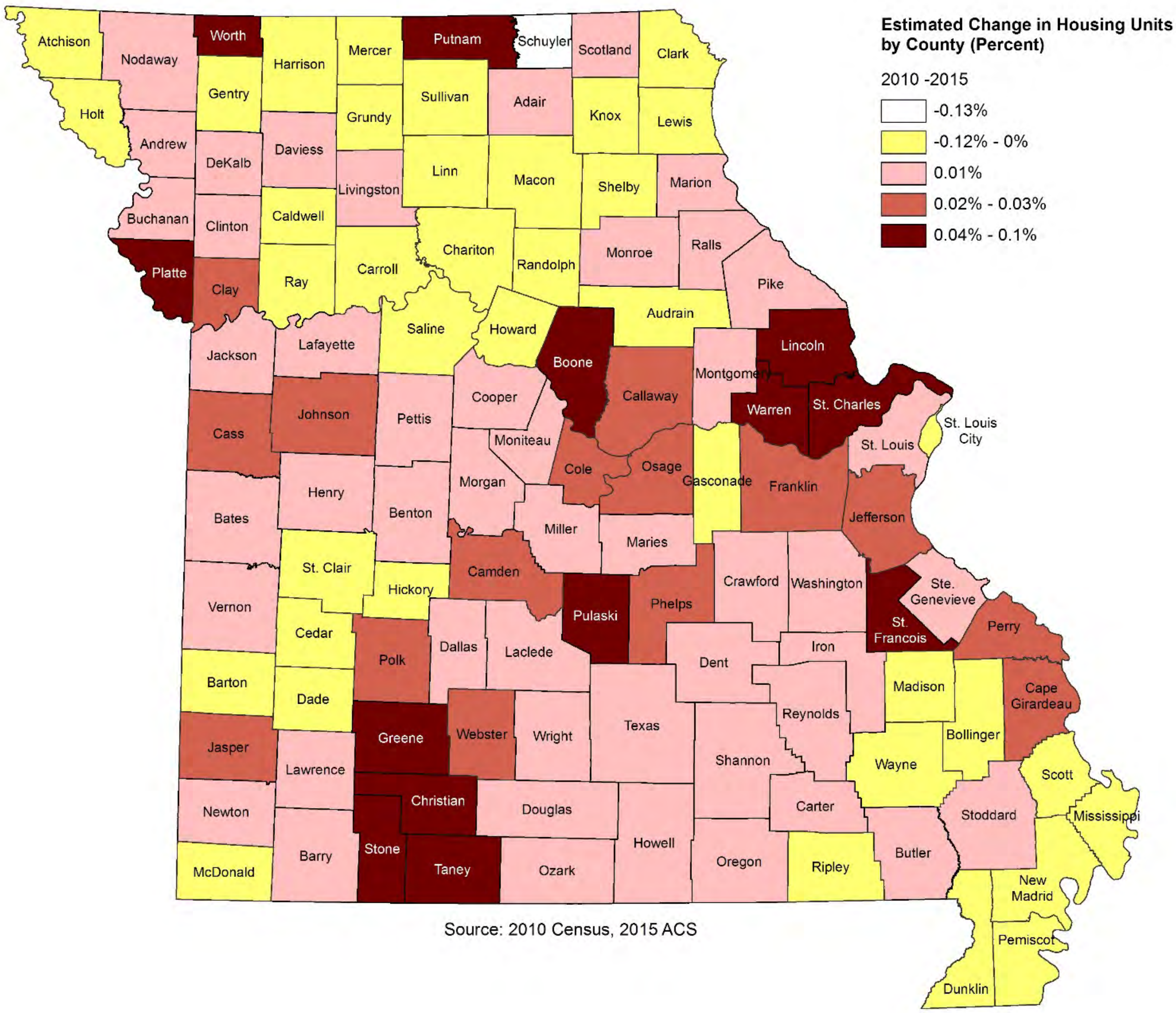
Source: U.S. Census Bureau, 2015 ACS

Figure 3.4. Estimated Change in Housing Units by County (Numerical), 2010-2015



Source: 2010 Census, 2015 ACS

Figure 3.5. Estimated Change in Housing Units by County (Percent), 2010-2015



Source: 2010 Census, 2015 ACS

Population Density

Missouri has a surface land area of 68,724 square miles and a population of 6,045,448 (2015 Census estimate). Based on the 2015 census estimates, Missouri ranked 18th in population among the 50 states. Table 3.15 presents population density and population density growth. Density is reported as people per housing units per square mile and is based on the square mileage of the counties in the 2010 census.

Table 3.15. Missouri Population Density Estimates

County	Population Density 2000	Population Density 2010	Population Density 2015	Pop Density Growth 2000-2015	Pop Density Growth 2010-2015
Adair	44.03	45.14	44.73	1.58%	-0.90%
Andrew	38.11	39.96	39.97	4.65%	0.03%
Atchison	11.75	10.39	9.69	-21.18%	-7.14%
Audrain	37.35	36.88	37.70	0.93%	2.17%
Barry	43.70	45.74	46.04	5.08%	0.65%
Barton	21.19	20.95	20.07	-5.56%	-4.39%
Bates	19.90	20.38	19.66	-1.26%	-3.67%
Benton	24.40	27.07	26.52	7.98%	-2.07%
Bollinger	19.47	20.01	19.71	1.26%	-1.49%
Boone	197.62	237.29	255.28	22.59%	7.05%
Buchanan	210.76	218.61	218.37	3.48%	-0.11%
Butler	58.83	61.60	61.83	4.85%	0.37%
Caldwell	21.03	22.10	21.14	0.50%	-4.55%
Callaway	48.85	53.12	53.72	9.07%	1.12%
Camden	56.49	67.08	67.44	16.24%	0.53%
Cape Girardeau	118.74	130.80	135.81	12.57%	3.69%
Carroll	14.81	13.38	12.95	-14.38%	-3.37%
Carter	11.71	12.35	12.34	5.14%	-0.03%
Cass	117.81	142.76	145.81	19.20%	2.09%
Cedar	28.94	29.47	29.37	1.44%	-0.34%
Chariton	11.23	10.42	10.10	-11.19%	-3.19%
Christian	96.48	137.60	148.01	34.82%	7.03%
Clark	14.69	14.15	13.48	-9.04%	-4.97%
Clay	463.14	558.62	593.10	21.91%	5.81%
Clinton	45.30	49.51	49.19	7.91%	-0.65%
Cole	181.33	192.99	94.84	6.94%	0.95%
Cooper	29.52	31.16	31.24	5.51%	0.23%
Crawford	30.71	33.26	33.03	7.02%	-0.69%
Dade	16.17	16.09	15.50	-4.32%	-3.79%
Dallas	28.96	31.02	30.31	4.47%	-2.34%
Daviess	14.23	14.97	14.65	2.87%	-2.18%
DeKalb	27.52	30.60	30.11	8.59%	-1.62%
Dent	19.83	20.80	20.71	4.27%	-0.41%
Douglas	16.08	16.82	16.44	2.16%	-2.33%
Dunklin	61.28	59.06	57.10	-7.32%	-3.42%
Franklin	101.67	110.00	111.01	8.41%	0.91%
Gasconade	29.63	29.40	28.69	-3.26%	-2.45%
Gentry	13.96	13.71	13.62	-2.53%	-0.69%
Greene	355.98	407.48	426.58	16.55%	4.48%
Grundy	23.97	23.57	23.20	-3.32%	-1.62%
Harrison	12.25	12.40	11.92	-2.73%	-3.97%

County	Population Density 2000	Population Density 2010	Population Density 2015	Pop Density Growth 2000-2015	Pop Density Growth 2010-2015
Henry	31.56	31.96	31.19	-1.20%	-2.46%
Hickory	22.40	24.12	23.05	2.84%	-4.63%
Holt	11.56	10.62	9.69	-19.34%	-9.55%
Howard	22.02	21.87	21.86	-0.72%	-0.05%
Howell	40.16	43.57	43.26	7.18%	-0.71%
Iron	19.44	19.32	18.40	-5.65%	-4.99%
Jackson	1,083.41	1,115.31	1,137.58	4.76%	1.96%
Jasper	163.96	183.88	185.74	11.73%	1.01%
Jefferson	301.69	333.11	341.32	11.61%	2.41%
Johnson	58.19	63.42	65.06	10.55%	2.51%
Knox	8.65	8.20	7.76	-11.53%	-5.65%
Laclede	42.52	46.52	46.39	8.34%	-0.28%
Lafayette	52.45	53.12	52.04	-0.79%	-2.08%
Lawrence	57.55	63.15	62.41	7.79%	-1.19%
Lewis	20.78	20.22	20.21	-2.81%	-0.04%
Lincoln	62.16	83.90	87.30	28.80%	3.89%
Linn	22.34	20.73	19.99	-11.75%	-3.68%
Livingston	27.35	28.54	28.23	3.13%	-1.11%
Macon	19.67	19.43	19.14	-2.78%	-1.51%
Madison	23.87	24.73	25.10	4.90%	1.47%
Maries	16.89	17.41	17.01	0.67%	-2.38%
Marion	64.75	65.87	66.10	2.05%	0.34%
McDonald	40.19	42.79	41.97	4.25%	-1.94%
Mercer	8.28	8.34	8.14	-1.71%	-2.46%
Miller	39.76	41.76	42.38	6.17%	1.45%
Mississippi	32.62	34.89	34.10	4.34%	-2.29%
Moniteau	35.73	37.60	38.46	7.12%	2.23%
Monroe	14.38	13.65	13.25	-8.48%	-2.99%
Montgomery	22.63	22.82	21.82	-3.70%	-4.55%
Morgan	32.31	34.41	33.75	4.27%	-1.95%
New Madrid	29.28	28.09	26.98	-8.52%	-4.11%
Newton	84.25	93.02	93.82	10.20%	0.85%
Nodaway	24.99	26.65	26.01	3.94%	-2.46%
Oregon	13.10	13.78	13.87	5.56%	0.66%
Osage	21.61	22.96	22.55	4.15%	-1.83%
Ozark	12.81	13.05	12.63	-1.41%	-3.34%
Pemiscot	40.70	37.15	35.49	-14.67%	-4.66%
Perry	38.22	39.99	40.44	5.48%	1.11%
Pettis	57.76	61.86	61.94	6.75%	0.13%
Phelps	59.28	67.22	66.68	11.09%	-0.81%
Pike	27.37	27.62	27.37	-0.02%	-0.92%
Platte	175.59	212.58	228.70	23.22%	7.05%
Polk	42.47	48.99	49.14	13.57%	0.29%
Pulaski	75.24	95.55	97.28	22.65%	1.78%
Putnam	10.10	9.62	9.39	-7.51%	-2.49%
Ralls	20.49	21.64	21.70	5.59%	0.28%
Randolph	51.10	52.65	52.01	1.76%	-1.23%
Ray	41.06	41.30	40.10	-2.38%	-3.00%
Reynolds	8.27	8.28	7.96	-4.00%	-4.10%
Ripley	21.46	22.40	21.92	2.12%	-2.16%

County	Population Density 2000	Population Density 2010	Population Density 2015	Pop Density Growth 2000-2015	Pop Density Growth 2010-2015
Saline	31.44	30.93	30.78	-2.14%	-0.48%
Schuyler	13.57	14.42	14.44	6.00%	0.11%
Scotland	11.41	11.09	11.12	-2.66%	0.23%
Scott	96.25	93.31	92.88	-3.62%	-0.47%
Shannon	8.29	8.41	8.23	-0.80%	-2.22%
Shelby	13.57	12.72	12.23	-10.95%	-4.00%
St. Charles	506.54	643.22	688.01	26.38%	6.51%
St. Clair	14.41	14.63	14.09	-2.25%	-3.87%
St. Francois	123.13	144.63	147.20	16.35%	1.75%
St. Louis	2,001.41	1,967.22	1,975.90	-1.29%	0.44%
St. Louis City	5,624.12	5,157.39	5,099.10	-10.30%	-1.14%
Ste. Genevieve	35.74	36.35	35.90	0.43%	-1.26%
Stoddard	36.08	36.40	36.27	0.53%	-0.35%
Stone	61.76	69.40	66.68	7.38%	-4.07%
Sullivan	11.14	10.36	9.80	-13.63%	-5.68%
Taney	62.78	81.71	86.32	27.27%	5.34%
Texas	19.54	22.09	21.82	10.46%	-1.24%
Vernon	24.75	25.60	25.20	1.79%	-1.60%
Warren	57.22	75.86	78.19	26.82%	2.98%
Washington	30.72	33.16	32.62	5.83%	-1.64%
Wayne	17.46	17.81	17.66	1.09%	-0.87%
Webster	52.39	61.09	63.26	17.18%	3.42%
Worth	8.93	8.14	7.72	-15.80%	-5.54%
Wright	26.34	27.60	26.79	1.71%	-2.99%
Total	**5,595,211**	**5,988,927**	**7%**	**6,045,448**	**8.05%**

Source: U.S. Census Bureau, 2015 ACS

Table 3.16. Top 10 Counties Ranked by Population/Housing Density, 2015

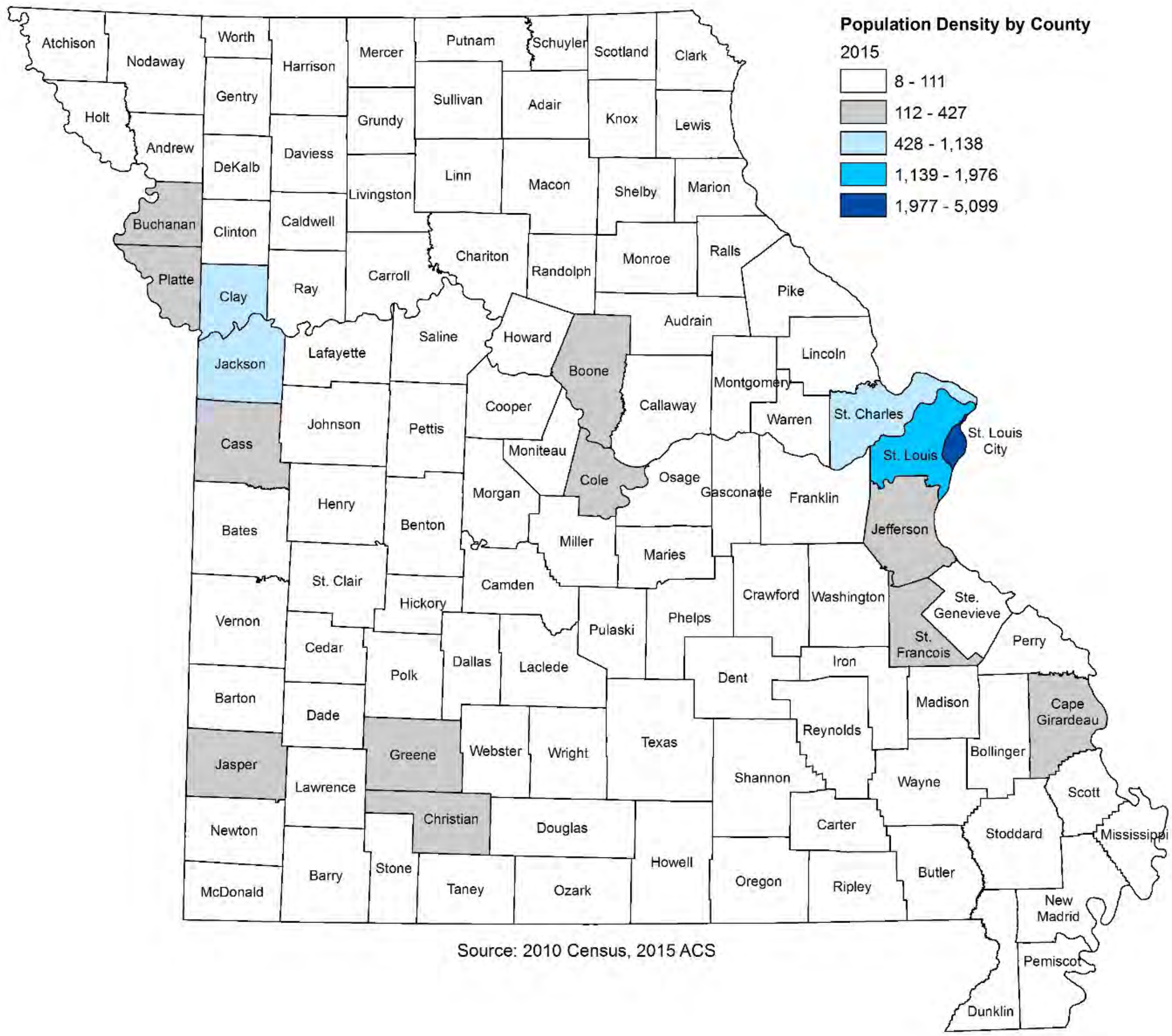
County	2015 Population Density	Population Density Change (%) 2010-2015	2015 Estimated Housing Density*	Housing Density* Change (%) 2010-2015
St. Louis City	5,099.10	-1.13%	2,836.23	0.59%
St. Louis	1,975.90	0.44%	862.69	0.79%
Jackson	1,137.58	2.00%	519.48	-1.53%
St. Charles	688.01	6.96%	259.98	-0.86%
Clay	593.10	6.17%	237.97	0.32%
Greene	426.58	4.69%	189.79	-0.75%
Jefferson	341.32	2.46%	134.91	0.42%
Boone	255.28	7.58%	105.32	0.36%
Platte	228.70	7.58%	94.90	-0.39%
Buchanan	218.37	-0.11%	94.32	5.23%

Source: U.S. Census Bureau, 2015 ACS

Notes: *Density is reported as people/housing units per square mile and is based on the square mileage of the counties in the 2010 census

**St. Louis City* is considered both a "place" and a "county" by the U.S. Census Bureau, so it is treated here as a as well as a city

Figure 3.6. Population Density by County, 2015



Source: 2010 Census, 2015 ACS

There is a direct correlation between the rate of growth in counties and increase in population density as is shown in **Table 3.17** and **Figure 3.7**.

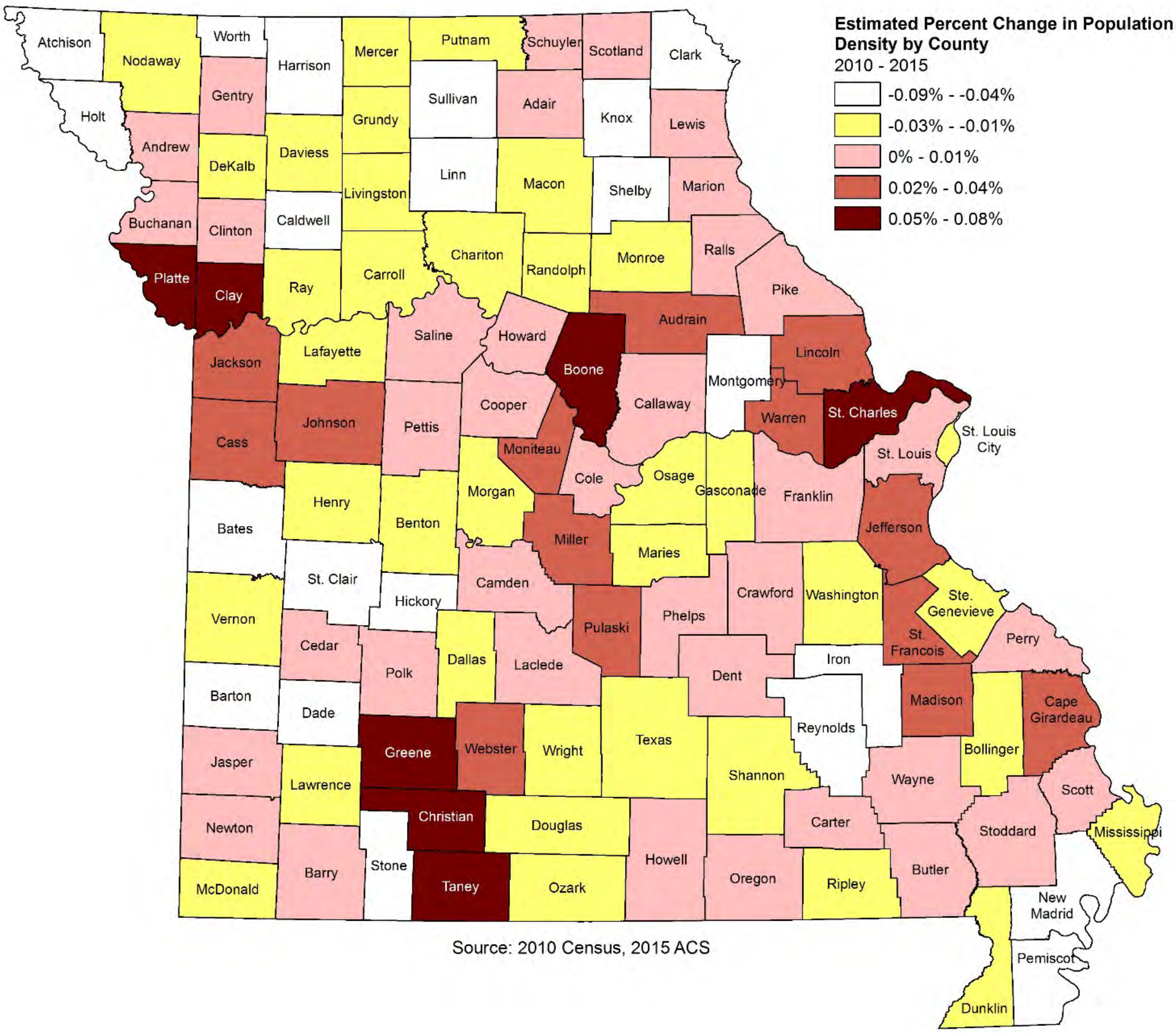
Table 3.17. Counties with Greatest Estimated Population Density Gains (Percent), 2010-2015

County	2010 Estimated Population Density	2015 Estimated Population Density	Population Density* Change (%) 2010-2015
Platte	212.58	228.70	7.58%
Boone	237.29	255.28	7.58%
Christian	137.60	148.01	7.57%
St. Charles	643.22	688.01	6.96%
Clay	558.62	593.10	6.17%
Taney	81.71	86.32	5.64%
Greene	407.48	426.58	4.69%

County	2010 Estimated Population Density	2015 Estimated Population Density	Population Density* Change (%) 2010-2015
Lincoln	83.90	87.30	4.05%
Cape Girardeau	130.80	135.81	3.83%
Webster	61.09	63.26	3.54%

Source: U.S. Census Bureau, 2015 ACS

Figure 3.7. Estimated Percent Change in Population Density by County, 2010-2015



Source: 2010 Census, 2015 ACS

Critical Facilities / Infrastructure – State Owned and/or Operated

For the purposes of this plan, a critical facility is defined as one that is essential in providing utility or direction either during the response to an emergency or during the recovery operation. FEMA's Hazus-MH loss estimation software uses the following three categories of critical assets:

- Essential facilities are those that if damaged would have devastating impacts on disaster response and/or recovery
- High potential loss facilities are those that would have a high loss or impact on the community
- Transportation and lifeline facilities are a third category of critical assets, consisting of transportation systems and utilities

Table 3.169 summarizes state facilities data obtained for this 2018 plan update.

Table 3.18. State Facilities Inventories

Source/Inventory	2010 # of Facilities Geolocated	2013 # of Facilities Geolocated	2018 # of Facilities Geolocated
Office of Administration/State Facilities—includes the following: Department of Agriculture (DOA) Department of Corrections (DOC) Department of Economic Development (DED) Department of Elementary and Secondary Education (DESE) Department of Labor and Industrial Relations (DLIR) Department of Mental Health (DMH) Department of Natural Resources (MoDNR) Department of Revenue (DOR) Department of Social Services (DOSS) Department of Public Safety (DPS)	3,477 (Owned) 0 (Leased)	3,437 (Owned) 959 (Leased)	7,229 (Owned) 954 (Leased)
Missouri Department of Transportation (MoDOT) Facilities Bridges	 0 7,124	 175 10,361	 295 10,400
Department of Higher Education (DHE) /Public Colleges and Universities	143	89	455
Missouri Department of Conservation (MDC)	688	0	1,511

For Missouri state-owned or operated facilities provided by the Office of Administration, Missouri Department of Transportation (MoDOT), and Missouri Department of Conservation (MDC) the State applied FEMA's guidelines for determining critical facilities to the asset use/facility types. A total of 1,950 facilities were determined to be critical facilities. For the MoDOT State Bridge Inventory, all 10,400 state-owned bridges in Missouri were considered critical.

Section 3.5 State Owned and Operated Facilities: Vulnerability and Loss Estimates, provides additional detailed information on critical facilities and infrastructure for the State.

Social Vulnerability

A Social Vulnerability Index compiled by the Hazards and Vulnerability Research Institute in the Department of Geography at the University of South Carolina measures the social vulnerability of U.S. counties to environmental hazards for the purpose of examining the differences in social vulnerability among counties. It synthesizes 42 socioeconomic and built environment variables that research literature suggests contributes to reduction in a community's ability to prepare for, respond to, and recover from hazards (i.e., social vulnerability). Eleven composite factors were identified that differentiate counties according to their relative level of social vulnerability: personal wealth, age, density of the built environment, single-sector economic dependence, housing stock and tenancy, race ethnicity, occupation, and infrastructure dependence.

The index can be used by the state to help determine where social vulnerability and exposure to hazards overlaps and how and where mitigation resources might best be used. **Figure 3.8** illustrates Missouri's geographic variation in social vulnerability. Social vulnerability rankings are mapped using quantiles. Scores in the top 20% are more vulnerable counties (High, dark red) and scores in the bottom 20% indicate the least vulnerable counties (Low, white). According to the social vulnerability index, the following counties are Missouri's most vulnerable: Dunklin, Hickory, New Madrid, Pemiscot, St. Louis City, and Taney.

Table 3.19. Social Vulnerability to Environmental Hazards, Comparison within the State, 2016

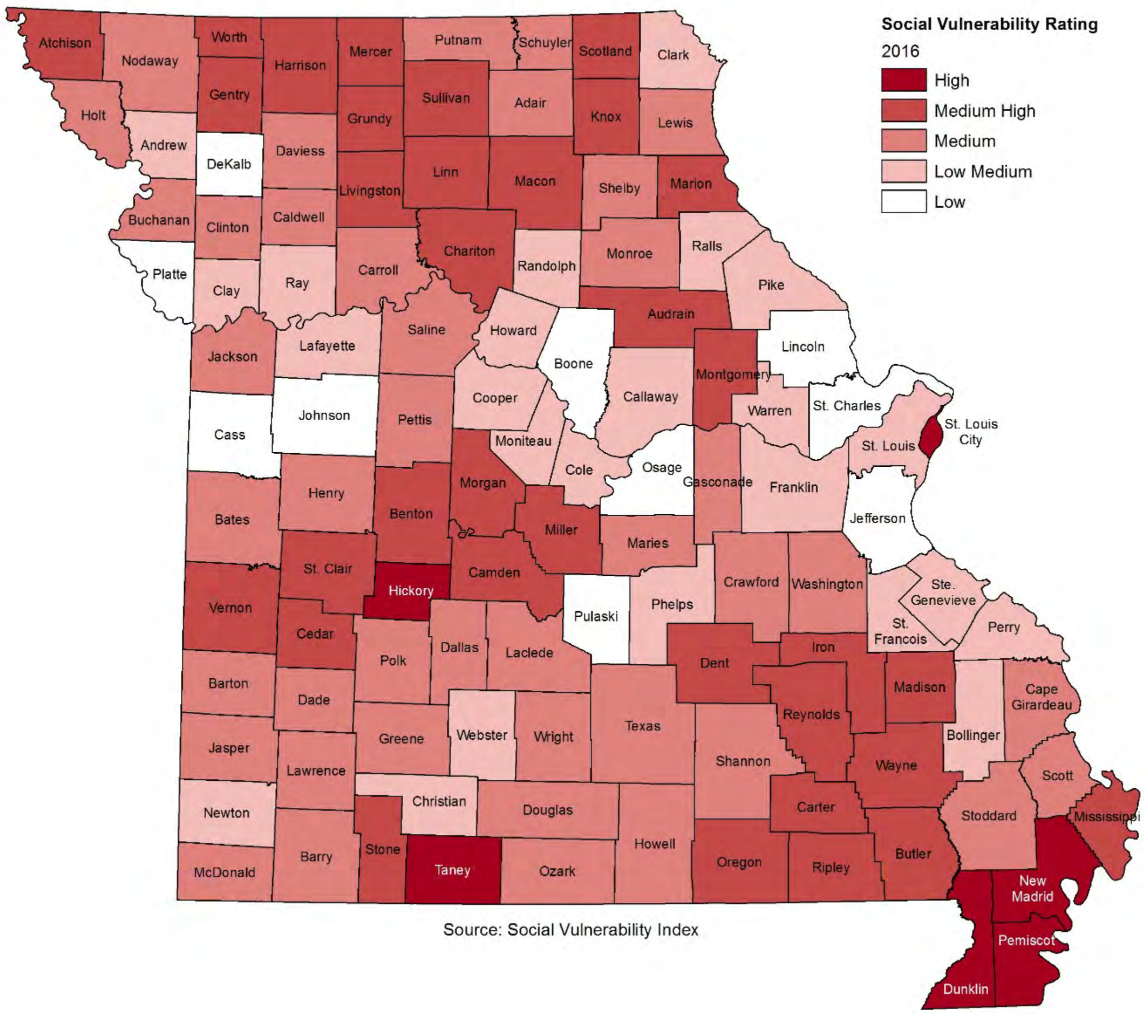
County	SOVI Index Ranking
Adair	Medium
Andrew	Medium Low
Atchison	Medium High
Audrain	Medium High
Barry	Medium
Barton	Medium
Bates	Medium
Benton	Medium High
Bollinger	Medium Low
Boone	Low
Buchanan	Medium
Butler	Medium High
Caldwell	Medium
Callaway	Medium Low
Camden	Medium High
Cape Girardeau	Medium
Carroll	Medium
Carter	Medium High
Cass	Low
Cedar	Medium High
Chariton	Medium High
Christian	Medium Low
Clark	Medium Low
Clay	Medium Low
Clinton	Medium

County	SOVI Index Ranking
Cole	Medium Low
Cooper	Medium Low
Crawford	Medium
Dade	Medium
Dallas	Medium
Daviess	Medium
DeKalb	Low
Dent	Medium High
Douglas	Medium
Dunklin	High
Franklin	Medium Low
Gasconade	Medium
Gentry	Medium High
Greene	Medium
Grundy	Medium High
Harrison	Medium High
Henry	Medium
Hickory	High
Holt	Medium
Howard	Medium Low
Howell	Medium
Iron	Medium High
Jackson	Medium
Jasper	Medium
Jefferson	Low

County	SOVI Index Ranking
Johnson	Low
Knox	Medium High
Laclede	Medium
Lafayette	Medium Low
Lawrence	Medium
Lewis	Medium
Lincoln	Low
Linn	Medium High
Livingston	Medium High
Macon	Medium High
Madison	Medium High
Maries	Medium
Marion	Medium High
McDonald	Medium
Mercer	Medium High
Miller	Medium High
Mississippi	Medium High
Moniteau	Medium Low
Monroe	Medium
Montgomery	Medium High
Morgan	Medium High
New Madrid	High
Newton	Medium Low
Nodaway	Medium
Oregon	Medium High
Osage	Low
Ozark	Medium
Pemiscot	High
Perry	Medium Low
Pettis	Medium
Phelps	Medium Low
Pike	Medium Low
Platte	Low

County	SOVI Index Ranking
Polk	Medium
Pulaski	Low
Putnam	Medium
Ralls	Medium Low
Randolph	Medium Low
Ray	Medium Low
Reynolds	Medium High
Ripley	Medium High
Saline	Medium
Schuyler	Medium
Scotland	Medium High
Scott	Medium
Shannon	Medium
Shelby	Medium
St. Charles	Low
St. Clair	Medium High
St. Francois	Medium Low
St. Louis	Medium Low
St. Louis City	High
Ste. Genevieve	Medium Low
Stoddard	Medium
Stone	Medium High
Sullivan	Medium High
Taney	High
Texas	Medium
Vernon	Medium High
Warren	Medium Low
Washington	Medium
Wayne	Medium High
Webster	Medium Low
Worth	Medium High
Wright	Medium

Figure 3.8. Social Vulnerability Rating, 2016



Source: Social Vulnerability Index

Cultural Resources

Cultural resources play an important role in preserving the identity of cultures within a state. Ensuring that these resources are maintained for future generations to enjoy is of extreme importance. Therefore, the vulnerability of these resources to natural disasters means that inventorying the natural, historical, and cultural assets in a community is critical. Inventorying resources is important for the following reasons: The community may decide that these types of resources warrant a greater degree of protection due to their unique and irreplaceable nature and contribution to the overall economy.

In the event of a disaster, an accurate inventory of natural, historical and cultural resources allows for more prudent care in the disaster's immediate aftermath when the potential for additional impacts is higher.

The rules for reconstruction, restoration, rehabilitation, and/or replacement are often different for these types of designated resources.

- Natural resources can have beneficial functions that reduce the impacts of natural hazards, for example, wetlands and riparian habitat which help absorb and attenuate floodwaters and thus support overall mitigation objectives.

Cultural and Historical Resources

Missouri has numerous historically significant homes, public buildings, and landmarks. The Missouri State Historic Preservation Office is the agency authorized to carry out the responsibilities of the National Historic Preservation Act of 1966, as amended. These activities include: reviewing nominations to the National Register of Historic Places, overseeing the state's architectural and archaeological survey programs, Section 106 Review and Compliance, managing Missouri's Certified Local Government Program, reviewing state and federal historic tax credit applications, and administering Historic Preservation Grant programs.

The National Register of Historic Places is the nation's official list of cultural resources worthy of preservation. The National Register is part of a program to coordinate and support public and private efforts to identify, evaluate, and protect historic and archeological resources. Properties listed on the National Register include districts, sites, buildings, structures, and objects that are significant in American history, architecture, archeology, engineering, and culture. **Table 3.20** presents the number of historic places by county.

Table 3.20. National Historic Places by County

County	Number of National Historic Places
Adair	15
Andrew	3
Atchison	8
Audrain	4
Barry	14
Barton	1
Bates	4
Benton	4
Bollinger	2
Boone	52
Buchanan	62
Butler	23
Caldwell	2
Callaway	20
Camden	9
Cape Girardeau	58
Carroll	6
Carter	30
Cass	7
Cedar	3
Chariton	7
Christian	2
Clark	5
Clay	39
Clinton	1
Cole	46
Cooper	43
Crawford	13
Dade	3
Dallas	1
Daviess	3
DeKalb	0
Dent	8
Douglas	1
Dunklin	8
Franklin	61
Gasconade	10
Gentry	4
Greene	72
Grundy	6
Harrison	2
Henry	8
Hickory	2
Holt	4
Howard	25
Howell	6
Iron	6
Jackson	343
Jasper	33
Jefferson	14
Johnson	20
Knox	2
Laclede	6
Lafayette	29
Lawrence	4
Lewis	12
Lincoln	5
Linn	5
Livingston	4
Macon	9
Madison	5
Maries	1
Marion	40
McDonald	3
Mercer	2
Miller	8

County	Number of National Historic Places	County	Number of National Historic Places
Mississippi	10	Saline	33
Moniteau	10	Schuyler	2
Monroe	10	Scotland	2
Montgomery	9	Scott	7
Morgan	4	Shannon	16
New Madrid	9	Shelby	4
Newton	12	St. Charles	36
Nodaway	8	St. Clair	2
Oregon	2	St. Francois	11
Osage	9	St. Louis	593
Ozark	2	St. Louis City	0
Pemiscot	7	Ste. Genevieve	6
Perry	7	Stoddard	4
Pettis	28	Stone	3
Phelps	10	Sullivan	6
Pike	21	Taney	6
Platte	16	Texas	5
Polk	4	Vernon	7
Pulaski	5	Warren	8
Putnam	1	Washington	11
Ralls	8	Wayne	3
Randolph	4	Webster	3
Ray	6	Worth	1
Reynolds	2	Wright	5
Ripley	8	Total	2244

Source: National Register of Historic Places

It should be noted that the number of Historic Places changes periodically due to those currently in the nomination process which may not yet be listed in a community. Additionally, as defined by the National Environmental Policy Act (NEPA), any property over 50 years of age is considered a historic resource and is potentially eligible for the National Register. Thus, if the property is to be altered, has been altered as the result of federal action, the property must be evaluated under the guidelines set forth by NEPA. Structural mitigation projects are considered alterations for the purpose of this regulation.

Many cultural and historical resources in Missouri are vulnerable to several hazards due to the nature of their design and construction and their location. Some of these risks include floods, earthquakes, wildfires and high winds.

Natural Resources

Natural resources are important to include in benefit/cost analyses for future projects. They may be used to leverage additional funding for mitigation projects and can also contribute to community goals for protecting sensitive or endangered resources. Awareness of natural assets can lead to opportunities for meeting multiple objectives. For instance, protecting wetlands areas also protects sensitive habitat as well as providing for the storage of floodwaters. The GIS Mapping data of wetland areas across Missouri is further described in Section 3.3 Hazard Profiles and State Risk Assessment. It can also be obtained from SEMA by contacting the SHMO.

Natural and Beneficial Functions

Floodplains have natural and beneficial functions. Wetlands function as natural sponges that trap and slowly release surface water, rain, snowmelt, groundwater and flood waters. Trees, root mats, and other wetland vegetation also slow the speed of floodwaters and distribute them more slowly over the floodplain. This combined water storage and braking action lowers flood heights and reduces erosion. Wetlands within and downstream of urban areas are particularly valuable, counteracting the increased rate and volume of surface water runoff from impervious surfaces such as pavement and buildings. The holding capacity of wetlands helps control floods and prevents water logging of crops. Preserving and restoring wetlands, together with other water retention and detention, can often provide the level of flood control otherwise provided by dredge operations and levees.

Special Status Species

To further understand natural resources that may be particularly vulnerable to a hazard event, as well as those that need consideration when implementing mitigation activities, it is important to identify at-risk species (i.e., endangered species) in the planning area. The US Fish and Wildlife Service maintains a list of threatened and endangered species in Missouri. State and federal laws protect the habitat of these species through the environmental review process. Several additional species are of special concern or candidates to make the protected list.

Table 3.21. Threatened and Endangered Animals in Missouri

Status	Species/Listing Name
E	Bat, gray Wherever found (Myotis grisescens)
E	Bat, Indiana Wherever found (Myotis sodalis)
T	Bat, Northern long-eared Wherever found (Myotis septentrionalis)
E	Bat, Ozark big-eared Wherever found (Corynorhinus (=Plecotus) townsendii ingens)
T	Cavefish, Ozark Wherever found (Amblyopsis rosae)
E	Cavesnail, Tumbling Creek Wherever found (Antrobia culveri)
E	Crayfish, cave Wherever found (Cambarus aculabrum)
T	Darter, Niangua Wherever found (Etheostoma nianguae)
E	Dragonfly, Hine's emerald Wherever found (Somatochlora hineana)
E	Hellbender, Ozark Wherever found (Cryptobranchus alleganiensis bishopi)
E	Higgins eye (pearlymussel) Wherever found (Lampsilis higginsii)
T	Knot, red Wherever found (Calidris canutus rufa)
T	Madtom, Neosho Wherever found (Noturus placidus)
E	Mapleleaf, winged Wherever found, except where listed as an experimental population (Quadrula fragosa)
E	Mucket, Neosho Wherever found (Lampsilis rafinesqueana)
E	Mucket, pink (pearlymussel) Wherever found (Lampsilis abrupta)
E	Mussel, scaleshell Wherever found (Leptodea leptodon)
E	Mussel, sheepnose Wherever found (Plethobasus cyphyus)
E	Mussel, snuffbox Wherever found (Epioblasma triquetra)
E	Pearlymussel, Curtis Wherever found (Epioblasma florentina curtisii)
T	Plover, piping except Great Lakes watershed (Charadrius melodus)
E	Pocketbook, fat Wherever found (Potamilus capax)
T	Rabbitsfoot Wherever found (Quadrula cylindrica cylindrica)
E	Sculpin, Grotto Wherever found (Cottus specus)
E	Shiner, Topeka Wherever found, except where listed as an experimental population (Notropis topeka (=tristis))
E	Spectaclecase (mussel) Wherever found (Cumberlandia monodonta)
E	Sturgeon, pallid Wherever found (Scaphirhynchus albus)
E	Tern, least interior pop. (Sterna antillarum)
E	Woodpecker, red-cockaded Wherever found (Picoides borealis)

Source: US Fish and Wildlife Service

3.1.2. Development Trends

Counties with growing populations and acceleration in housing will have increased vulnerability to hazard events such as tornadoes and floods. Extreme southeastern Missouri counties are experiencing little (less than 5 percent) or no growth. Most counties experiencing development pressures participate in the National Flood Insurance Program. Even though these counties and communities have a flood damage prevention ordinance, this does not mean the flood risk should be less. Incorporation of higher regulatory standards is one way in which counties can better protect building, infrastructure, and save lives.

Rural communities with declining populations and housing will have increased vulnerability to weather-related hazards and a lower resilience to loss because there is reduced or little surplus capacity to absorb crop or livestock income losses. Even small losses might feed back into poverty and future vulnerability. Additionally, declining population and housing may also result in fewer number of response and recovery resources, such as fire departments and medical facilities. While counties are not experiencing development pressure, participation in the NFIP remains a recommended mitigation measure.

3.1.3. Changing Future Conditions

State Hazard Mitigation Plans must consider how future risk and vulnerability may be affected by changing future conditions, development patterns, and population demographics. In furtherance of FEMA's Climate Change Adaptation Policy (2011-OPPA-01) which directed all FEMA programs and policies to integrate considerations of climate change adaptation, the FEMA State Mitigation Plan Review Guide effective March 6, 2016 clarified that the probability of future hazard events must also include consideration of the effects of long-term changes in weather patterns and climate on the future conditions related to identified hazards. Changes in the probability of future hazard events may include changes in location, increases or decreases to the impacts, and/or extent of known natural hazards, such as flood or drought. Changes in temperature, intensity, hazard distribution, and/or frequency of weather events may increase vulnerability to these hazards in the future.

It is difficult to predict the scope, severity, and pace of changing future conditions and the impacts posed by more intense storms, frequent heavy participation, heat waves, drought, and extreme flooding; none-the-less, according to the FEMA Climate Change Adaptation Policy Statement, they can significantly change the probabilities and magnitudes of hazards faced by communities.

According to the U.S. Environmental Protection Agency, "Climate change refers to any significant change in the measures of climate lasting for an extended period of time. In other words, climate change includes major changes in temperature, precipitation, or wind patterns, among other effects that occur over several decades or longer" https://www.epa.gov/climatechange/climate-change-basic-information).

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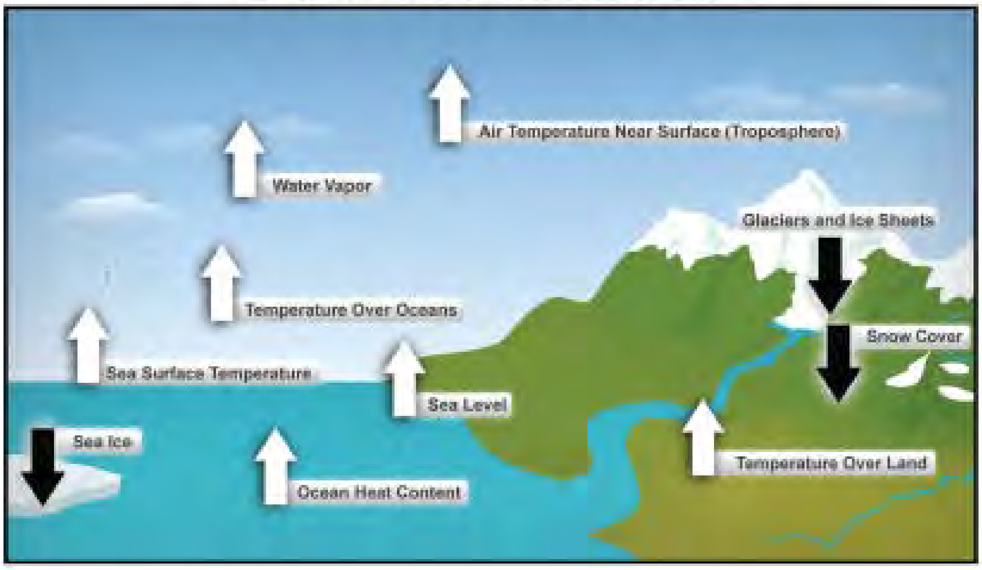
Ten Indicators of a Warming World



NCEI:www.ncei.noaa.gov/climate-information/climate-change-and-variability

NOAA’s National Centers for Environmental Information (NCEI) defines climate as long-term averages and variations in weather measured over a period of several decades. The Earth’s climate system includes the land surface, atmosphere, oceans, and ice. Many aspects of the global climate are changing rapidly, and many experts believe that the primary drivers of that change are human in origin. Evidence for changes in the climate system abounds, from the top of the atmosphere to the depths of the oceans.

The Global Change Research Act of 1990 is a federal law which requires research into global warming and related issues. A report to Congress is required every four years on the environmental, economic, health and safety consequences of climate change. The National Climate Assessment is the report prepared to meet this law and is forwarded to the President and to Congress.

The National Climate Assessment presents 12 key messages about the United States’ changing climate (see Key Findings below) and it looks at how the changing climate impacts 13 different Sectors such as water, energy, transportation, agriculture, forests, and rural communities to name a few.

Third U.S. National Climate Assessment Key Findings

- Global climate is changing and this is apparent across the United States in a wide range of observations. The global warming of the past 50 years is primarily due to human activities, predominantly the burning of fossil fuels.
- Some extreme weather and climate events have increased in recent decades, and new and stronger evidence confirms that some of these increases are related to human activities.
- Human-induced climate change is projected to continue, and it will accelerate significantly if global emissions of heat-trapping gases continue to increase.
- Impacts related to climate change are already evident in many sectors and are expected to become increasingly disruptive across the nation throughout this century and beyond.

- Climate change threatens human health and well-being in many ways, including through more extreme weather events and wildfire, decreased air quality, and diseases transmitted by insects, food, and water.
- Infrastructure is being damaged by sea level rise, heavy downpours, and extreme heat; damages are projected to increase with continued climate change.
- Water quality and water supply reliability are jeopardized by climate change in a variety of ways that affect ecosystems and livelihoods.
- Climate disruptions to agriculture have been increasing and are projected to become more severe over this century.
- Climate change poses threats to Indigenous Peoples' health, wellbeing, and ways of life.
- Ecosystems and the benefits they provide to society are being affected by climate change. The capacity of ecosystems to buffer the impacts of extreme events like fires, floods, and severe storms is being overwhelmed.
- Ocean waters are becoming warmer and more acidic, broadly affecting ocean circulation, chemistry, ecosystems, and marine life.
- Planning for adaptation (to address and prepare for impacts) and mitigation (to reduce future climate change, for example by cutting emissions) is becoming more widespread, but current implementation efforts are insufficient to avoid increasingly negative social, environmental, and economic consequences.

Missouri's Conditions

Missouri has a continental type of climate marked by strong seasonality. Missouri's location in the interior of the North American Continent exposes it to a climate with large ranges in temperature with hot, humid summers and cold winters. The lack of mountain barriers both to the north and to the south, and the state's inland location away from the moderating effects of the oceans allow it to be influenced by both cold Arctic air masses and warm, moist air masses from the Gulf of Mexico. Missouri experiences regional differences in climatic characteristics, but these differences don't have obvious geographic boundaries (Missouri Climate Center).

Average annual temperatures across the state vary over a range of about 10 degrees' Fahrenheit (F) form north to south. The year 2012 was the hottest on record, with an average annual temperature of 58.6 degrees F, 4.1 degrees F higher than the long-term average. The Missouri Climate Center indicates that temperatures over 100 degrees F are rare, but they have occurred in every section of the state. Temperatures rise to 90 degrees F or higher on an average of 40 to 50 days in the western and northern parts of the state and 55 to 60 days in the southeastern parts of the state.

The Missouri Climate Data Center indicates that mean annual participation varies along the same gradient as temperature from a low of 34 inches per year in the northwest to a high of 50 inches in the southeast. Two types of air masses generally control the rain patterns across the state. The northwestern rain patterns are controlled by the continental influences while the southeastern parts of the state are subject to the subtropical air masses.

Important data from the Missouri Climate Center indicates that "All of Missouri experiences "extreme" climate events, and such events must be considered part of the normal climate. Though infrequent in occurrence and often very geographically restricted, these "disturbances" produce environmental changes that may not otherwise have happened and that may be relatively long lasting in their effect. Among these extreme climatic events are high-intensity rains, protracted drought, heat waves and cold waves, ice storms, windstorms, and tornadoes. These climatic events, in turn, may lead to other environmental disturbances such as floods, fires, landslides, and abrupt changes in plant and animal populations and distributions."

Trends and Projected Changes – Climate Indicators

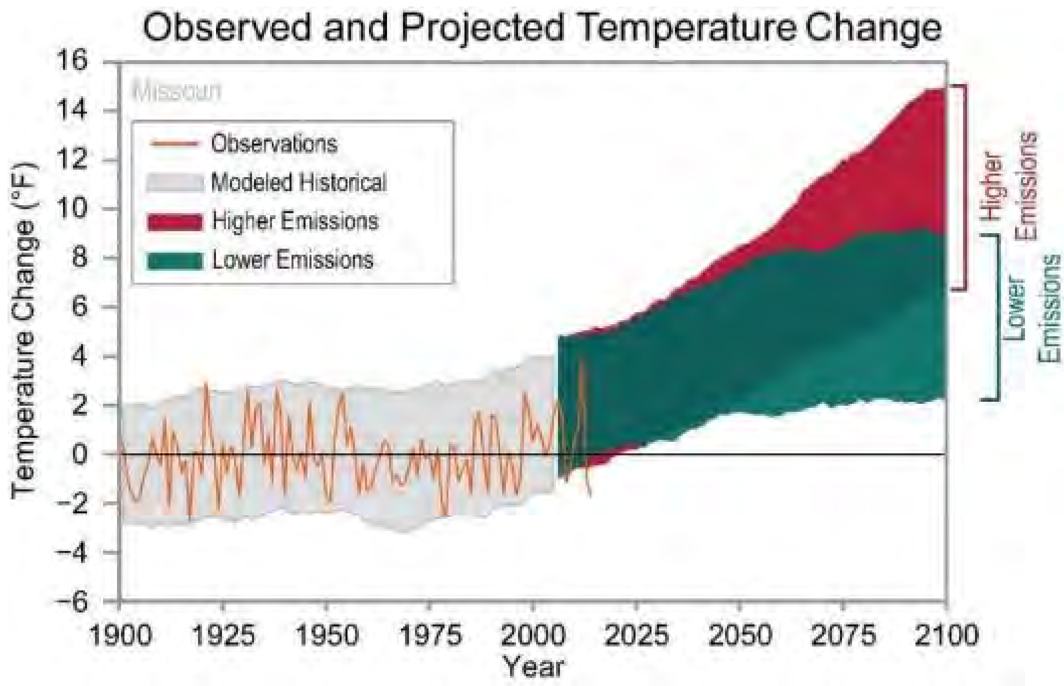
The remainder of this section presents information on general trends and projected changes in Missouri's climate with respect to the following climate indicators:

- Temperature
- Precipitation
- Wind Patterns

Temperature

According to NOAA's National Centers for Environmental Information, State Climate Summaries, Missouri's average annual temperature has increased about 0.5 degrees F since the early 20th Century. Additionally, as shown in **Figure 3.9**, this trend is expected to continue. This model shows two scenarios; projected temperature change with lower emissions and projected temperature change with higher emissions. Per this data, average annual temperature can be expected to increase another 4 to 10 degrees F. At 4 degrees, F temperature change translates to a climate in central Missouri that would be similar to what northern Arkansas experiences today.

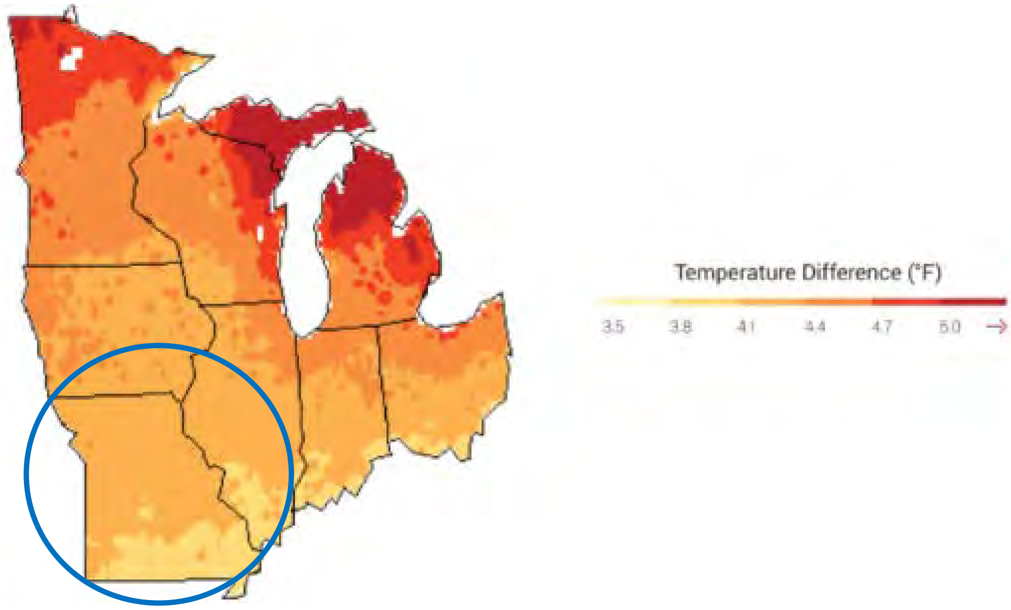
Figure 3.9. Observed and Projected Temperature Change



Source: NOAA National Centers for Environmental Information: State Climate Summaries, https://statesummaries.ncics.org/mo accessed 3/3/2017

The National Climate Assessment indicates that Missouri's projected increase in average annual temperature by mid-century (2041 – 2070) as compared to the 1971 to 2000 period Will see a temperature difference of between 3.5 degrees F to 5.0 degrees F; however, most of the state will see a temperature difference of 4.1 degrees F to 4.4 degrees F as is show in **Figure 3.10**.

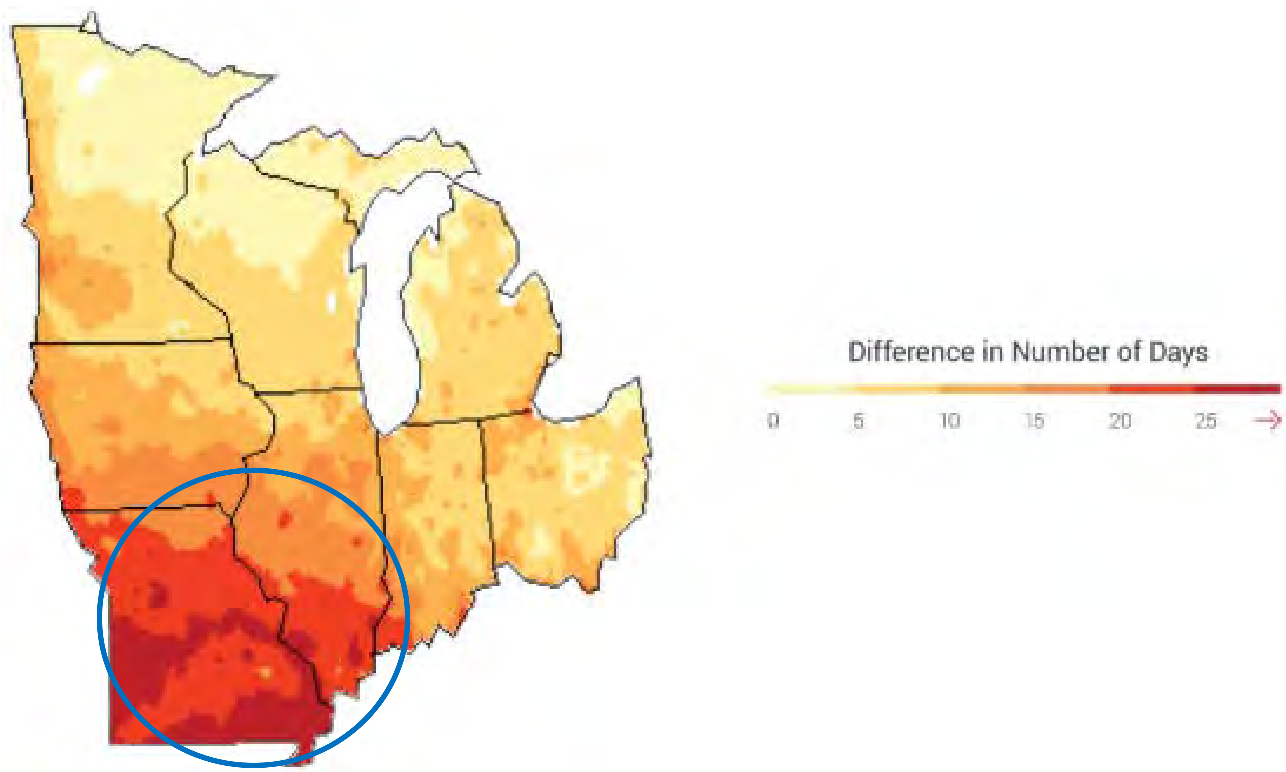
Figure 3.10. Projected Increase in Average Temperatures



Source: 3rd National Climate Assessment Report

Within the Midwest Region of the National Climate Assessment, Missouri can expect 20 to 30 days per year with temperatures reaching above 95 degrees F between 2041 and 2070 compared to the period 1971 to 2000 as is shown below in **Figure 3.11**.

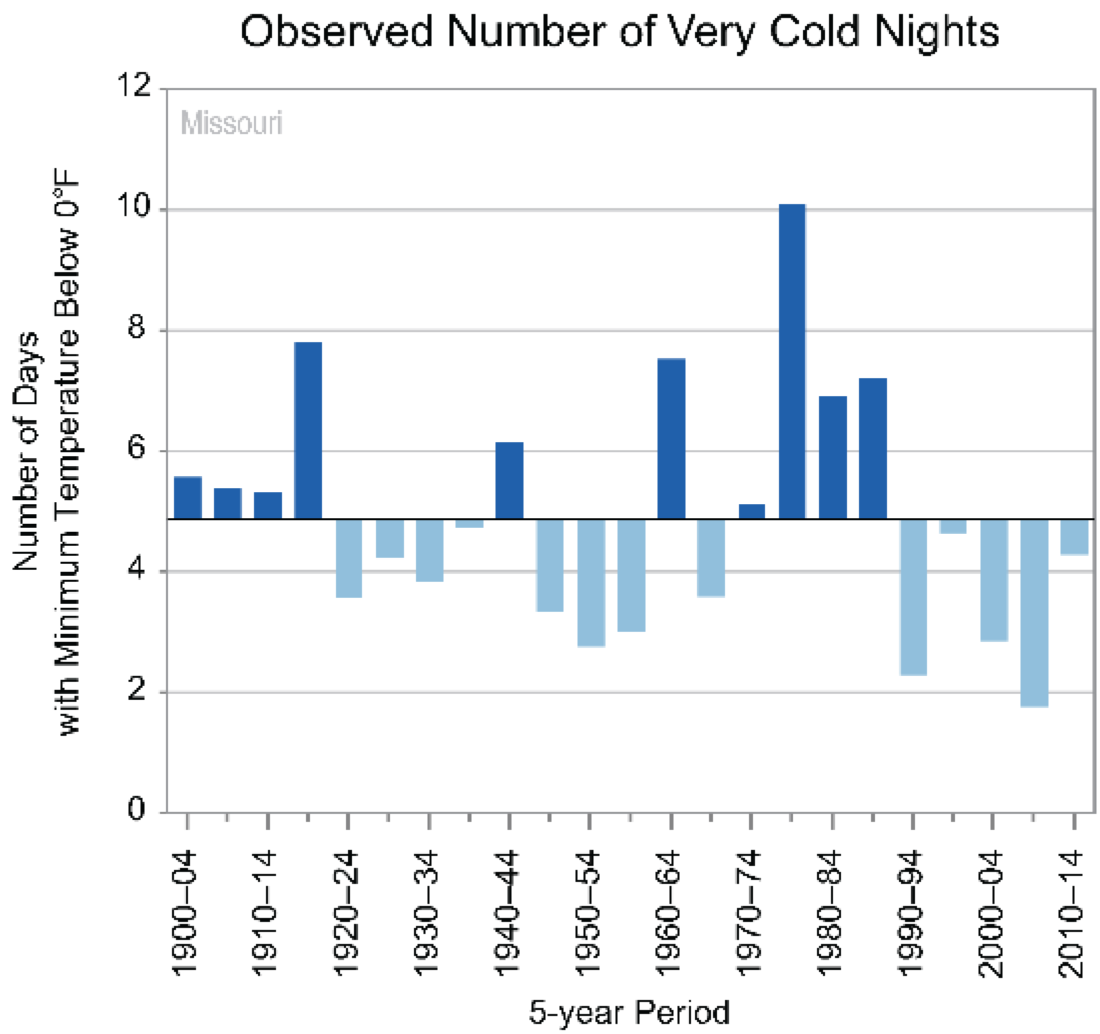
Figure 3.11. Projected Increase in Days Above 95 Degrees F



Source: 3rd National Climate Assessment Report

The warming has been concentrated in the winter and spring and has been characterized by a below average occurrence of extremely cold days since 1990. **Figure 3.12** shows the trend in observed number of very cold nights in comparison to the annual average. This shows that since 1990, there have been below average numbers of very cold nights in Missouri.

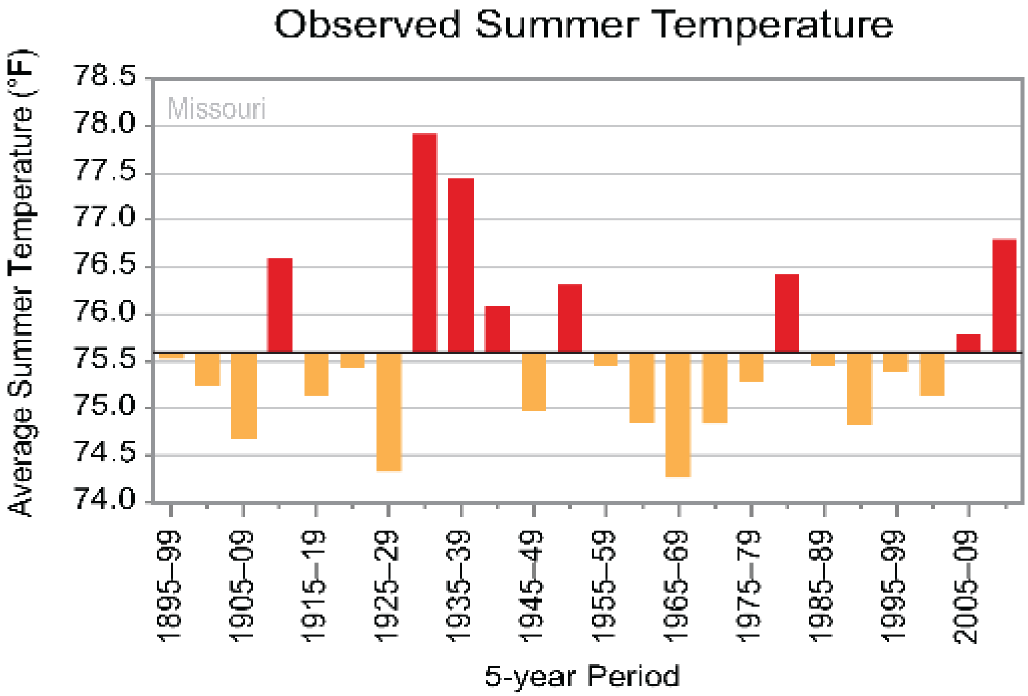
Figure 3.12. Observed Number of Very Cold Nights in Missouri



Source: NOAA National Centers for Environmental Information: State Climate Summaries, https://statesummaries.ncics.org/mo with data from the Cooperative Institute for Climate and Satellites-North Carolina (CICS-NCI); Description: The dark horizontal line represents the annual average. The values are from 24 long-term stations.

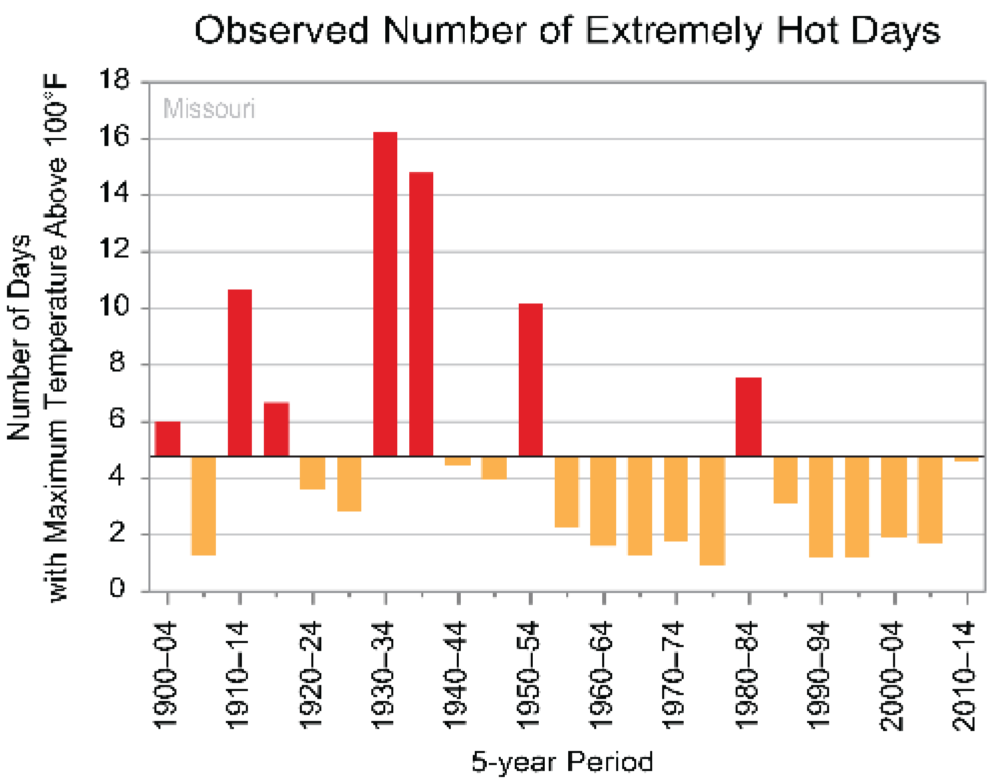
Summer temperatures have not increased substantially in the state until the most recent five years (see **Figure 3.13** and **Figure 3.14**). The summer warming that has occurred has been characterized by much warmer nights while daytime highs have only increased a little. Since 1950, the annual number of these very warm nights at the St. Louis Lambert Airport weather station has increased by about 2 days per decade.

Figure 3.13. Observed Average Summer Temperature, Missouri



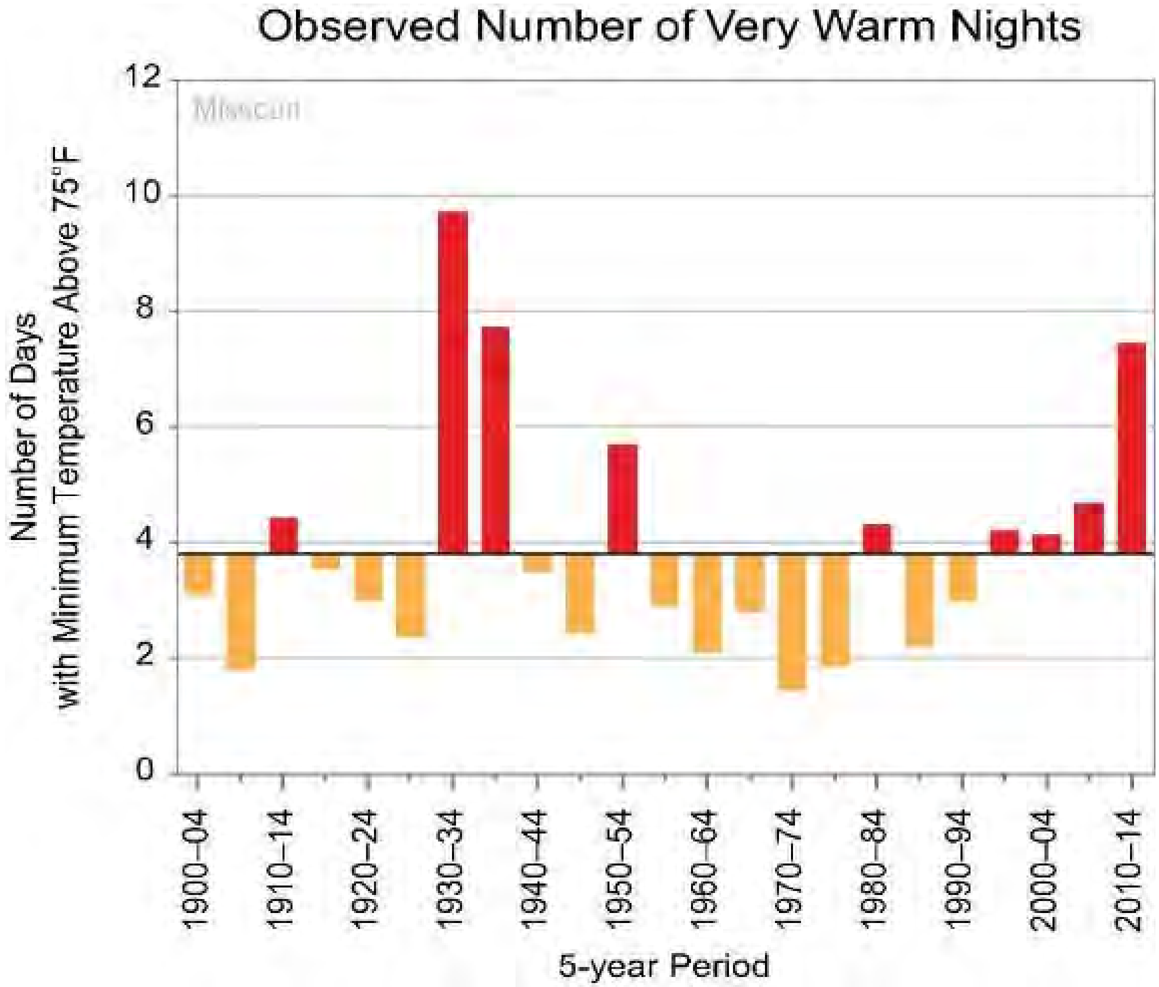
Source: NOAA National Centers for Environmental Information: State Climate Summaries, https://statesummaries.ncics.org/mo with data from the Cooperative Institute for Climate and Satellites-North Carolina (CICS-NCI); Description: Description: The dark horizontal line represents the annual average. The values are from 24 long-term reporting stations.

Figure 3.14. Observed Number of Extremely Hot Days in Missouri



Source: NOAA National Centers for Environmental Information: State Climate Summaries, https://statesummaries.ncics.org/mo with data from the Cooperative Institute for Climate and Satellites-North Carolina (CICS-NCI); Description: Description: The dark horizontal line represents the annual average. The values are from 24 long-term reporting stations.

Figure 3.15. Observed Number of Very Warm Nights in Missouri



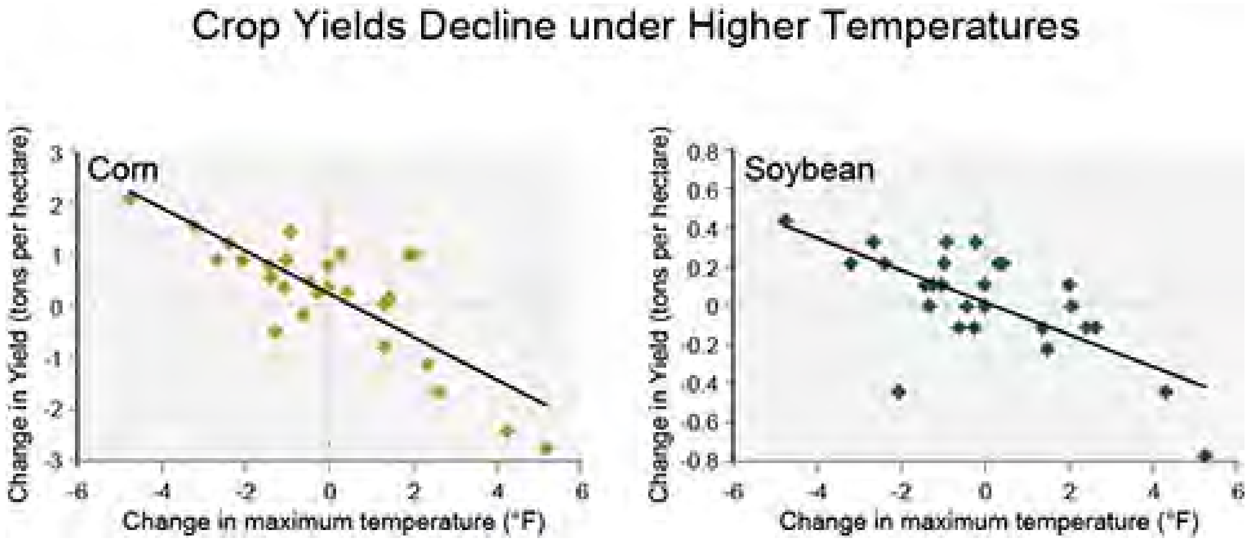
Source: NOAA National Centers for Environmental Information: State Climate Summaries, https://statesummaries.ncics.org/mo with data from the Cooperative Institute for Climate and Satellites-North Carolina (CICS-NCI); Description: Description: The dark horizontal line represents the annual average. The values are from 24 long-term reporting stations.

In addition to the upward trend in temperatures, there has been an upward trend in summer humidity since the mid-20th Century.

Crop yields are subject to temperature and rainfall, but they are especially sensitive to high temperatures during the pollination and grain filling period per the National Climate Assessment. There is a distinct correlation between below average yields to growing seasons which are warmer and drier.

Agriculture dominates the Midwest land use with more than 2/3 of the 8 states in the region designated as farmland. The United States Department of Agriculture, Economic Research Service indicates that 65% of the total corn and soybean production comes from the Midwest region. Future crop yields are more likely to be strongly influenced anomalous weather events than by changes in average temperatures and annual participation according to the National Climate Assessment.

Figure 3.16. Changes in Crop Yield Resulting From Higher Temperatures



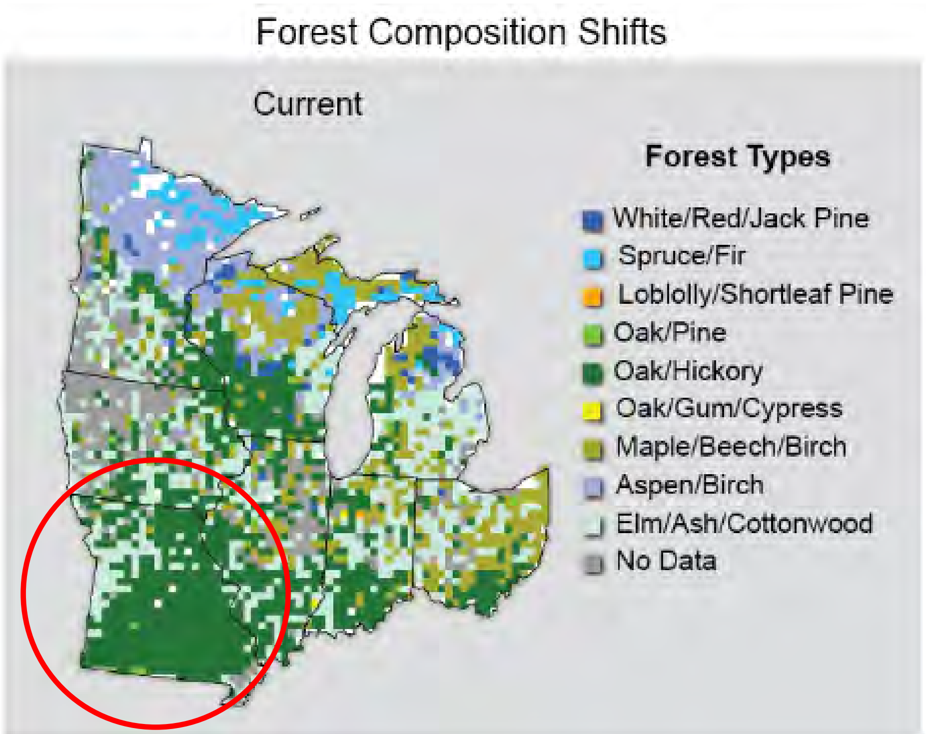
Source: 3rd National Climate Assessment Report

Forest Composition Shifts

There is concern by the National Climate Assessment that the Midwest region forests are expected to change as rising temperatures drive some habitat northward. Among the varied ecosystems, the Midwest region's forest systems are vulnerable to multiple stresses. For example, there are some quintessential tree species such as which paper birch, quaking aspen, balsam fir, and black spruce are projected to decline substantially across the northern Midwest as they shift northward, while species that are common farther south, including several oaks and pines, expand their ranges northward into the region.

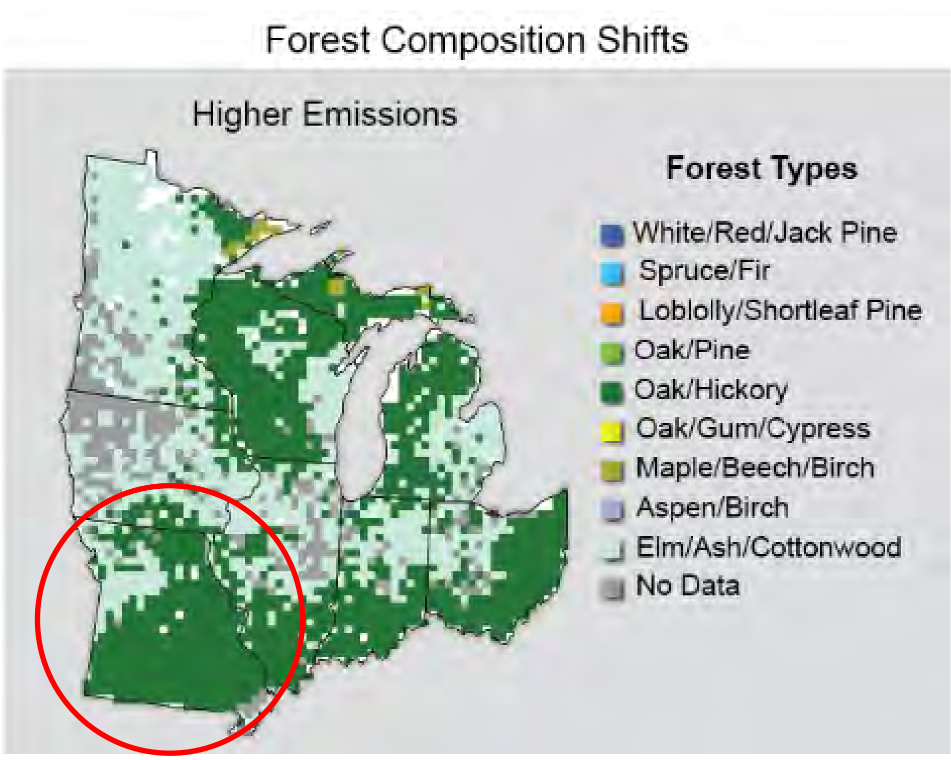
The following figures display that as the climate changes species can generally adapt by changing where they migrate and grow**.** **Figure 3.17** shows the current forest composition. The National Climate Assessment evaluated the impacts of forest composition shifts based on two different emission scenarios. **Figure 3.18** represents a higher emission scenario which assumes a continued increase in emissions versus **Figure 3.19** which represents a lower scenario which assumes a reduction in heat trapping gas emissions.

Figure 3.17. Forrest Composition Shifts - Current



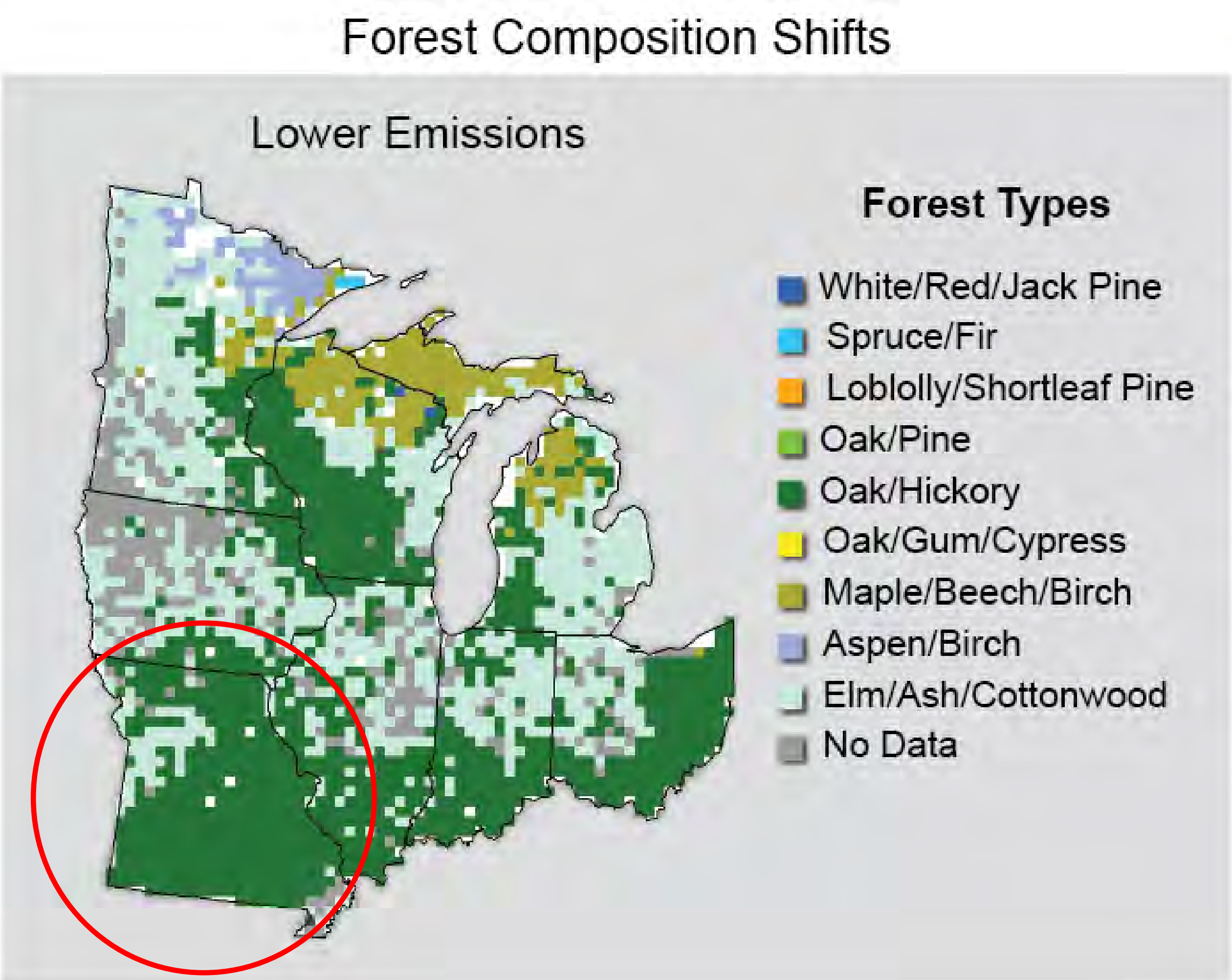
Source: 3rd National Climate Assessment Report

Figure 3.18. Forrest Composition Shifts – High Emissions



Source: 3rd National Climate Assessment Report

Figure 3.19. Forrest Composition Shifts – Low Emissions



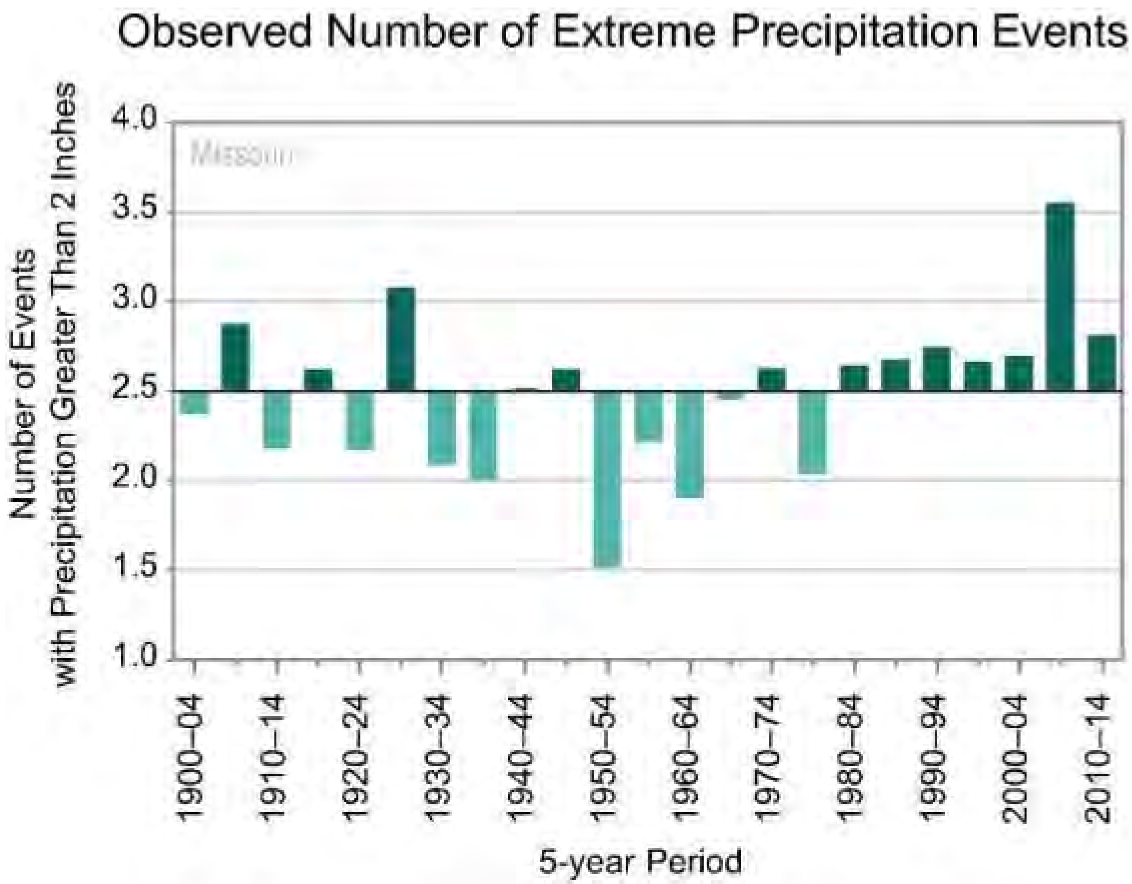
Source: 3rd National Climate Assessment Report

Precipitation

Agriculture is an important component of Missouri's economy. In addition, many cities and other developed areas lie along the State's Rivers and tributaries. Thus, the state is particularly vulnerable to extreme precipitation conditions. Both floods and droughts can result in billions of dollars in losses. The drought of 2012 had large impacts on Missouri as rainfall during critical grow months of May, June, and July were several inches below average.

Missouri has experienced an increase in the number of heavy rain events. As shown in **Figure 3.20,** over the last three decades Missouri has experienced an above average number of extreme precipitation events. The average number of extreme precipitation events is 2.5 per year. This graphic shows that during 2005-2009 a typical station experienced 3-4 such events each year. For large portions of the state, more than 40% of the total annual precipitation occurs on the 10 wettest days of the year.

Figure 3.20. Observed Number of Extreme Precipitation Events.

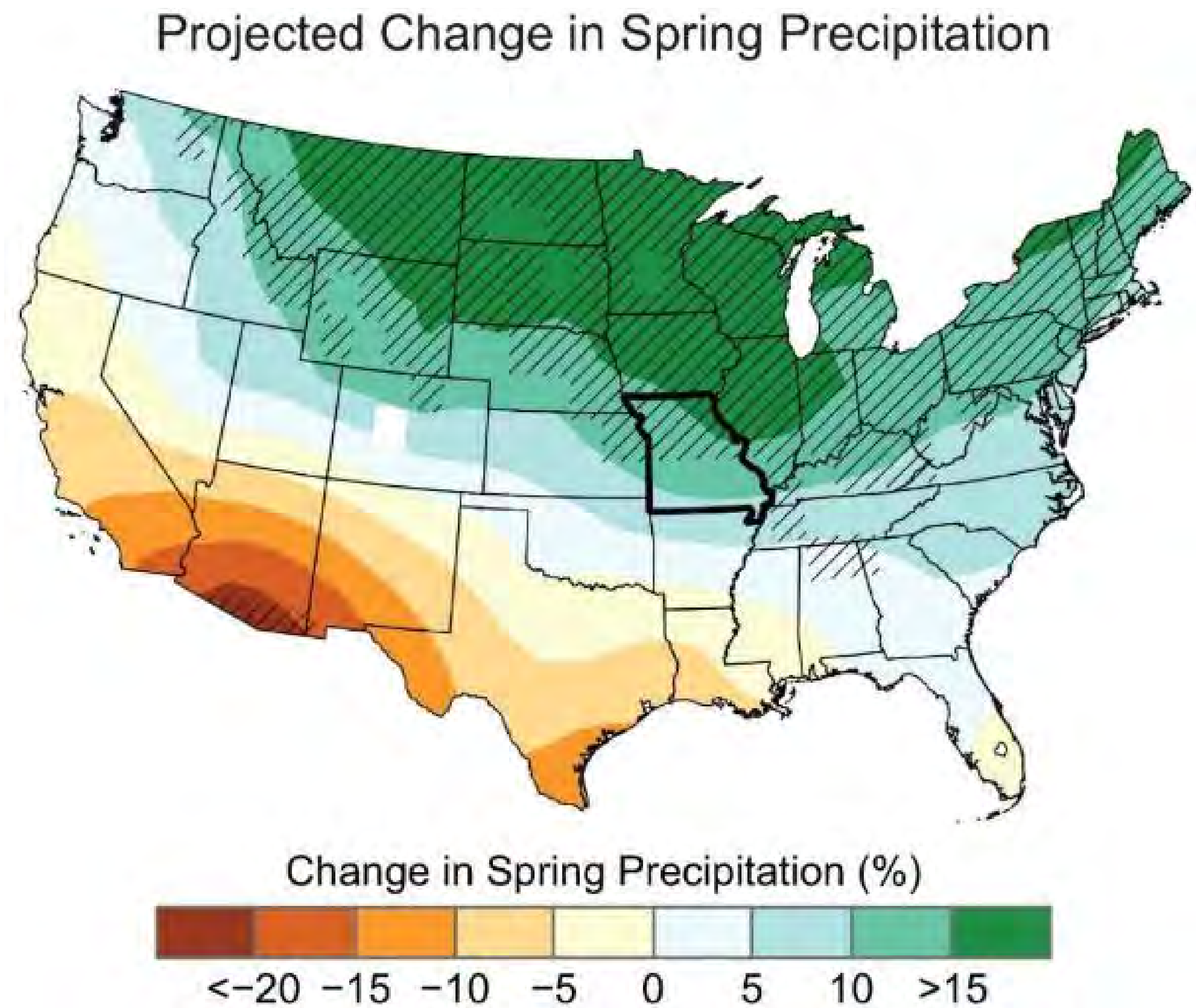


Source: NOAA National Centers for Environmental Information: State Climate Summaries, https://statesummaries.ncics.org/mo with data from the Cooperative Institute for Climate and Satellites-North Carolina (CICS-NCI); Description: The observed number of days with extreme precipitation events (annual number of days with precipitation above 2 inches) for 1900–2014, averaged over 5-year periods; these values are averages from 28 long-term reporting stations. The dark horizontal lines represent the long-term average.

The state's position in the lower river basins of several large Midwestern rivers makes downstream flooding an extreme hazard in the state.

Although projections of overall annual precipitation are uncertain, winter and spring precipitation are projected to increase by 10 to 15 percent for most of the state (see **Figure 3.21**), while summer precipitation may decrease. Additionally, extreme precipitation is projected to increase, potentially increasing the frequency and intensity of floods. Springtime flooding could pose a threat to Missouri's important agricultural economy by delaying planting and resulting in loss of yield.

Figure 3.21. Projected Change in Spring Precipitation

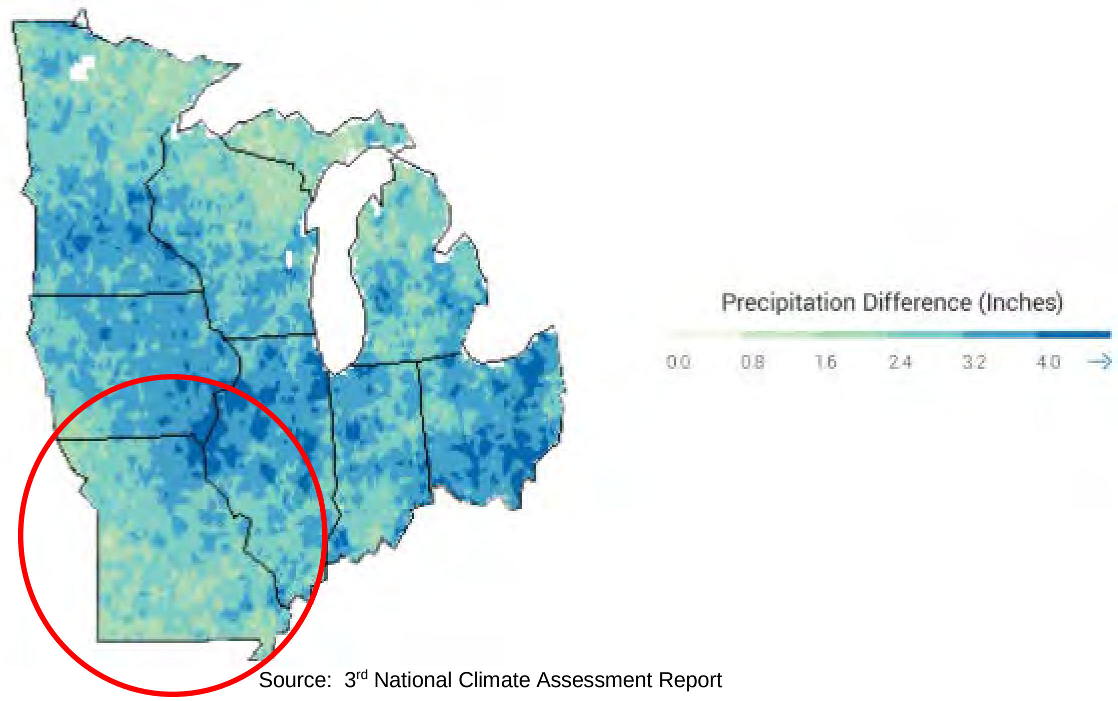


Source: Source: NOAA National Centers for Environmental Information: State Climate Summaries, https://statesummaries.ncics.org/mo with data from the Cooperative Institute for Climate and Satellites-North Carolina (CICS-NC) and National Environmental Modeling Center (NEMAC)

The National Climate Assessment predicts that precipitation patterns in the Midwest region will affect many parts of life from agriculture to urban storm drains. Flooding can impact the stability of the aquatic ecosystem and can cause human and economic consequences throughout a state. Missouri has seen the brunt of major flooding along the Mississippi, Arkansas, White and Missouri rivers over the years. Snowfall can be a secondary affect and increase the magnitude of a flood event.

Per the National Climate Assessment, Missouri is projected to have an increase in the annual rainfall across the state between 0.8 inches and 5.0 inches between 2041 and 2070 as compared to the period 1971 to 2000 as show below in **Figure 3.22**.

Figure 3.22. Projected Increase in Annual Rainfall



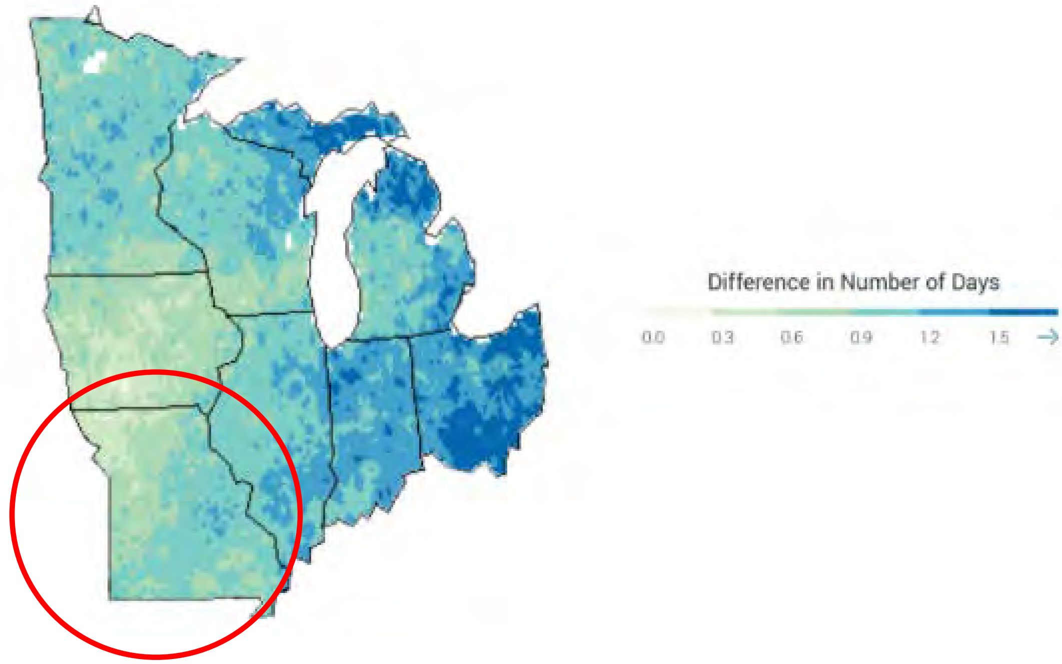
Source: 3rd National Climate Assessment Report

The National Climate Assessment indicates that across the Midwest region, the total amount of water from rainfall and snowfall is projected to increase in that 29-year period (2041 to 2070). **Figure 3.23** below indicates that Missouri will see an increase in the number of days with very heavy precipitation based on the top 2% of rainfalls each year. Across Missouri the data show that between 0.3 and 2 days more of heavy precipitation.

Figure 3.24 shows an increase in the amount of rain falling in the wettest 5-day period over a year based on a projection from 2041 to 2070 compared to the period 1971 to 2000. Missouri is projected to see an increase in the 5 wettest days of the year from between 0.2 and 1.5 inches.

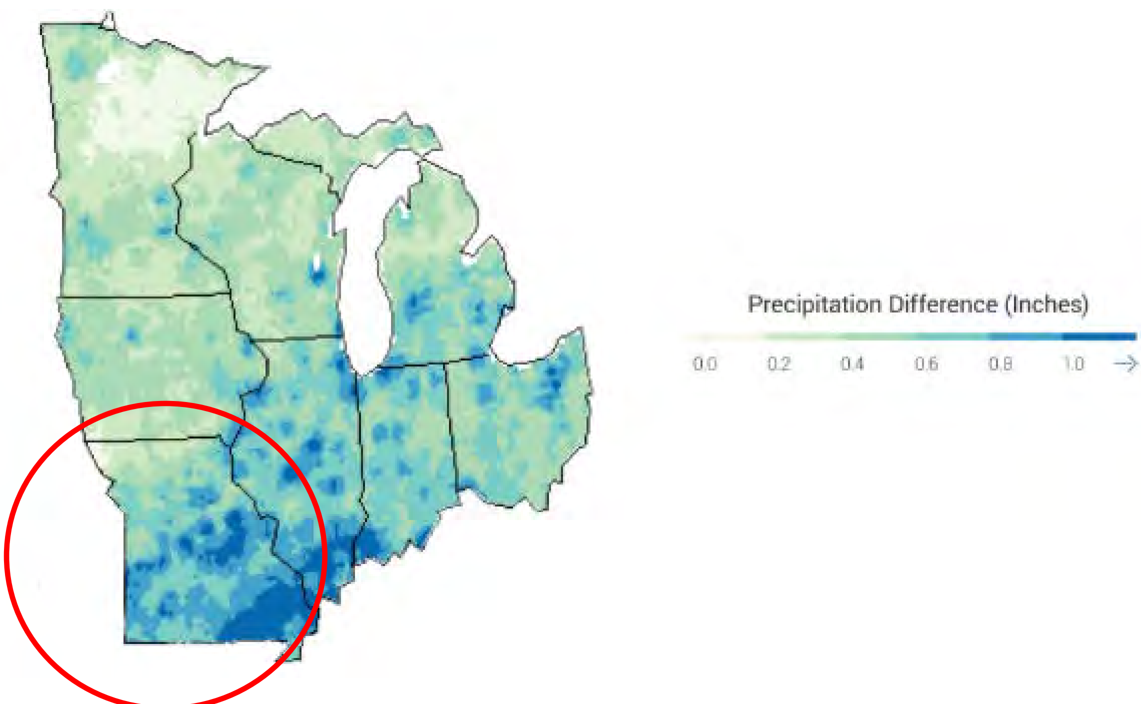
Based on the number of days with heavy rainfall and an increase in the amount of rain falling in the 5 wettest days, Missouri can expect that heavy precipitation events will increase in intensity in the future.

Figure 3.23. Number of Days With Heavy Rainfall



Source: 3rd National Climate Assessment Report

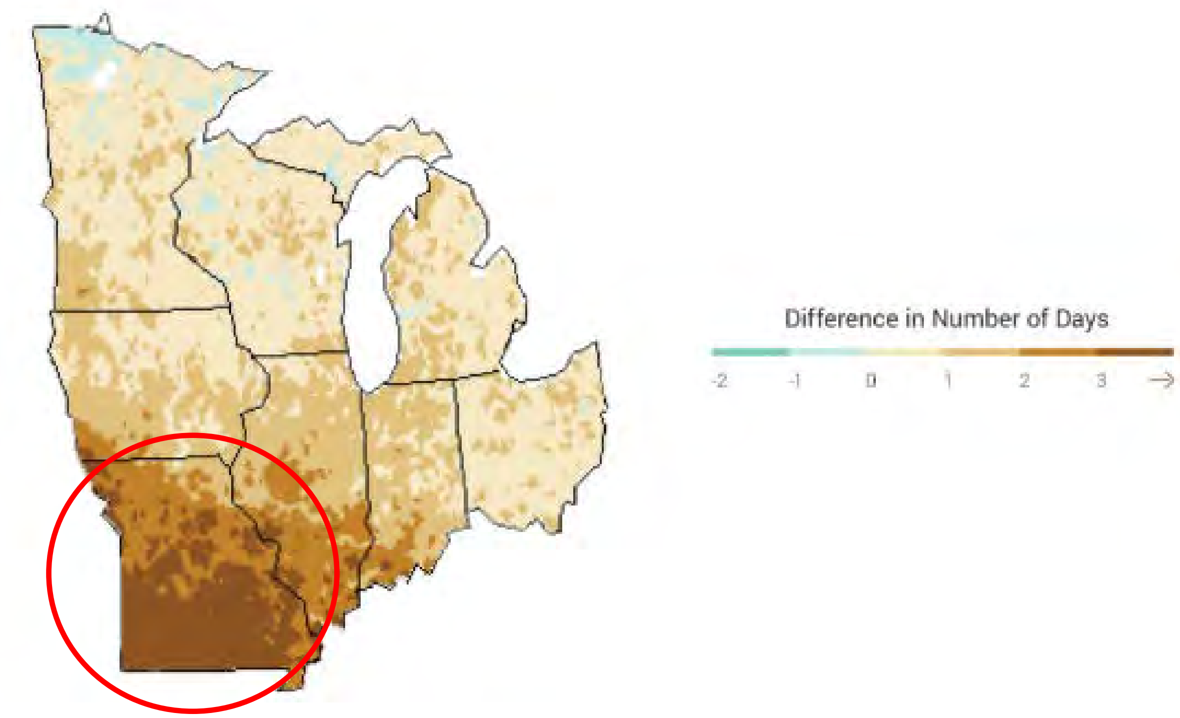
Figure 3.24. Increase in the Amount of Rain Falling in the 5 Wettest Days



Source: 3rd National Climate Assessment Report

Per the National Climate Assessment, **Figure 3.25** shows the number of consecutive days each year with less than 0.01 inches of inches of precipitation. From 2041 to 2070 Missouri is projected to have between 1 and 3 additional days without rainfall; more specifically, the southern half of the state is anticipated to be impacted more substantially.

Figure 3.25. Number of Consecutive Dry Days



Source: 3rd National Climate Assessment Report

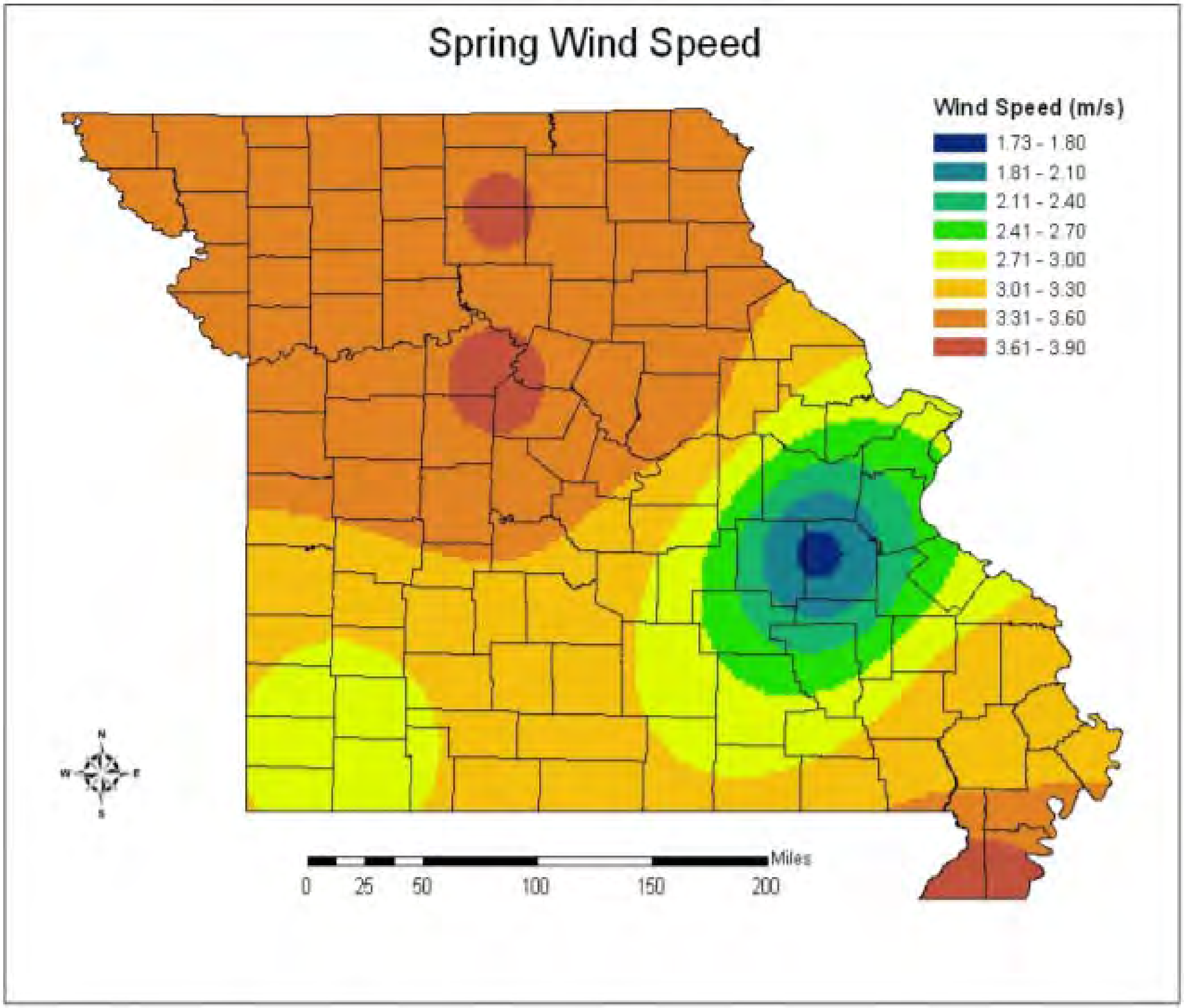
Wind Patterns

Severe thunderstorms are common in Missouri. During the summer, the state's lack of geographic barriers allows cold, dry air from the north to collide with warm moist air from the Gulf of Mexico, triggering severe thunderstorms which can produce high winds, heavy rain, tornadoes, and hail. Missouri has a long and deadly history of tornadic storms. Although more research is needed, preliminary studies suggest that changing climatic conditions may also increase the frequency of conditions favorable to severe thunderstorms.

A colloboration of state and federal agencies published the Missouri Climate Atlas for Design of Land Application Systems (MDNR WP-1400) in 2004. The Missiouri Department of Natural Resources funded this project over a two-year period with funding from the United States Environmental Protection Agency. This document provides statewide data on wind patterns based on the four seasons (Spring, Summer, Autumn and Winter). The study measured wind speed and direction at 3 meters above ground from the stations in the Automated Weather Stations Network with augmented data from the National Weather Service stations.

The report indicates that normal wind speed is generally greater in the northern part of the state than in the southern part. It also indicates that a weak wind center is located leeward of the OzarK Plateau in southeastern Missouri. Prevailing winds vary widely from the effects of the local terrain and topography. The following images show both the prevailing winds and wind speed for all four seasons of the year.

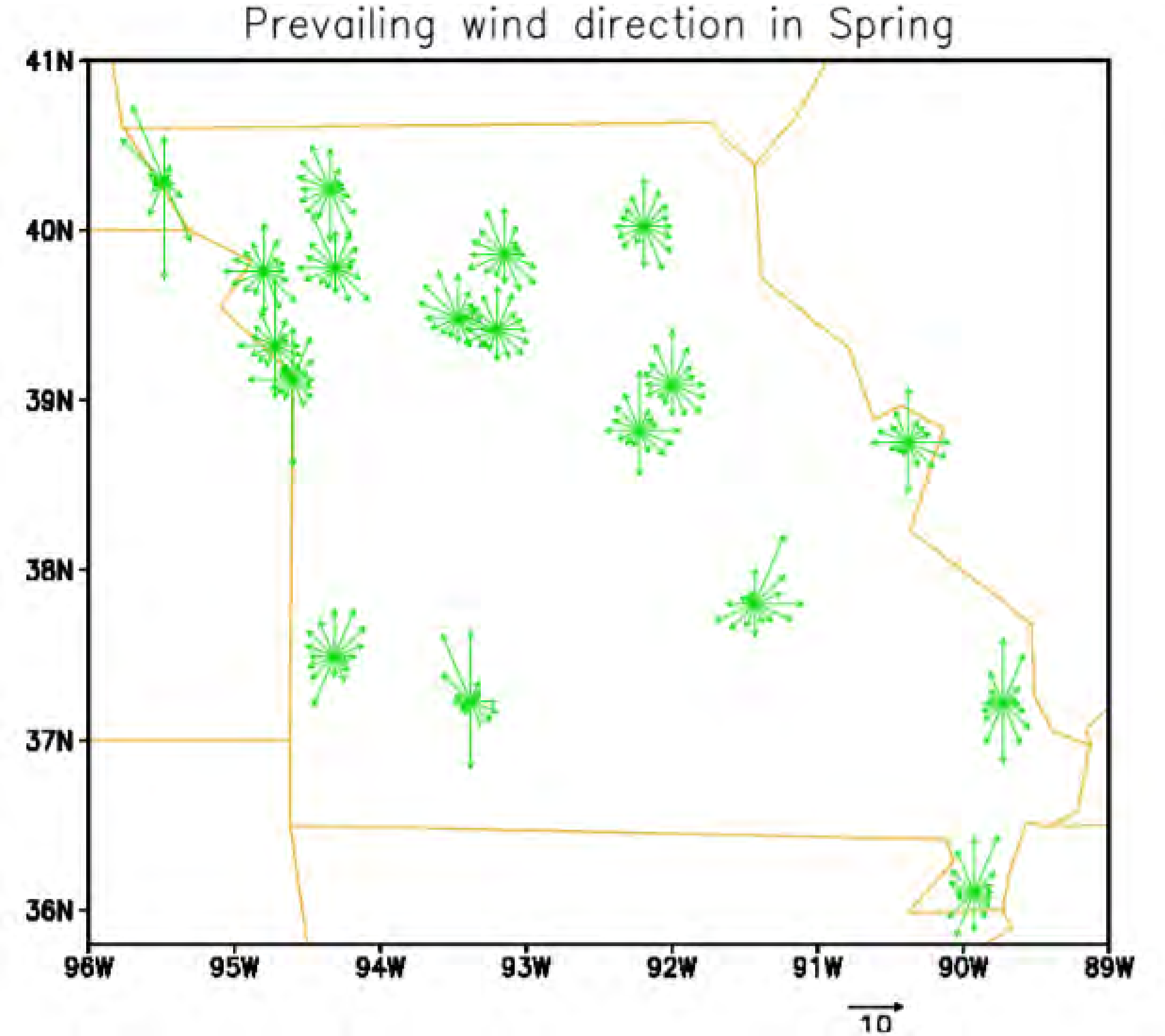
Figure 3.26. Spring Wind Speed



Source: Missouri Climate Atlas for Design of Land Application Systems (MDNR WP-1400) in 2004

Figure 3.27. Prevailing Wind Direction in the Spring

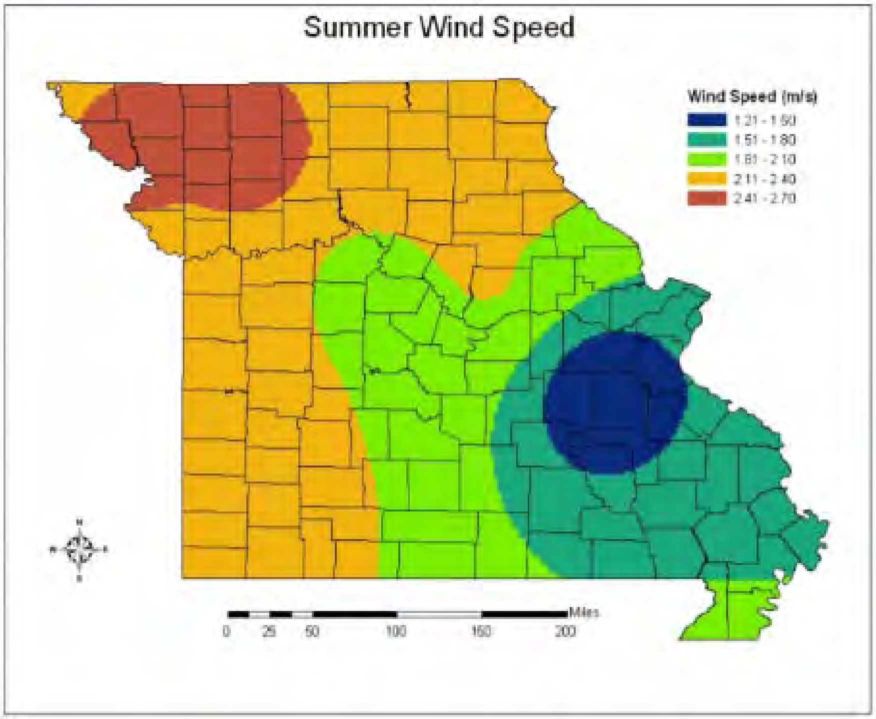
Note



Source: Missouri Climate Atlas for Design of Land Application Systems (MDNR WP-1400) in 2004

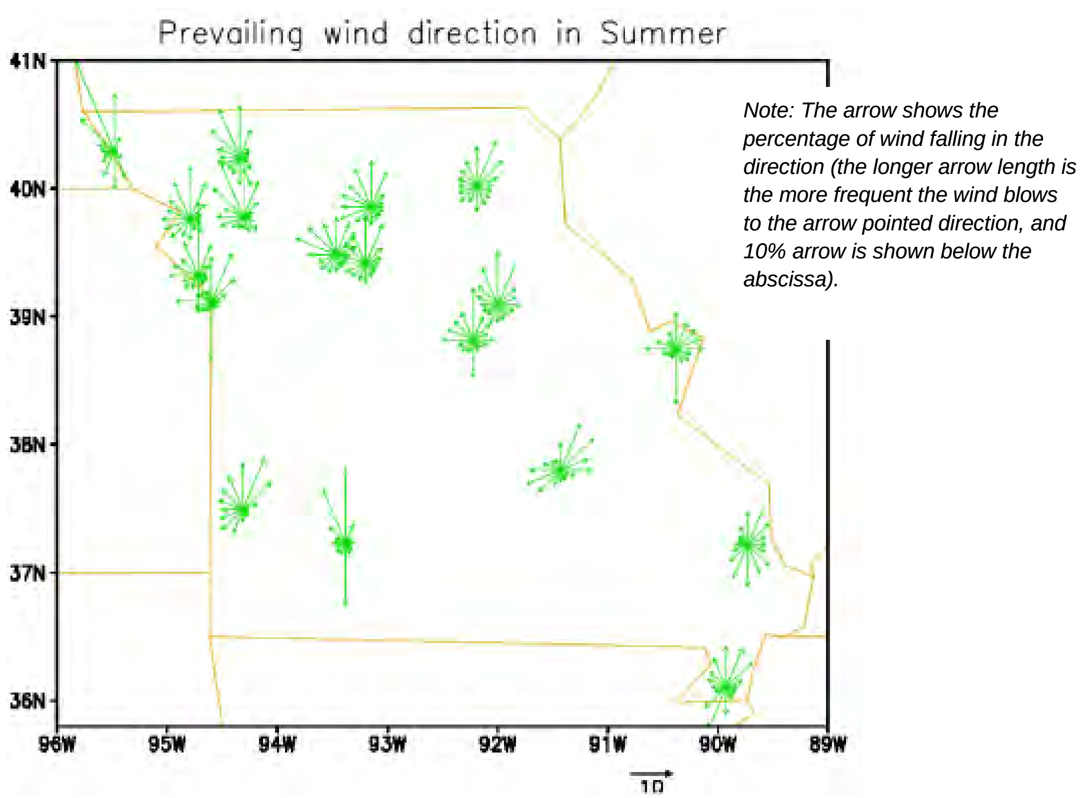
Note: The arrow shows the percentage of wind falling in the direction (the longer arrow length is the more frequent the wind blows to the arrow pointed direction, and 10% arrow is shown below the abscissa).

Figure 3.28. Summer Wind Speed



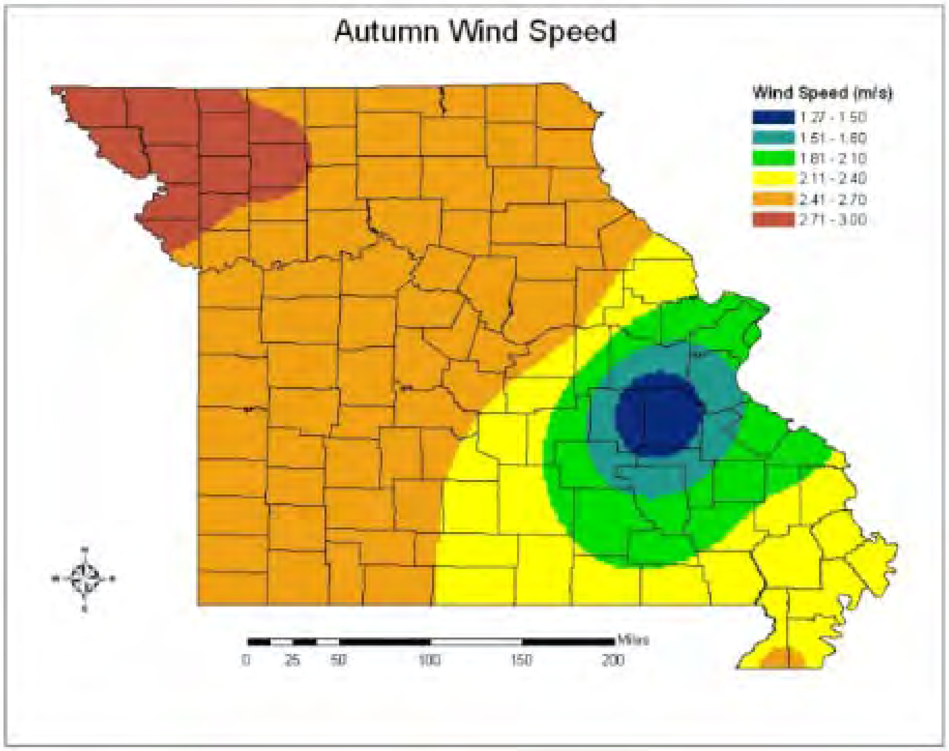
Source: Missouri Climate Atlas for Design of Land Application Systems (MDNR WP-1400) in 2004

Figure 3.29. Prevailing Wind Direction in the Summer



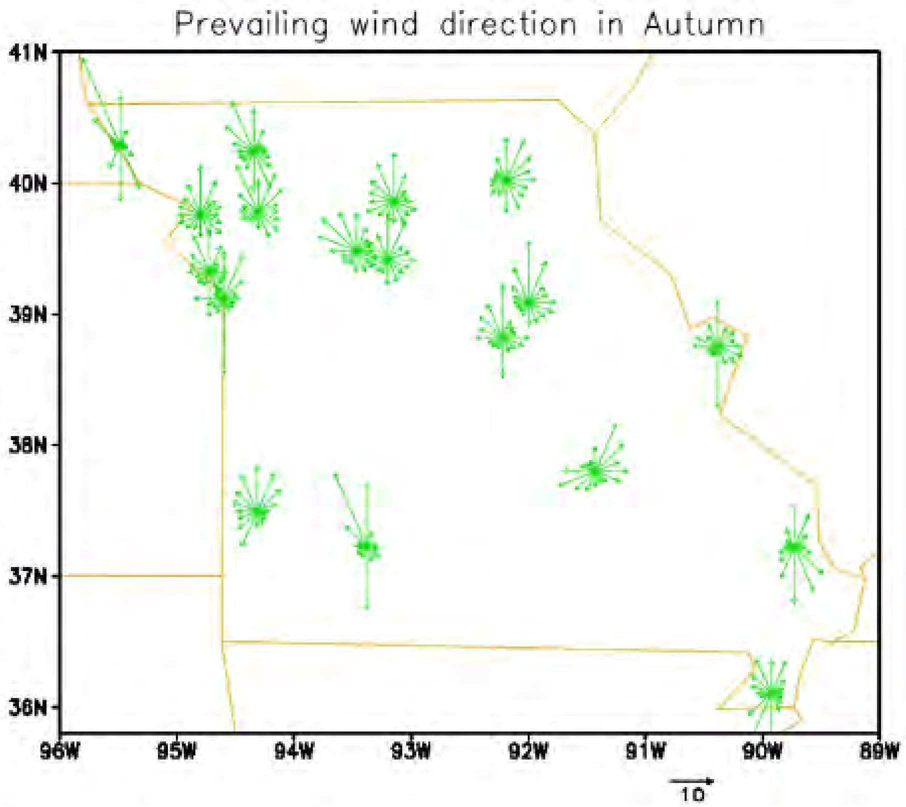
Source: Missouri Climate Atlas for Design of Land Application Systems (MDNR WP-1400) in 2004

Figure 3.30. Autumn Wind Speed



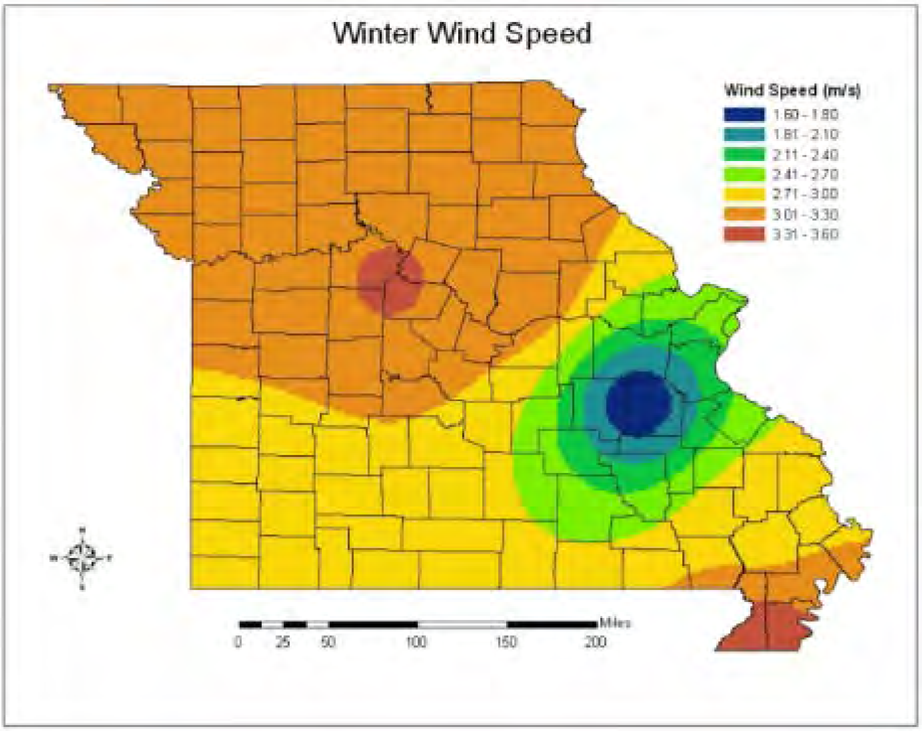
Source: Missouri Climate Atlas for Design of Land Application Systems (MDNR WP-1400) in 2004

Figure 3.31. Prevailing Wind Direction in the Autumn



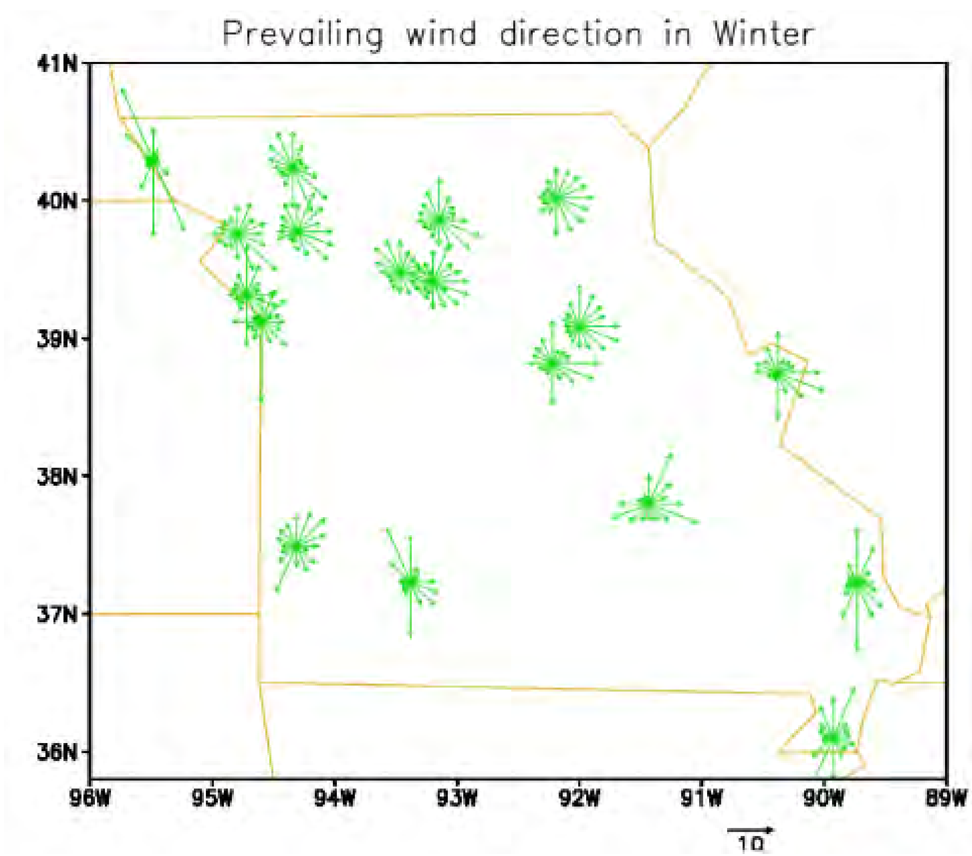
Source: Missouri Climate Atlas for Design of Land Application Systems (MDNR WP-1400) in 2004

Figure 3.32. Winter Wind Speed



Source: Missouri Climate Atlas for Design of Land Application Systems (MDNR WP-1400) in 2004

Figure 3.33. Prevailing Wind Direction in Winter



Source: Missouri Climate Atlas for Design of Land Application Systems (MDNR WP-1400) in 2004

Addressing Changing Future Conditions through Adaptive Planning

Effectively planning for changing future conditions is generally termed “adaptive planning”. Adaptive planning is a planning process that is flexible, continuous, and iterative. An adaptive plan’s goals, strategies, and/or implementation actions are subject to changes as more is understood about changing future conditions and will require experimenting with new approaches, integrating existing systems, building flexibility into plans and strategies, and revising them regularly as new information becomes available. Inclusion of data on trends and projections with respect to key climate indicators as well as discussion of anticipated effects on vulnerability to Missouri’s hazards will enhance the other elements of vulnerability analyses for Missouri’s hazards profiled in this plan to fully inform the State’s mitigation strategy in laying out a comprehensive approach to reduce long-term risk to human life and property throughout the State.

At a larger community or societal scale, health outcomes are strongly influenced by adaptive capacity factors, including those related to the natural and built environments (for example, the state of infrastructure), governance and management (health-protective surveillance programs, regulations and enforcement, or community health programs), and institutions (organizations operating at all levels to form a national public health system). For example, natural resource, public health, and environmental agencies in the Missouri provide many public health safeguards, such as monitoring water quality and issuing advisories to reduce risk of exposure and illness if water becomes contaminated. Some aspects of climate change health impacts may therefore be mediated by factors like strong social networks, fully functional government, and institutions that maintain the State’s generally high level of adaptive capacity. On the other hand, the evidence base regarding the effectiveness of public health interventions in a climate change context is still relatively weak. Current levels of adaptive capacity may not be sufficient to address multiple impacts that occur simultaneously or in close succession, or impacts of climate change that result in unprecedented damages.

Within each hazard subsection in Section 3.3, Changing Future Conditions Considerations are discussed for each hazard.

3.2. Hazard Identification

Requirement §201.4(c)(2)(i): The state risk assessment shall include an] overview of the type…of all natural hazards that can affect the State.

Because Missouri is located in the middle section of the United States, it is prone to several kinds of natural hazards. Missouri has a continental climate; in other words, the weather is changeable and has wide variations in temperature and precipitation.

Missouri serves as a major thoroughfare for transportation and has an abundant share of industrial, agricultural and recreational facilities. Thus, human-caused/technological disasters can also occur, such as hazardous materials releases, nuclear facility incidents and other emergencies caused by human action.

Missouri has four topographically distinct regions: glaciated plains in the north, plains or prairie in the west, lowlands in the extreme southeast and the Missouri Ozarks in between.

The plains section, both glaciated and unglaciated, encompasses nearly all the area north of the Missouri River and a large area south of the river in the western part of the State. The topography varies from rolling hills in the east to hills in the west that average about 450 feet above sea level. There are numerous wide, flat valleys cut by the river and its tributaries.

The Ozarks, which comprise about half of the State, are characterized by rugged areas of sharp ridges and deep narrow valleys. Elevations range from about 1,000 to more than 1,600 feet above sea level. The southeastern lowlands cover about 3,000 square miles, with elevations from 230 to 300 feet above sea level. Much of the region is excellent farmland, channeled by an extensive system of drainage ditches.

Because the State is situated along two of the continent's greatest rivers, the Missouri and the Mississippi, the potential for great floods is high. While six large flood control dams have been built on the main stream of the Missouri River, they have lessened but not eliminated the flood threat.

Warm and cool air masses often collide along sharply divided fronts, accompanied by violent thunderstorms having intense rains, strong winds, hail, lightning, and tornadoes. These frontal storm systems can pass across the State at any time of the year, but are most frequent during the spring months (March, April and May). There are two important truths about Missouri's weather: 1) the State is subject to weather extremes, and 2) extreme weather changes can occur rather quickly.

Most of the natural disasters that occur in Missouri (except for earthquakes, land subsidence and possibly dam failures) result from a weather extreme or an extreme weather change. Because Missouri is situated in the center of the United States, it is subject to many different influences that determine weather patterns.

According to Dr. Grant Darkow, Department of Atmospheric Science at the University of Missouri-Columbia, specific recognizable weather patterns are responsible for Missouri's weather, especially those that "*tend to produce extremes in precipitation, resulting in unusually wet or drought conditions, and extremes in temperature, either abnormally warm or cold.*" Darkow explains:

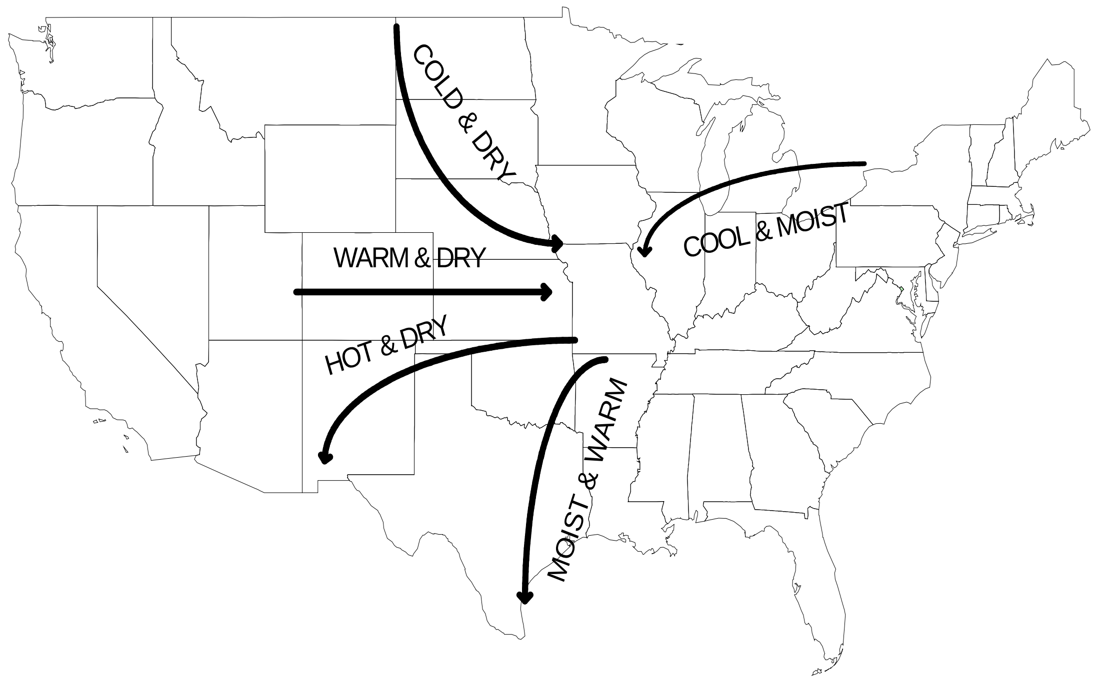
The character of air over Missouri on any particular day or series of days is dominated by the source regions from which it comes. Missouri's midcontinental location makes it subject to air flows from a variety of source regions with markedly different properties.

The state is close enough to the Gulf of Mexico that warm air with high humidity can flow into the state from a southerly direction at almost any time of the year. This warm, moist air is the principal source of spring, summer, and fall precipitation and, occasionally, precipitation in winter as well.

In contrast, air arriving over Missouri from semi-arid to arid regions to the southwest is warm or hot and usually dry as. Air that has moved from west to east over the Rocky Mountains arrives warm and dry, having lost most of its low-level moisture as it climbed the west side of the mountains.

Abnormally cold air in the winter and cold summer air with only very small moisture content arrives over Missouri from the northwest or north, whereas air entering Missouri from the northeast will tend to be cool and moist.

Figure 3.34. Source Regions and Atmospheric Characteristics for Air Arriving in Missouri



Darkow goes on to explain:

Normally, the flow from one of the principal source regions will last for two or three days before switching to a different direction and source region. These transitions typically are accompanied by a frontal passage during which the change in wind direction, temperature, and moisture content, or any combination, is concentrated.

In some instances, however, a particular flow pattern may be very persistent or dominant for a period of weeks or even months. These periods can lead to wet, dry, hot, or cold spells, and the extremes associated with these periods. These periods are characterized by particular upper air flow patterns and associated surface weather patterns (see Figure 3.35, Figure 3.36, Figure 3.37, Figure 3.38, Figure 3.39, and Figure 3.40), sourced from the 2012 State Hazard Analysis, Missouri and Kentucky Universities.

Figure 3.35. Upper Air Pattern: Results in weather that is Warm or hot and usually dry

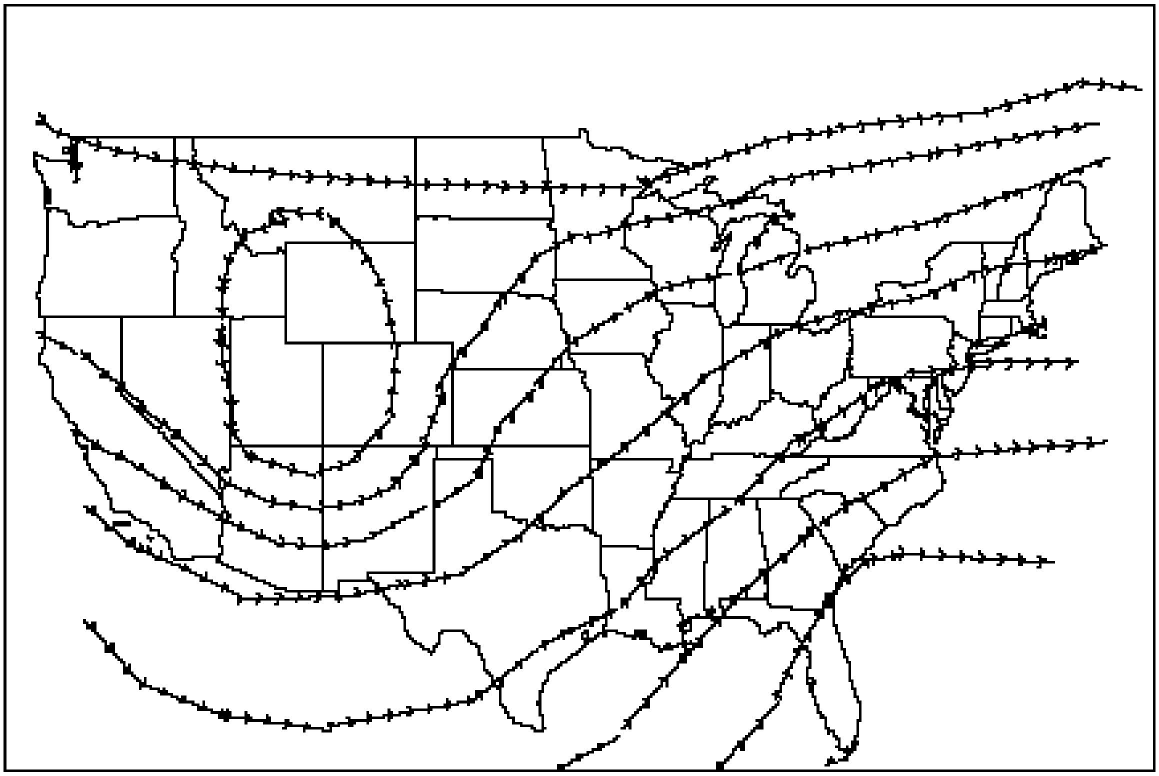


Figure 3.36. Surface Air Pattern: Results in weather that is Cool and Moist

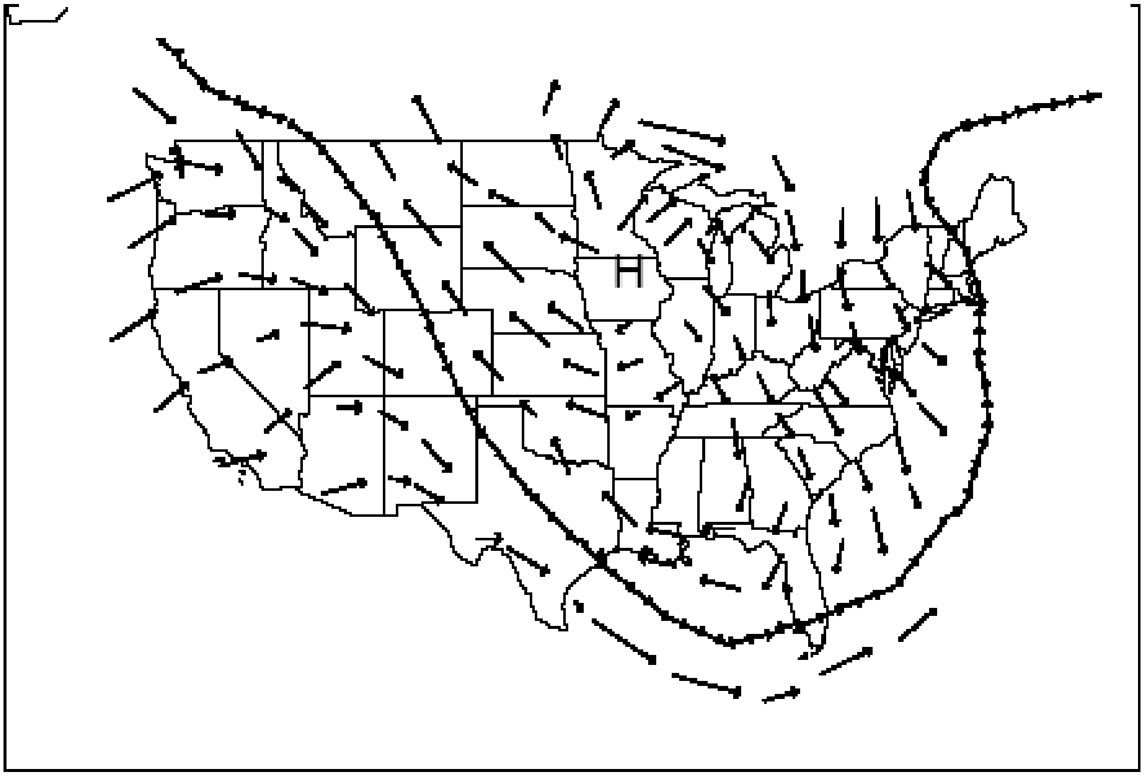


Figure 3.37. Upper Air Pattern: Results in weather that is Cold and Dry

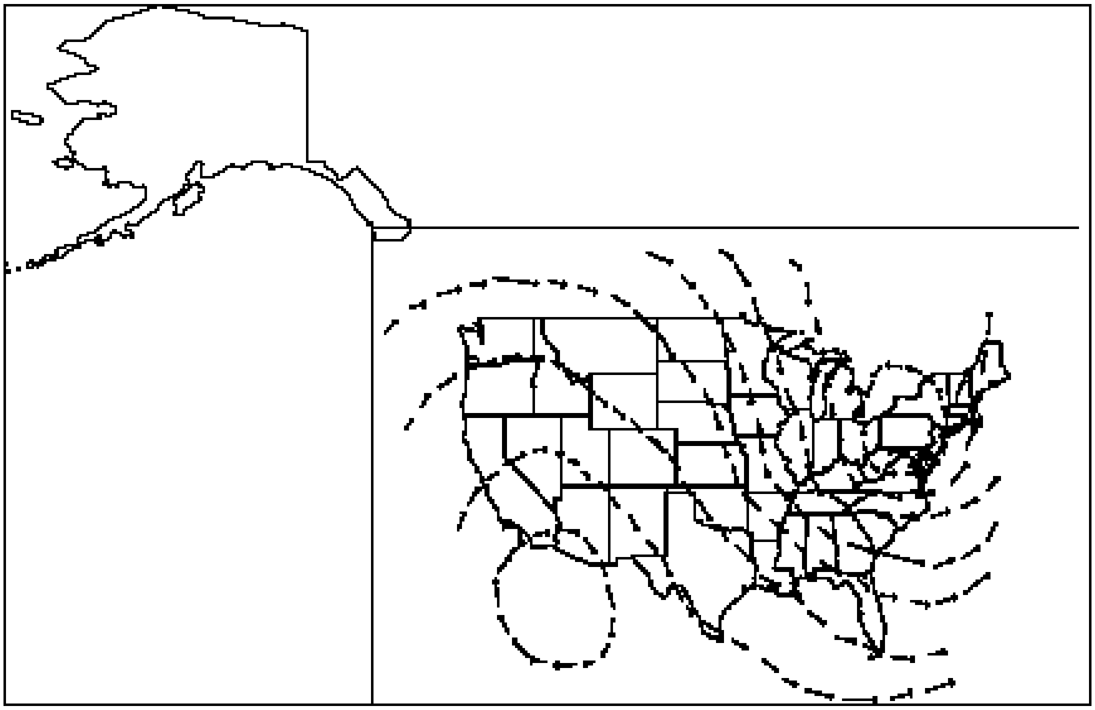


Figure 3.38. Surface Air Pattern: Results in weather that is Warm and Moist

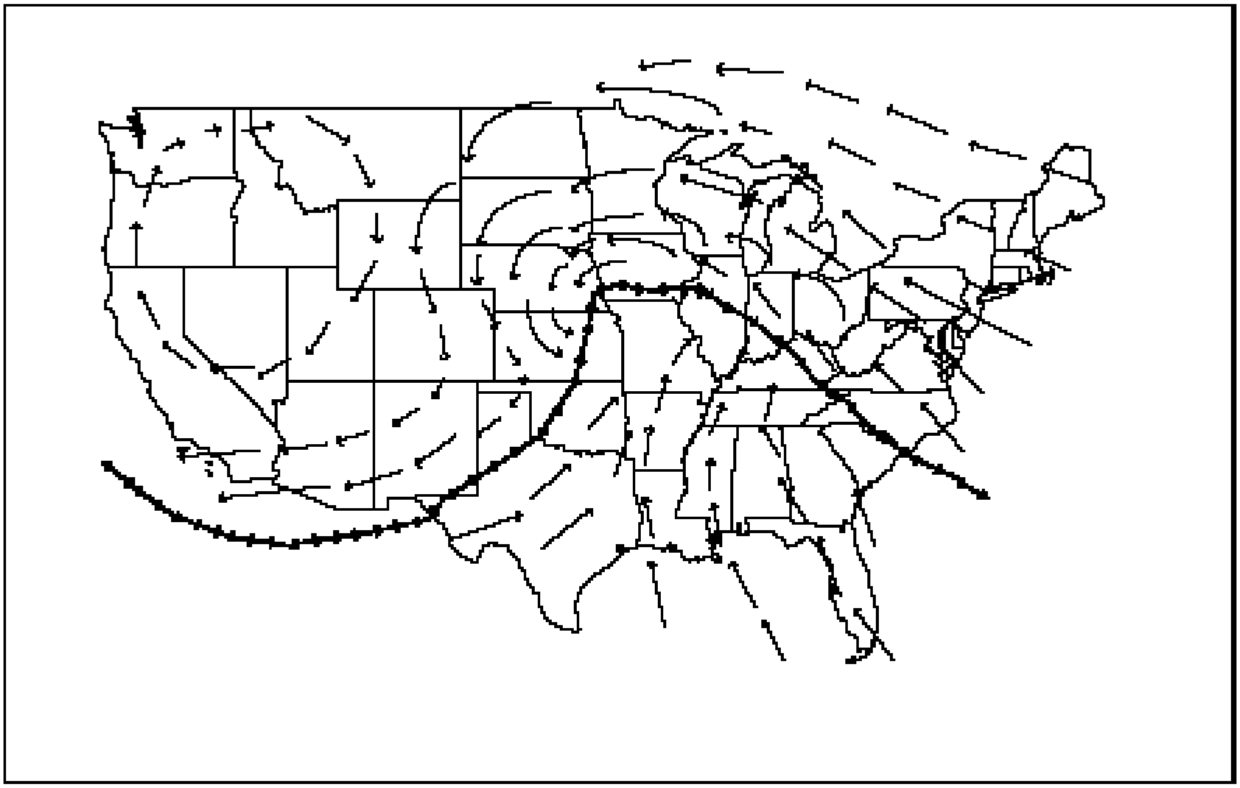


Figure 3.39. Upper Air Pattern: Results in weather that is Hot and Dry

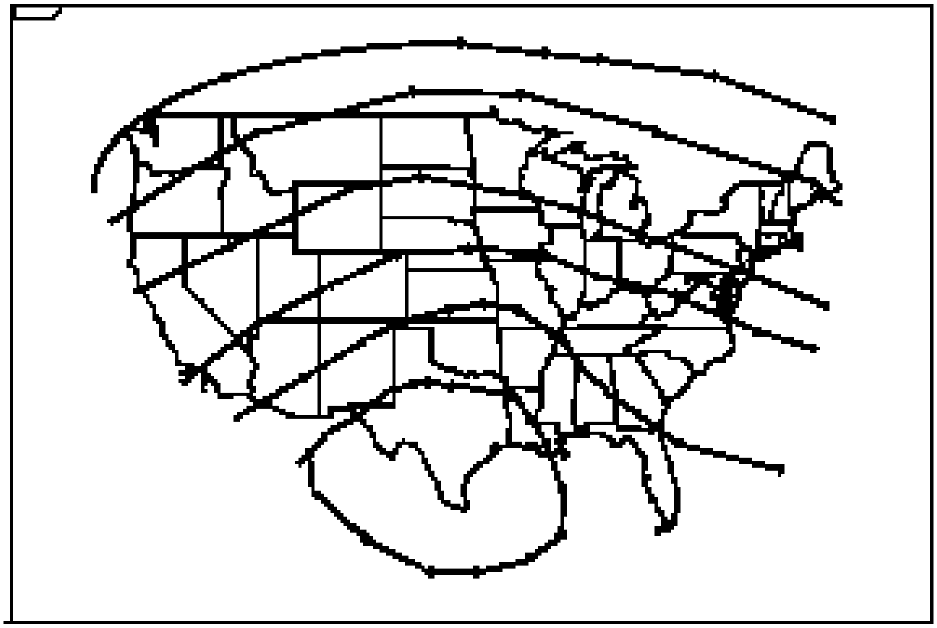
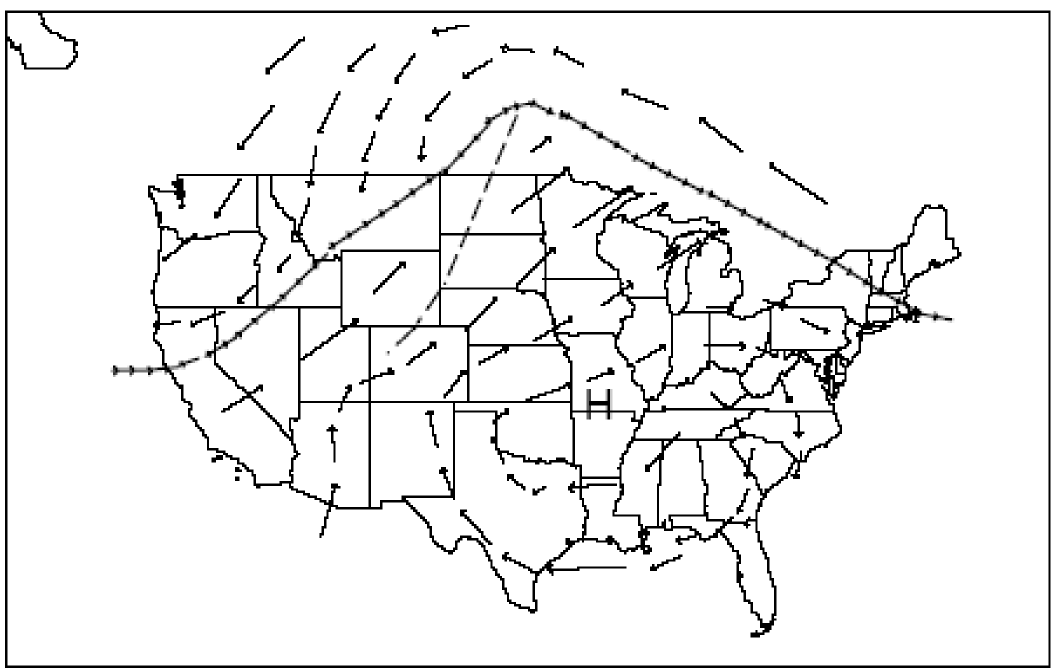


Figure 3.40. Surface Air Pattern: Results in weather that is Warm and Moist



The persistence of these weather patterns and the possible resulting condition is the subject of several of the natural disasters discussed in this study. Specifically, floods, droughts, fires, heat waves, severe cold, and winter storms can be the result of the persistence of one of these weather patterns, whereas tornadoes can represent the outgrowth of rapid shifts in weather patterns. Knowing these patterns may assist in alerting disaster planners and the general public to the possibility of a developing emergency situation.

This State Hazard Mitigation Plan considers natural, human-caused, technological, and other hazards as discussed in the following sections.

3.2.1. Natural Hazards

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

➢ Flooding (Major and Flash) ➢ Levee Failure ➢ Dam Failure	Natural Flood-Related Hazards
➢ Earthquake ➢ Land Subsidence / Sinkholes	Natural Geologic Hazards
➢ Drought ➢ Extreme Temperature ➢ Severe Thunderstorms ➢ Severe Winter Weather ➢ Tornadoes	Natural Meteorological Hazards
➢ Wildfire	Natural Other Hazard

The list above of natural hazards is the same as those identified in the 2013 State Hazard Mitigation Plan Update with the following exception;

Wildfire - during the planning process for the 2018 plan update, it was decided to split "Fires (Structural, Urban, and Wild) into two separate hazard sections as follows: Wildfire classified as a Natural Other Hazard and Urban/Structural Fire as a Human-Caused/Technological Hazard. The rationale behind the classifications is based on the "fuel" for the fires. Since Wildfire fuel is a natural fuel comprised of wildland vegetation, it was classed with the Natural hazards and since Urban/Structural Fire fuel is man-made buildings, it was classed with Human-Caused/Technological hazards.

Table 3.22 below identifies the natural hazards that were excluded from the State Risk Assessment along with the reason for their exclusion.

Table 3.22. Natural Hazards Excluded from State Risk Assessment

Hazard	Reason for Exclusion
Avalanche	No identified avalanche risk areas and no history of occurrence
Coastal Erosion	No coastal areas in Missouri
Coastal Storms	No coastal areas in Missouri
Hurricanes	Missouri is an inland state. Although in 2008 Hurricane Ike did indirectly cause severe weather in Missouri, it was the resulting hazards that are profiled (flooding, winds, hail, and tornadoes) that directly affected Missouri.
Tsunamis	Missouri is an inland state.
Volcanoes	No identified volcanoes in Missouri.
Expansive Soils	During the 2018 plan update process, further consultation with the Missouri Department of Natural Resources Geological Resources Section resulted in the continued exclusion of this

Hazard	Reason for Exclusion
	hazard as a profiled hazard in the State Hazard Mitigation Plan. According to MoDNR, expansive soils are a limited risk with no identified risk areas.
Landslide/Rockfall	During the 2018 plan update process, further consultation with the Missouri Department of Transportation resulted in the continued exclusion of this hazard as a profiled hazard in the State Hazard Mitigation Plan. Landslide/Rockfall is not considered to be a widespread hazard of concern in the state. Although there are areas within the state where landslide/rockfall can potentially impact roadways, these risk areas and any identified mitigation fall under the jurisdiction of MoDOT. It was determined that additional analysis of these limited areas would duplicate effort.

3.2.2. Human-Caused / Technological Hazards

Each year there are increases in human-caused/technological incidents which can be just as devastating as natural disasters. The following human-caused/technological hazard that can threaten Missouri are included in the State Risk Assessment:

- CBRNE Attack (Chemical, Biological, Radiological, Nuclear and Explosive
- Civil Disorder
- Cyber Disruption
- Hazardous Materials
- Mass Transportation Accidents
- Nuclear Power Plants (Fixed Nuclear Facilities)
- Public Health Emergencies/Environmental Issues
- Special Events
- Terrorism
- Urban/Structure Fire
- Utilities (Interruptions and System Failures)

As discussed above with regard to the wildfire hazard, during the planning process for the 2018 plan update, it was decided to separate Urban/Structure Fire from Wildfire and profile separately as a human-caused/technological based on the fuel for urban/structure fires being man-made materials.

3.2.3. Disaster Declarations

In the United States, 95 percent of all presidentially declared major disasters have been related to weather or flood events. In Missouri, 100 percent of the presidentially declared major disasters since 1975 have been related to weather or flood events. Between the 2013 and 2018 updates of the State Hazard Mitigation Plan, there were six presidential disaster declarations. Of these six disasters, five were major disaster declarations and one was an emergency declarations. **Table 3.23** summarizes presidential major disaster declarations, emergency declarations and fire management assistance declarations for Missouri since 1975. Additional information on presidential declared disasters can be found at http://www.fema.gov/news/disasters.fema.

Table 3.23. Presidential Disaster Declarations for Missouri, 1975-May 2018

Declaration Date	Disaster No.	Incident Type	No. of Counties Designated	Type of Assistance By County*
Major Disaster Declarations				
May 3, 1975	DR 466	Tornadoes, High Winds, Hail	4	IA & PA: 4
July 21, 1976	DR 516	Severe Storms, Flooding	4	IA & PA: 4

Declaration Date	Disaster No.	Incident Type	No. of Counties Designated	Type of Assistance By County*
May 7, 1977	DR 535	Tornadoes, Flooding	7	IA & PA: 7
September 14, 1977	DR 538	Severe Storms, Flooding	6	IA & PA: 6
April 21, 1979	DR 579	Tornadoes, Torrential Rain, Flooding	17	IA Only: 1 IA & PA: 16
May 15, 1980	DR 620	Severe Storms, Tornadoes	1	IA Only: 1
August 26, 1982	DR 667	Severe Storms, Flooding	3	IA Only: 1 IA & PA: 2
December 10, 1982	DR 672	Severe Storms, Flooding	17	IA Only: 18 PA Only: 1 IA & PA: 5
June 21, 1984	DR 713	Severe Storms, Flooding	11	IA Only: 1 PA Only: 8 IA & PA: 2
October 14, 1986	DR 779	Severe Storms, Flooding	30	IA Only: 7 PA Only: 15 IA & PA: 8
May 24, 1990	DR 867	Flooding, Severe Storm	10	IA Only: 2 IA & PA: 8
May 11, 1993	DR 989	Severe Storm, Flooding	8	IA Only: 8
July 9, 1993	DR 995	Flooding, Severe Storm	101 & St. Louis City*	IA Only: 14 IA & PA: 88
December 1, 1993	DR 1006	Flooding, Severe Storm, Tornadoes	24	IA Only: 10 IA and PA: 14
April 21, 1994	DR 1023	Severe Storm, Flooding, Tornadoes	17 & St. Louis City*	IA Only: 18
June 2, 1995	DR 1054	Severe Storm, Tornadoes, Hail, Flooding	61 & St. Louis City*	IA Only: 19 IA & PA: 43
October 14, 1998	DR 1253	Severe Storm and Flooding	19	IA and PA: 5 PA Only: 14
October 19, 1998**	DR 1256	Severe Storm and Flooding	2 & St. Louis City*	IA Only: 3
April 20, 1999	DR 1270	Severe Storms and Flooding	6	IA Only: 6
May 12, 2000	DR 1328	Severe Thunderstorms and Flash Flooding	10	IA: 10 IA and PA: 3
February 6, 2002	DR 1403	Ice Storm	43	IA Only: 17 IA and PA: 26
May 6, 2002	DR 1412	Severe Storms and Tornadoes	79	IA Only: 9 PA Only: 31 IA and PA: 39
May 6, 2003	DR 1463	Severe Storms, Tornadoes, and Flooding	76	IA Only: 42 PA Only: 2 IA and PA: 32
June 11, 2004	DR 1524	Severe Storms, Tornadoes, and Flooding	37	IA: 37
March 16, 2006	DR 1631	Severe Storms, Tornadoes, and Flooding	41	IA Only: 12 PA Only: 4 IA and PA: 25
April 5, 2006	DR 1635	Severe Storms, Tornadoes, and Flooding	7	IA Only: 3 IA and PA: 4
November 2, 2006 ***	DR 1667	Severe Storms	St. Louis City*	PA Only: 1
December 29, 2006	DR 1673	Severe Winter Storms	13 & St. Louis City*	PA Only: 14
January 15, 2007	DR 1676	Severe Winter Storms and Flooding	38 & St. Louis City*	PA Only: 39

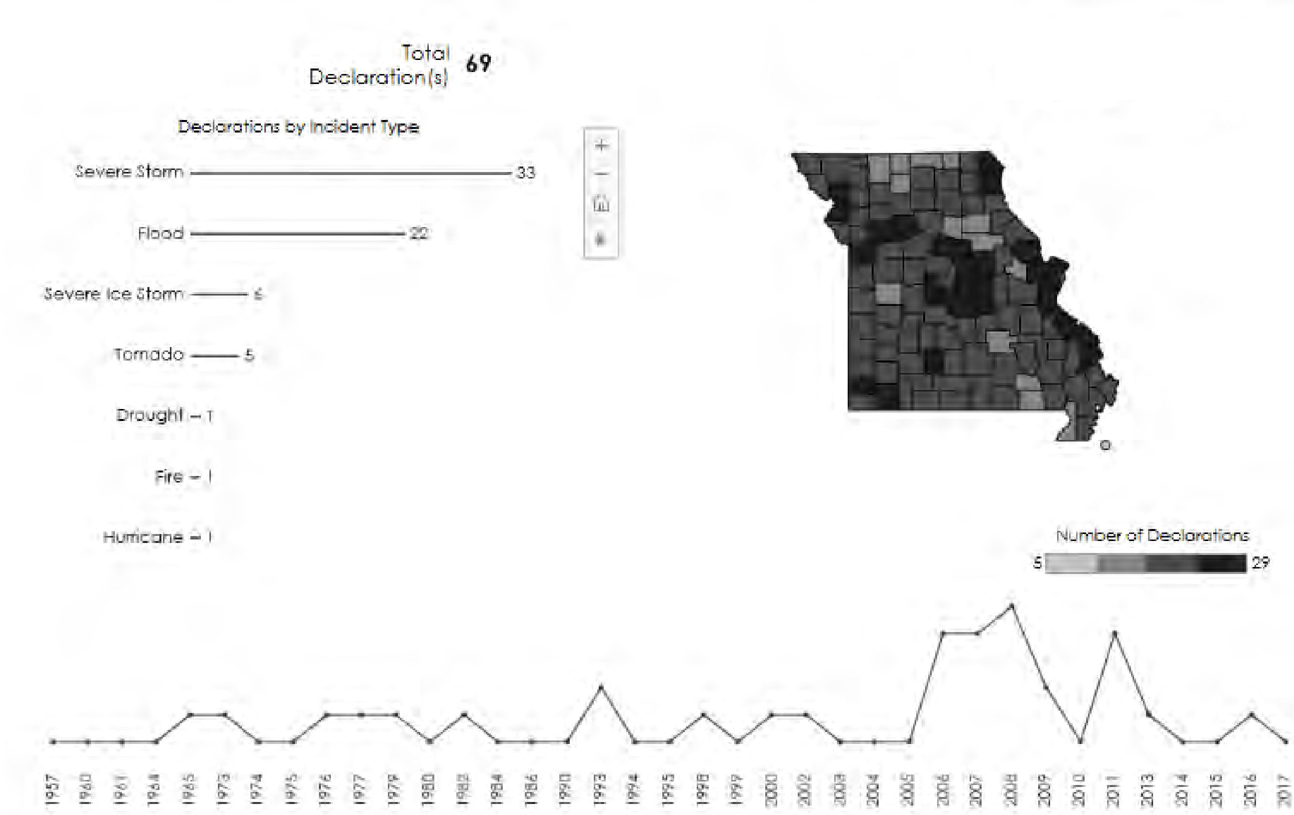
Declaration Date	Disaster No.	Incident Type	No. of Counties Designated	Type of Assistance By County*
June 11, 2007	DR 1708	Severe Storms and Flooding	30	IA Only: 6 PA Only: 12 IA and PA: 12
September 21, 2007	DR 1728	Severe Storms and Flooding	7	PA Only
December 27, 2007	DR 1736	Severe Winter Storms	42	PA Only
February 5, 2008	DR 1742	Severe Storms, Tornadoes, and Flooding	9	PA Only
March 12, 2008	DR 1748	Severe Winter Storms and Flooding	18	PA Only
March 19, 2008	DR 1749	Severe Storms and Flooding	56	IA Only: 5 PA Only: 21 IA and PA: 30
May 23, 2008	DR 1760	Severe Storms and Tornadoes	3	IA Only
June 25, 2008	DR 1773	Severe Storms and Flooding	53	IA Only: 3 PA Only: 26 IA and PA: 24
November 13, 2008	DR 1809	Severe Storms, Flooding, and a Tornado	56	IA Only: 7 PA Only: 26 IA and PA: 12
February 17, 2009	DR 1822	Severe Winter Storm	21	PA Only
June 19, 2009	DR 1847	Severe Storms, Tornadoes, and Flooding	52	PA Only: 24 IA Only: 4 IA and PA: 24
August 17, 2010	DR-1934	Severe Storms, Flooding, and Tornadoes	37	PA Only
March 23, 2011	DR1961	Severe Winter Storm and Snow Storm	62	PA Only
April 22, 2011	DR-1980	Severe Storms, Tornadoes, and Flooding	38	PA Only: 13 IA and PA: 25
August 22, 2011	DR-4012	Severe Storms, Tornadoes, and Flooding	10	PA Only: 4 IA and PA: 6
July 18, 2013	DR-4130	Severe Storms, Straight-Line Winds, Tornadoes, and Flooding	28	PA Only
September 6, 2013	DR-4144	Severe Storms, Straight-Line Winds and Flooding	18	PA Only
October 31, 2014	DR-4200	Severe Storms, Tornadoes, Straight-Line Winds and Flooding	20	PA Only
August 7, 2015	DR-4238	Severe Storms, Tornadoes, Straight-Line Winds and Flooding	76	PA Only
January 21, 2016	DR-4250	Severe Storms, Tornadoes, Straight-Line Winds and Flooding	52	IA Only: 10 PA Only: 19 IA and PA: 23
June 2, 2017	DR-4317	Severe Storms, Tornadoes, Straight-Line Winds and Flooding	56	IA Only: 2 PA Only: 20 IA and PA: 34
Emergency Declarations				
March 12, 1979	EM 3071	Ice Jam, Flooding	2	PA Only: 2
September 10, 2005	EM 3232	Hurricane Katrina Evacuation	114 & St. Louis City*	PA Only: 115
July 21, 2006	EM 3267	Severe Storms	7 & St. Louis City*	PA Only: 8
December 12, 2007	EM 3281	Severe Winter Storms	116	PA Only:
January 30, 2009	EM 3303	Severe Winter Storms	115	PA Only:
January 2, 2016	EM-3374	Severe Storms, Tornadoes, Straight-Line Winds and Flooding	74	
Fire Management Assistance				
March 9, 2000	FMA 2292	Camden Fire Complex	n/a	n/a

Source: Federal Emergency Management Agency

Notes: *IA denotes Individual Assistance; PA denotes Public Assistance

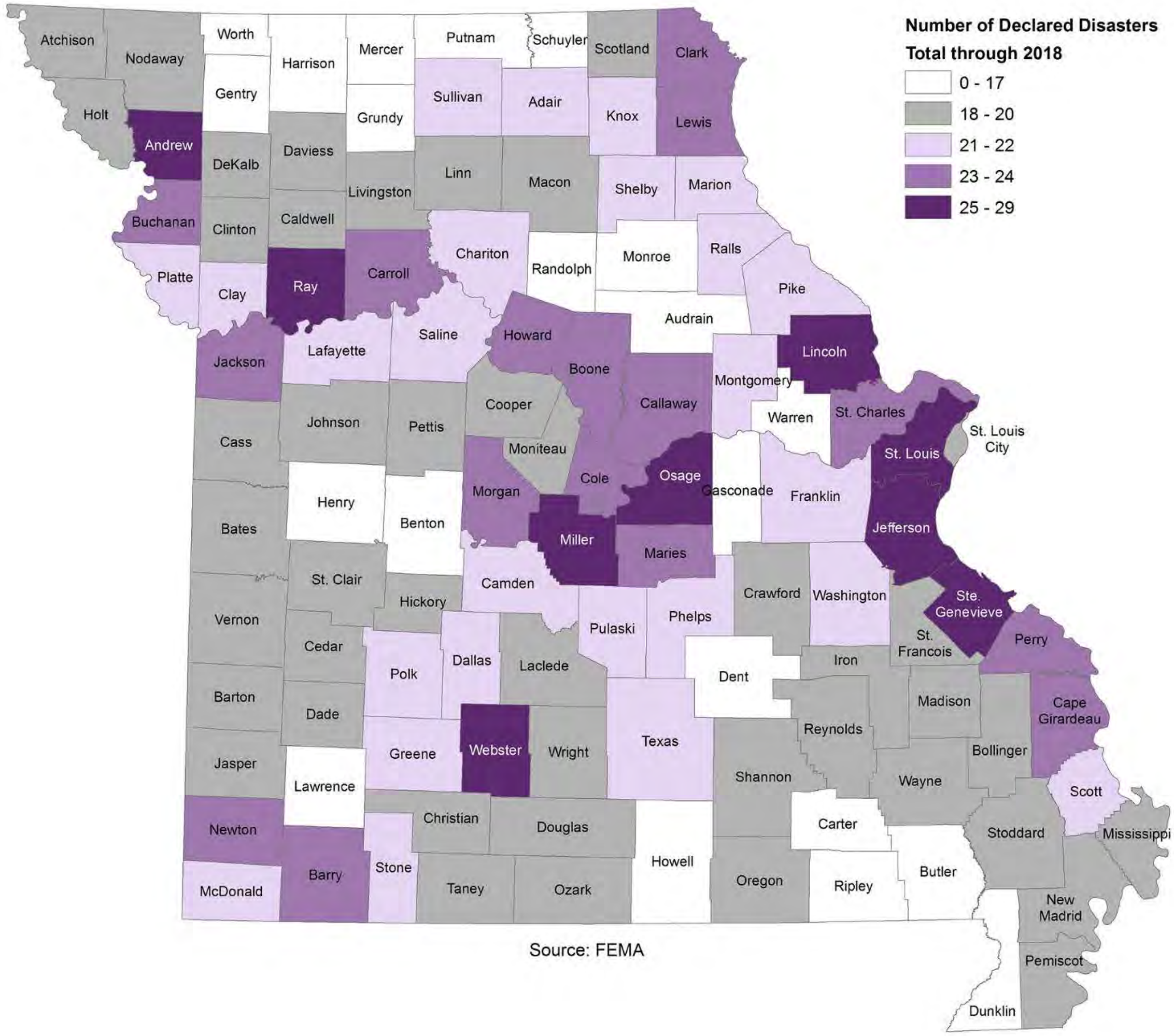
Since 1953, most of Missouri's federally declared disasters have been for severe Storms with a spike in declarations from 2005 to 2008 and again in 2011. (see **Figure 3.41**). Figure 3.42 illustrates the declared disasters in Missouri by County from 1965 to February 2018.

Figure 3.41. Missouri Declarations by Incident Type and Year, 1953 to 2016



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

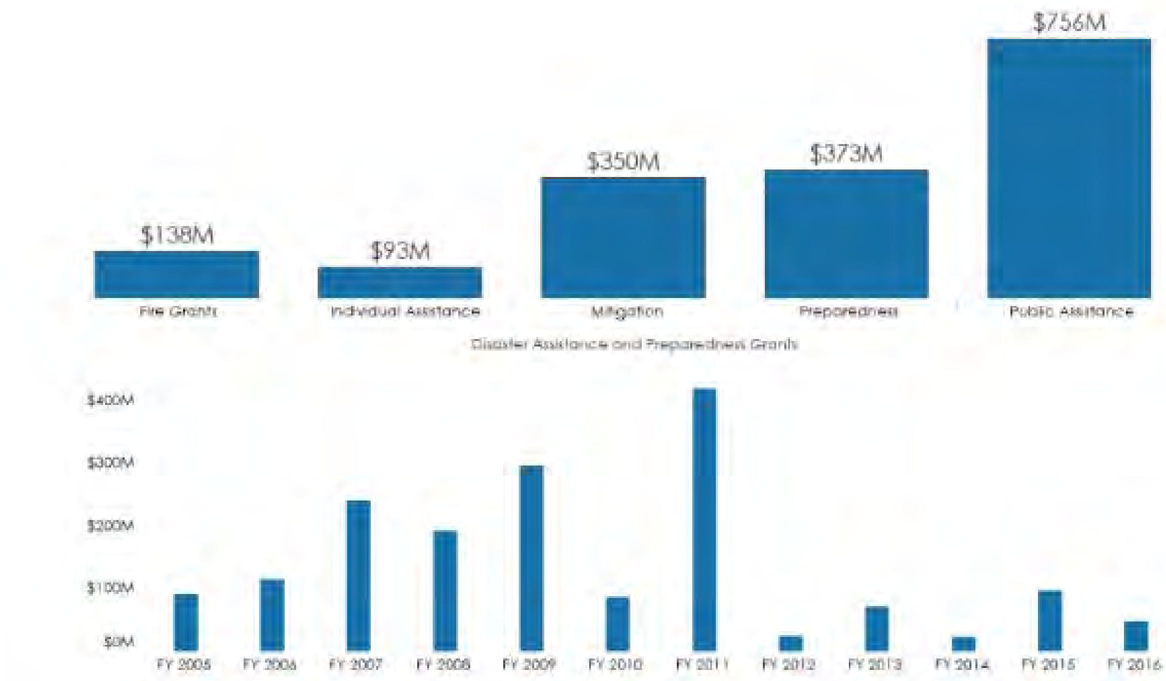
Figure 3.42. Presidentially Declared Disasters by County in Missouri, 1965-February 2018



Source: FEMA; https://www.fema.gov/media-library/assets/documents/106308

Since 2005, FEMA has provided $1.7 Billion in disaster assistance and preparedness grants (see **Figure 3.43**).

Figure 3.43. FEMA Disaster Assistance and Preparedness Grants for Missouri, 2005-2016



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

During this time period Mitigation, Public Assistance and Individual Assistance funding totaled over $1.1 Billion.

Table 3.24. Individual Assistance, Public Assistance and Mitigation Funding in Missouri, 2005-2016

Row Labels	Individual Assistance	Public Assistance	Hazard Mitigation Grant Program	Flood Mitigation Assistance	Repetitive Flood Claims Grant Program	Severe Repetitive Loss Grant Program	Grand Total
FY 2005		$1,751,641		$419,200			$2,170,841
FY 2006	$4,199,351	$31,993,551	$5,385,705	$300,290			$41,878,898
FY 2007	$2,428,002	$123,925,844	$25,448,443				$151,802,289
FY 2008	$20,934,138	$91,094,449	$22,586,693		$675	$172,423	$134,788,379
FY 2009	$12,287,808	$171,451,197	$45,510,391	$94,511	$1,336,716		$230,680,623
FY 2010		$17,450,778	$2,099,104				$19,549,882
FY 2011	$40,262,163	$199,960,705	$137,011,998				$377,234,866
FY 2013		$27,574,621	$21,414,244				$48,988,865
FY 2014				$215,600			$215,600
FY 2015		$55,453,106	$25,262,506	$895,632			$81,611,244
FY 2016	$13,088,319	$35,288,544	$97,924	$164,700			$48,639,487
Total	**$93,199,782**	**$755,944,437**	**$284,817,008**	**$2,089,933**	**$1,337,391**	**$172,423**	**$1,137,560,974**

Source: Federal Emergency Management Agency, https://www.fema.gov/media-library/assets/documents/106308

3.3. Hazard Profiles and State Risk Assessment

Requirement §201.4(c)(2)(i): [The state risk assessment shall include an overview of the] location of all natural hazards that can affect the state, including information on previous occurrences of hazard events, as well as the probability of future hazard events, using maps where appropriate.

Requirements §201.4(c)(2)(ii) and §201.4(c)(2)(iii): The state risk assessment shall include an] overview and analysis of the state's vulnerability to the hazards described in this paragraph (c)(2), based on estimates provided in local risk assessments as well as the State risk assessment. The state shall describe vulnerability in terms of the jurisdictions most threatened by the identified hazards, and most vulnerable to damage and loss associated with hazard events.

[The state risk assessment shall include an] overview and analysis of potential losses to identified vulnerable structures, based on estimates provided in local risk assessments as well as the State risk assessment.

Requirement for Update §201.4(d): Plan must be reviewed and revised to reflect changes in development.

Organization of the Hazard Profiles and State Risk Assessment

This Risk Assessment assesses various risks facing the State and its communities in order to evaluate and rank them. This process is then used to characterize hazards for emergency planning. It estimates the probability of occurrence and the severity of consequences for each hazard and provides a method of comparison. The evaluation involves many interrelated variables (toxicity, demographics, topography, etc.) and should be used by state and local officials in planning and prioritizing allocation of resources.

The Hazard Profiles and State Risk Assessment Section is organized by hazard type as follows:

- Natural Flood-Related Hazards
  - Flooding
  - Levee Failure
  - Dam Failure
- Natural Geologic Hazards
  - Earthquake
  - Land Subsidence / Sinkholes
- Natural Meteorological Hazards
  - Drought
  - Extreme Temperature
  - Severe Thunderstorms
  - Severe Winter Weather
  - Tornadoes
- Natural Other Hazard
  - Wildfire
- Human-Caused / Technological Hazards
  - CBRNE Attack
  - Civil Disorder
  - Cyber Disruption
  - Fires (Urban/Structural)
  - Hazardous Materials
  - Mass Transportation Accidents
  - Nuclear Power Plants
  - Public Health Emergencies / Environmental Issues
  - Special Events
  - Terrorism
  - Utilities (Interruptions and System Failures)

Within each hazard section, the following sub-sections are included for each hazard:

- Description/Location
- Extent
- Previous Occurrences
- Probability of Future Hazard Events
- Changing Future Conditions Considerations
- State Vulnerability Overview
- State Estimates of Potential Losses
- Hazard Impact on Future Growth and Development
- EMAP Consequence Analysis
- Risk Summary

Description/Location

This section consists of a general description of the hazard and the types of impacts it may have as well as the geographic location of the hazard in the planning area. Where available, maps are utilized to indicate the specific locations of the planning area that are vulnerable to the subject hazard.

Extent

This section will provide details on the strength or magnitude of the hazard.

Previous Occurrences

This section includes information on historic incidents and their impacts. Documentation of previous occurrences is sourced from available data repositories for each hazard. The National Oceanic and Atmospheric Administration's (NOAA) National Centers for Environmental Information (NCEI) is the source for the historical hazard events for many of the meteorological hazards profiled in this Plan. While information contained in NCEI's Storm Events Database is generally the best, and sometimes the only, data available, the following disclaimer should be noted:

Some information appearing in Storm Data may be provided by or gathered from sources outside the National Weather Service (NWS), such as the media, law enforcement and/or other government agencies, private companies, individuals, etc. An effort is made to use the best available information, but because of time and resource constraints, information from these sources may be unverified by the NWS. Accordingly, the NWS does not guarantee the accuracy or validity of the information. Other data limitations to note include the following: data collecting for some hazards did not begin until 1993, damages reported are purely estimates based on the reporting entity and damages reported are area-wide and not specific to the location.

Probability of Future Hazard Events

The frequency of past events is one of the elements used to gauge the likelihood of future occurrences. Where possible, the probability or chance of occurrence was calculated based on historical data. Probability was determined by dividing the number of events observed by the number of years and multiplying by 100. This gives the percent chance of the event happening in any given year. An example would be three droughts occurring over a 30-year period, which suggests a 10 percent chance of a drought occurring in any given year.

Changing Future Conditions Considerations

This section will include a summary of climate change impacts that may impact future hazard events including changes in the probability, location, impacts and extent. Although past occurrences are one important element of a factual basis of hazard risk, the challenges posed by climate change, such as more intense storms, frequent heavy precipitation, heat waves, drought and extreme flooding could significantly alter the types and magnitudes of hazards impacting the State in the future.

Vulnerability Overview and State Estimates of Potential Loss

The Vulnerability Overview will provide an overview and analysis of the State's *vulnerability* to the hazards which will serve to describe vulnerability in terms of the jurisdictions most threatened by the identified hazards, and most vulnerable to damage and loss associated with hazard events. The overview vulnerability analysis was completed using a variety of methods, including, HAZUS, other GIS-based risk modeling, statistical analysis of exposure, census data and past historic losses.

Where data is available, the State Estimates of Potential Loss Section will provide the results of analysis of *potential losses* to the identified vulnerable structures utilizing a combination of HAZUS, other GIS-based risk modeling, statistical analysis of past historic losses and hypothetical scenario-based estimates. The methods utilized are described in greater detail for each hazard where data is available. For those hazards for which data is not available, the limitations which preclude analysis of potential losses will be described.

Table 3.25. Summary of Vulnerability Analysis/Loss Estimation Updates

Hazard	2013 Vulnerability/Loss Estimation Summary	2018 Vulnerability Analysis/Loss Estimation Summary
Natural Flood-Related Hazards		
Flooding	Hazus 2.1 Level 2 hazard modeling and loss estimation utilizing HAZUS and DFIRM floodplain boundaries (where available); created depth grids from DFIRM floodplain boundaries using available LIDAR data and 10 Meter USGS NED grids	HAZUS MH 4.0 - 1% Annual Chance flood loss scenario. All counties were updated utilizing the newly released version of HAZUS. For counties which have RiskMAP products available, the depth grids for those communities were utilized as part of the HAZUS analysis. For counties with new floodplains developed since 2010 for which there are no RiskMAP products, depth grids were created utilizing the updated DFIRM data. The MSDIS structure inventory was used to supplement HAZUS as the source for numbers and types of at-risk structures.
Levee Failure	Analysis of MLI and NLD data to determine loss estimates for levees known to provide protection against 0.1 percent flood.	GIS analysis of levee protected areas in National Flood Hazard Layer and National Levee Database against HAZUS/MSDIS exposure data for values, numbers, and types of structures at risk. Estimated population at risk based on number of residential properties in protected areas times average household size.
Dam Failure	GIS analysis for State-regulated dams based on State Hazard Class (1, 2 or 3) definitions, number of vulnerable buildings, average structure value and household size using U.S. Census data and MoDNR high risk dam inundation zones.	GIS analysis of Inundation maps against HAZUS/MSDIS exposure data -State-regulated High Hazard dams -Federal dams to determine types, numbers and values of buildings at risk estimated population at risk based on number of residential properties in inundation areas times average household size.
Natural Geologic Hazards		
Earthquake	Hazus2.1 Level 2 hazard modeling and loss estimation of an average annualized loss scenario and event with a 2% probability of exceedance in 50 years (modeling worst case scenario)	HAZUS MH 4.0 - 2% annual chance in 50 years probabilistic scenario. This analysis was also supplemented with additional funding provided by CUSEC to further analyze additional facilities at risk including: bridges, chemical facilities, fire stations, schools and medical facilities.

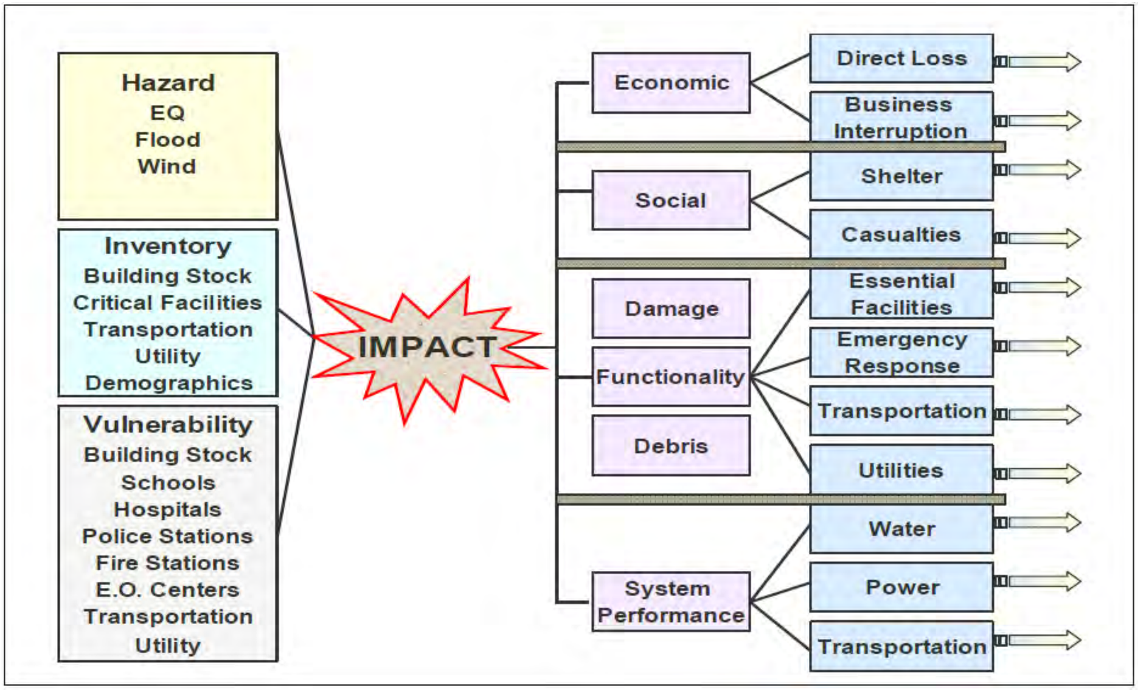
Hazard	2013 Vulnerability/Loss Estimation Summary	2018 Vulnerability Analysis/Loss Estimation Summary
Land Subsidence / Sinkholes	Updated GIS modeling of sinkhole and mine locations in Missouri from the Department of Natural Resources.	The sinkhole hazard layer was used in conjunction with the MSDIS structure file and potentially layers locating specific infrastructure, to determine structures that fall within sinkhole areas as well as structures that are within a buffered distance of sinkholes. The number of mines and caves per county was reported through data presentation as available from the Department of Natural Resources.
Natural Meteorological Hazards		
Drought	Incorporation of vulnerability studies in the Missouri Drought Plan and updated statistical analysis of 10-year USDA crop insurance claims resulting from drought and crop exposure values from USDA.	Updated statistical analysis utilizing the following factors: 1. # of Average Annual Drought Impacts (Drought Impact Reporter) 2. Crop Exposure (2012 USDA Census of Agriculture 3. Annualized Crop Claims (USDA RMA 2007-2016) 4. SOVI (University of South Carolina)
Extreme Temperature	Updated analysis of statistical data from Missouri Department of Health and Senior Services for hyperthermia mortality in Missouri.	Updated statistical analysis utilizing the following factors: 1. Likelihood of Occurrence (NCEI events / years 1993-2016) 2. SOVI (University of South Carolina) 3. Population (2015 ACS) 4. % population age 65 and up (2015 ACS)
Severe Thunderstorms	Analysis was completed of the most recent storm data available from the NCEI on hail, lightning and wind form 1993 – September 2012. US Census housing and population data was updated. *USDA crop insurance data is still being compiled federally*	Updated statistical analysis utilizing the following factors: 1. Likelihood of Occurrence (NCEI events / yrs.) 2. Building Exposure Value (HAZUS) 3. Annualized Property Loss (NCEI / HAZUS)-hail, wind, and lightning 4. SOVI 5. Housing Density (2015 ACS) 6. # Mobiles Homes (2010 Census)
Severe Winter Weather	Analysis was completed on updated NCEI data, as well as FEMA public assistance payments. Housing exposure values were generated through HAZUS. *USDA crop information is still being compiled at the federal level, and not yet available*	Updated statistical analysis utilizing the following factors: 1. Likelihood of Occurrence (NCEI events / yrs.) 2. Building Exposure Value (HAZUS) 3. Annualized Property Loss (NCEI / HAZUS) 4. SOVI (University of South Carolina) 5. Housing Density (2015 ACS)
Tornadoes	Update to statistical analysis of NCEI data incorporating recent events, Hazus 2.1 exposure values and U.S. Census data.	Updated statistical analysis utilizing the following factors: 1. Likelihood of Occurrence (NCEI events / yrs.) 2. Building Exposure Value (HAZUS) 3. Annualized Property Loss (NCEI / HAZUS) 4. SOVI 5. Population Density (2015 ACS) 6. # Mobile Homes
Natural Other Hazard		
Wildfire	Wildfire: Statistical analysis of updated Department of Conservation wildfire records.	GIS layers available from SILVIS Lab at University of Wisconsin - Madison were utilized to quantify the population and buildings at risk within wildfire risk zones
Human-Caused / Technological Hazards		
CBRNE Attack	Hypothetical Scenario-based Estimates	EMCAPS scenarios for 1. Chemical 2. Biological 3. IED-ammonium nitrate 4. Radiological IED

Hazard	2013 Vulnerability/Loss Estimation Summary	2018 Vulnerability Analysis/Loss Estimation Summary
Civil Disorder	Hypothetical Scenario-based Estimates	Data presentation of past civil disorder events to provide a basis for potential future event
Cyber Disruption	Hypothetical Scenario-based Estimates	Data presentation of known cyber disruption events to provide a basis for potential future events
Fires (Urban/Structural)	Structural & Urban: Statistical analysis of updated National Fire Incident Reporting System (NFIRS) records; Hazus 2.1 exposure values; U.S. Census housing and population.	Updated statistical analysis utilizing the following factors: 1. Likelihood of Occurrence-structure fire (NFIRS) 2. Building Exposure Value (HAZUS) 3. Annualized Property Loss (NFIRS) 4. Housing Density (2015 ACS) 5. # of Deaths / Injuries (NFIRS) 6. SOVI
Hazardous Materials	Updated statistical analysis of Hazardous Materials Incidents reported to the Missouri Environmental Emergency Response Tracking System (MEERTS) database for railroad/rail yard incidents, fixed facility incidents, and agricultural facility incidents.	Data Presentation and narrative description including updates of Hazardous Materials Incidents reported to the Missouri Environmental Emergency Response Tracking System (MEERTS).
Mass Transportation Accidents	Updated hypothetical scenario-based estimates	Data Presentation and narrative description
Nuclear Power Plants	Hypothetical Scenario-based Estimates	Data Presentation and narrative description
Public Health Emergencies / Environmental Issues	Updated statistical analysis utilizing planning assumptions from the Department of Health and Senior Services; US Census population; and average hospital charges from the Missouri Hospital Association's Hospital Industry Data Institute	Data Presentation and narrative description focusing on the following public health considerations 1. Pandemic Influenza 2. Smallpox 3. St. Louis Encephalitis 4. Meningitis 5. Lyme Disease 6. West Nile Virus 7. SARS 8. Zika Virus 9. Ebola Virus 10. Tuberculosis 11. Air Pollution 12. Water Pollution
Special Events	Hypothetical Scenario-based Estimates	EMCAPS scenario for IED - ammonium nitrate fuel oil in crowded stadium
Terrorism	Hypothetical Scenario-based Estimates	EMCAPS scenario for Chemical Attack - mustard gas in crowded stadium
Utilities (Interruptions and System Failures)	Updated statistical analysis utilizing FEMA standard values and U.S. Census population to determine loss of use values for water, wastewater, and electric utilities	Descriptions along with the presentation of data on causes of utility interruptions and system failures including the following: • Electrical power • Natural gas • Public water (potable and wastewater treatment) • Communications systems Causes of utility interruption discussed include: • Cascading impacts of other primary hazards (thunderstorm, winter storm, flooding, tornado, cyber disruption, terrorism, etc.) • Space Weather / geomagnetic storms • Lack of Maintenance • Human Error • System Overload / Failure

HAZUS and Other GIS-Based Loss Estimation Methodology

HAZUS-MH is FEMA's standardized loss-estimation software program built upon an integrated geographic information system platform (see **Figure 3.44**). The HAZUS-MH risk assessment methodology is parametric in that distinct hazard, vulnerability, and inventory parameters (earthquake spectral ordinates, building construction, and building classes) were modeled using the HAZUS-MH software to determine the impact on the built environment (damage and losses). This risk assessment applied HAZUS-MH to produce regional profiles and estimate losses for two hazards: earthquakes and riverine flooding.

Figure 3.44. Conceptual Model of HAZUS-MH Methodology



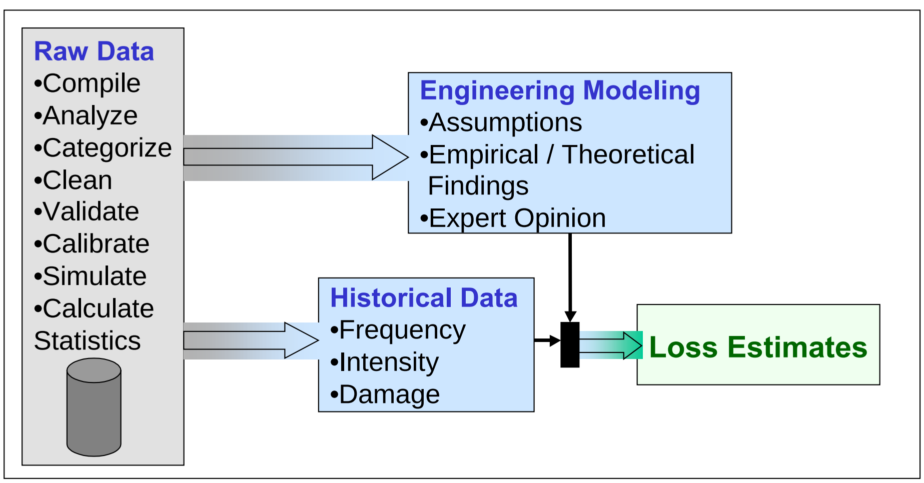
For some hazards, such as dam failure, levee failure, land subsidence and wildfire, geographic locations of areas at risk to the hazard are known. However, these hazards are outside the scope of HAZUS-MH. For these hazards, the known locations of areas at risk are mapped utilizing geographic information systems to show areas of the State that are at greatest risk.

Statistical Risk Assessment Methodology

The statistical risk assessment methodology was applied to analyze hazards of concern that are outside the scope of HAZUS-MH or other GIS-based risk-modeling. This approach is based on different principals than HAZUS-MH and does not rely on readily available automated software. It uses a statistical approach and mathematical modeling of risk to predict a hazard's frequency of occurrence and estimated impacts based on recorded or historic damage information. Historical data for each hazard are used and statistical evaluations are performed using manual calculations. **Figure 3.45** illustrates a conceptual model of the statistical risk assessment methodology. The general steps used in the statistical risk assessment methodology are summarized below:

- Compile data from national and local sources
- Conduct statistical analysis of data to relate historical patterns within data to existing hazard models (minimum, maximum, average and standard deviation)
- Categorize hazard parameters for each hazard to be modeled
- Develop model parameters based on analysis of data, existing hazard models and risk engineering judgment
- Apply hazard model including:
    - Analysis of frequency of hazard occurrence
    - Analysis of intensity and damage parameters of hazard occurrence
    - Development of intensity and frequency tables and curves based on observed data
    - Development of simple damage function to relate hazard intensity to a level of damage (e.g., one flood = $ in estimated damage)
    - Where applicable, development of exceedance and frequency curves relating a level of damage for each hazard to an annual probability of occurrence
    - Development of annualized loss estimates

Figure 3.45. Conceptual Model of the Statistical Risk Assessment Methodology



Hypothetical Scenario-based Estimates

Specific scenario-based loss estimates are provided for several of the manmade and other hazards of concern that are outside the scope of HAZUS-MH, GIS-based risk-modeling and statistical analysis. For these hazards information on historical losses was not available. In addition, since there are so many variables involved with manmade hazards, it is difficult to make generalized assumptions for future events. In these instances, the planning team chose to analyze specific scenarios to establish an acceptable loss estimation methodology.

Economic Impact

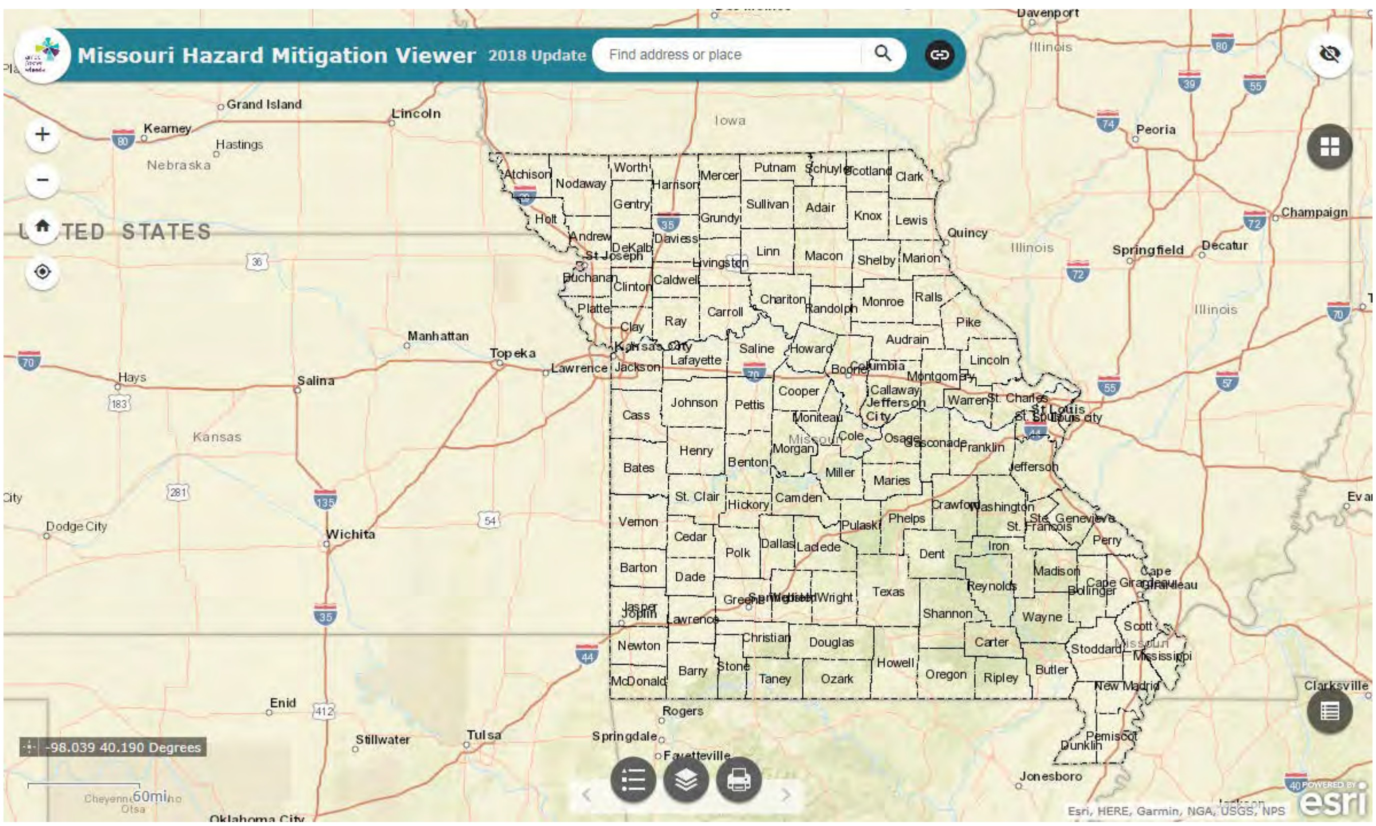
Risk assessment is presented for annualized losses, whenever possible. In general, presenting results in the annualized form is very useful for three reasons: 1) Contribution of potential losses from all (long term) future disasters is accounted for with this approach; 2) Results in this form for different hazards are readily comparable and hence easier to rank; and 3) When evaluating mitigation alternatives, use of annualized losses is an objective approach.

Where possible, the economic loss results are presented according to annualized loss. The estimated annualized loss addresses key components of risk: the probability of a hazard event occurring in the study area, the consequences of the event (largely a function of building construction type and quality), and the intensity of the event. By annualizing estimated losses, this factors in historic patterns of frequent small events with infrequent larger events to provide a balanced presentation of the risk. In HAZUS-MH, losses are annualized for earthquake return periods of 100, 250, 500, 750, 1,000, 1,500, 2000 and 2,500 years.

Missouri Hazard Mitigation Viewer

With the 2018 Plan Update, SEMA is pleased to provide online access to all of the risk assessment data and associated mapping for all 114 counties in the State, including the independent City of St. Louis. Through a web-based Missouri Hazard Mitigation Viewer (see **Figure 3.46**), local planners or other interested parties can obtain all State Plan datasets. This effort removes a barrier for local mitigation planners to performing all the needed local risk assessments by providing the data developed during the 2018 State Plan Update.

Figure 3.46. Missouri Hazard Mitigation Viewer



Functionality will combine all data layers developed or provided by SEMA planners and partners (State and Local) into one central location. The Missouri Hazard Mitigation Viewer includes a Map Viewer with a legend of clearly labeled features, a north arrow, a base map that is either aerial imagery or a street map, risk assessment data symbolized the same as in the 2018 State Plan for easy reference, search and query capabilities, zoom levels to county level data and capable of downloadable PDF format maps.

The Missouri Hazard Mitigation Viewer can be accessed here: http://bit.ly/MoHazardMitigationPlanViewer2018. A Users Guide for the web-based Viewer is provided in Appendix A1.

Hazard Impact on Future Growth and Development

Where applicable, changes in development will be discussed as they pertain to identified hazard-prone areas.

EMAP Consequence Analysis

The Emergency Management Accreditation Program (EMAP) is an independent non-profit organization that applies a standards-based voluntary assessment and peer review accreditation process for government programs responsible for coordinating prevention, mitigation, preparedness, response and recovery activities for natural and human caused disasters. Accreditation is based on compliance with collaboratively developed national standards, the Emergency Management Standard by EMAP. As part of the State of Missouri EMAP accreditation process, an analysis of the potential for detrimental impacts of hazards was conducted and integrated into the Plan. This information provides useful data to better assess risk and provide input for the development of mitigation strategies. This analysis was completed based on the 2016 Emergency Management Standard Published in April 2016. This document is available at this link: http://www.emap.org/index.php/root/about-emap/96-emap-em-4-2016. The results of the EMAP impact analysis are presented in each hazard profile's discussion of impact.

Risk Summary

This Risk Assessment assesses various risks facing the State and its communities in order to evaluate and rank them. This process is then used to characterize hazards for emergency planning. It estimates the probability of occurrence and the severity of consequences for each hazard and provides a method of comparison. The evaluation involves many interrelated variables (toxicity, demographics, topography, etc.) and should be used by state and local officials in planning and prioritizing allocation of resources.

The following definitions explain the probability and severity ratings for each hazard:

Probability—The likelihood that the hazard will occur. Based on available data, probability was determined for each hazard by either a statistical analysis of historical occurrences or a statistical model of probable occurrence. In addition, input from the SRMT was considered in the probability determination process.

Severity—The deaths, injuries, or damage (property or environmental) that could result from the hazard.

- **Low**—Few or minor damage or injuries are likely.
- **Moderate**—Injuries to personnel and damage to property and the environment is expected.
- **High**—Deaths and major injuries and damage will likely occur.

The hazards covered in the risk assessment, along with the probability and severity ratings that were determined from the updated risk assessment are provided in **0.**

Table 3.26. Probability/Severity Rating Summary

Natural Hazards	Probability	Severity
Natural Flood-Related Hazards		
Flooding (Riverine & Flash)	100%	High
Levee Failure	100%	Moderate
Dam Failure	45%	Moderate
Natural Geologic Hazards		
Earthquake	72%	High
Land Subsidence/Sinkholes	100%	Low
Natural Meteorological Hazards		
Drought	6-11%	High
Extreme Temperature	100%	Moderate
Severe Thunderstorms	100%	Moderate
Severe Winter Weather	100%	Moderate
Tornadoes	100%	High
Natural Other Hazard		
Wildfire	100%	Low to Moderate
Human-caused/Technological Hazards		
CBRNE Attack	<1%	High
Civil Disorder	<1%	Low to High
Cyber Disruption	<1%	Low to High
Urban/Structure Fire	100%	Moderate
Hazardous Materials	100%	Moderate
Mass Transportation Accidents	100%	Moderate
Nuclear Power Plants	<1%	Low to High
Public Health Emergencies/Environmental Issues	<1%	Low to High
Special Events	<1%	Low to High
Terrorism	<1%	Low to High
Utilities (Interruptions and System Failures)	100%	Low

Natural Flood-Related Hazards

3.3.1. Flooding

Probability	Severity
100% 42 Disaster Declarations in 41 years	High

Description/Location

A flood is the 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. Flash flooding is characterized by rapid accumulation or runoff of surface waters from any source. This type of flooding impacts smaller rivers, creeks, and streams and can occur as a result of dams being breached or overtopped. Because flash floods can develop in a matter of hours, most flood-related deaths result from this type of event. Between 2012 and 2016, Missouri recorded more than fifty deaths attributed to flooding.

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, based on historical records. Floodplains are a vital part of a larger entity called a basin, which is defined as all the land drained by a river and its branches.

Figure 3.47. December 2016 Assessing the Flooding Missouri

Source: Photo courtesy of USGS

The land that forms the State of Missouri is contained within the Mississippi, Missouri, and Arkansas-White-Red River Basins (see **Figure 3.48**). The Mississippi River Basin drains the eastern part of the State, the Missouri River Basin drains most of the northern and central part of the State, the White River Basin drains the south-central part of the State, and the Arkansas River Basin drains the southwest part of the State. The Missouri River Basin drains over half the State. When the Missouri River joins the Mississippi River at St.

Louis, it becomes part of the Mississippi River Basin, which is the largest basin in terms of volume of water drained on the North American continent.

Figure 3.48. River Basins within Missouri

Source: MoDNR

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 disperse 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 into basements, which damages mechanical systems and can create serious public health and safety concerns.

Extent

Flood severity categories, as defined by the National Weather Service, describe the severity of flood impacts in the corresponding river reach. The first three of these flood categories—minor, moderate, and major flooding—are bounded by an upper and lower flood stage, with flood stage defined as an established gage height for a given location at which a rise in water surface level begins to create a hazard to lives, property, or commerce.

The severity of flooding at a given stage is not necessarily the same at all locations along a river reach due to varying channel and bank characteristics or the presence of levees. Therefore, the upper and lower stages for a given flood category are usually associated with water levels corresponding to the most significant flood impacts somewhere in the reach.

The flood severity categories are defined as:

- Minor Flooding - minimal or no property damage, but possibly some public threat (e.g., inundation of roads)
- Moderate Flooding - some inundation of structures and roads near stream, evacuations of people and/or transfer of property to higher elevations
- Major Flooding - extensive inundation of structures and roads, significant evacuations of people and/or transfer of property to higher elevations
- Record Flooding - flooding which equals or exceeds the highest stage or discharge observed at a given site during the period of record. The highest stage on record is not necessarily above the other three flood categories – it may be within any of them or even less than the lowest, particularly if the period of record is short (e.g., a few years)

The NWS has also defined three response levels for alerting the public as to the danger of floods, as described in **Table 3.27**.

Table 3.27. National Weather Service Flood Response Levels/Activities

Alert Level	Definition
Flood Watch	Atmospheric and hydrologic conditions are favorable for long duration areal or river flooding
Flood Warning	Long duration areal or river flooding is occurring or is imminent, which may result from excessive rainfall, rapid snow melt, ice jams on rivers or other similar causes
Flood Advisory	Thunderstorms have produced heavy rainfall that may result in ponding of water on roadways and in low-lying areas, as well as rises in small stream levels, none of which pose an immediate threat to life and property

Source: National Weather Service

Previous Occurrences

Missouri has a long history of extensive flooding over the past century. Scores of river communities, including those along the Mississippi and Missouri rivers, have become quite skilled and experienced in flood-fighting efforts due to frequent instances of severe flooding in recent years. Flooding along Missouri's major rivers generally results in slow moving disasters. River crest levels are forecast several days in advance, allowing communities downstream sufficient time to take protective actions, such as sandbagging and evacuations. Nevertheless, these flood disasters exact a heavy toll in terms of human suffering and extensive losses to public and private property. By contrast, flash flood events in recent years have caused a higher number of deaths and major property damage in many areas of Missouri.

Floods are the most common natural disaster in the United States. The State of Missouri has had more than 40 flood-related disaster declarations since 1976, of which, all the counties within the state have been affected to some degree (see **Figure 3.49**). Certain parts of the State have been minimally affected by flooding, i.e. Dent, Grundy, Linn, Madison, Monroe, Oregon, Randolph and Sullivan Counties with one 1 declaration each. Other parts have been severely affected, i.e. Platte County (9 declarations) and Andrew, Buchanan, Clay, Franklin, Jackson, St. Charles, and St. Louis counties with 8 declarations each. The figure below helps to identify the areas of the State where counties have had numerous declarations and, as such, demonstrate a high risk of repeated flooding. Additional details for Missouri flood-related disaster declarations are provided in **Table 3.28.**

Figure 3.49. Number of Flood-Related Presidential Declarations by County

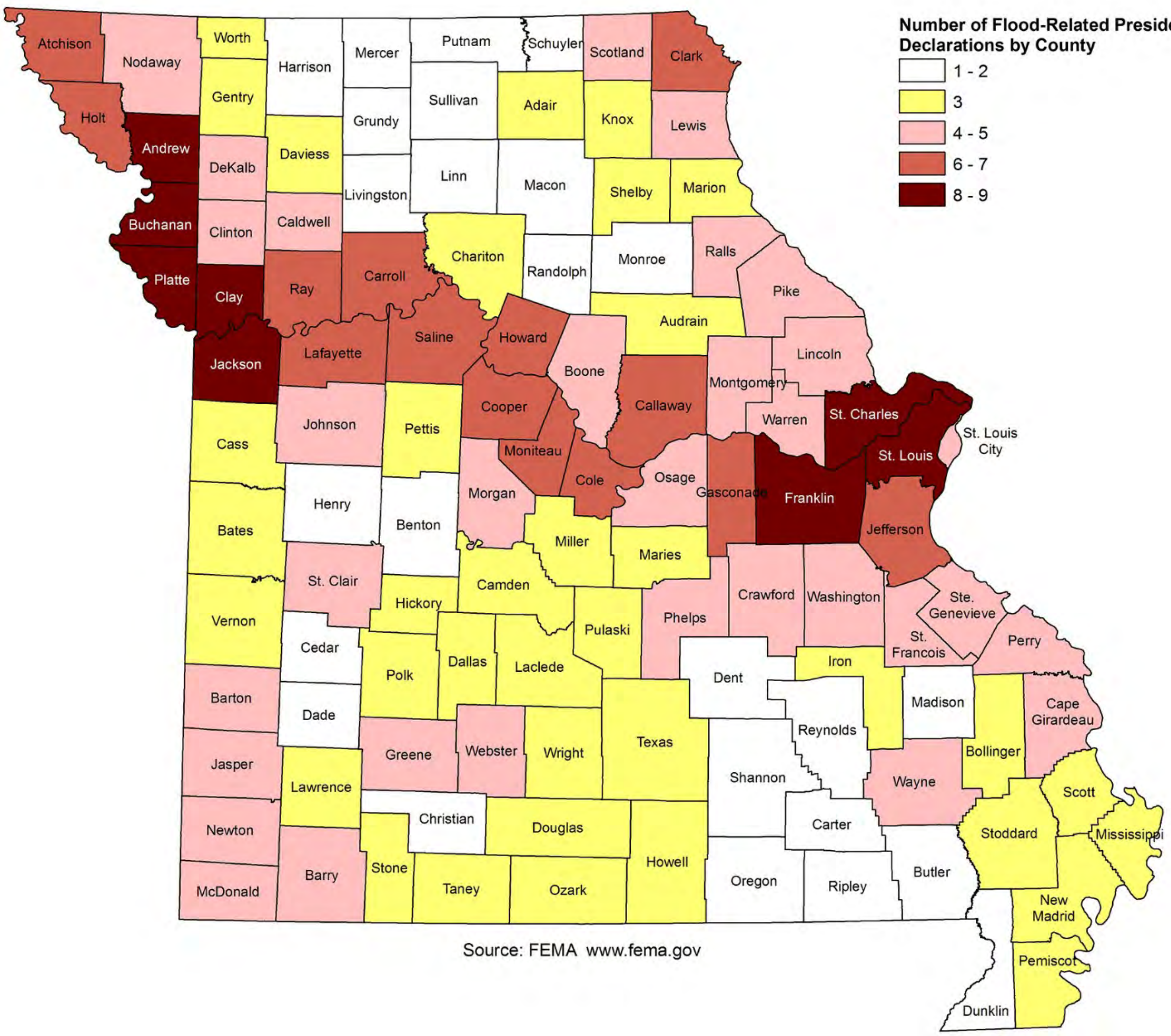


Table 3.28. Presidential Declarations for Missouri Floods Since 1975

Declaration Date	Disaster No.	Incident Type	Counties Declared	Type of Assistance*
July 21, 1976	DR 516	Severe Storms, Flooding	Barton, Jasper, Newton, Wayne	IA & PA
May 7, 1977	DR 535	Tornadoes, Flooding	Carroll, Cass, Clay, Jackson, Lafayette, Pettis, Ray	IA & PA
September 14, 1977	DR 538	Severe Storms, Flooding	Buchanan, Clay, Jackson, Lafayette, Platte, Ray	IA & PA
March 12, 1979	EM 3071	Ice Jam, Flooding	Andrew, Clark	None
April 21, 1979	DR 579	Tornadoes, Torrential Rain, Flooding	Cape Girardeau, Dunklin, Jefferson, Maries, Mississippi, New Madrid, Pemiscot, Pike, Pulaski, Scott, St. Charles, St. Louis, Ste. Genevieve, Stoddard, Texas, St. Louis City	IA
			Cape Girardeau, Dunklin, Jefferson, Maries, Mississippi, New Madrid, Pemiscot, Pike, Scott, St. Charles, St. Louis, Ste. Genevieve, Stoddard, Texas, St. Louis City	PA

Declaration Date	Disaster No.	Incident Type	Counties Declared	Type of Assistance*
August 26, 1982	DR 667	Severe Storms, Flooding	Cass, Clay, Jackson	IA
			Cass, Jackson	PA
December 10, 1982	DR 672	Severe Storms, Flooding	Bollinger, Butler, Cape Girardeau, Carter, Franklin, Iron, Jefferson, Lincoln, Perry, Phelps, Ripley, St. Charles, Wayne	IA
			Bollinger, Butler, Carter, Iron, Phelps, Wayne	PA
June 21, 1984	DR 713	Severe Storms, Flooding	Buchanan, Holt, Platte	IA
			Andrew, Atchison, Buchanan, Caldwell, Clinton, DeKalb, Gentry, Holt, Knox, Worth	PA
October 14, 1986	DR 779	Severe Storms, Flooding	Boone, Callaway, Cole, Cooper, Franklin, Gasconade, Howard, Moniteau, Montgomery, Osage, Saline, St. Charles, St. Louis, Vernon, Warren	IA
			Bates, Benton, Callaway, Cass, Clark, Franklin, Gasconade, Henry, Johnson, Lewis, McDonald, Miller, Montgomery, Morgan, Pettis, Ralls, Saline, Scotland, Shelby, St. Charles, St. Clair, Vernon, Warren	PA
May 24, 1990	DR 867	Flooding, Severe Storm	Bates, Boone, Callaway, Clay, Greene, Jackson, Johnson, Moniteau, Platte, Webster	IA
			Bates, Boone, Callaway, Clay, Jackson, Johnson, Moniteau, Platte	PA
May 11, 1993	DR 989	Severe Storm, Flooding	Jefferson, Lincoln, Marion, Pike, Ralls, St. Charles, St. Louis, Ste. Genevieve	IA
July 9, 1993	DR 995	Flooding, Severe Storm	Adair, Andrew, Atchison, Audrain, Barry, Barton, Bates, Benton, Boone, Buchanan, Caldwell, Callaway, Camden, Cape Girardeau, Carroll, Cass, Chariton, Christian, Clark, Clay, Clinton, Cole, Cooper, Crawford, Dade, Dallas, Daviess, DeKalb, Douglas, Franklin, Gasconade, Gentry, Greene, Grundy, Harrison, Henry, Hickory, Holt, Howard, Howell, Jackson, Jasper, Jefferson, Johnson, Knox, Laclede, Lafayette, Lawrence, Lewis, Lincoln, Linn, Livingston, Macon, Maries, Marion, McDonald, Mercer, Miller, Mississippi, Moniteau, Monroe, Montgomery, Morgan, New Madrid, Newton, Nodaway, Osage, Ozark, Pemiscot, Perry, Pettis, Phelps, Pike, Platte, Polk, Pulaski, Putnam, Ralls, Randolph, Ray, Saline, Schuyler, Scotland, Scott, Shelby, St. Charles, St. Clair, St. Francois, St. Louis, Ste. Genevieve, Stoddard, Stone, Sullivan, Taney, Texas, Vernon, Warren, Washington, Wayne, Webster, Worth, Wright, St. Louis City	IA
			Adair, Andrew, Atchison, Barry, Barton, Bates, Benton, Boone, Buchanan, Caldwell, Callaway, Camden, Cape Girardeau, Carroll, Cass, Chariton, Christian, Clark, Clay, Clinton, Cole, Cooper, Crawford, Dade, Dallas, Daviess, DeKalb, Douglas, Franklin, Gasconade, Gentry, Greene, Grundy, Harrison, Henry, Holt, Howard, Jackson, Jefferson, Johnson, Knox, Laclede, Lafayette, Lawrence, Lewis, Lincoln, Linn, Livingston, Macon, Maries, Marion, McDonald, Mercer, Miller, Mississippi, Moniteau, Monroe, Montgomery, Morgan, New Madrid, Newton, Nodaway, Osage, Ozark, Pemiscot, Perry, Pettis, Pike, Platte, Polk, Pulaski, Putnam, Ralls, Ray, Saline, Schuyler, Scotland, Shelby, St. Charles, St. Clair, St. Louis, Ste. Genevieve, Stone, Sullivan, Texas, Warren, Worth, Wright, St. Louis City	PA
December 1, 1993	DR 1006	Flooding, Severe Storm, Tornadoes	Bollinger, Butler, Cape Girardeau, Carter, Crawford, Dent, Franklin, Howell, Iron, Jefferson, Madison, Oregon, Perry, Pulaski, Reynolds, Ripley, Shannon, St. Francois, St. Louis, Ste. Genevieve, Stoddard, Texas, Washington, Wayne	IA
			Carter, Dent, Howell, Iron, Madison, Oregon, Perry, Reynolds, Shannon, St. Francois, Ste. Genevieve, Texas, Washington, Wayne	PA
April 21, 1994	DR 1023	Severe Storm, Flooding, Tornadoes	Barry, Callaway, Clay, Cole, Franklin, Jefferson, Lincoln, Morgan, Pemiscot, Phelps, Pulaski, Reynolds, Shannon, St. Charles, St. Louis, Vernon, Washington, St. Louis City	IA

Declaration Date	Disaster No.	Incident Type	Counties Declared	Type of Assistance*
June 2, 1995	DR 1054	Severe Storm, Tornadoes, Hail, Flooding	Adair, Andrew, Atchison, Barry, Barton, Bates, Benton, Boone, Callaway, Camden, Cape Girardeau, Carroll, Cass, Chariton, Clark, Cole, Cooper, Dallas, Daviess, DeKalb, Franklin, Gasconade, Gentry, Henry, Howard, Jackson, Jasper, Jefferson, Johnson, Lafayette, Lewis, Lincoln, Linn, Macon, Maries, McDonald, Mercer, Miller, Mississippi, Moniteau, Montgomery, Morgan, New Madrid, Newton, Nodaway, Osage, Pemiscot, Perry, Ray, Saline, Scotland, Scott, St. Charles, St. Clair, St. Francois, St. Louis, Ste. Genevieve, Stone, Sullivan, Vernon, Warren, St. Louis City	IA
			Andrew, Atchison, Barry, Bates, Benton, Boone, Callaway, Cape Girardeau, Carroll, Chariton, Clark, Cole, Cooper, Daviess, DeKalb, Franklin, Gasconade, Gentry, Henry, Howard, Jefferson, Johnson, Lafayette, Linn, Macon, McDonald, Mercer, Miller, Mississippi, Moniteau, Montgomery, Nodaway, Perry, Ray, Saline, St. Charles, St. Clair, St. Louis, Ste. Genevieve, Stone, Sullivan, Vernon, Warren	PA
October 14, 1998	DR 1253	Severe Storm and Flooding	Carroll, Clay, Jackson, Platte, Ray	IA
			Andrew, Barton, Caldwell, Carroll, Cedar, Chariton, Clay, Dade, DeKalb, Jackson, Linn, Livingston, Macon, Miller, Moniteau, Morgan, Platte, Polk, Ray	PA
Oct. 19, 1998	DR 1256	Severe Storm and Flooding	Jackson, St. Louis, St. Louis City	IA
April 20, 1999	DR 1270	Severe Storms and Flooding	Andrew, Cole, Iron, Macon, Madison, Osage	IA
May 12, 2000	DR 1328	Severe Thunderstorms and Flash Flooding	Crawford, Franklin, Jefferson, Gasconade, St. Charles, St. Francois, St. Louis, Ste. Genevieve, Warren, Washington	IA
			Franklin, Gasconade, Jefferson	PA
May 6, 2003	DR 1463	Severe Storms, Tornadoes, and Flooding	Barry, Barton, Bates, Benton, Bollinger, Buchanan, Camden, Cape, Cass, Cedar, Christian, Clay, Clinton, Cooper, Crawford, Dade, Dallas, Dent, Douglas, Franklin, Knox, Gasconade, Girardeau, Greene, Henry, Hickory, Iron, Jackson, Jasper, Jefferson, Johnson, Laclede, Lafayette, Lawrence, McDonald, Miller, Monroe, Morgan, Newton, Osage, Perry Pettis, Phelps, Platte, Polk, Pulaski, Ray, St. Francois, St. Louis, Ste. Genevieve, Saline, Scott, St. Clair, Stoddard, Stone, Taney, Vernon, Washington, Webster	IA
			Bollinger, Crawford, Franklin, Gasconade, Knox, Maries, Miller, Oregon, Osage, Pulaski, Washington	PA
June 11, 2004	DR 1524	Severe Storms, Tornadoes, and Flooding	Adair, Andrew, Bates, Benton, Caldwell, Carroll, Cass, Cedar, Chariton, Clay, Clinton, Daviess, DeKalb, Gentry, Grundy, Harrison, Henry, Hickory, Jackson, Johnson, Knox, Linn, Livingston, Macon, Mercer, Monroe, Nodaway, Platte, Polk, Randolph, Ray, Shelby, St. Clair, Sullivan, Vernon, Worth	IA
March 16, 2006	DR 1631	Severe Storms, Tornadoes, and Flooding	Bates, Benton, Boone, Carroll, Cass, Cedar, Christian, Cooper, Crawford, Greene, Henry, Hickory, Howard, Iron, Jefferson, Johnson, Lawrence, Lincoln, Mississippi, Monroe, Montgomery, Morgan, New Madrid, Newton, Perry, Pettis, Phelps, Putnam, Randolph, St. Clair, Ste. Genevieve, Scott, Saline, Taney, Vernon, Webster, Wright	IA
			Bates, Bollinger, Benton, Boone, Carroll, Cedar, Christian, Daviess, Greene, Henry, Hickory, Howard, Iron, Lawrence, Monroe, Montgomery, Morgan, Perry, Pettis, Putnam, Randolph, Ray, Saline, St. Clair, Vernon, Washington, Webster, Wright	PA
April 5, 2006	DR 1635	Severe Storms, Tornadoes, and Flooding	Andrew, Butler, Dunklin, Pemiscot, St. Francois, Stoddard	IA
			Andrew, Jefferson, Pemiscot, Pettis, St. Francois	PA

Declaration Date	Disaster No.	Incident Type	Counties Declared	Type of Assistance*
January 15, 2007	DR 1676	Severe Winter Storms and Flooding	Barry, Barton, Benton, Boone, Callaway, Camden, Cedar, Christian, Cole, Crawford, Dade, Dallas, Dent, Franklin, Gasconade, Greene, Hickory, Jasper, Laclede, Lawrence, Lincoln, Maries, McDonald, Miller, Montgomery, Newton, Osage, Phelps, Polk, Pulaski, St. Charles, St. Clair, St. Louis, Stone, Texas, Warren, Webster, Wright Counties, St. Louis City	PA
June 11, 2007	DR-1708	Severe Storms and Flooding	Andrew, Atchison, Buchanan, Carroll, Chariton, Clay, Clinton, Daviess, DeKalb, Gentry, Holt, Jackson, Lafayette, Livingston, Morgan, Nodaway, Osage, and Platte Counties	IA
			Andrew, Atchison, Bates, Caldwell, Carroll, Cass, Chariton, Clinton, Daviess, Gentry, Grundy, Harrison, Holt, Howard, Lafayette, Linn, Livingston, Mercer, Nodaway, Platte, Ray, Saline, Sullivan and Worth	PA
September 21, 2007	DR-1728	Severe Storms and Flooding	Dade, Dallas, Greene, Laclede, Lawrence, Polk, and Webster Counties	PA
February 5, 2008	DR-1742	Severe Storms, Tornadoes, and Flooding	Barry, Dallas, Laclede, Maries, McDonald, Newton, Phelps, Stone, and Webster Counties	PA
March 12, 2008	DR-1748	Severe Winter Storms and Flooding	Bollinger, Butler, Cape Girardeau, Carter, Christian, Douglas, Greene, Madison, Mississippi, Ozark, Reynolds, Scott, Shannon, Stoddard, Texas, Wayne, Webster, and Wright	PA
March 19, 2009	DR-1749	Severe Storms and Flooding	Bollinger, Carter, Christian, Franklin, Greene, Iron, Jasper, Jefferson, Maries, Newton, Oregon, Phelps, Pulaski, Reynolds, St. Francois, Stone, Texas, Washington, and Wayne Counties	IA
			Audrain, Barry, Barton, Boone, Bollinger, Butler, Callaway, Camden, Cape Girardeau, Carter, Cedar, Christian, Cole, Cooper, Crawford, Dade, Dallas, Dent, Douglas, Dunklin, Franklin, Gasconade, Greene, Hickory, Howard, Howell, Iron, Jasper, Jefferson, Laclede, Lawrence, Lincoln, Madison, Maries, McDonald, Miller, Mississippi, Montgomery, Moniteau, Morgan, New Madrid, Newton, Oregon, Osage, Ozark, Pemiscot, Perry, Phelps, Pike, Polk, Pulaski, Reynolds, Ripley, St. Charles, St. Clair, St. Francois, St. Louis, Ste. Genevieve, Shannon, Scott, Stoddard, Stone, Taney, Texas, Vernon, Warren, Washington, Wayne, Webster, and Wright	PA
June 25, 2008	DR-1773	Severe Storms and Flooding	Adair, Andrew, Callaway, Cass, Chariton, Clark, Gentry, Greene, Harrison, Holt, Johnson, Lewis, Lincoln, Linn, Livingston, Macon, Marion, Monroe, Nodaway, Pike, Putnam, Ralls, St. Charles, Stone, Taney, Vernon, and Webster	IA
			Adair, Andrew, Atchison, Audrain, Bates, Callaway, Cape Girardeau, Carroll, Chariton, Clark, Christian, Daviess, Gentry, Grundy, Harrison, Howard, Holt, Knox, Lewis, Lincoln, Linn, Macon, Marion, Miller, Mississippi, Monroe, Morgan, Nodaway, Perry, Pettis, Pike, Putnam, Ralls, Ray, Shelby, St. Charles, Stone, Sullivan, Taney, and Vernon Counties for Public Assistance. Also, the counties of Buchanan, Jefferson, Pemiscot, Platte, New Madrid, Scott, St. Louis, and the independent City of St. Louis for Category B Public Assistance	PA
November 13, 2008	DR-1809	Severe Storms, Flooding, and a Tornado	Boone, Callaway, Chariton, Howell, Jefferson, Lewis, Lincoln, Linn, Marion, Montgomery, Osage, Schuyler, St. Charles, St. Louis, Stone, Taney, Texas, and Webster Counties and the Independent City of St. Louis	IA
			Adair, Audrain, Barry, Bollinger, Butler, Callaway, Cape Girardeau, Carter, Chariton, Christian, Clark, Crawford, Dent, Douglas, Dunklin, Howard, Howell, Knox, Lewis, Lincoln, Linn, Madison, Maries, Marion, Miller, Mississippi, New Madrid, Oregon, Ozark, Perry, Ralls, Randolph, Ray, Reynolds, Ripley, Schuyler, Scotland, Scott, Shannon, Shelby, St. Genevieve, Stoddard, Stone, Sullivan, Taney, Texas, Wayne, Webster, and Wright	PA

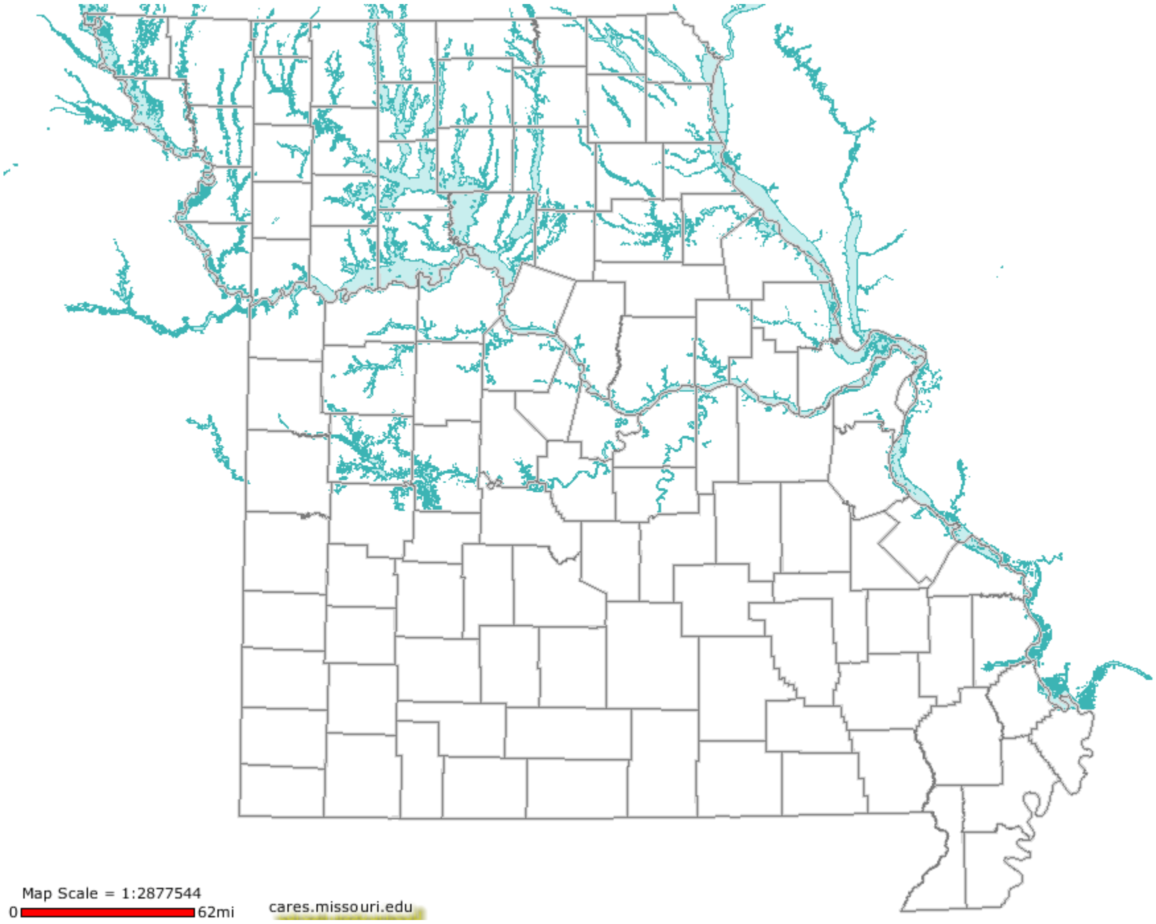
Declaration Date	Disaster No.	Incident Type	Counties Declared	Type of Assistance*
June 19, 2009	DR-1847	Severe Storms, Tornadoes, and Flooding	Adair, Barry, Barton, Bollinger, Cape Girardeau, Christian, Dade, Dallas, Dent, Douglas, Greene, Howell, Iron, Jasper, Jefferson, Laclede, Lawrence, Madison, Newton, Ozark, Polk, Reynolds, Ripley, St. Francois, Shannon, Texas, Washington, Webster	IA
			Adair, Barton, Bollinger, Camden, Cape Girardeau, Cedar, Crawford, Dade, Dallas, Dent, Douglas, Greene, Hickory, Howell, Iron, Jasper, Knox, Laclede, Lewis, Madison, Maries, Marion, Miller, Newton, Oregon, Ozark, Perry, Phelps, Polk, Pulaski, Ray, Reynolds, Ripley, St. Francois, Ste. Genevieve, Saline, Shannon, Shelby, Stone, Sullivan, Texas, Vernon, Washington, Wayne, Webster, Wright	PA
August 17, 2010	DR-1934	Severe Storms, Flooding, and Tornadoes	Adair, Andrew, Atchison, Buchanan, Caldwell, Carroll, Cass, Chariton, Clark, Clinton, Daviess, DeKalb, Gentry, Grundy, Harrison, Holt, Howard, Jackson, Knox, Lafayette, Lewis, Linn, Livingston, Marion, Mercer, Monroe, Nodaway, Perry, Pike, Putnam, Ralls, Ray, Schuyler, Scotland, Shelby, Sullivan, and Worth.	PA
May 9, 2011	DR-1980	Severe Storms, Tornadoes, and Flooding	Bollinger, Butler, Cape Girardeau, Carter, Dunklin, Howell, Jasper, Lawrence, McDonald, Mississippi, New Madrid, Newton, Pemiscot, Pettis, Phelps, Pulaski, Reynolds, Ripley, Saint Francois, Saint Louis, Scott, Stoddard, Stone, Taney, and Wayne	IA
			Barry, Bollinger, Butler, Cape Girardeau, Carter, Christian, Douglas, Dunklin, Howell, Iron, Jasper, Madison, McDonald, Miller, Mississippi, New Madrid, Newton, Oregon, Ozark, Pemiscot, Perry, Pettis, Polk, Reynolds, Ripley, Saint Francois, Saint Louis, Sainte Genevieve, Scott, Shannon, Stoddard, Stone, Taney, Texas, Washington, Wayne, Webster, and Wright	PA
August 12, 2011	DR-4012	Flooding	Andrew, Atchison, Buchanan, Holt, Lafayette and Platte	IA
			Andrew, Atchison, Buchanan, Carroll, Cooper, Holt, Howard, Lafayette, Platte, Ray and Saline.	PA
July 18, 2013	DR-4130	Severe Storm	Barton, Callaway, Cape Girardeau, Chariton, Clark, Howard, Iron, Knox, Lewis, Lincoln, Maries, Marion, Miller, Montgomery, Osage, Perry, Pike, Putnam, Ralls, Scotland, Shelby, St. Charles, St. Louis, Ste. Genevieve, Stoddard, Sullivan, Texas, Webster	PA
August 6, 2013	DR-4144	Severe Storm	Barry, Camden, Cedar, Dade, Dallas, Laclede, Maries, McDonald, Miller, Osage, Ozark, Phelps, Pulaski, Shannon, Taney, Texas, Webster, Wright	PA
October 31, 2014	DR-4200	Severe Storm	Adair, Andrew, Atchison, Daviess, Gentry, Grundy, Harrison, Holt, Knox, Lewis, Linn, Livingston, Macon, Mercer, Nodaway, Putnam, Ralls, Shelby, Sullivan, Worth	PA
August 7, 2015	DR-4238	Severe Storm	Adair, Andrew, Atchison, Audrain, Barry, Bates, Benton, Buchanan, Caldwell, Camden, Chariton, Christian, Clark, Clay, Clinton, Cole, Crawford, Dade, Dallas, Daviess, DeKalb, Douglas, Gentry, Harrison, Henry, Hickory, Holt, Jackson, Jefferson, Johnson, Knox, Laclede, Lafayette, Lewis, Lincoln, Linn, Livingston, Macon, Maries, Marion, McDonald, Miller, Moniteau, Monroe, Montgomery, Morgan, New Madrid, Nodaway, Oregon, Osage, Ozark, Pemiscot, Perry, Pettis, Phelps, Pike, Platte, Polk, Putnam, Ralls, Ray, Saline, Schuyler, Scotland, Shannon, Shelby, St. Clair, Ste. Genevieve, Stone, Sullivan, Taney, Texas, Washington, Webster, Worth, Wright	PA
January 2, 2016	DR-3374	Flood	Audrain, Barry, Barton, Bollinger, Boone, Butler, Callaway, Camden, Cape Girardeau, Carter, Cedar, Christian, Clark, Cole, Cooper, Crawford, Dallas, Dent, Douglas, Dunklin, Franklin, Gasconade, Greene, Hickory, Howard, Howell, Iron, Jasper, Jefferson, Laclede, Lawrence, Lewis, Lincoln, Madison, Maries, Marion, McDonald, Miller, Mississippi, Moniteau, Montgomery, Morgan, New Madrid, Newton, Oregon, Osage, Ozark, Pemiscot, Perry, Phelps, Pike, Polk, Pulaski, Ralls, Reynolds, Ripley, Scott, Shannon, St. Charles, St. Clair, St. Francois, St. Louis, Ste. Genevieve, Stoddard, Stone, Taney, Texas, Vernon, Warren, Washington, Wayne, Webster, Wright	PA

Declaration Date	Disaster No.	Incident Type	Counties Declared	Type of Assistance*
January 21, 2016	DR-4250	Flood	Barry, Barton, Camden, Cape Girardeau, Cole, Crawford, Franklin, Gasconade, Greene, Hickory, Jasper, Jefferson, Laclede, Lawrence, Lincoln, Maries, McDonald, Morgan, Newton, Osage, Phelps, Polk, Pulaski, Scott, St. Charles, St. Francois, St. Louis, Ste. Genevieve, Stone, Taney, Texas, Webster, Wright	IA
			Barry, Bollinger, Camden, Cape Girardeau, Cedar, Crawford, Dade, Dallas, Douglas, Dunklin, Franklin, Gasconade, Greene, Howell, Iron, Jasper, Jefferson, Lawrence, Lincoln, McDonald, Mississippi, New Madrid, Newton, Ozark, Pemiscot, Perry, Phelps, Pulaski, Reynolds, Scott, Shannon, St. Charles, St. Clair, St. Louis, St. Louis, Ste. Genevieve, Stoddard, Stone, Taney, Texas, Washington, Webster	PA
June 2, 2017	DR-4317	Severe Storms, Tornadoes, Straight-line Winds, and Flooding	Bollinger, Butler, Carter, Christian, Crawford, Dent, Douglas, Dunklin, Franklin, Gasconade, Greene, Howell, Iron, Jasper, Jefferson, Madison, Maries, McDonald, Newton, Oregon, Osage, Ozark, Pemiscot, Phelps, Pulaski, Reynolds, Ripley, Shannon, St. Louis, Ste. Genevieve, Stone, Taney, Texas, Wayne, Wright	IA
			Barry, Barton, Bollinger, Boone, Butler, Camden, Cape Girardeau, Carter, Cedar, Christian, Cole, Crawford, Dade, Dallas, Dent, Douglas, Dunklin, Franklin, Gasconade, Howell, Iron, Jefferson, Lawrence, Madison, Maries, McDonald, Miller, Mississippi, Morgan, New Madrid, Newton, Oregon, Osage, Ozark, Pemiscot, Perry, Phelps, Pike, Pulaski, Ralls, Reynolds, Ripley, Scott, Shannon, St. Louis, Ste. Genevieve, Stone, Taney, Texas, Washington, Wayne, Webster, Wright	PA

Source: Federal Emergency Management Agency, State Emergency Management Agency
FEMA Data Visualization Dataset - https://www.fema.gov/media-library/assets/documents/106308
Note: IA denotes Individual Assistance; PA denotes Public Assistance

While most of the flooding in the State has been related to the Missouri River to some extent, this is not always the case. **Figure 3.50** depicts the extent of flooding throughout the state during the 1993 floods. Some areas have more detail due to studies done on those watersheds. By comparing this figure to **Figure 3.49**, showing the number of disaster declarations per county, one could form a clearer understanding of the flooding risk and potential for flood loss within the state.

Figure 3.50. Flooding Extent during the 1993 Floods



Ranking among the State's most notable flood disasters are the Missouri River flood of 1927, which spread destruction across 17 million acres, and the flood of 1951, which caused an estimated $400 million in damage. Record flooding also occurred in 1973 along the Mississippi River, where backwater inundated 474,000 acres at a loss of $40 million. The unseasonably heavy rainfall produced severe headwater flooding along many of the area’s tributary streams, particularly in the St. John's Basin in Missouri and along the St. Francis and White Rivers in Arkansas. Of special historic interest is the December 1982 flood that spread dioxin-contaminated soil in the Times Beach area near St. Louis and led to a federal buyout of the entire town. In the fall of 1986, record flooding returned in Missouri, as well as in Michigan, Illinois, Kansas, and Oklahoma, with all these states declared federal disaster areas. Significant flooding next occurred in the State in the spring of 1990, particularly along the Missouri River in western, central, and portions of eastern Missouri. Record-level, repetitive flooding occurred from 1993 through 1995, and flash flooding ravaged several areas of the State in July and October 1998. In the Spring of 1999 and 2000, flash flooding and severe storms again battered portions of the State. A significant flooding event in the spring of 2011, the Birds Point-New Madrid Area Flood, required the levees to be intentionally blown in order to relieve flood waters downstream.

For 2013, there were 2 Presidential Declarations, DR4130 July 18, 2013 affecting 28 counties spread across the state and DR4144 September 6, 2013 affecting 18 counties focused in the south-central part of the State. 2014 brought a single Presidential Declaration, DR4200 October 31, 2014 with 20 counties affected concentrated in the north-central part of the State. August 7, 2015 brought Presidential Declaration DR4238 affecting 76 counties across the state.

The year 2016 was also a critical year for flooding in Missouri. With the 76 counties affected in August 2015 by DR4238 still in recovery mode, another flooding event took place in late December centered along I-44 in Missouri were affected by flooding due to a relatively narrow band of storms that unusually heavy rainfall that averaged over 5 inches across the affected areas. Presidential Declaration DR 3374 was made on January 2, 2016. This disaster was followed on the heels by a rare December flooding in 2016, in which 52 counties were affected across the State. This second event was a Presidential Declared Disaster DR4250 on January 21, 2016. For many of these counties, this event became the new flood of record. In areas were mapping updates were underway, partnerships formed at an unprecedented rate between government agencies, including but not limited to USACE, USGS, NWS, NOAA, SEMA and MoDNR to include the new calculations in the flood risk analysis being performed.

In May 2017, 35 counties were designated in the Federal Disaster Declaration for the flooding that occurred from April 28 to May 11. $19 million was paid to policyholders before the federal disaster was declared. Over 25% of the NFIP claims filed addressed damage outside of the Special Flood Hazard Area. This flooding ranged from I-44 to the southern Stateline and resulted in levee breaches just across the Arkansas State line and numerous road overtoppings. Almost 12 inches of precipitation was reported over the 10-day period in a series of events. April 2017 has preliminarily been ranked as the wettest April on record by NOAA.

Additional details for historical flood events are provided in the following paragraphs.

Floods of 1993–1995

The floods of 1993 through 1995 represent Missouri's worst repetitive flood events. Within this time frame, there were five presidential disaster declarations, including four in just one 12-month period. This period extended from May 11, 1993, when the first declaration was issued by President Clinton, through April 21, 1994, when the fourth declaration was approved. Flooding in the spring of 1995 resulted in a fifth disaster declaration, issued on June 2, 1995.

The ravages of these floods left a legacy of destruction, human suffering, and property damage of unprecedented terms in Missouri history. The fact that Missouri would need several years to recover from these repetitive flood disasters was undisputed.

In 1993 alone, a total of 112 of Missouri's 114 counties were included in at least one or more of the declarations. Only Cedar County in southwest Missouri and Dunklin County in the southeast portion of the State were not included in any of the 1993 declarations.

A number of flood-level records were broken in 1993 and, in the USACE St. Louis and Kansas City Districts, 867 of 947 federal and nonfederal levees failed or were overtopped and greatly contributed to the flooding. The Missouri River, normally no more than a half-mile wide, expanded to 5-6 miles wide north of St. Joseph and 8-10 miles wide east of Kansas City. Just north of St. Louis, it reached 20 miles wide near its confluence with the Mississippi. As a result, almost half of the 620 square miles of St. Charles County were underwater. **Table 3.29 and Table 3.30** highlight high-water stages and levee failures that resulted from the summer flood of 1993.

Table 3.29. Record High-Water Stages in Missouri During the Summer 1993 Flood

Community	1993 Level	Previous Record	Flood Stage
Mississippi River			
Hannibal	31.8	28.6	16
St. Louis	49.4	43.3	30
Cape Girardeau	48.0	45.6	32
Missouri River			

Community	1993 Level	Previous Record	Flood Stage
St. Joseph	32.7	26.8	17
Kansas City	48.9	46.2	32
Jefferson City	38.6	34.2	23
Hermann	36.3	35.8	21
St. Charles	39.5	37.5	25

Source: U.S. Army Corps of Engineers (1993)

Table 3.30. Distribution of Levee Failures by USACE District/Number of Failed or Overtopped Levees, Summer 1993 Flood

Corps of Engineers District	Federal Levees	Non-federal Levees
St. Louis*	12 of 42	39 of 47
Kansas City**	6 of 48	810 of 810
Total Levees	18 of 90	849 of 857

Source: Natural Disaster Survey Report, "The Great Flood of '93."

Notes: The difference in the failure rates above is because most federal levees are designed to withstand a 100- to 500-year flood, while non-federal levees, predominantly protecting agricultural lands, are frequently designed for a flood with a return period of 50 years or less.

*Includes eastern Missouri and portions of Illinois

**Includes northwestern, west-central, and portions of southwest Missouri and areas in Kansas and Nebraska

The 1993-1995 flood disasters inflicted tremendous loss in terms of damage to personal property, businesses, infrastructure/public property, and agriculture. Total losses for all areas impacted during the 1993 flood disasters were estimated at approximately $3 billion, making it the flood of record in most counties. In addition, agricultural losses were estimated at $1.8 billion, as 3.1 million acres of farmland were either damaged or went unplanted because of the 1993 rains. The U.S. Department of Agriculture estimated that 445,000 acres of Missouri River bottomland were destroyed by washouts and sand scouring. While levees designed to protect up to 50-year floods did their jobs, the amount of rain and up-river flooding took their toll. Of the 1,456 public and private levees in the State, approximately 840 were damaged.

Almost every Missourian was at some time affected by the 1993 floods through inundation of roadways, airports, and drinking water and sewage treatment facilities, and by loss of income. The Missouri Department of Labor and Industrial Relations reported that $6.2 million was dispersed for disaster unemployment assistance for people who lost work due to flooding from July 1993 through March 1994. The floods of 1993 and 1994 pointed out that too many Missourians were living in a floodplain. To rebuild in the floodplains, those whose homes sustained substantial damage (50 percent or more) were required to elevate the structures above the base-flood level to protect from future flood damage. Under Missouri's Community Buyout Program, more than $30 million in federal money was committed to moving Missourians voluntarily out of the floodplains through the acquisition of primary residential properties. As a result of those actions, it is estimated that state taxpayers will save more than $200 million in future flood disaster claims.

Floods of 1998

Severe flash flooding in the summer and fall of 1998 took a heavy toll in terms of lives lost and extensive property damage in several areas of the State. In all, at least 17 people died as a result of the two flood events. Almost all of the casualties occurred when people attempted to drive their vehicles through rushing water, overturned their vehicle into floodwaters, or were trapped and swept off a flooded bridge. Both flood incidents ultimately resulted in presidential disaster declarations to provide state and federal assistance in the declared counties.

Spring 1999 and 2000 Floods

On April 3, 1999, a heavy rainstorm in southeast Missouri caused severe flash flooding in Madison County, including the communities of Fredericktown and Marquand. One death (due to electrocution) was attributed to that flood event when 7 to 10 inches of rain fell over a two-hour period, causing the St. Francois River to crest at twice the height of flood stage. More than 400 homes were adversely affected, with nearly half receiving significant water damage within the living spaces. Seven businesses were damaged, and five were determined to be destroyed. On April 20, 1999, a presidential disaster declaration for individual assistance (DR 1270) was approved for Madison County and five additional counties (Andrew, Cole, Osage, Iron, and Macon) were later approved by FEMA as add-ons to that declaration as a result of subsequent tornadoes and storms. More than 30 Missouri counties were also designated as eligible for disaster relief for agricultural losses suffered from the April storms.

For two consecutive spring seasons, Missouri experienced devastating flash flooding that forced hundreds of people from their homes and caused millions of dollars in property damage to both homes and businesses. Although the flash flooding in both events was confined to a few areas, the type of devastation was equal or greater than some of Missouri's worst river flooding events. On May 6 and 7, 2000, a slow-moving storm unleashed 15 inches of rain in Franklin and Jefferson counties in less than 24 hours. The city of Union in Franklin County was among the hardest hit due to extreme flooding from Flat Creek. In all, 10 counties were included in a presidential disaster declaration (DR 1328) issued on May 12, 2000. Three counties were declared eligible for Public Assistance and Individual Assistance, and seven others were declared for Individual Assistance.

Spring 2003 Flood

Flash flooding occurred on May 7 and 8, 2003, and became a major flooding event across all of southern and central Missouri through the early afternoon of May 9. In addition to the numerous road closures; bridges blocked by debris; evacuations of towns, campgrounds, and parks; and moderate river flooding, many communities had their worst flooding in more than 10 years. In Howell County, the most significant damage occurred after the Warm Fork River washed out a portion of train track four miles southeast of West Plains, resulting in a train derailment. Four locomotives, each weighing 260,000 pounds, and 10 railroad cars were knocked off the tracks pouring out diesel fuel. In addition to all of the flash flooding reports, river flooding became significant as all of the southern Missouri rivers rose above flood stage by the middle of May. Some of the rivers crested at levels equivalent to the 1993 flood event.

Flood of 2004

The month of May 2004 saw severe storms containing heavy rains and large hail. A strong storm moved through the State from west to east, roughly along the Interstate 70 corridor, during the night of May 18–19, 2004. The most severe hit area appeared to be in Cass County south of Kansas City. Twenty-two homes were evacuated in Freeman and Lake Annett in Cass County as a result of major flash flooding.

Spring 2006 Flood

A series of severe weather systems pushed across Missouri in March and April. These storms produced a variety of damaging elements which included high winds, tornados, flooding and heavy snow. Forty-nine Missouri counties received Federal Major Disaster Declarations. Through June 14, 2006, homeowners, renters and business owners who were affected by the severe storms, tornadoes and flooding of March 8-13 and March 30 - April 3, 2006, had been approved to receive more than $32,605,969 million in assistance from FEMA, the U.S. Small Business Administration (SBA) and the SEMA.

Floods of 2007

On January 12-14, a series of severe winter storms swept across Missouri causing heavy damage throughout the State from rain, freezing rain and flooding. An area from Joplin to St. Louis along the I-44 corridor was the heaviest hit. More winter weather came through much of the State on January 20, bringing 4-6" inches of snow in some areas and additional minor ice accumulations. Hundreds of thousands were without power to their homes resulting in 119 shelters being opened across the State.

During the weekend of May 4-7, 2007, a strong upper level storm system generated numerous rounds of heavy rainfall across the Midwest. Even though in the record books the May 2007 floods will not go down as the worst flooding ever experienced in the Midwest, in many locations May 2007 flooding was in the top three events of all time. More significantly, two cities experienced the all-time record flood levels at their locations. The Tarkio River near the city of Fairfax, MO experienced a record high river crest of 25.78 ft. recorded Monday, May 7th. This river stage broke the previous record of 25.60 ft. set on July 23, 1993. The second location to experience record flooding was near the city of Napoleon, MO. At Napoleon, the Missouri River reached a record level of 28.86 ft., eclipsing the previous record of 27.40 ft. set back on May 19, 1995. The Association of Missouri Electric Cooperatives reported that a cooperative in Holt County had an estimated $159,000 in damages as a result of this event.

Heavy rainfall and flash flooding occurred over the Missouri Ozarks and southeast Kansas from the 19th to the 20th of August 2007. The heavy rain was a result of the remnant energy from tropical system "Erin" as it interacted with high levels of moisture in the atmosphere. The heaviest rainfall occurred in a band that affected northern Lawrence, Eastern Dade, northern Greene and southern Polk counties, where 10 to 12 inches of rainfall occurred. Tropical moisture, high radar reflectivities and slow movement to the storms led to the powerful flash flooding which damaged roadways and bridges and caused one death in Laclede County.

Floods of 2008

An unusually early severe weather outbreak hit the Missouri Ozarks Monday afternoon, January 7th, into the early morning hours Tuesday, January 8th, 2008. Numerous supercell thunderstorms spawned at least 33 tornadoes that resulted in significant damage to homes, trees and power lines. The supercell thunderstorms were followed by a violent squall line that produced damaging straight line winds in excess of 70 mph. In addition, the storms produced torrential rainfall and flash flooding. The storms developed as an intense storm system tracked out of the Rockies and interacted with an unseasonably warm, moist and unstable airmass across the Ozarks.

March 2008

This event was primarily a winter storm disaster with large amounts of snow. However, due to the large amounts of rain and ice buildup that accompanied the storm, flooding was included in the declaration request.

An intensifying wave of low pressure developed on March 17, 2008 in the Texas panhandle, and headed to the lower Midwest. This system tapped into abundant Gulf moisture and combined with a strong upper level jet and a warm, unstable atmosphere to produce extremely heavy rain from southwestern Missouri eastward into southern Indiana over the next three days. The first area it affected was southwestern Missouri, which received most of the heavy rain on March 17th and early on March 18th. Much of the region received four to six inches of rain, with isolated areas had10 inches or more. By the morning of March 18th, the surface low pressure system was located near St. Louis, and heavy rain was falling from the central Ozarks into southern Illinois and Indiana. The NWS cooperative observer located in Cape Girardeau, MO reported 13.84 inches for the 48-hour period from the morning of March 18 to the morning of March 20th. The Cape Girardeau Regional Airport reported 11.49 inches for just the 18th alone. Preliminary measurements indicate that 17.83 inches of rain fell at Cape Girardeau in March 2008. This breaks the previous all-time monthly record at Cape Girardeau of 16.89 inches, set in May of 1973, and as well as the March record rainfall of 11.89 inches sent in 1977. Five Missourians died as a result of these storms–two in Greene County, one in Reynolds County, one in Bollinger County and one in Lawrence County. At one point during the event, the Missouri Department of Transportation reported 190 locations on state roads that were closed due to flooding. A few of those locations would remain closed through August as the year of 2008 continued to set record levels of rainfall in Missouri and the Midwest. Nine cooperatives in the Association of Missouri Electric Cooperatives reported total estimated damages in the amount of $885,800 as a result of this event. In all, 17 counties were included in Presidential Disaster Declaration FEMA-1749-DR, for individual assistance issued on March 19, 2008. Another 78 counties were declared eligible for public assistance.

The period February through April 2008 was the wettest on record for the Midwest region, with an average 11.64 inches of precipitation. This was also the wettest February-April for Missouri with 18.92 inches. The wet weather pattern over the southern Midwest in February and March continued into the first half of April. On April 3rd and April 4th two to four inches of rain fell from the Missouri Ozarks into western Kentucky, southern Illinois, and southern Indiana, with isolated amounts in excess of 6.50 inches. The heavy rain caused another round of flash flooding and road closures in these areas, and exacerbated flooding already in progress on rivers and streams. On April 8-10 another strong spring storm moved through the Midwest on a more northerly track. This storm dropped another 3 to 4 inches of rain on southwestern Missouri, and one to three inches of rain in a band from northwestern Missouri into southeastern Iowa.

June of 2008 was a very wet month across a significant portion of the Midwest. Precipitation was more than 200 percent of normal across much of Missouri. The wet first half of the year, along with the record June rainfall caused devastating flooding and numerous flash floods in Missouri. This resulted in record flooding on parts of the Mississippi River. This flooding exceeded levels reached during the Great Flood of 1993 in some locations. Springfield, MO received 3.88 inches in a day, breaking the old record for the date of 2.00 daily inches set in 2004. The flash flooding of Galloway Creek in Springfield significantly damaged Galloway Village, a historic section of specialty and antique shops. Water levels reached three feet in just an hour. Flood waters also washed away tons of rock from the railroad line to the James River Power Plant, interrupting coal shipments until workers could finish replacing the rock several days later. Along the Mississippi, many levees were dealing with structural failure possibilities even without overtopping. More rain caused already weakened levees to give way. Several cities were wholly or partially flooded by levee failures or overtopping, including Clarksville, Winfield, Foley, and St. Charles. The Winfield failure was especially illustrative of the fragility of some levees, as the flood waters broke through a 3-inch tunnel dug by a muskrat and water poured out under pressure like a fire hose. Many volunteers and National Guard troops were able to keep most of the levees intact. Three cooperatives in the Association of Missouri Electric Cooperatives reported total estimated damages of $142,000 as a result of this event. Presidential

Disaster Declaration FEMA-1773 issued on June 25, 2008, included 27 counties for individual assistance and 72 counties eligible for public assistance.

Spring 2009

A wide swath of severe weather tore across Missouri on May 8, 2009. The fast-moving complex of severe thunderstorms brought damaging winds, large hail and tornadoes to southern Missouri and Illinois. Thousands of trees were uprooted, numerous buildings and homes sustained damage from wind and hail. In addition, three to locally five inches of rainfall caused extensive flash flooding from Crawford County, Missouri to Randolph County, Illinois. Rainfall totals across the southern half of the State reached 200 percent of normal for the first week of the month. Two weather systems tracked across northern Missouri May 12th through the 16th. The heavy rainfall pushed some locations in the State to rainfall totals exceeding 300 percent of normal. Flash flood warnings blanketed the affected areas as storms dumped their rain on saturated ground. Roads were closed due to flooding in many rural and urban areas.

July 2009

An early July low pressure developed along the front in the southern Plains and moved along the front, setting off thunderstorms from Missouri through Ohio. Late on July 2, 2009 two to six inches of rain fell in western Missouri northwest of Kansas City. The rain caused flash flooding in Parkville, MO. The lower levels of 20 homes were flooded in one subdivision when debris blocked drainage tubes at a bridge. In central Missouri, three to four inches of rain fell in Moniteau, Cole, and Osage counties. The week of July 24th brought extremely heavy rains to previously saturated portions of Missouri. Rainfall exceeded 12 inches in portions of northern Missouri, and amounts from 3 to 6 inches were reported from southern Iowa to just north of St. Louis, resulting in flash flood watches and warnings for much of the region. The largest 24-hour rainfall amount reported was 14.95 inches one mile west of Brunswick, MO. A dam on a 2-acre pond at a country club near Kirksville was breached and water was flooding a major highway. Two men were rescued from a tree after their vehicle was swept off of a road by floodwaters in Ralls County, and authorities reported numerous vehicle rescues. The next round of heavy rain came on July 29-30 as the remnants of Hurricane Dolly entered the Midwest. Heavy rain fell from north of Kansas City, MO across north-central Missouri, preventing any recovery from the flooding caused by the previous two systems. In Platte City, MO, 7.70 inches of rain was recorded into the 24-hour period ending at 7:00 a.m. on July 30, and there were numerous reports of 2 to 3 inches of rain in northwestern Missouri. The heavy rain closed many roads and kept rivers and streams in flood. Three cooperatives in the Association of Missouri Electric Cooperatives reported a total estimated $190,000 in damages as a result of this event. In the wake of the week of heavy rain in Missouri, Mark Twain Lake, a flood control reservoir and major recreational destination, reached a record level of 640.36 feet on July 30, swelling it to twice its normal size. The previous record was 636.77 feet in 1993. On July 30 USACE closed the lake to all boating traffic, and increased the water released through the dam into the Salt River to 50,000 cubic feet per second (cfs). Releases above 12,000 cfs were unprecedented. Authorities also closed the Salt River to recreational boating traffic from the Clarence Cannon Dam to the Mississippi River because of flooding. This had a serious impact on area businesses during the height of the tourist season.

Two tropical systems, Gustav and Ike, brought heavy rain to the central Midwest during the first half of September. Many locations from Missouri through Illinois into southern Michigan received two to three times normal September rainfall, and much of that rain fell the first two weeks of the month. A number of locations set monthly records for precipitation. The heaviest rains occurred across the northern half of the State. In northeast Missouri, Kirksville received a total of 8.14 inches of rain, while in Columbia

7.19 inches of rain from the remnants of Hurricane Ike were reported. The St. Louis area was also hard hit, with O'Fallon reporting 5.84 inches of rain. Three deaths were reported in association with the storm. A woman was killed when a tree was struck by lightning and a limb fell on her in Ladue. Two other people were killed in University City when they were swept away by flood waters while trying to move their vehicles to higher ground. Numerous roads were closed by flooding, including a stretch of Interstate 70. At the peak of the storm nearly 106,000 people were without power in the St. Louis Area.

Spring 2010

On July 27, 2010, a major disaster declaration was requested due to severe storms, flooding, and tornadoes during the period of June 12 to July 31, 2010. The Governor requested a declaration for Individual Assistance for 11 counties and Public Assistance for 29 counties and Hazard Mitigation for the entire State of Missouri. During the period of July 7 – 20, 2010, joint Federal, State, and local Preliminary Damage Assessments (PDAs) were conducted in the requested counties and are summarized below. PDAs estimate damages immediately after an event and are considered, along with several other factors, in determining whether a disaster is of such severity and magnitude that effective response is beyond the capabilities of the State and the affected local governments, and that Federal assistance is necessary.

On August 17, 2010, the President declared that a major disaster exists in the State of Missouri. This declaration made Public Assistance requested by the Governor available to State and eligible local governments and certain private nonprofit organizations on a cost-sharing basis for emergency work and the repair or replacement of facilities damaged by the severe storms, flooding, and tornadoes in Adair, Andrew, Atchison, Buchanan, Caldwell, Carroll, Cass, Chariton, Clark, Clinton, Daviess, DeKalb, Gentry, Grundy, Harrison, Holt, Howard, Jackson, Lafayette, Lewis, Livingston, Mercer, Nodaway, Putnam, Ray, Schuyler, Scotland, Sullivan, and Worth Counties. This declaration also made Hazard Mitigation Grant Program assistance requested by the Governor available for hazard mitigation measures statewide.

Spring 2011

On May 5, 2011, a major disaster declaration was requested due to severe storms, tornadoes, and flooding beginning on April 19, 2011, and continuing. The Governor requested a declaration for Individual Assistance for 29 counties, Public Assistance for 38 counties, and Hazard Mitigation statewide. The Governor further requested direct Federal assistance. During the period of April 27 to May 5, 2011, joint Federal, State, and local Preliminary Damage Assessments (PDAs) were conducted in the requested counties and are summarized below. PDAs estimate damages immediately after an event and are considered, along with several other factors, in determining whether a disaster is of such severity and magnitude that effective response is beyond the capabilities of the State and the affected local governments, and that Federal assistance is necessary.

On May 9, 2011, the President declared that a major disaster exists in the State of Missouri. This declaration made Individual Assistance requested by the Governor available to affected individuals and households in Butler, Mississippi, New Madrid, St. Louis, and Taney Counties. This declaration also made Public Assistance, including direct Federal assistance requested by the Governor available to State and eligible local governments and certain private nonprofit organizations on a cost-sharing basis in St. Louis County. Finally, this declaration made Hazard Mitigation Grant Program assistance requested by the Governor available for hazard mitigation measures statewide.

Summer 2011

On July 25, 2011, a major disaster declaration was requested due to flooding during the period of June 1 to August 1, 2011. The Governor requested a declaration for Individual Assistance for eleven counties, Public Assistance for 22 counties and Hazard Mitigation for the entire State of Missouri. During the period of July 18-22, 2011, joint federal, state, and local Preliminary Damage Assessments (PDAs) were conducted in the requested counties and are summarized below. PDAs estimate damages immediately after an event and are considered, along with several other factors, in determining whether a disaster is of such severity and magnitude that effective response is beyond the capabilities of the state and the affected local governments, and that Federal assistance is necessary.

On August 12, 2011, the President declared that a major disaster exists in the State of Missouri. This declaration made Individual Assistance requested by the Governor available to affected individuals and households in Andrew, Atchison, Buchanan, Holt, Lafayette, and Platte Counties. This declaration also made Hazard Mitigation Grant Program assistance requested by the Governor available for hazard mitigation measures statewide.

The table below was pulled from a Corps of Engineers Vulnerabilities assessment concerning the 2011 flooding. It summarizes the studies research within each sector.

Table 3.31. 2011 Flood Vulnerability Report

2011 Flood Vulnerability Report			
Vulnerability Report Section	***Salient Feature Addressed***	***Key Points***	***Vulnerability/ Remaining Work***
Economics	Economic Impact to Basin	• Impacted 1+M acres, 10,000+ people, and almost 6,000 structures • Corps Reservoirs and emergency operations prevented nearly $8B in damages	• There is need to update Stage Damage Curves as well as Socioeconomic Data
Reservoirs and Water Management	Reservoir and Dam Infrastructure	• All critical assessments have been completed • Additional funding may be needed to restore system, pending studies	• Ft Peck Plunge pool and Ring Gates continue to be assessed and evaluated • Need to evaluate unlined spillways at Oahe and Pipestem • Some other Miscellaneous measures to restore existing systems • Depending on assessments, some operating restrictions may be implemented
	Water Management	• There are currently no formal operating restrictions on system • Record runoff that flowed into system needed to exit system	• Need to update Water Control Manuals • Implementing the 6 Independent External Panel Recommendations • Restore/maintain all project features to maximize flexibility in system
River Corridor and Conveyance	Floodway and Channel Performance	• Bank stabilization navigation projects, Navigation Channel, Habitat areas, and sedimentation and aggradation issues are being addressed and/or evaluated • Considerable damage did occur in river structures. Most known repairs funded	• assessments and repairs are being addressed • Several river bends may require attention due to damage or flood determination • Additional studies may be required to fully assess channel condition • Complete the flow corridor study as planned

2011 Flood Vulnerability Report			
Vulnerability Report Section	***Salient Feature Addressed***	***Key Points***	***Vulnerability/ Remaining Work***
	Levees	• Critical repairs have been made • Some overtopping and under seepage was issue throughout basin	• Some flow constrictions exist in levee alignment • Repairs are funded but will carry into Fiscal Year 13
Other Considerations	Tribal and Cultural Resources	• Cultural sites were impacted and are being assessed	• Tribes and others need to remain engaged thru Programmatic Agreement meetings and other partnering meetings
	Communications	• MRJIC worked to communicate and engage local state, and Federal and Tribal interests • MRFTF was a successful joint Federal effort to restore system	• MR Basin Interagency Roundtable(MRBIR) will inherit tasks/initiatives started by MR Flood Task Force (MRFTF)
Shared Responsibilities	Flood Risk Management	• Federal Government has little control over local land uses • Federal Government has little control over local land uses • Local and some states can help in reducing flood risk and expose	• Federal Government can assist when and if requested • MRBIR will continue the Stakeholder Communications started with MRFTF • To understand FRM, the 8 Authorized Purposes need continued education throughout the basin

Summer 2013

A large complex of thunderstorms produced heavy rainfall in July 2013 which led to widespread flooding and isolated reports of wind damage. This was the start of an unsettled and very wet weather pattern that lasted into early August.

Fall 2014

On September 9 and 10, unusually intense and heavy rainfall occurred over parts of northern Missouri, especially along and north of Highway 36. Cooperative weather observers in Holt, Grundy, Linn, Macon, Adair, Knox and Lewis counties reported more than 7 inches of rain, much of it falling in less than 6 hours. Extensive flooding and flash flooding was reported with numerous reports of closed and washed out roads. Widespread bottomland flooding was also reported. Highest amounts were reported in northern Holt county (9.48") and northeastern Linn county (10.42"). http://climate.missouri.edu/news/arc/oct2014.php

Summer 2015

Major flooding occurred on portions of the Mississippi River. The active June weather pattern continued through July, bringing fronts that moved in and near the region's river basins. The wet period of spring and summer resulted in prolonged high water levels in lakes, rivers and streams. These conditions unfortunately contributed to an increased number of drowning deaths. The Missouri State Highway Patrol reported 34 drownings this year, while 25 were reported in all of 2014. Most of the fatalities have been attributed to flooding.

Winter 2015-2016

Historic flooding impacted Missouri during December 2015 with the eastern and southern sections of the State experiencing the brunt of the extreme weather. A highly unusual heavy rainfall event from December 26 through 29 dropped 7.5-10 inches of rain along a 60-mile wide corridor extending from just south of Joplin to St. Louis. Rivers and streams reacted quickly to the post-Christmas rainfall event, and flash flooding was widespread with hundreds of water rescues reported, especially over the southern half of the state. There were 27 flood fatalities reported in 2015. This was more than the combined number for the previous 7 years and represented the highest number since 1993, the highest number on record for the State. Of those 27 deaths, 23 (85%) were killed in motor vehicles. Of the 49 deaths recorded during the floods of 1993, 35 (71 percent) were from flash floods. In that same category, 20 deaths (77 percent) were related to motor vehicles caught in flash floods or attempting to cross high water. Missouri's river flooding in 1993 claimed 14 lives, with 6 deaths (23 percent) attributed to motor vehicles. Drowning, electrocution and cardiac arrest are the remaining causes of flood related deaths.

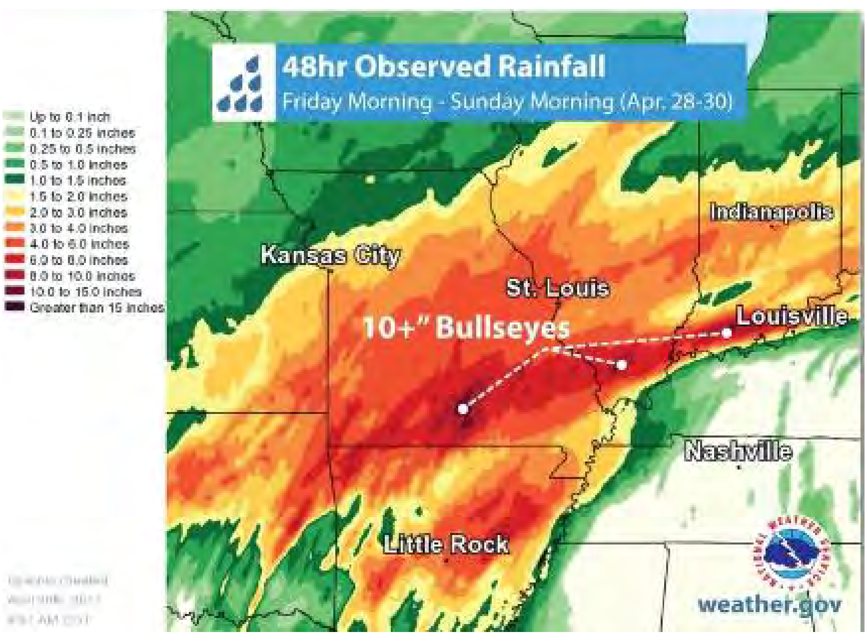
Transportation was also severely impacted by the flooding, with portions of major interstates closed for a period of time, including I-44, I-55, and I-70. Amtrak service was temporarily suspended and barge traffic along the Mississippi River at St. Louis was shutdown. Record flood crests were reported along parts of the Mississippi (Cape Girardeau, Thebes), Meramec (Pacific, Eureka, Valley Park, Arnold) and Gasconade Rivers (Jerome), among other streams and tributaries. Thousands of homes and hundreds of businesses were flooded as President Obama designated Missouri a federal disaster area on Saturday, January 2.

Spring 2017

A powerful storm system brought torrential rainfall and historic flooding to the Missouri Ozarks and southeastern Kansas from Friday night, April 28 through Sunday, April 30. Storm total rainfall amounts generally ranged from 4 to 8 inches with some areas of far southern and south-central Missouri receiving from 10 to 12 inches. This rainfall event resulted in widespread and historic flooding. Numerous roads, bridges and buildings were destroyed. Many roads were flooded through the event including state highways and Interstate 44. Several rivers reached major and historic levels, including the Mississippi River which reached major flood stage in many locations north of the confluence of the Ohio River and the St. Francis River which crested at a new record high at the Patterson gage.

The heavy rainfall events in April were followed by another heavy rainfall event in early May. Total rainfall amounts for the May 11th event ranged from around one-half to one inch over mainly southern Missouri to one and one-half to over two inches over far western Missouri and extreme southeast Kansas. The heaviest rainfall amounts occurred over an area roughly between US Highways 60 and 54. The rain fell over saturated soils saturated from the April event prompting two flash flood warnings and several areal flood warnings.

Figure 3.51. Observed Rainfall April 28-30, 2017



Source: NWS; https://www.weather.gov/sgf/28-30AprilHistoricFloodingEvent

Probability of Future Hazard Events

Flooding has resulted in more federal disaster declarations in Missouri than any other hazard in the past three decades. With 42 disaster declarations over the 41-year period from 1976 to 2017, there is a 100% likelihood of a flooding event in Missouri in any given year. Prior to the Statewide flood of record, the Great Flood of 1993, Missouri received major disaster declarations due to flooding in the spring of 1990, October 1986, June 1984, December 1982, August 1982 (Jackson County), April 1979, September 1977, May 1977, July 1976, June 1974, and for extensive flooding in April 1973 and again in November 1973. Since the Great Flood of 1993, there have been 21 major flooding events which include the events of April 1994, June 1995, October 1998, April 1999, May 2000, May 2002, May 2003, June 2004, March 2006, January 2007, March 2008, June 2009, August 2010, May 2011, June 2011, July 2013, October 2014, August 2015, August 2016, December 2016 and May 2017. Further details on these flood-related major disaster and emergency declarations are presented in Table 3.28.

Additionally, flash flooding can occur virtually anywhere in the State experiencing an abundance of rainfall in a very short time span, as with the November 1993 flood disaster and floods of 1998 and 1999. The backing up of tributary stream flows creates flooding problems along the Mississippi River, especially in the southern area of the State where the land tends to be very flat and at low elevations. Even though many flood control projects have been implemented and directly aid in flood prevention, the State is still flood-prone due to its geography and location.

The threat of flooding is more likely in the spring, when late winter or spring rains, coupled with melting snow, fill river basins with too much water too quickly. Spring also represents the onset of severe weather in the form of thunderstorms, tornadoes, and heavy rains, which can generate flash flooding along these storm fronts. As historically demonstrated, severe flooding can occur in Missouri at any time of the year however May is the most comment month.

Changing Future Conditions Considerations

If departure from normal with respect to increased precipitation intensity continues, frequency of floods in Missouri is likely to increase as well. Over the last half century, average annual precipitation in most of the Midwest has increased by 5 to 10 percent. But rainfall during the four wettest days of the year has increased about 35 percent, and the amount of water flowing in most streams during the worst flood of the year has increased by more than 20 percent.

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

Flooding occasionally threatens navigation and riverfront communities, and greater river flows could increase these threats. In April and May 2011, a combination of heavy rainfall and melting snow caused a flood that closed the Mississippi River to navigation, threatened Caruthersville, and prompted evacuation of Cairo, Illinois, due to concerns that its flood protection levees might fail.

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

Jurisdictions updating or installing stormwater management systems should consider potentially larger future discharge amounts when sizing culverts and drainage ways; storage capacity can also be increased by building retention basins to hold excess stormwater. Communities already prone to flooding should be prepared for a potential increase in facility closures and/or damages, as well as an increase in public demand for flood response and assistance. Natural features that experience repeated flooding may manifest changes in the form of stream bank instability and changing shoreline, floodplain, and wetland boundaries. Communities may also wish to plan for the potential loss of cropland and damage to both private property and public infrastructure such as bridges.

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

State Vulnerability Overview

The vulnerability of Missouri to flooding is significant. For the 2018 State Plan Update, SEMA used the most recent release of Hazus, version 4.0, to model flood vulnerability and estimate flood losses for all 114 counties and the City of St. Louis due to depth of flooding. Additional hazard data inputs were utilized, as available, to perform Hazus Level 2 analyses. This included the extensive use of the FEMA special flood hazard area data and RiskMAP flood risk datasets and resulted in Missouri being among the first in the nation, if not the first in the nation, to do so.

Flood Hazard Area and Depth of Flooding Determinations

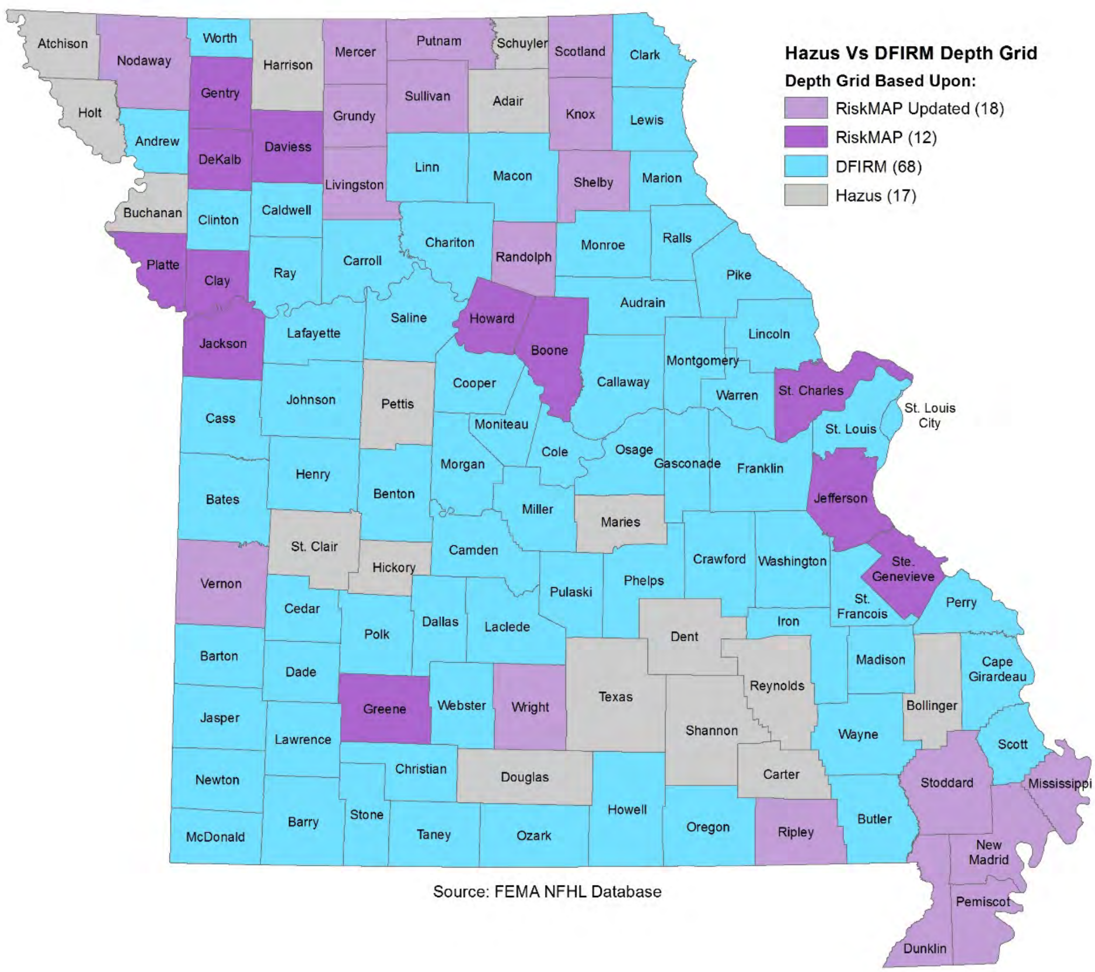
For the Hazus analysis, the flood hazard area and depth of flooding was determined for each county using one of the following three methods:

1. **For counties without digital FIRMs**, the Hazus software was utilized to generate the flood hazard boundary and associated depth of flooding. This analysis applies to 35 counties. Model parameters include:
    - Thirty-meter resolution Digital Elevation Models (DEM) were used as the terrain base to develop hydrologic and hydraulic models
    - Streams and rivers with a minimum drainage basin area of 10 square miles were modeled as all experiencing a base flood at the same time
    - U.S. Geological Survey hydrologic regional regression equations and stream gage data were included in Hazus
    - Draft floodplain data for 18 counties became available in January 2018. For those 18 counties, the MSDIS structure exposure count was updated. These counties are noted as RiskMAP Updated in **Figure 3.52**.
2. **For counties with digital FIRMs,** the regulatory special flood hazard area was utilized. Next, depth grids were generated using cross sections from the FIRM database and/or hydraulic models in combination with the terrain elevation data from which the DFIRM was derived. This analysis applies to 68 counties and the City of St. Louis.

3. **For counties with RiskMAP flood risk datasets**, the regulatory special flood hazard area was utilized along with the 1-percent annual chance flood depth grid, a non-regulatory product. This analysis applies to 12 counties. Flood depth grids are rasters where depth is calculated as the difference in feet between the water surface elevation and the ground surface elevation.

Figure 3.52 indicates which analysis was performed per county.

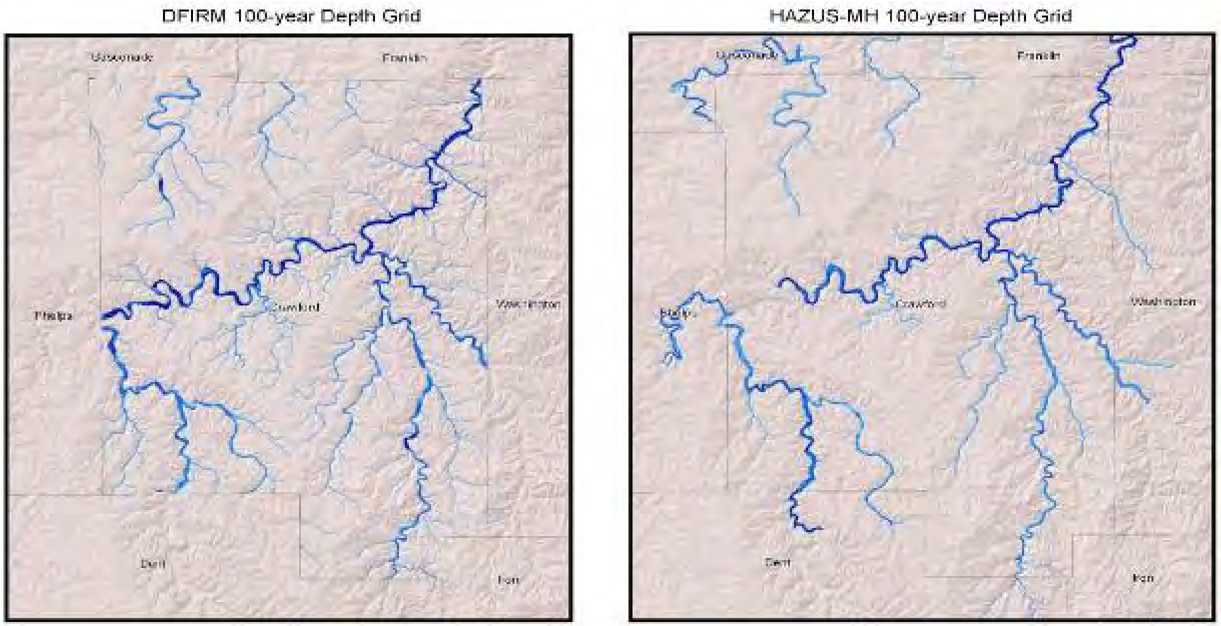
Figure 3.52. RiskMAP, DFIRM and Hazus based Depth Grids used in Hazus Analysis



Defining the flood hazard area and depth of flooding from the digital FIRM data and the RiskMAP flood risk datasets (methods 2 and 3) are preferred over production within Hazus (method 1), because the floodplains derived from digital FIRM and RiskMAP datasets are more comprehensive and accurate than those produced entirely by Hazus, which will result in more accurate vulnerability and loss estimations. The hydrology and hydraulics model used to produce the digital FIRM floodplains and RiskMAP datasets creates streams based on drainage areas less than 1 square mile, while the Hazus model uses a larger 10 square mile drainage area. The smaller drainage area in the model generates more streams per unit area.

As an example, **Figure 3.53** provides a comparison between a digital FIRM floodplain and a Hazus-generated floodplain data for Crawford County.

Figure 3.53. Crawford County: DFIRM and Hazus 100-year Flood



When DFIRM boundaries are used to generate a user-defined depth grid, the more accurate, surveyed floodplain boundaries and flood depths are preserved. It should be noted because of the recognition of this increased accuracy, user-generated depth grids were produced wherever digital FIRM data was available, both with regards to detailed and approximate (Zone A) flood zones. These data were used in conjunction with available LIDAR data from the Missouri Spatial Data Information Service and the US Army Corps of Engineers. In areas that had digital FIRM data where LiDAR was not entirely available, USGS 10-meter digital elevation models were used to supplement these gaps in LiDAR coverage.

In order to automate the process of generating user-generated (digital FIRM) depth grids in areas where they were not previously produced as part of the DFIRM project, ArcGIS Model-builder was utilized to create a series of models using DFIRM and elevation data as inputs. The methodologies for approximate and detailed flooding were developed separately to allow for the most accurate results possible. **Figure 3.54 and Figure 3.55** each show a sample of a depth grid generated by the model and then input into Hazus for flood vulnerability and loss analysis.

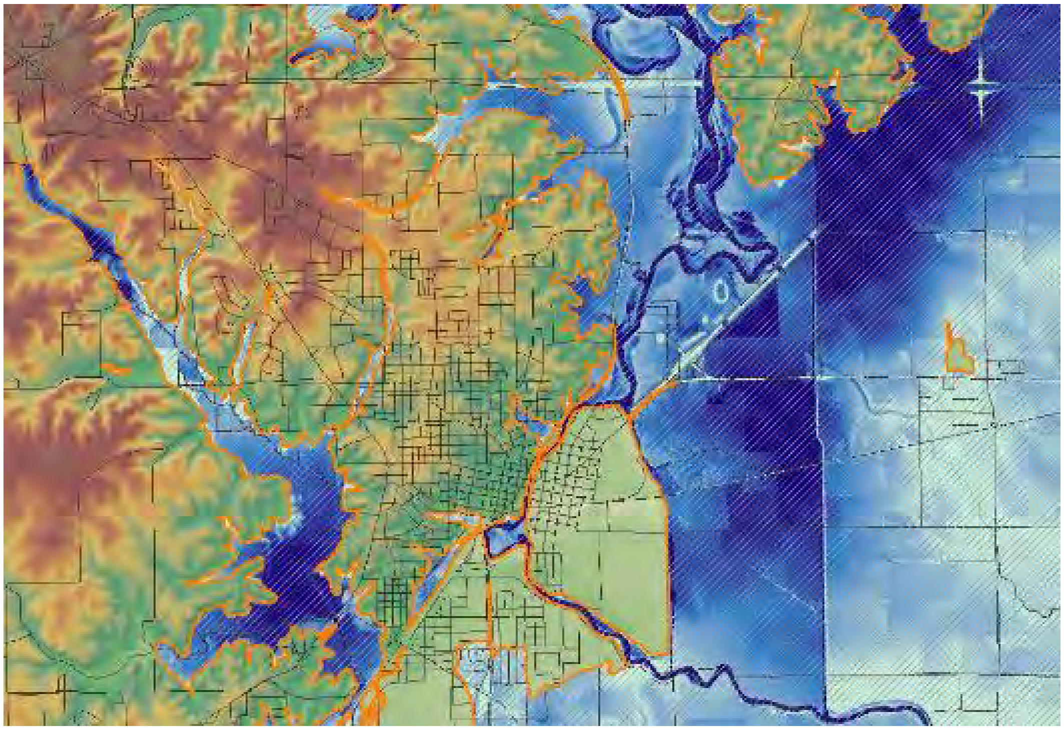
Within Figure 3.55, the black lines define census blocks. The smaller the census blocks and the more densely clustered the block polygons, the more likely the area is to be densely developed and populated. The orange line represents the modeled base flood hazard boundary. The blue color indicates flood depth, with deeper blue representing deeper water.

For the 79 counties with digital effective FIRM data and RiskMAP datasets, as well as the City of St. Louis, **Figure 3.56** presents the developed 1-percent-annual-chance floodplain boundaries.

Figure 3.54. Example of a DFIRM Depth Grid in Approximate Areas — Carroll County

Source: Hazus 2.1 and DFIRM

Figure 3.55. Example of a DFIRM Depth Grid in Detailed Areas — Butler County



Source: Hazus 2.1and DFIRM

Figure 3.56. Digital FIRM and Hazus Countywide Base-Flood Scenarios: Modeled Floodplain Boundaries

Source: FEMA NFHL Database

Building Inventory

For the previous 2013 State Plan, the number of structures at risk was determined using the default census block inventory available in Hazus. A noted limitation with this data was that it is susceptible to rounding errors that may produce inaccurate structure count results. To address this limitation, for the 2018 State Plan, SEMA enhanced the Hazus analysis with a structure inventory dataset developed by the University of Missouri GIS Department (MSDIS) to indicate the number of structures exposed to the risk. MSDIS created a point and/or footprint dataset for every roof line in every county in the state of Missouri. This dataset is attributed with the type of structure such as Residential, Commercial, etc. The MSDIS dataset was intersected with the depth grid outside of the Hazus environment for this risk assessment analysis to give an estimated number of structures, by type, exposed to risk of flooding with the flood zone attributed and the estimated depth of water for the twelve counties with existing depth grids from FEMA RiskMAP Products. Tables include both results:

- Hazus building inventory with enhanced Level 2 essential facility data from HSIP (2017) summarized to the census block level with a demographic/loss estimate ratio applied to reflect population changes from 2000 – 2010.
- MSDIS building inventory intersection with the floodplain summarized to the county level.

Flood Insurance Claims Analysis

In addition to the Hazus flood runs and local mitigation plans, SEMA analyzed National Flood Insurance Program (NFIP) flood-loss data to determine areas of Missouri with the greatest flood risk. Missouri flood-loss information was obtained from BureauNet which documents losses from 1978 to the present (this analysis is based on the report dated November 30, 2017). To date Missouri has sustained 47,700 losses resulting in a total of $813,050,620 in payment.

With this flood-loss information, there are noted limitations, including:

- Only losses to participating NFIP communities are represented
- Communities joined the NFIP at various times since 1978
- The number of flood insurance policies in effect may not include all structures at risk to flooding
- Some of the historic loss areas have been mitigated with property buyouts

Despite these limitations, the data depict a pattern of historic flood losses in the State. The greatest losses have been in the counties along the Mississippi River corridor, particularly St. Charles, St. Louis, Jefferson, Lincoln, and St. Genevieve Counties. Counties along the Missouri River corridor also have considerable claims and losses, particularly Clay County. **Table 3.32** lists the details of the 10 Missouri counties with the greatest historic dollar losses. **Figure 3.57 and Figure 3.58** present the geographic distribution of flood payouts and claims by county across the entire state. Please note that only communities that participate in the National Flood Insurance Program can have flood insurance losses. Uninsured losses are not depicted in these tables and figures.

Note that while St. Louis County has the most historical dollars paid, St. Charles County has had more flood claims and has less than half as many policies.

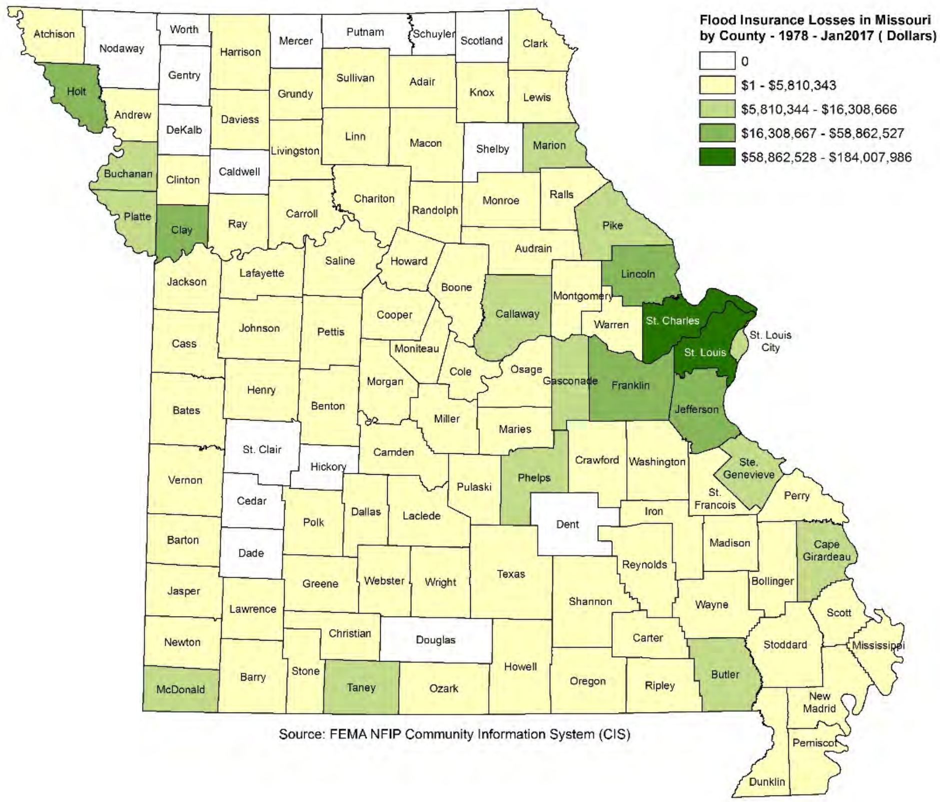
Table 3.32. Top 10 Counties for Flood Insurance Dollars Paid (Historical), 1978-2017

County	Dollars Paid (Historical)	Flood Claims	Current Policies	Coverage
St. Louis	$ 184,007,986	10,427	3,968	$1,024,874,500
St. Charles	$ 135,291,321	10,999	1,707	$361,441,500
Jefferson	$ 58,862,527	4,604	1.101	$187,524,500
Clay	$ 44,314,003	2,351	1.469	$398,377,000
Holt	$ 34,003,713	1,106	214	$24,946,800
Lincoln	$ 32,481,413	2,332	360	$40,671,900
Franklin	$ 25,889,776	1,092	412	$70,329,700
Taney	$ 16,308,666	387	517	$90,706,400
Platte	$ 13,828,821	380	182	$47,705,800
Buchanan	$ 13,514,850	435	352	$69,651,900
Totals	**$558,503,076**	**34,113**	**7,715**	**$2,316,230,000**

Source: FEMA CIS November 2017 Note: Only NFIP participating communities can have flood insurance losses.

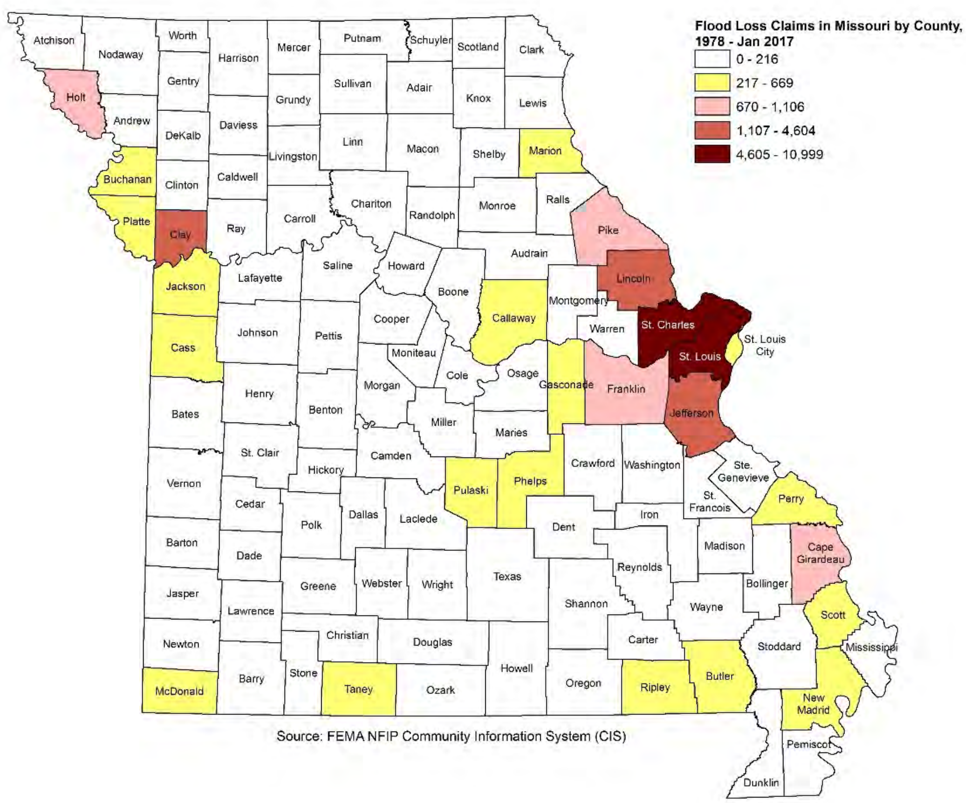
Additional flood insurance claim statistics and analyses, addressing repetitive loss (RL) and severe repetitive loss (SRL) properties, are provided in Section 4.3, Repetitive Flood Loss Strategy.

Figure 3.57. Map of Dollars Paid Historically for Flood Insurance Losses in Missouri by County, 1978-January 2017



Source: FEMA NFIP Community Information System (CIS)

Figure 3.58. Flood Loss Claims in Missouri by County, 1978-January 2017



Source: FEMA NFIP Community Information System (CIS)

State Estimates of Potential Losses

The intent of this analysis was to enable the State to estimate where flood losses could occur and the degree of severity using a consistent methodology. The statewide analysis used best available data; that is, digital effective FIRM data where obtainable (79 counties and City of St. Louis), draft floodplain data where obtainable (18 counties) and Hazus-generated floodplain data elsewhere (17 counties). The computer models help quantify risk along known flood-hazard corridors such as along the Mississippi and Missouri Rivers. In addition, flood losses are estimated for certain lesser streams and rivers where the flood hazard may not have been previously studied.

The Hazus analysis provides the number of buildings impacted, estimates of the building repair costs, and the associated loss of building contents and business inventory. Building damage can also cause additional losses to a community as a whole by restricting a building's ability to function properly. Income loss data accounts for losses such as business interruption and rental income losses as well as the resources associated with damage repair and job and housing losses. These losses are calculated by Hazus using a methodology based on the building damage estimates.

Flood damage is directly related to the depth of flooding. For example, a two-foot-deep flood generally results in about 20 percent damage to the structure (which translates to 20 percent of the structure's replacement value). Hazus takes into account flood depth when modeling damage (based on FEMA's depth-damage functions). Hazus reports capture damage by occupancy class (in terms of square footage impacted) by damage percent classes. Occupancy classes in Hazus include agriculture, commercial, education, government, industrial, religion, and residential. Damage percent classes are grouped by 10 percent increments: 1-10 percent, 11-20 percent, etc., up to 50 percent. Buildings that sustain more than 50 percent damage are considered to be substantially damaged.

The displaced population is based on the inundation area. Individuals and households will be displaced from their homes even when the home has suffered little or no damage either because they were evacuated (i.e., a warning was issued) or there was no physical access to the property because of flooded roadways. Displaced people using shelters will most likely be individuals with lower incomes and those who do not have family or friends within the immediate area. Age plays a secondary role in shelter use in that there are some individuals who will go to a public shelter even if they have the financial means to go elsewhere. These will usually be younger, less established families and elderly families (Hazus User's Manual). Hazus does not model flood casualties given that flood-related deaths and injuries typically do not have the same significant impact on the medical infrastructure as those associated with earthquakes.

Hazus impact analyses were completed all counties, and the City of St. Louis, to see which counties ranked the highest on these risk indicators (**see Table 3.34** and figures that follow). Using GIS, Hazus flood results were mapped to show flood loss potential and how it varies across the State. The primary indicators used to assess flood losses were:

- **Direct building losses** are calculated within Hazus from US Census data.
- **Loss ratio of the direct building losses compared to overall building inventory -** The loss ratio of the direct building losses compared to overall building inventory per county gives an indication of the severity of impacts on community sustainability. While a large urban area may have the greatest dollar losses, it may be able to absorb the impact better than a more rural area where a flood could impact a significant amount of the infrastructure in the entire county.
- **Count of Residential Buildings Exposed to Flooding (MSDIS)** – To determine the number of residential buildings exposed to the 1-percent annual chance flood event, the MSDIS dataset was

intersected with the depth grids outside of the Hazus environment. This provides an indication of the potential magnitude of a flood event. This exposure count was updated for 18 counties using the draft datasets available from the SEMA CTP Mapping Program.

- **Count of Residential Buildings Potentially Damaged by Flooding (Hazus) –** To determine the number of damaged residential structures, the analysis performed within Hazus utilized US Census data to estimate the number of residential structures which are at risk of damage and the number expected to receive substantial damage during a 1-percent annual chance flood event. Note, there are instances where the Hazus analysis predicted a greater number of damaged buildings than were identified with the exposed MSDIS points. This is due a fundamental premise of the Hazus Level 1 flood loss methodology that the buildings are uniformly distributed within census blocks.
- **Income losses, Population displaced by the flood, and Shelter needs** – all computed within Hazus from US Census data

Table 3.33 lists the top ten most severely impacted counties based on building loss, loss ratio, and displaced population indicators. St. Louis, Jackson, Clay, Boone, St. Charles, Jefferson, Greene, Butler, Lincoln and Franklin Counties are present on more than one of these lists and are the most vulnerable to the 100-year flood. Clay and Jackson Counties are split by the Missouri River and are heavily populated with Kansas City metropolitan communities. St. Charles and St. Louis Counties are also split by the Missouri River; they are heavily populated with St. Louis City metropolitan communities. Boone, Carroll, Chariton and Franklin Counties border the Missouri River. Butler, Bollinger, Reynolds, Scott and Wayne counties are subject to extensive flooding in the southern part of the state.

Table 3.34 A and B and the figures that follow present the results of the primary indicators for each of Missouri's 114 Counties and the City of St. Louis.

Table 3.33. Top Ten Counties at Risk to the 100-year Flood for Building Loss, Loss Ratio, and Displaced Population

Building Loss	Loss Ratio	Displaced Population
St. Louis	Pemiscot	St. Louis
Jackson	Wayne	Jefferson
St. Charles	Holt	Pemiscot
Jefferson	Carter	St. Charles
Pemiscot	Reynolds	Franklin
Franklin	Ralls	Boone
Boone	New Madrid	Jackson
Clay	Gasconade	Butler
Cape Girardeau	Butler	Clay
St. Louis	Pemiscot	St. Louis

Table 3.34. A. Total Direct Building Loss and Income Loss to all Counties and the City of St. Louis

County	Countywide Building Exposure	Structural Damage	Loss Ratio	Contents Loss	Inventory Loss	Total Direct Loss	Total Income loss	Total Direct and Income Loss	# MSDIS Residential Structures Exposed	# Hazus Bldgs Risk	#Substantially damaged	# Displaced People	# Shelter Needs
Adair	$2,599,614,000	$7,445,000	0.29%	$6,613,000	$225,000	$14,283,000	$35,000	$14,318,000	15	17	0	329	33
Andrew	$1,724,819,000	$29,193,000	1.69%	$17,870,000	$373,000	$47,436,000	$223,000	$47,659,000	211	78	23	998	238
Atchison	$806,754,000	$18,643,000	2.31%	$16,334,000	$745,000	$35,722,000	$64,000	$35,786,000	70	24	9	286	50
Audrain	$2,689,090,000	$7,605,000	0.28%	$9,862,000	$318,000	$17,785,000	$45,000	$17,830,000	139	26	0	336	130
Barry	$3,736,121,000	$21,248,000	0.57%	$38,569,000	$2,998,000	$62,815,000	$277,000	$63,092,000	585	34	1	590	140
Barton	$1,414,960,000	$16,684,000	1.18%	$14,973,000	$523,000	$32,180,000	$85,000	$32,265,000	145	111	15	1,109	370
Bates	$1,650,150,000	$16,291,000	0.99%	$10,483,000	$586,000	$27,360,000	$41,000	$27,401,000	21	36	4	742	82
Benton	$2,478,458,000	$14,831,000	0.60%	$11,997,000	$306,000	$27,134,000	$61,000	$27,195,000	175	17	3	396	68
Bollinger	$1,035,129,000	$17,686,000	1.71%	$17,040,000	$383,000	$35,109,000	$152,000	$35,261,000	124	39	3	783	215
Boone	$18,473,209,000	$196,763,000	1.07%	$188,994,000	$2,666,000	$388,423,000	$2,049,000	$390,472,000	775	963	130	7,338	4,487
Buchanan	$10,579,076,000	$107,272,000	1.01%	$188,962,000	$18,751,000	$314,985,000	$843,000	$315,828,000	632	333	153	1,681	856
Butler	$4,144,110,000	$115,978,000	2.80%	$121,024,000	$3,868,000	$240,870,000	$726,000	$241,596,000	3,185	738	91	5,012	2,819
Caldwell	$984,103,000	$2,087,000	0.21%	$1,983,000	$50,000	$4,120,000	$10,000	$4,130,000	1	0	0	116	0
Callaway	$4,410,445,000	$34,430,000	0.78%	$36,713,000	$1,671,000	$72,814,000	$136,000	$72,950,000	207	72	3	1,477	377
Camden	$8,325,943,000	$94,534,000	1.14%	$103,007,000	$4,330,000	$201,871,000	$780,000	$202,651,000	1,122	454	43	1,510	339
Cape Girardeau	$8,792,829,000	$121,786,000	1.39%	$130,253,000	$8,024,000	$260,063,000	$633,000	$260,696,000	372	213	72	2,527	964
Carroll	$1,199,939,000	$30,738,000	2.56%	$37,050,000	$3,432,000	$71,220,000	$95,000	$71,315,000	164	20	0	686	81
Carter	$519,266,000	$21,012,000	4.05%	$13,606,000	$207,000	$34,825,000	$144,000	$34,969,000	137	51	33	513	122
Cass	$10,922,958,000	$53,489,000	0.49%	$38,591,000	$911,000	$92,991,000	$143,000	$93,134,000	162	239	1	2,878	897
Cedar	$1,307,607,000	$13,952,000	1.07%	$14,895,000	$363,000	$29,210,000	$115,000	$29,325,000	3	19	4	485	28
Chariton	$938,756,000	$17,212,000	1.83%	$9,861,000	$144,000	$27,217,000	$55,000	$27,272,000	201	57	0	737	128
Christian	$7,747,900,000	$45,592,000	0.59%	$40,208,000	$1,205,000	$87,005,000	$200,000	$87,205,000	208	150	22	1,944	546
Clark	$709,999,000	$8,106,000	1.14%	$5,727,000	$96,000	$13,929,000	$21,000	$13,950,000	92	2	0	300	32
Clay	$27,589,080,000	$165,453,000	0.60%	$132,741,000	$2,791,000	$300,985,000	$693,000	$301,678,000	551	695	204	4,992	2,989
Clinton	$2,282,850,000	$8,520,000	0.37%	$5,418,000	$49,000	$13,987,000	$5,000	$13,992,000	31	20	0	524	76
Cole	$10,724,282,000	$115,892,000	1.08%	$117,846,000	$2,207,000	$235,945,000	$1,646,000	$237,591,000	234	328	123	3,347	2,267
Cooper	$1,797,081,000	$30,236,000	1.68%	$22,074,000	$659,000	$52,969,000	$80,000	$53,049,000	47	28	8	854	115
Crawford	$2,389,455,000	$57,048,000	2.39%	$46,649,000	$1,068,000	$104,765,000	$296,000	$105,061,000	145	123	27	1,741	469
Dade	$738,641,000	$2,826,000	0.38%	$1,985,000	$75,000	$4,886,000	$11,000	$4,897,000	19	0	0	175	1
Dallas	$1,358,763,000	$13,834,000	1.02%	$7,328,000	$115,000	$21,277,000	$12,000	$21,289,000	39	38	14	775	68
Daviess	$958,602,000	$10,587,000	1.10%	$17,465,000	$2,731,000	$30,783,000	$29,000	$30,812,000	40	15	0	214	4
DeKalb	$1,090,102,000	$4,407,000	0.40%	$3,509,000	$92,000	$8,008,000	$7,000	$8,015,000	70	2	0	184	7
Dent	$1,451,544,000	$17,538,000	1.21%	$12,429,000	$158,000	$30,125,000	$45,000	$30,170,000	31	29	13	557	121
Douglas	$1,047,849,000	$14,913,000	1.42%	$31,131,000	$1,645,000	$47,689,000	$384,000	$48,073,000	40	4	1	210	5
Dunklin	$2,976,060,000	$7,368,000	0.25%	$8,774,000	$152,000	$16,294,000	$57,000	$16,351,000	77	99	0	963	382
Franklin	$11,417,093,000	$256,069,000	2.24%	$225,564,000	$10,346,000	$491,979,000	$1,056,000	$493,035,000	1,368	802	251	7,607	4,052
Gasconade	$1,888,630,000	$53,253,000	2.82%	$35,440,000	$762,000	$89,455,000	$163,000	$89,618,000	192	154	67	1,305	222
Gentry	$689,499,000	$3,412,000	0.49%	$3,177,000	$179,000	$6,768,000	$7,000	$6,775,000	24	1	0	139	5
Greene	$32,106,732,000	$35,964,000	0.11%	$28,723,000	$1,091,000	$65,778,000	$125,000	$65,903,000	532	76	3	1,282	396
Grundy	$1,175,303,000	$5,351,000	0.46%	$5,564,000	$142,000	$11,057,000	$16,000	$11,073,000	21	2	0	201	19
Harrison	$1,024,720,000	$7,899,000	0.77%	$6,869,000	$222,000	$14,990,000	$18,000	$15,008,000	22	8	2	236	34
Henry	$2,536,896,000	$33,854,000	1.33%	$27,551,000	$464,000	$61,869,000	$265,000	$62,134,000	52	100	14	1,351	403

County	Countywide Building Exposure	Structural Damage	Loss Ratio	Contents Loss	Inventory Loss	Total Direct Loss	Total Income loss	Total Direct and Income Loss	# MSDIS Residential Structures Exposed	# Hazus Bldgs Risk	#Substantially damaged	# Displaced People	# Shelter Needs
Hickory	$865,580,000	$8,640,000	1.00%	$6,317,000	$43,000	$15,000,000	$34,000	$15,034,000	23	39	17	296	136
Holt	$622,760,000	$36,137,000	5.80%	$26,892,000	$755,000	$63,784,000	$189,000	$63,973,000	559	297	107	515	155
Howard	$1,086,442,000	$14,826,000	1.36%	$16,209,000	$786,000	$31,821,000	$51,000	$31,872,000	124	36	0	460	148
Howell	$3,550,892,000	$31,472,000	0.89%	$46,797,000	$2,957,000	$81,226,000	$364,000	$81,590,000	347	118	0	1,930	468
Iron	$978,688,000	$8,432,000	0.86%	$6,871,000	$108,000	$15,411,000	$10,000	$15,421,000	306	31	2	465	114
Jackson	$89,309,906,000	$737,320,000	0.83%	$1,044,344,000	$53,377,000	$1,835,041,000	$11,241,000	$1,846,282,000	1,123	1,264	380	7,075	4,426
Jasper	$12,070,483,000	$62,009,000	0.51%	$58,133,000	$1,990,000	$122,132,000	$617,000	$122,749,000	605	393	3	3,958	1,627
Jefferson	$22,249,768,000	$367,906,000	1.65%	$271,767,000	$6,116,000	$645,789,000	$1,766,000	$647,555,000	4,809	2,214	540	13,463	8,981
Johnson	$6,044,509,000	$30,246,000	0.50%	$25,744,000	$686,000	$56,676,000	$100,000	$56,776,000	149	102	5	1,851	428
Knox	$438,423,000	$3,344,000	0.76%	$2,159,000	$34,000	$5,537,000	$2,000	$5,539,000	0	10	0	199	10
Laclede	$3,218,581,000	$30,642,000	0.95%	$38,079,000	$1,803,000	$70,524,000	$234,000	$70,758,000	66	37	2	1,285	236
Lafayette	$3,841,393,000	$14,033,000	0.37%	$12,417,000	$431,000	$26,881,000	$39,000	$26,920,000	25	6	0	568	23
Lawrence	$3,495,760,000	$22,767,000	0.65%	$25,930,000	$1,052,000	$49,749,000	$284,000	$50,033,000	274	135	1	1,828	422
Lewis	$995,873,000	$14,567,000	1.46%	$10,306,000	$189,000	$25,062,000	$224,000	$25,286,000	120	11	2	480	85
Lincoln	$4,719,921,000	$74,186,000	1.57%	$49,864,000	$1,428,000	$125,478,000	$135,000	$125,613,000	830	341	101	2,252	1,008
Linn	$1,551,785,000	$6,767,000	0.44%	$4,965,000	$168,000	$11,900,000	$16,000	$11,916,000	53	13	0	277	61
Livingston	$1,711,120,000	$11,844,000	0.69%	$18,190,000	$1,282,000	$31,316,000	$105,000	$31,421,000	13	25	0	320	100
Macon	$1,634,837,000	$4,989,000	0.31%	$3,724,000	$165,000	$8,878,000	$6,000	$8,884,000	63	3	0	290	10
Madison	$1,135,602,000	$30,199,000	2.66%	$40,721,000	$2,135,000	$73,055,000	$174,000	$73,229,000	196	87	8	1,256	347
Maries	$955,863,000	$14,377,000	1.50%	$7,518,000	$89,000	$21,984,000	$13,000	$21,997,000	47	18	12	268	24
Marion	$3,224,641,000	$40,809,000	1.27%	$37,763,000	$2,116,000	$80,688,000	$95,000	$80,783,000	493	86	43	867	180
McDonald	$1,683,620,000	$36,855,000	2.19%	$24,195,000	$626,000	$61,676,000	$85,000	$61,761,000	315	116	42	1,303	371
Mercer	$401,520,000	$6,197,000	1.54%	$7,572,000	$428,000	$14,197,000	$56,000	$14,253,000	1	10	0	166	23
Miller	$2,404,472,000	$29,949,000	1.25%	$16,289,000	$258,000	$46,496,000	$51,000	$46,547,000	252	213	15	708	193
Mississippi	$1,114,534,000	$13,347,000	1.20%	$13,548,000	$847,000	$27,742,000	$58,000	$27,800,000	188	58	3	533	174
Moniteau	$1,508,058,000	$14,710,000	0.98%	$9,910,000	$283,000	$24,903,000	$17,000	$24,920,000	38	8	0	536	48
Monroe	$979,485,000	$5,943,000	0.61%	$4,176,000	$103,000	$10,222,000	$9,000	$10,231,000	84	1	0	204	8
Montgomery	$1,397,445,000	$6,592,000	0.47%	$5,114,000	$207,000	$11,913,000	$10,000	$11,923,000	46	1	0	235	9
Morgan	$2,872,295,000	$45,451,000	1.58%	$24,822,000	$296,000	$70,569,000	$187,000	$70,756,000	574	707	34	896	217
New Madrid	$1,765,289,000	$59,431,000	3.37%	$71,200,000	$3,454,000	$134,085,000	$558,000	$134,643,000	1,252	486	43	2,919	1,490
Newton	$5,509,504,000	$54,940,000	1.00%	$58,763,000	$2,474,000	$116,177,000	$361,000	$116,538,000	832	412	18	3,796	1,615
Nodaway	$2,447,800,000	$10,093,000	0.41%	$16,674,000	$928,000	$27,695,000	$164,000	$27,859,000	12	4	0	239	3
Oregon	$891,037,000	$13,019,000	1.46%	$14,294,000	$461,000	$27,774,000	$114,000	$27,888,000	117	28	7	322	90
Osage	$1,611,790,000	$41,820,000	2.59%	$20,504,000	$103,000	$62,427,000	$83,000	$62,510,000	1,252	112	63	1,090	242
Ozark	$926,358,000	$12,308,000	1.33%	$14,133,000	$856,000	$27,297,000	$108,000	$27,405,000	142	9	8	254	27
Pemiscot	$1,642,290,000	$334,476,000	20.37%	$316,820,000	$5,942,000	$657,238,000	$2,906,000	$660,144,000	3,849	2,059	746	10,035	7,838
Perry	$2,233,009,000	$26,519,000	1.19%	$17,807,000	$615,000	$44,941,000	$117,000	$45,058,000	90	44	5	951	209
Pettis	$4,468,128,000	$10,829,000	0.24%	$8,812,000	$334,000	$19,975,000	$13,000	$19,988,000	8	21	0	617	140
Phelps	$4,743,488,000	$21,988,000	0.46%	$14,622,000	$189,000	$36,799,000	$79,000	$36,878,000	239	30	9	835	203
Pike	$1,861,578,000	$23,999,000	1.29%	$21,106,000	$1,056,000	$46,161,000	$61,000	$46,222,000	341	143	48	486	64
Platte	$11,360,168,000	$76,465,000	0.67%	$74,818,000	$2,757,000	$154,040,000	$610,000	$154,650,000	181	255	15	1,709	794
Polk	$2,708,704,000	$15,388,000	0.57%	$13,350,000	$272,000	$29,010,000	$120,000	$29,130,000	39	51	2	1,171	165
Pulaski	$5,334,660,000	$79,599,000	1.49%	$48,555,000	$545,000	$128,699,000	$187,000	$128,886,000	202	260	137	2,051	1,314

County	Countywide Building Exposure	Structural Damage	Loss Ratio	Contents Loss	Inventory Loss	Total Direct Loss	Total Income loss	Total Direct and Income Loss	# MSDIS Residential Structures Exposed	# Hazus Bldgs Risk	#Substantially damaged	# Displaced People	# Shelter Needs
Putnam	$532,020,000	$3,679,000	0.69%	$2,133,000	$85,000	$5,897,000	$3,000	$5,900,000	2	5	0	169	7
Ralls	$1,155,646,000	$44,173,000	3.82%	$59,928,000	$5,403,000	$109,504,000	$86,000	$109,590,000	99	33	5	598	142
Randolph	$2,425,165,000	$4,104,000	0.17%	$2,966,000	$90,000	$7,160,000	$13,000	$7,173,000	15	3	0	227	7
Ray	$2,537,055,000	$34,966,000	1.38%	$28,228,000	$626,000	$63,820,000	$180,000	$64,000,000	318	289	0	2,034	712
Reynolds	$669,647,000	$25,922,000	3.87%	$31,244,000	$1,811,000	$58,977,000	$187,000	$59,164,000	180	97	28	698	235
Ripley	$1,131,335,000	$29,116,000	2.57%	$21,287,000	$553,000	$50,956,000	$220,000	$51,176,000	239	129	88	782	344
Saline	$2,437,646,000	$14,892,000	0.61%	$8,902,000	$89,000	$23,883,000	$18,000	$23,901,000	88	14	0	578	74
Schuyler	$401,800,000	$1,919,000	0.48%	$812,000	$2,000	$2,733,000	$0	$2,733,000	0	3	0	104	3
Scotland	$541,487,000	$3,158,000	0.58%	$2,658,000	$49,000	$5,865,000	$19,000	$5,884,000	1	3	0	136	6
Scott	$4,036,288,000	$38,473,000	0.95%	$45,007,000	$2,845,000	$86,325,000	$518,000	$86,843,000	2,260	535	33	3,276	1,812
Shannon	$678,728,000	$9,292,000	1.37%	$6,283,000	$64,000	$15,639,000	$27,000	$15,666,000	119	12	0	302	46
Shelby	$786,622,000	$4,856,000	0.62%	$8,736,000	$539,000	$14,131,000	$9,000	$14,140,000	7	0	0	99	1
St. Charles	$41,845,005,000	$396,021,000	0.95%	$369,753,000	$14,725,000	$780,499,000	$3,206,000	$783,705,000	4,342	1,958	410	9,257	5,933
St. Clair	$936,097,000	$7,781,000	0.83%	$4,927,000	$42,000	$12,750,000	$29,000	$12,779,000	5	6	5	250	16
St. Francois	$6,180,166,000	$48,567,000	0.79%	$40,798,000	$1,236,000	$90,601,000	$278,000	$90,879,000	268	184	32	2,352	877
St. Louis	$138,887,850,000	$1,829,251,000	1.32%	$2,637,150,000	$147,062,000	$4,613,463,000	$18,569,000	$4,632,032,000	11,187	5,498	838	29,468	22,277
St. Louis City	$46,880,213,000	$57,005,000	0.12%	$62,928,000	$2,591,000	$122,524,000	$545,000	$123,069,000	1,075	258	21	1,440	1,142
Ste. Genevieve	$2,163,144,000	$26,703,000	1.23%	$24,007,000	$1,060,000	$51,770,000	$97,000	$51,867,000	531	43	12	808	215
Stoddard	$2,989,130,000	$8,815,000	0.29%	$6,752,000	$334,000	$15,901,000	$19,000	$15,920,000	251	30	1	697	119
Stone	$3,936,498,000	$77,345,000	1.96%	$57,416,000	$1,158,000	$135,919,000	$344,000	$136,263,000	228	163	37	1,524	399
Sullivan	$624,603,000	$4,010,000	0.64%	$6,629,000	$633,000	$11,272,000	$28,000	$11,300,000	3	6	0	208	11
Taney	$6,120,612,000	$106,726,000	1.74%	$86,238,000	$1,421,000	$194,385,000	$521,000	$194,906,000	1,095	517	189	2,558	1,508
Texas	$2,293,426,000	$13,128,000	0.57%	$8,195,000	$155,000	$21,478,000	$14,000	$21,492,000	45	2	2	308	21
Vernon	$2,251,400,000	$7,861,000	0.35%	$3,556,000	$20,000	$11,437,000	$3,000	$11,440,000	12	17	5	369	98
Warren	$3,478,576,000	$22,451,000	0.65%	$18,950,000	$847,000	$42,248,000	$64,000	$42,312,000	107	22	1	788	131
Washington	$1,730,986,000	$8,962,000	0.52%	$5,033,000	$122,000	$14,117,000	$10,000	$14,127,000	117	12	4	431	58
Wayne	$1,256,590,000	$94,209,000	7.50%	$76,403,000	$2,711,000	$173,323,000	$401,000	$173,724,000	576	614	367	2,927	1,397
Webster	$2,782,115,000	$11,569,000	0.42%	$6,808,000	$111,000	$18,488,000	$18,000	$18,506,000	20	34	0	988	171
Worth	$269,532,000	$1,617,000	0.60%	$797,000	$17,000	$2,431,000	$0	$2,431,000	14	0	0	57	0
Wright	$1,602,331,000	$5,912,000	0.37%	$4,208,000	$89,000	$10,209,000	$15,000	$10,224,000	3	0	0	221	10
	$709,564,189,000	$7,304,914,000		$8,025,378,000	$364,357,000	$15,694,649,000	$58,942,000	$15,753,591,000	43,486	26,998	5,833	194,043	96,635

Note: Columns headers in dark blue refer to computations within Hazus; column headers in light blue refer to computations performed outside of the Hazus environment.

B. Total Direct Building Loss and Income Loss to all Counties and the City of St. Louis

	Residential		Agriculture		Commercial		Education		Government		Industrial			
County	# Residential Structures	Total $$ of Loss	# Agriculture Structures	Total $$ of Loss	# Commercial Structures	Total $$ of Loss	# Education Structures	Total $$ of Loss	# Government Structures	Total $$ of Loss	# Industrial Structures	Total $$ of Loss	Total # Population Affected	Total Loss - Hazus Layer
Adair	15	$3,192,420	29	$12,584,24									35	$15,776,662
Andrew	211	$45,455,322	145	$31,443,643	14	$7,914,546			15	$10,957,500	2	$623,895	530	$96,394,907
Atchison	70	$15,500,447	954	$466,443,783	6	$3,780,726			3	$1,419,273	43	$23,030,800	149	$510,175,029
Audrain	139	$27,050,65	127	$29,738,484	21	$13,647,010			6	$3,780,529	3	$3,376,993	359	$77,593,669
Barry	585	$93,300,527	632	$173,079,298	221	$147,303,546	1	$1,667,792	31	$23,543,308	31	$40,822,479	1562	$479,716,949
Barton	145	$25,361,764	291	$66,209,827	60	$37,970,577	1	$1,906,846	2	$1,164,933	10	$14,675,669	349	$147,289,617
Bates	21	$3,713,666	71	$55,000,054	12	$7,143,509	2	$944,561	4	$1,992,200			51	$68,793,991
Benton	175	$27,649,874	5	$4,619,286	1292	$848,681,846					2	$1,896,524	399	$882,847,529
Bollinger	124	$24,791,556	168	$112,379,077	10	$5,823,158							317	$142,993,791
Boone	775	$202,290,325	162	$48,540,066	24	$21,404,276	5	$16,121,006	12	$12,581,277			1868	$300,936,950
Buchanan	632	$141,681,847	639	$155,086,821	69	$65,966,673	6	$6,942,188	113	$99,950,822	507	$659,519,721	1631	$1,129,148,073
Butler	3,185	$584,733,857	2153	$755,888,603	240	$158,952,513	14	$22,597,628	23	$19,644,140	131	$113,478,593	7994	$1,655,295,334
Caldwell	1	$184,997	58	$11,185,798									2	$11,370,795
Callaway	207	$43,643,591	284	$54,997,692	37	$23,223,348	4	$6,613,375	15	$9,676,731	37	$23,105,255	522	$161,259,992
Camden	1,122	$252,163,261	76	$18,201,073	14992	$12,094,779,267			8	$6,172,250	3	$1,987,488	2917	$12,373,303,340
Cape Girardeau	372	$87,272,723	658	$164,378,270	10	$8,260,377			1	$762,156	58	$44,421,323	926	$305,094,849
Carroll	164	$32,761,967	1437	$928,653,267	12	$7,902,740			21	$16,220,235	25	$29,383,051	407	$1,014,921,259
Carter	137	$22,852,496	63	$21,294,000	10	$5,504,096							348	$49,650,592
Cass	162	$41,717,032	264	$71,432,557	67	$36,534,529					27	$12,314,472	426	$161,998,590
Cedar	3	$438,105	13	$4,231,500	28	$16,060,201			1	$652,467			7	$21,382,273
Chariton	201	$36,736,227	650	$667,140,741	30	$18,540,690					1	$616,545	507	$723,034,202
Christian	208	$48,204,047	211	$43,219,338	43	$21,606,608	1	$1,892,433	6	$4,723,500	12	$11,837,640	560	$131,483,566
Clark	92	$15,637,764	196	$141,631,778	16	$8,524,000			2	$853,765			223	$166,647,307
Clay	551	$151,045,375	192	$45,148,845	143	$151,070,167	1	$1,929,165	14	$15,698,048	65	$72,450,963	1433	$437,342,564
Clinton	31	$7,304,425	16	$2,841,633	69	$33,279,022							77	$43,425,080

County	Residential		Agriculture		Commercial		Education		Government		Industrial			
	# Residential Structures	Total $$ of Loss	# Agriculture Structures	Total $$ of Loss	# Commercial Structures	Total $$ of Loss	# Education Structures	Total $$ of Loss	# Government Structures	Total $$ of Loss	# Industrial Structures	Total $$ of Loss	Total # Population Affected	Total Loss - Hazus Layer
Cole	234	$61,262,374	153	$34,750,259	16	$12,796,527	4	$6,352,323	11	$15,466,787	19	$12,049,644	571	$142,677,913
Cooper	47	$9,285,133	119	$26,697,608	127	$66,673,361					5	$3,478,955	116	$106,135,057
Crawford	145	$167,887	179	$206,700	108	$554,899			9	$614,000	5	$755,175	378	$2,298,660
Dade	19	$2,862,359	16	$7,624,000	30	$14,830,070			1	$327,059			44	$25,643,488
Dallas	39	$6,023,596	64	$22,567,226					1	$509,400			102	$29,100,222
Daviess	40	$7,389,328	239	$48,111,027	459	$209,173,479			1	$280,308	4	$3,593,425	106	$268,547,566
DeKalb	70	$16,496,444	30	$6,162,273	10	$60,938,981							174	$83,597,698
Dent	31	$164,856	131	$463,706	38	$769,535					3	$1,239,762	81	$2,637,859
Douglas	40	$5,637,630	85	$72,977,750	4	$3,115,795			4	$2,917,500	6	$4,707,455	102	$89,356,130
Dunklin	77	$12,466,783	132	$48,853,689	3	$1,933,373							188	$63,253,845
Franklin	1,368	$297,298,075	462	$1,472,519	345	$158,837,366	9	$7,742,137	13	$6,218,875	49	$96,204,726	3461	$567,773,698
Gasconade	192	$36,012,668	381	$86,487,000	79	$43,553,651			1	$799,579			451	$166,852,898
Gentry	24	$3,971,592	28	$13,998,486	69	$43,186,418			3	$2,299,286	1	$447,341	57	$63,903,123
Greene	532	$130,296,313	235	$59,666,433	180	$154,470,664	6	$11,228,000	29	$27,182,667	43	$35,835,071	1229	$418,679,147
Grundy	21	$4,047,684	135	$28,683,098	3	$1,809,930			11	$6,808,313			51	$41,349,024
Harrison	22	$4,025,005	108	$21,085,761	1	$671,866							52	$25,782,632
Henry	52	$9,397,590	161	$45,311,000	35	$22,378,067			11	$8,472,063	33	$35,711,000	119	$121,269,720
Hickory	23	$2,625,656	4	$1,347,273									52	$3,972,929
Holt	559	$95,288,291	1190	$319,856,808	25	$11,391,765			21	$9,597,000	27	$14,593,846	1179	$450,727,710
Howard	124	$24,206,632	118	$25,545,127	61	$25,772,729	2	$1,822,174	1	$654,941	1	$429,618	314	$78,431,221
Howell	347	$54,137,634	72	$13,278,056	215	$124,005,085	8	$9,360,970	17	$11,085,297	80	$54,363,385	850	$266,230,426
Iron	306	$48,013,141	384	$106,971,429	10	$4,992,994			2	$1,082,800	22	$24,364,766	753	$185,425,130
Jackson	1,123	$297,260,050	218	$63,320,119	1095	$1,216,751,171	2	$4,444,236	1	$1,429,894	598	$711,502,597	2740	$2,294,708,066
Jasper	605	$118,567,482	282	$87,823,435	140	$107,705,329	3	$6,934,750	5	$4,812,361	28	$26,488,867	1525	$352,332,225
Jefferson	4,809	$958,407,803	653	$5,331,344	752	$302,883,891	13	$22,196,936	19	$13,844,430	163	$243,459,963	12888	$1,546,124,367
Johnson	149	$34,981,008	57	$11,522,444	6	$3,803,298	3	$20,059,923			7	$5,393,989	371	$75,760,662
Knox	0		22	$27,750,462	4	$2,003,733					4	$1,282,600		

	Residential		Agriculture		Commercial		Education		Government		Industrial			
County	# Residential Structures	Total $$ of Loss	# Agriculture Structures	Total $$ of Loss	# Commercial Structures	Total $$ of Loss	# Education Structures	Total $$ of Loss	# Government Structures	Total $$ of Loss	# Industrial Structures	Total $$ of Loss	Total # Population Affected	Total Loss - Hazus Layer
Laclede	66	$164,067	119	$217,704	22	$663,128					18	$859,444	172	$1,904,344
Lafayette	25	$5,559,495	103	$12,383,099	13	$8,784,637					1	$595,866	61	$27,323,097
Lawrence	274	$48,627,405	116	$45,177,451	60	$31,067,865			16	$7,520,000	16	$14,222,938	712	$146,615,659
Lewis	120	$22,092,048	297	$212,111,036	29	$13,684,940			4	$1,623,158	30	$23,916,923	294	$273,428,105
Lincoln	830	$189,182,582	804	$2,165,660	43	$68,353,931			1	$1,374,650			2382	$261,076,822
Linn	53	$9,985,535	111	$9,985,535	22	$13,154,812			1	$628,231			134	$48,665,734
Livingston	13	$2,530,013	56	$14,549,547	2	$1,608,236							31	$18,687,795
Macon	63	$10,907,135	243	$50,150,655	14	$8,277,943							153	$69,335,733
Madison	196	$29,994,462	130	$31,215,600	77	$45,552,169			3	$1,750,875	4	$3,102,892	515	$111,615,997
Maries	47	$178,381	47	$206,381	10	$591,282							115	$976,043
Marion	493	$108,496,971	128	$28,438,400	78	$48,218,516			10	$7,168,387	12	$9,692,222	1198	$202,014,496
McDonald	315	$48,274,835	322	$155,352,615	26	$11,756,717					13	$11,712,058	854	$227,096,226
Mercer	1	$242,103	18	$13,497,750									2	$13,739,853
Miller	252	$42,422,296	149	$35,890,605	996	$537,206,347			6	$3,120,000	5	$2,671,965	658	$621,311,213
Mississippi	188	$30,559,058	482	$156,650,000	2	$909,350							453	$188,118,408
Moniteau	38	$7,729,937	134	$28,992,854	2	$959,045			3	$2,630,250			100	$40,312,086
Monroe	84	$13,977,919	69	$21,075,667	20	$7,865,668							204	$42,919,254
Montgomery	46	$8,007,282	244	$55,073,695	8	$4,235,824							109	$4,235,824
Morgan	574	$91,349,823	96	$21,404,632	5813	$3,370,363,960					3	$1,417,148	1464	$3,484,535,563
New Madrid	1,252	$219,784,761	985	$257,413,333	28	$15,530,226	9	$13,970,250	20	$9,683,571	12	$16,634,215	3117	$533,016,357
Newton	832	$149,877,828	208	$38,859,077	202	$128,338,427	11	$35,125,026	5	$3,716,974	17	$11,296,748	2180	$367,214,080
Nodaway	12	$2,905,236	52	$15,897,017	3	$1,879,871			2	$1,175,643			27	$21,857,768
Oregon	117	$16,413,713	271	$146,410,937	79	$45,016,444	2	$2,876,000	8	$4,344,000	4	$1,421,807	290	$216,482,901
Osage	254	$51,653,184	468	$296,227,862	47	$29,992,302			1	$672,059	30	$46,606,957	665	$425,152,363
Ozark	142	$20,354,069	232	$89,937,554	211	$105,849,470			1	$591,000	2	$1,799,938	315	$218,532,030
Pemiscot	3,849	$673,477,516	1147	$289,961,600	221	$119,162,357	36	$61,497,000	25	$17,842,708	18	$20,613,877	9738	$1,182,555,059
Perry	90	$20,285,553	573	$2,991,325	23	$3,821,900			1	$400,000	1	$1,800,771	29	$29,299,549

County	Residential		Agriculture		Commercial		Education		Government		Industrial			
	# Residential Structures	Total $$ of Loss	# Agriculture Structures	Total $$ of Loss	# Commercial Structures	Total $$ of Loss	# Education Structures	Total $$ of Loss	# Government Structures	Total $$ of Loss	# Industrial Structures	Total $$ of Loss	Total # Population Affected	Total Loss - Hazus Layer
Pettis	8	$1,514,980	28	$7,766,111					13	$12,076,594			20	$21,357,685
Phelps	239	$211,900	119	$189,330	30	$699,978	2	$2,031,980	5	$914,872			602	$4,048,060
Pike	341	$67,023,567	126	$587,619	111	$39,270,852			2	$2,261,806	19	$4,957,894	842	$114,101,737
Platte	181	$55,708,197	109	$27,181,777	82	$71,359,460			26	$30,855,741	42	$37,870,378	445	$222,975,553
Polk	39	$6,723,541	47	$10,716,000	14	$7,037,198			3	$2,148,667	3	$1,088,952	98	$27,714,358
Pulaski	202	$287,984	132	$200,140	13	$639,233	4	$1,199,591			2	$518,606	574	$2,845,554
Putnam	2	$298,837	18	$13,739,000							10	$7,082,778	4	$21,120,614
Ralls	99	$18,345,527	172	$36,816,390	30	$12,413,014			5	$3,395,500	24	$31,126,652	250	$102,097,083
Randolph	15	$2,717,538	7	$3,326,273	12	$7,898,904			2	$1,451,806			41	$15,394,521
Ray	318	$72,134,138	502	$182,858,327	22	$12,229,749			4	$2,778,727	11	$8,777,340	836	$278,778,282
Reynolds	180	$30,722,780	66	$219,478	33	$9,344,317					29	$2,936,846	432	$43,223,420
Ripley	239	$33,092,545	137	$188,054	26	$17,283,108					2	$3,574,200	614	$54,137,908
Saline	88	$19,961,648	205	$87,019,485	5	$3,173,184					2	$1,078,256	218	$111,232,574
Schuyler	0		20	$14,320,000										$14,320,000
Scotland	1	$181,996	14	$13,764,800	10	$6,859,130			1	$1,443,923			3	$22,249,850
Scott	2,260	$56,193,903	937	$256,181,436	85	$56,193,903			7	$5,286,697	23	$21,174,139	5695	$754,802,232
Shannon	119	$17,927,962	169	$907,442	96	$7,524,243	13	$1,776,094	3	$540,571	1	$81,309	298	$28,757,622
Shelby	7	$1,287,751	31	$7,593,045	3	$1,214,446							17	$10,095,242
St. Charles	4,342	$1,295,502,491	2199	$32,261,531	957	$824,448,956	6	$15,426,708	52	$80,195,101	182	$391,234,729	11506	$2,639,069,515
St. Clair	5	$689,952	11	$5,134,643	6	$4,205,574							12	$10,030,169
St. Francois	268	$56,985,979	47	$381,635	360	$144,975,457			6	$1,491,846	14	$13,941,508	624	$217,776,425
St. Louis	11,187	$2,703,525,540	483	$82,866,179	4350	$1,932,785,282	33	$52,165,654	124	$91,400,900	767	$1,708,051,261	27296	$6,570,794,816
St. Louis City	1,075	$342,815,214	1	$1,949,500	260	$396,071,617			20	$546,659,455	1585	$2,064,207,620	2365	$3,351,703,406
Ste. Genevieve	531	$107,955,280	274	$581,913	35	$35,192,039					34	$24,090,404	1317	$167,819,636
Stoddard	251	$45,390,024	640	$158,620,690	7	$12,057,500					2	$1,332,363	610	$217,400,577
Stone	228	$42,105,869	299	$78,790,333	1892	$1,005,888,356	11	$15,655,750	5	$2,570,000	3	$1,131,423	552	$1,146,141,732
Sullivan	3	$446,918	8	$2,214,359	11	$5,468,196					2	$1,349,182	8	$9,478,654

	Residential		Agriculture		Commercial		Education		Government		Industrial			
County	***# Residential Structures***	***Total $$ of Loss***	***# Agriculture Structures***	***Total $$ of Loss***	***# Commercial Structures***	***Total $$ of Loss***	***# Education Structures***	***Total $$ of Loss***	***# Government Structures***	***Total $$ of Loss***	***# Industrial Structures***	***Total $$ of Loss***	***Total # Population Affected***	***Total Loss - Hazus Layer***
Taney	1,095	$239,482,799	1136	$238,783,758	447	$313,736,103	4	$4,713,481	25	$17,700,000	16	$5,691,748	2661	$820,107,889
Texas	45	$8,239,248	136	$253,085	9	$3,077,361							120	$11,569,694
Vernon	12	$2,265,421	32	$20,291,097									30	$22,556,518
Warren	107	$37,219,701	499	$1,114,427	15	$19,567,829			1	$2,053,167			293	$59,955,123
Washington	117	$18,879,941	221	$118,756	30	$6,536,319			4	$1,044,178	4	$1,386,173	312	$27,965,367
Wayne	576	$77,495,936	461	$106,004,389	33	$17,215,902	9	$9,223,200					1400	$209,939,426
Webster	20	$3,361,691	125	$30,034,341	5	$2,476,009			5	$3,144,375	1	$550,545	56	$39,566,961
Worth	14	$2,616,727	48	$32,529,600							1	$430,692	32	$35,577,020
Wright	3	$492,534	29	$63,771									7	$556,304

Figure 3.59. Hazus Countywide Base-Flood Scenarios: Building Exposure

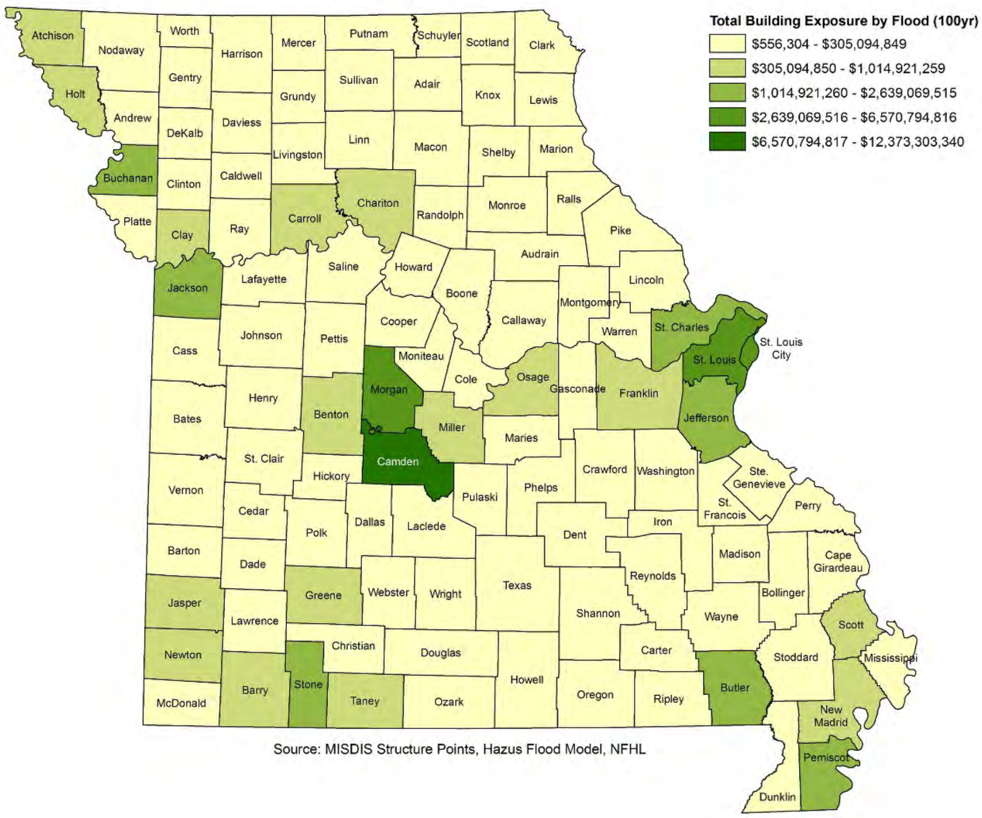


Figure 3.60. Hazus Countywide Base-Flood Scenarios: Building Impacted Ratio

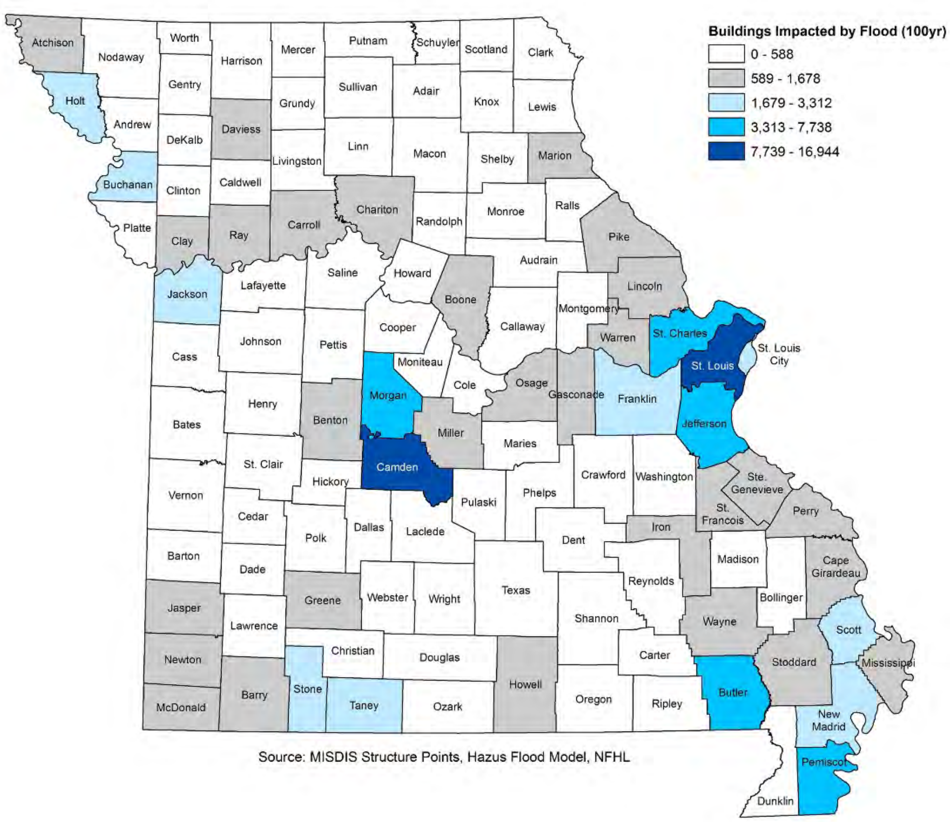
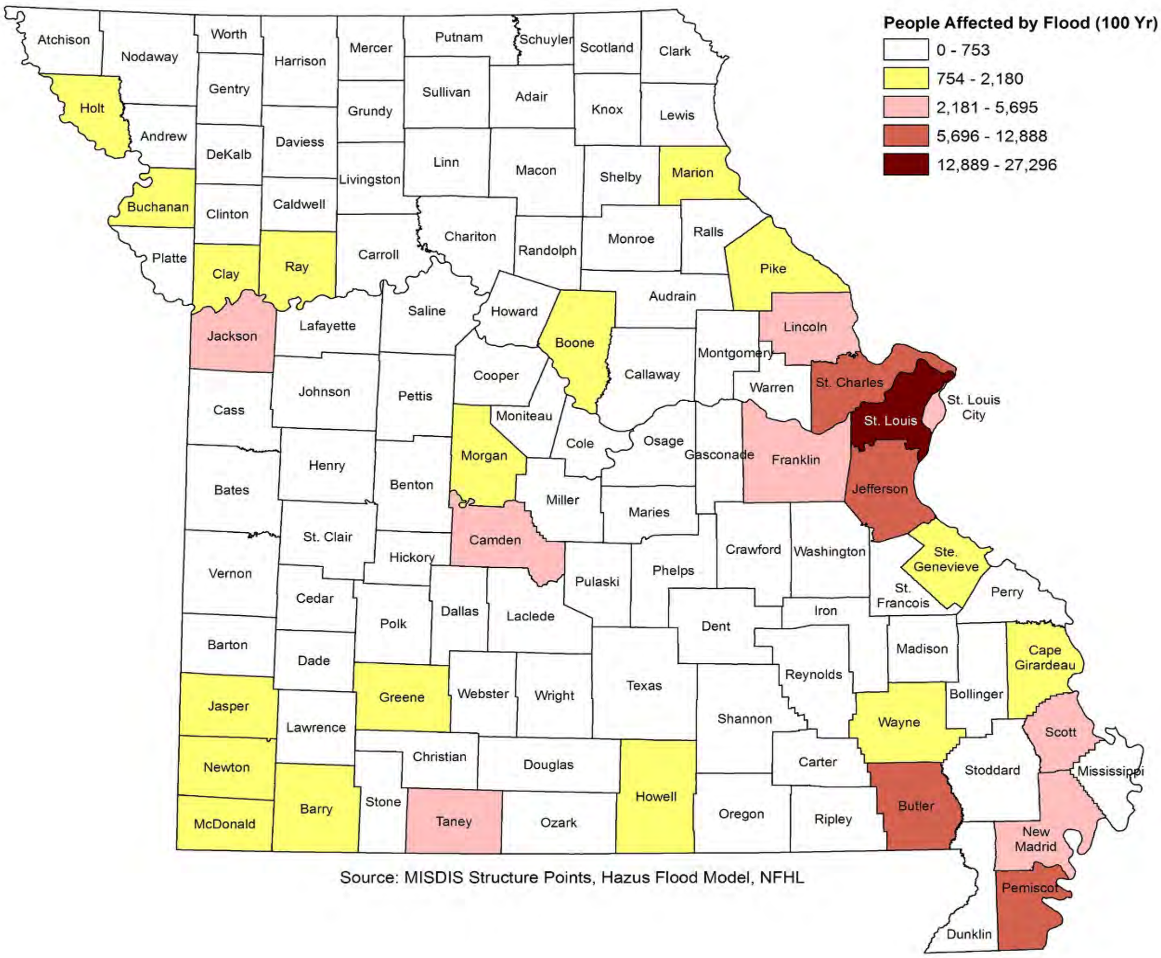


Figure 3.61. Hazus Countywide Base-Flood Scenarios: Displaced People



Source: MISDIS Structure Points, Hazus Flood Model, NFHL

Using the GIS Analysis with the FEMA special flood hazard areas and the MSDIS structure points described earlier, it is estimated that more than 43,486 Missouri households are within the special flood hazard area. In addition, thousands of other Missouri residents are at risk to the dangers of flash flooding from rapidly rising creeks and tributaries, storm water runoff, and other similar flooding events. Nationwide, most flood deaths are from flash floods, and nearly half of these fatalities are auto-related, according to the NWS.

Hazus analyzes loss estimates for critical infrastructure and facilities as well, including vehicle losses, utility system losses, essential facility impacts, transportation impacts, as well as agricultural losses. Hazus also provides the results in more detail, and some results, spatially. Project files for each county are available for use by local governments from SEMA by contacting the SHMO.

Levees may not be detected on the computer terrain models for the Hazus only county analysis. Thus, some communities that may be protected from 1-percent-annual-chance flood events from levees may be modeled by Hazus as inundated and the risk may be overestimated. These results, for those counties with levee protection, should be considered as the “worst-case scenario” and may represent losses that could result from a levee breach.

Lastly, it should be noted that the loss estimates previously presented in Table 3.34 have been adjusted to maintain consistency between the other hazard (earthquakes) modeled using FEMAs Hazus software. Results derived from earthquake runs in Hazus and the flood analysis are aggregated to the census tract level, data which has been updated by FEMA to reflect the 2010 census effort.

Agricultural Losses

Historically the southeast Missouri Bootheel region is where the State's prime agricultural lands are located, in the lowlands of the Mississippi River floodplain. Therefore, historically this area has seen the most dramatic losses from excess moisture/rain and flooding. This analysis has shown a slight shift in the largest losses per county. Counties in the Bootheel region still top the list but the top 5 counties ranked by total loss included the northeast region of the State over the last 5 years. Stoddard County in the Bootheel region sustained the most losses over the period, followed by Audrain, New Madrid, Pike and Shelby Counties. Over the five-year period, $777,866,981 in agricultural losses were realized statewide. The top five counties accounted for $112,672,196 in losses. There were no counties in the state that did not sustain some losses over the period analyzed.

Table 3.35 presents the actual recorded insurance payments due to flood-related crop losses Statewide from 2012-2016 for the top ten counties by total loss. These losses are caused by excess moisture and flooding. Note, from the January 2017 Missouri Crop Insurance Report, the percent of insured crop acreage statewide was 92-percent.

Table 3.35. Recorded USDA Crop Insurance Losses

County	2012	2013	2014	2015	2016	Grand Total
Stoddard	$344,316	$8,782,483	$5,500,784	$6,520,277	$7,664,965	$28,812,826
Audrain	$973,580	$1,134,222	$791,187	$21,852,880	$452,196	$25,204,066
New Madrid	$479,458	$7,426,593	$3,987,505	$9,426,484	$3,085,689	$24,405,730
Pike	$120,407	$3,614,292	$1,980,227	$16,635,442	$270,813	$22,621,182
Shelby	$704,864	$2,697,133	$972,552	$16,955,139	$298,701	$21,628,390
Lewis	$408,102	$3,397,578	$1,576,051	$15,306,941	$302,021	$20,990,693
Holt	$1,659,398	$1,971,826	$1,485,805	$13,206,294	$1,635,537	$19,958,861
Barton	$559,147	$10,103,017	$890,560	$7,084,910	$563,852	$19,201,487
Vernon	$320,605	$7,746,873	$988,839	$9,563,041	$513,037	$19,132,396
Chariton	$570,716	$2,396,539	$1,194,688	$12,658,808	$474,623	$17,295,375
Total	$6,140,593	$49,270,556	$19,368,202	$129,210,219	$15,261,438	$219,251,009

Hazard Impact on Future Growth and Development

To determine the jurisdictions that are most vulnerable to flood losses and are also increasing in population and housing units, the top 10 counties at risk to the 1-percent-annual-chance flood event for building loss, loss ratio and displaced population were compared against the top 10 counties experiencing population gains and housing gains. St. Charles County, Clay County and Boone County appear at the top of the lists for population gain with Christian and Pulaski Counties rounding out the top five. St. Louis County, Jackson County, St. Louis City, St. Charles County and Greene are the top five counties for countywide building exposure with a total exposure for the group of $376,618,786 with 49% of that being in St. Louis area. Pemiscot County resulted in the greatest loss ratio with Wayne, Holt, Carter and Reynolds Counties completing the top five lists. St. Louis County tops the list for building losses followed by Jackson, St. Charles, Jefferson and Pemiscot Counties. St. Louis County is the greatest impacted by the displaced population with Jefferson, Pemiscot, St. Charles and Franklin Counties filling out the top five lists.

The counties experiencing the most development pressures all participate in the National Flood Insurance Program. Therefore, flood risk should not be increasing; assuming that floodplain ordinances are being effectively implemented and wise use of floodplains is being encouraged.

SEMA's Floodplain Management Section is actively updating mapping to reflect the risk from flooding across the state. Thirty-two counties are currently in the process of being updated. Development pressures is a key factor in the prioritization of counties within the Five-Year Business Plan for funding requests.

EMAP Consequence Analysis

The information in **Table 3.36** is from the Impact Analysis of Potential for Detrimental Impacts of Hazards done for the Emergency Management Accreditation Program.

Table 3.36. EMAP Impact Analysis: Flooding

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

Risk Summary

Floods are often accompanied by other types of severe weather, including tornadoes, lightning, and severe thunderstorm activity. These storms also present a danger to life and property, often resulting in many injuries, and in some cases, fatalities. Floodwaters themselves often interact with hazardous materials. This has prompted the evacuation of many citizens near such materials stored in large containers that could break loose or puncture as a result of flood activity.

Public health concerns that may result from flooding include the need for disease and injury surveillance, community sanitation to evaluate flood-affected food supplies, private water and sewage sanitation, and vector control (for mosquitoes and other entomology concerns).

Problem Statement:

Using the indicators of Building Loss, Lost Ratio and Displaced Persons and the top ten counties with the highest risk for these indicators, the data suggests that it would be most feasible to spend effort and dollars on mitigating losses in these top ten locations. Mitigation efforts for buyouts, floodproofing and insurance awareness to reduces losses to structures would most likely prove most helpful in St. Louis City and Jackson, St. Charles, Jefferson, Pemiscot, Franklin, Boone, Clay and Cape Girardeau Counties. Mitigation efforts for displaced populations such as partnerships with agencies providing temporary housing would most likely prove most effective in St. Louis City and Jefferson, Pemiscot, St. Charles, Franklin, Boone, Jackson, Butler, Clay and St. Louis Counties. Mitigation efforts focused on a combination of buyouts, floodproofing, insurance awareness and pre-staging of emergency response resources would most likely prove helpful for Pemiscot, Wayne, Holt, Carter, Reynolds, Ralls, New Madrid, Gasconade, Butler and Pemiscot Counties.

Flood Risk Products

There are a variety of products available to communities which detail flood risk and which were utilized in the 2018 risk assessment. These products are described below along with source information.

Flood Hazard Information Products (Regulatory)

- **Flood Insurance Rate Map (FIRM)** - The official map of a community on which FEMA has delineated both the special hazard areas and the risk premium zones applicable to the community.
- **Flood Insurance Study (FIS)** - A Flood Insurance Study (FIS) is a compilation and presentation of flood risk data for specific watercourses, lakes, and coastal flood hazard areas within a community. When a flood study is completed for the NFIP, the information and maps are assembled into an FIS. The FIS report contains detailed flood elevation data in flood profiles and data tables.
- **FIRM Database and National Flood Hazard Layer -** These databases are compilations of digital GIS data representing the same information presented on the FIRMs, and in the FIS report. The GIS data is designed to provide the user with the ability to determine the flood zone, base flood elevation and the floodway status for a particular location in their own mapping software.

Flood Risk Products (Non-Regulatory)

For those communities that have been through the Risk MAP process (see **Figure 3.52**), the following additional flood risk resources are available.

- **Flood Risk Map (FRM)** - The FRM depicts flood risk data for a flood risk project area. Typical maps might show the potential flood losses associated with the 1-percent annual chance flood event for each census block, areas planned for new or revised maps, key watershed features that affect local flood risk and information about potential or successful past projects to reduce flood risk
- **Flood Risk Report (FRR)** - The FRR provides community and watershed specific flood risk information extracted from the Flood Risk Database (FRD), explains the concept of flood risk and identifies useful tools and reference materials. The FRR, used in combination with Flood Risk Map (FRM), is a good tool for communities to use for raising local flood risk awareness
- **Flood Risk Database (FRD)** - The FRD stores all flood risk data for a flood risk project, including the information shown in the Flood Risk Report (FRR) and on the Flood Risk Map (FRM). The FRD provides a wealth of data that may be used to analyze, communicate and visualize flood risk on an ad-hoc basis for a variety of uses. Elements in the FRD include:
  - **Changes Since Last FIRM** shows where the Special Flood Hazard Area (SFHA) has changed since the last effective Flood Insurance Rate Map (FIRM)
  - **Areas of Mitigation Interest** (AOMI) communicates where conditions have contributed to the severity of flooding losses, allowing for better prioritization of flood mitigation efforts and use of funds
  - **Flood Depth and Analysis Grids** communicate the depth and velocity of floodwaters as well as the probability of an area being flooded over time. Available grids include:
    - Water Surface Elevation Grid' (WSEL) which is attributed with the base flood elevation data
    - Percent Annual Chance' grid that uses the WSEL to calculate the percent annual chance of flooding for each grid cell
    - '30-Year Percent Chance Flood grid' that represents the percent chance of flooding for a location along a flooding source over a 30-year period (or over the life of the typical mortgage).
  - **Flood Risk Assessment Data** provides an assessment of potential financial consequences and other impacts associated with structures located in a SFHA.

Flood Risk Data Sources

- **FEMA Flood Map Service Center (MSC)** - the official online resource for all flood hazard mapping products created under the National Flood Insurance Program (NFIP), including your community's flood map, called a Flood Insurance Rate Map (FIRM). https://msc.fema.gov/portal
- **Missouri Hazard Mitigation Viewer -** 2018 risk assessment data and mapping is available through the Missouri Hazard Mitigation Viewer: http://bit.ly/MoHazardMitigationPlanViewer2018.
- **Missouri Hazard Mitigation Viewer User Guide -** A User Guide on how to navigate the Missouri Hazard Mitigation Viewer website and data export features is presented in Appendix A1.
- **How to Identify Mitigation Actions Using Flood Risk Data and Products** - This User Guide was developed as training material for SEMA Mitigation Workshops in 2017 and assists in identifying mitigation projects using the Risk MAP products. It is included in Appendix B.
- **SEMA Local Mitigation Plan Outline** workshops and training materials will be updated in the summer of 2018 to include how to utilize the Risk MAP data and the Missouri Hazard Mitigation Viewer.

3.3.2. Levee Failure

Probability	Severity
100% 100 events in 70 years	Moderate

Description/Location

Levees are earth embankments constructed along rivers and coastlines to protect adjacent lands from flooding. Nationwide, approximately 30,000 miles of levees protect communities, infrastructure, and property. Floodwalls are concrete structures, often components of levee systems, designed for urban areas where there is insufficient room for earthen levees. When levees and floodwalls and their appurtenant structures are stressed beyond their capabilities to withstand floods, levee failure can result in loss of life and injuries as well as damages to property, the environment, and the economy. Levees are usually engineered to withstand a flood with a computed risk of occurrence.

USACE

The U.S. Army Corps of Engineers (USACE) is tasked nationally with the development and maintenance of the National Levee Database (NLD) which serves as the primary source of information for this risk assessment. The USACE is currently working with States and private owners to perform a national comprehensive Inventory and Review Effort (I&R). The mission of this effort is to collect critical information about each levee similar to the National Inventory of Dams inventory. The current NLD includes information on inspections and risk assessments, levee condition information, identification and characterization of flood risks associated with the levee collected to help inform repair and rehabilitation needs, partners for flood risk management, investments, flood fighting and emergency management activities. The USACE is conducting the I&R effort and one-time inspection for the levees in the inventory as a precursor and key component of a National Levee Safety Program currently authorized, but not funded, by Congress as Title IX of the Water Resources Development Act of 2007, as amended by Section 3016 of the Water Resources Reform and Development Act of 2014.

The USACE is currently working closely with the State of Missouri in I&R effort. The latest version of the NLD includes a previous dataset known as the Missouri Levee Inventory (MLI) and thus supersedes it as a data source. In Missouri, there are an estimated 1,926 miles of levees, many of which were largely constructed to protect agricultural land and are not built to design standards established to protect people and property. Missouri's levee systems are part of the greatest concentration of levees in the lower 48 states as shown in **Figure 3.62** below.

Figure 3.62. The U. S. Levee System

Source: The 2017 USACE National Levee Inventory (NLD) displayed in ArcGIS 10.2

The presence of levees can, in some cases, generate a false sense of security. If a larger flood occurs, then that structure will likely be compromised. In the event of a levee failure, the water behind it can be released as flash flood. Failed levees can create floods that are catastrophic to life and property in part because of the tremendous energy of the released water. **Figure 3.63** depicts a levee failure that occurred in Lincoln County, MO.

Figure 3.63. 2008 Levee Failure in Missouri

Source: Jocelyn Augustino, FEMA, Elsberry, MO -- A levee in the Elsberry levee district breaks, flooding farmland and houses in the area.

Levees in Missouri in the USACE Levee Safety Program:

In Missouri, there are currently 182 levee systems in the USACE Levee Safety Program. Of those, 23 are considered to be designed to provide protection from the 1-percent-annual-chance flood event. An additional seven are designed to provide protection from the 0.2-percent-annual-chance flood event. The remaining levees provide protection against lower level flooding that occurs more frequently than the 1-perecent annual chance flood. To see the full extent of the NLD or to export the sections of levees for a local analysis, please visit the Missouri Hazard Mitigation Viewer at http://bit.ly/MoHazardMitigationPlanViewer2018 or from the USACE at http://nld.usace.army.mil.

According to the latest system inspection report from the USACE NLD, there are 28 levee systems within the USACE levee safety program in the state of Missouri that received an unacceptable rating from routine maintenance inspections conducted prior to January 2018. The levee systems that received an unacceptable rating are shown in **Table 3.37.** The full listing of all levees is not added to the table to preserve space in the document but may be extracted from the Missouri Hazard Mitigation Viewer in a CSV format and opened as an Excel table using the procedure described in the Mitigation Viewer User Guide found in Appendix A1.

Table 3.37. Missouri Levee Systems with Unacceptable Ratings

System Name	USACE District	County	Sponsor(s)	Last Routine Inspection Date
Elk Chute Levee System	Memphis	Dunklin, Pemiscot	Elk Chute Dd	12/9/2016
Castor River Levee System	Memphis	Bollinger, Cape Girardeau, Stoddard, Wayne	Little River Dd	11/22/2016
Consolidated North County Levee System	St. Louis	Saint Charles	Consolidated North County Levee District	11/21/2016
Greens Bottom Levee Sec2 System	St. Louis	Saint Charles	Greens Bottom Levee District, Section 2	10/21/2016
Mo University Levee System	St. Louis	Saint Charles	Missouri Dept Of Conservation (University Levee)	10/6/2016
Darst Levee System	St. Louis	Saint Charles	Darst Bottom Levee District, Section 2	10/6/2016
Stone Murdoch Levee System	St. Louis	Pike	Stone Murdock Levee District	9/26/2016
Kissinger Levee System	St. Louis	Pike	Kissinger Levee District	9/26/2016
Winfield Pin Oaks Levee System	St. Louis	Lincoln	Winfield Levee and Drainage District (Pin Oaks Levee)	9/19/2016
Dutzow / Augusta Levee System		Saint Charles, Warren	Augusta Bottom Levee Association, Dutzow Bottom Levee District	9/14/2016
Brevator Levee System	St. Louis	Lincoln	Brevator Drainage District	9/14/2016
Sandy Creek Levee System	St. Louis	Lincoln	Sandy Creek Drainage District	9/12/2016
Elsberry / King's Lake System	St. Louis	Lincoln, Pike	Elsberry Drainage & Levee District, Kingâ€™S Lake Drainage District	9/7/2016
Pike Grain Levee No. 1 Levee System	St. Louis	Pike	Pike Grain Company (No. 1 Levee)	9/1/2016
Pike Grain Levee No. 2 Levee System	St. Louis	Pike	Pike Grain Company (No. 2 Levee)	8/31/2016
Pike Grain Levee No. 4 Levee System	St. Louis	Pike	Pike Grain Company (No. 4 Levee)	8/31/2016
Pike Grain Levee No. 3 Levee System	St. Louis	Pike	Pike Grain Company (No. 3 Levee)	8/31/2016
L-536-550 Turkey Crk LB, Rock Crk LB, Mo Riv LB, & Mill Crk RB	Omaha	Atchison, Holt	Atchison County Levee District No. 1, Unknown Non-Project Sponsor	8/26/2016
L-550 - Rock Creek LB & Turkey Creek RB	Omaha	Atchison	Atchison County Levee District No. 1	8/25/2016
L-550-561 - Missouri River LB	Omaha	Atchison, Nemaha	Atchison County Levee District No. 1	8/25/2016
L-561 - Nishnabotna LB	Omaha	Atchison	Atchison County Levee District No. 1	8/23/2016
Missouri Bottoms Levee System	St. Louis	Saint Louis	Missouri Bottom Levee District	8/31/2015
Elm Point Levee System	St. Louis	Saint Charles	Elm Point Levee Association	8/31/2015
St Louis Flood Protection Project System	St. Louis	Saint Louis City, Saint Louis	St. Louis City Street Dept. / Metropolitan St. Louis Sewer District	8/25/2015
Kuhs Levee System	St. Louis	Saint Charles	Kuhs Levee District	7/31/2014
Greens Bottom Levee Sec1 System	St. Louis	Saint Charles	Greens Bottom Levee District, Section 1	7/24/2014

System Name	USACE District	County	Sponsor(s)	Last Routine Inspection Date
Ring Levee Drainage District/North Inter-River Drainage District	Little Rock	Butler	North Inter-River Drainage District, Ring Levee Drainage District	9/13/2010
Reorganized Butler County Drainage District No. 7	Little Rock	Butler	Reorganized Butler County Drainage District No. 7	6/18/2008

Source: USACE NLD; http://nld.usace.army.mil/egis/f?p=471:58:994716546449901::NO

An unacceptable rating means a project has one or more deficient conditions that can be reasonably foreseen to prevent the project from functioning as designed, intended, or required. This information reflects a snapshot in time. It is dynamic and subject to change as projects are re-inspected, owner's correct deficiencies and new data becomes available.

National Flood Insurance Program (NFIP)

The National Flood Insurance Program (NFIP) defines a levee system in Title 44, Chapter 1, Section 59.1 of the Code of Federal Regulations (44 CFR 59.1) as a flood risk reduction system that consists of a levee, or levees and associated structures like closure and drainage devices that are constructed and operated with sound engineering practices to protect aa specified area. It is a manmade structure, generally earthen that is designed and constructed with sound engineering practices to contain, control or divert the flow of water to provide temporary protection from flooding.

FEMA states on its Levee Resource Library website that it does not build, own or certify levees. The USACE is responsible for the building and maintaining levee's in its inventory and for inspection of its inventory. There may be states, communities and private levee owners that have responsibility for maintaining and operating levees according to specific guidelines. The State of Missouri does not currently have a Levee Safety Program and does not currently own or operate any levees.

> FEMA's role, and thus SEMA's role as the Cooperating Technical Partner (CTP) for the State is to "*identify, analyze, and map the flood hazards associated with levees, and depict accreditation on Flood Insurance Rate Maps (FIRMs) for those levee systems for which the appropriate certification documentation has been submitted. Specifically, a levee system that is designed to reduce the hazard from the 1%-annual-chance flood may be accredited by FEMA, and areas immediately behind them mapped as a moderate-hazard zone. In order for a levee system to be accredited, a community must provide data demonstrating that the levee system is in compliance with the requirements outlined in Section 65.10 of the National Flood Insurance Program regulations. Once FEMA determines compliance with Section 65.10 has been demonstrated, the levee system can be shown as accredited on the effective FIRM panels. However, just because a levee system has been accredited on the map, does not mean that people or the property behind the levee are protected – the risk of flooding may have only been reduced, not removed. Levees can fail or be overtopped by more extreme events and the flooding that follows can be catastrophic. That is why FEMA strongly recommends that residents and business owners living near all levees carry flood insurance.*"

For levees depicted on a FIRM showing protection for the base flood elevation, FEMA categorizes levees into one of 2 categories: 1) Accredited and 2) Non-Accredited. Accredited levees are ones in which the levee owner has provided data to FEMA demonstrating that the levee system in in compliance with Section 65.10. If a community is the process of a mapping update and the levee accreditation process is underway, a special note can be placed on the FIRMs called a Provisionally Accredited Levee or PAL note which is a temporary designation denoting that the levee owners are undergoing the accreditation process and are expecting to reach accreditation within 2 years. If accreditation has not been reached during that timeframe, a mapping project to remove the note and depict the risk without the levee is initiated.

In July 2013, FEMA Released its Levee Analysis and Mapping Procedure (LAMP) for Non-Accredited Levees New Approach which outlines the approach to use for analyzing and mapping areas of risk on the landward side of non-accredited levee systems. Previously, if a levee accreditation was not attained, an analysis called "without levee analysis" removed the levee from the prediction modeling completely and modeled as if it were not there at all and those results were shown on the mapping. A more refined approach was introduced with the LAMP process which specified a four-prong approach to modeling to make the final determination of the risk for these areas. These four components include:

1. Conducting the without levee scenario now more aptly named Natural Valley Procedure which results in a new Zone D designation,
2. Conducting an interior drainage analysis inside the protected area (landward of the levee) which assumes the levee stays in place,
3. Conducting an analysis of the flooding source assuming the levee stays in place (wet side of the levee) and
4. Merging the three resultant identified risk areas (SFHAs).

The merged results are then mapped for each levee reach. A reach is defined individually per levee system and is a continuous length of a system to which a single analysis may be applied and a mapping designation may be given. Reaches may be mapped as one of five designations depending on the analysis results: Sound Reach, Freeboard Deficient, Overtopping, Structural-Based Inundation or Natural Valley.

- **Sound Reach** is a single section of levee of any length which operates as it was designed and built to do providing protection from a base flood event. This differs from an accredited levee in that it is a section of the system working properly where the whole system may not function properly.
- **Freeboard Deficient** in which the base flood is contained by the levee but it cannot meet the freeboard standard (distance between normal water level and the top of the structure).
- **Overtopping** is applied when the base flood is above the crest of the levee but the reach is not anticipated to fail structurally.
- **Structural-Based Inundation** (also known as Breach Analysis) is for reaches with known structural integrity issues that may provide some protection by impeding some flooding conveyance but not all. It does not predict the exact location that a breach may occur or the likelihood of a breach simply a scenario that could occur for that reach.

Natural Valley is modeling as if the levee reach were not present or a return to the natural ground surface before the levee was built.

Levees in Missouri Recognized through the RiskMAP Program on FEMA Digital Flood Insurance Rate Maps (DFIRMs) as Providing Protection from the 1% Annual Chance Flood:

Many levees shown on effective FIRMs were originally mapped in the 1970s and 1980s. FEMA has made a concerted effort to update these FIRMs through the RiskMAP Program. Prior to 1986, levees were shown on FIRMs as providing protection from the base flood (accredited) when they were designed and constructed in accordance with sound engineering practices. Since 1986, levees have been accredited on FIRMs only when they meet the requirements of 44 CFR 65.10 “Mapping Areas Protected by Levee Systems,” including certification by a registered professional engineer or a Federal agency with responsibility for levee design.

Levees that do not meet the requirements of 44 CFR 65.10 cannot be accredited on a FIRM. Furthermore, areas behind the levee and at risk to base flood inundation are mapped as high-risk areas subject to FEMA’s minimum floodplain management regulations and mandatory flood insurance purchase requirement.

As DFIRMs are developed, levees fall under one of the four following mapping categories:

1) Accredited Levee - With the exception of areas of residual flooding (interior drainage), if the data and documentation specified in 44 CFR 65.10 is readily available and provided to FEMA, the area behind the levee will be mapped as a moderate-risk area. There is no mandatory flood insurance purchase requirement in amoderate-risk area, but flood insurance is strongly recommended.

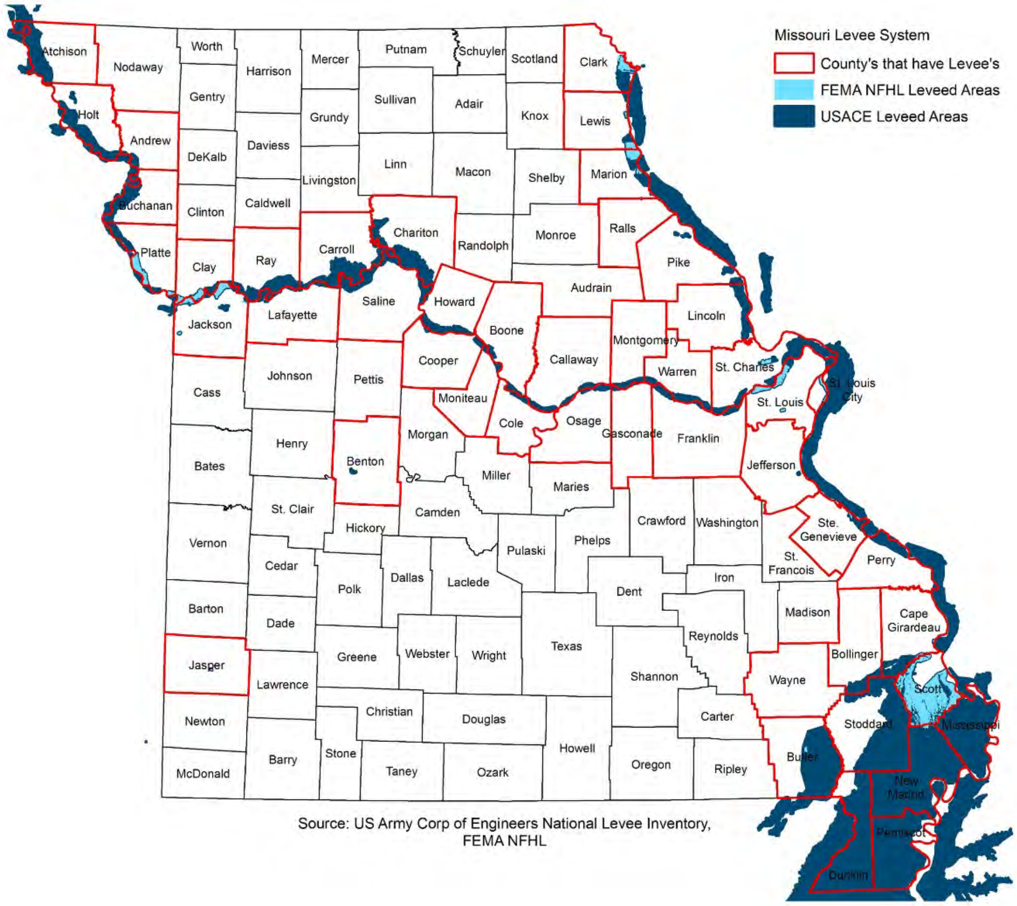
2) Provisionally Accredited Levee (PAL) - If data and documentation is not readily available, and no known deficiency precludes meeting requirements of 44 CFR 65.10, FEMA can allow the party seeking recognition up to two years to compile and submit full documentation to show compliance with 44 CFR 65.10. During this two-year period of provisional accreditation, the area behind the levee will be mapped as moderate-risk with no mandatory flood insurance purchaserequirement.

3) De-Accredited Levees – If the information established under 44 CFR 65.10 is not readily available and provided to FEMA, and the levee is not eligible for the PAL designation, the levee will be de-accredited by FEMA. The area behind the levee will be mapped as a high-risk area subject to mandatory flood insurance purchase requirement.

4) Never Accredited Levees - levees that have never been shown on a FIRM as meeting the criteria of 44CFR65.10.

Of the 114 Missouri counties, and the City of St. Louis, 47 have levees (shown in red outline in **Figure 3.64**); of the 47 counties, 17 have levees showing protection on current FEMA FIRMs.

Figure 3.64. Missouri Counties Impacted by Levees



provides the accreditation status of levees in these 17 counties plus the City of St. Louis as of March 2018. Since Levee Systems are made up of many Levee Reach names, these levee system reaches can be found by exporting the NLD dataset on the Hazard Mitigation Viewer website for a particular county or area from the USACE website.

Table 3.38. Levee Accreditation Status in DFIRM Counties in Missouri

County Name	Primary Community	Levee Owner	USACE Program Levee	Levee Status	Mapping Updates Underway
Andrew	Amazonia	Amazonia Levee District	Yes	De-accredited	No
Buchanan	Buchanan County Unincorporated Areas	Halls Levee District	Yes	PAL	Yes
Buchanan	Buchanan County Unincorporated Areas	Halls Levee District	Yes	PAL	Yes
Buchanan	St. Joseph & Buchanan County Unincorporated Areas	South St. Joseph Drainage District	Yes	PAL	Yes
Butler	Poplar Bluff	Butler County Drainage District No. 12	Yes	PAL	Yes
Butler	Butler County Unincorporated Areas	Central Clay Drainage District	Yes	LAMP	Yes
Butler	Butler County Unincorporated Areas	North Inter-River Drainage District	Yes	LAMP	Yes
Butler	Butler County Unincorporated Areas	Reorganized Butler County Drainage District No. 7	Yes	LAMP	Yes
Butler	Butler County Unincorporated Areas	Ring Levee Drainage District	Yes	LAMP	Yes

County Name	Primary Community	Levee Owner	USACE Program Levee	Levee Status	Mapping Updates Underway
Cape Girardeau	City of Cape Girardeau	City of Cape Girardeau	Yes	PAL	Yes
Clark	Alexandria	Des Moines & Mississippi Levee District #1	Yes	PAL	No
Clay	Kansas City, MO	Birmingham Drainage District	Yes	PAL	No
Clay	Kansas City, MO; North Kansas City	City of Kansas City, MO	Yes	Accredited	No
Clay	North Kansas City	North Kansas City Levee District	Yes	PAL	No
Franklin	New Haven	City of New Haven	Yes	Accredited	No
Franklin	Franklin County Unincorporated Areas	Berger Levee District	Yes	PAL eligible	Yes
Franklin	Franklin County Unincorporated Areas	Labadie Bottom Levee District	Yes	PAL eligible	Yes
Franklin	Franklin County Unincorporated Areas	St. Albans Partners Levee District	Yes	PAL eligible	Yes
Franklin	Franklin County Unincorporated Areas	St. Johns Bottom Levee District	Yes	PAL eligible	Yes
Jackson	Kansas City MO	City of Kansas City MO	Yes	PAL	No
Jackson	Jackson County Unincorporated Areas	Atherton Levee District	Yes	PAL	No
Jackson	Jackson County Unincorporated Areas	Atherton-Blue Mills Levee District	Yes	PAL	No
Jackson	Kansas City MO	GSA	Yes	Accredited	No
Jackson	Levasy	Northeast Industrial District (East Bottom)	Yes	Not PAL Eligible	No
Lewis	Canton	City of Canton	Yes	PAL	No
Marion	Hannibal	City of Hannibal	Yes	Accredited	No
Marion	Marion County Unincorporated Areas	South River Drainage District	Yes	PAL	No
Marion	Marion County Unincorporated Areas	Fabius River Drainage District	Yes	Accredited	No
Montgomery County	Montgomery County Unincorporated Areas	Tri-County Levee District	Yes	PAL eligible	Yes
Platte	Platte County Unincorporated Areas	Waldron Levee District	Yes	PAL	No
Platte	Platte County Unincorporated Areas	Farley-Beverly Levee District	Yes	PAL	No
Platte	Riverside	Riverside-Quindaro Bend Levee District	Yes	PAL	No
Platte	Riverside	Riverside-Quindaro Bend Levee District	Yes	PAL	No
Scott	Scott County Unincorporated Areas	Little River Drainage District	Yes	Accredited	No
St. Charles	City of St. Peters	City of St. Peters	Yes	Accredited	No
St. Charles	Unincorporated Areas	St Charles County	Yes	De-accredited	No
St. Louis	Chesterfield; St. Louis County Unincorporated Areas	Monarch-Chesterfield Levee District	Yes	Accredited	Yes
St. Louis	Maryland Heights; Bridgeton; Unincorporated Areas	Earth City Levee District	Yes	Accredited	Yes
St. Louis	Bridgeton	Missouri Bottoms Levee District	Yes	Not PAL Eligible	Yes
St. Louis	Maryland Heights	Riverport Levee District	Yes	Accredited	Yes
St. Louis	Maryland Heights; Chesterfield	Howard Bend Levee District	Yes	Accredited	Yes
St. Louis	Valley Park	City of Valley Park	Yes	Accredited	Yes

County Name	Primary Community	Levee Owner	USACE Program Levee	Levee Status	Mapping Updates Underway
St. Louis City	City of St. Louis	City of St. Louis	Yes	Accreditation Underway	Yes
Ste. Genevieve	St. Genevieve City	St. Genevieve County Levee District No. 3	Yes	De-accredited	Yes
Warren	Warren County Unincorporated Areas	Tri-County Levee District	Yes	Accredited	Yes

Source: Federal Emergency Management Agency, as of August 2017.

Other known levees:

There are also other levees throughout the State that are intended to mitigate low-level flooding and/or protect agricultural land that are not in the USACE Levee Safety Program nor recognized on FEMA FIRMs. These levees may provide a false sense of security to residents. Information about these levees is very limited. As mapping updates are being developed, these “berms” are identified with the new LiDAR topography, as available, and are being addressed in the new engineering models.

There are non-DFIRM counties which have only paper FIRMS. These counties currently have mapping projects underway through a temporary FEMA funding allocation, Paper Inventory Reduction (PIR). The PIR counties with levees currently shown as providing protection are undergoing review by the SEMA CTP and FEMA RVII for PAL eligibility, and are presented in **Table 3.39**.

Table 3.39. PIR Counties and Levee Status in Missouri

County Name	Primary Community	Levee Owner	Levee Status	Mapping Updates Underway
Atchison	Atchison County Unincorporated Areas	District	PAL eligible	Yes
Dunklin	Dunklin County Unincorporated Areas	St. Francis River District #4	PAL eligible	Yes
Holt	Holt County Unincorporated Areas	Cannon Levee District	PAL eligible	Yes
New Madrid	New Madrid County Unincorporated Areas	St. John’s Levee District	PAL eligible	Yes
Mississippi	Mississippi County Unincorporated Areas	Levee District No. 3	PAL eligible	Yes
Pemiscot	Pemiscot County Unincorporated Areas	St. Francis Levee District	PAL eligible	Yes
Stoddard	Stoddard County Unincorporated Areas	Little River Drainage District	PAL eligible	Yes

Source: FEMA, Map Service Center, https://msc.fema.gov/portal

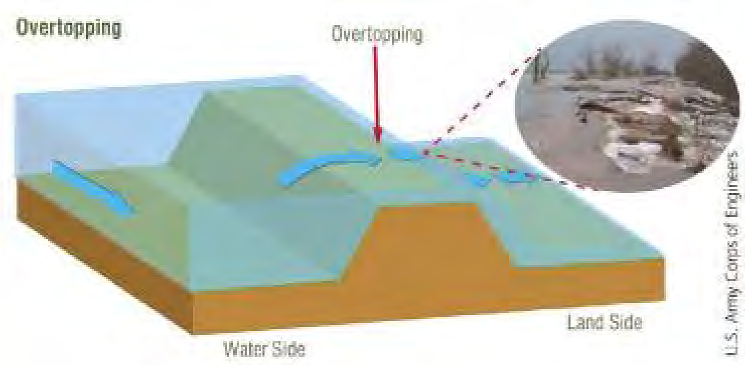
Extent

Levee failure can mean either *breaching* or *overtopping* of a levee. A levee breach is when part of the levee structure breaks away leaving an opening for water to rush through. Similar to dam failures, levee failures during flooding events damage assets with the velocity of the water caused by sudden release resulting in a flood surge or flood wave downstream. If the levee is overtopped as a result of flood waters in excess of the levee design, impacts are similar to flood impacts plus water may become trapped behind the levee in unbreeched areas, unable to drain quickly.

Overtopping: When a Flood is Too Big

Overtopping occurs when floodwaters exceed the height of a levee and flow over its crown. As the water passes over the top, it may erode the levee, worsening the flooding and potentially causing an opening, or breach, in the levee (see **Figure 3.65**).

Figure 3.65. Overtopping: When a Flood Is Too Big

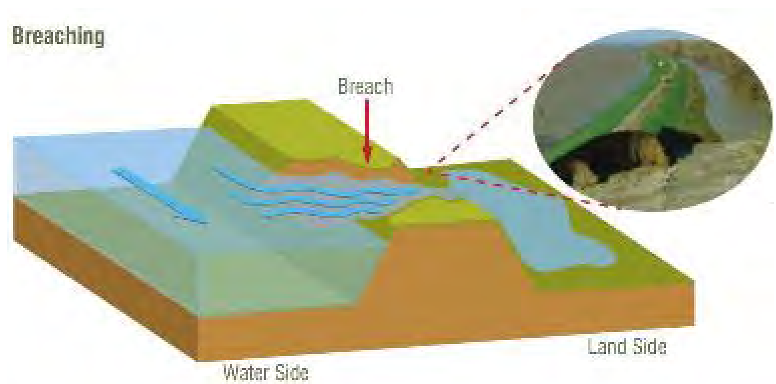


Breaching: When a Levee Gives Way

A levee breach occurs when part of a levee gives way, creating an opening through which floodwaters may pass (see **Figure 3.66**). A breach may occur gradually or suddenly. The most dangerous breaches happen quickly during periods of high water. The resulting torrent can quickly swamp a large area behind the failed levee with little or no warning.

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

Figure 3.66. Breaching: When a Levee Gives Way

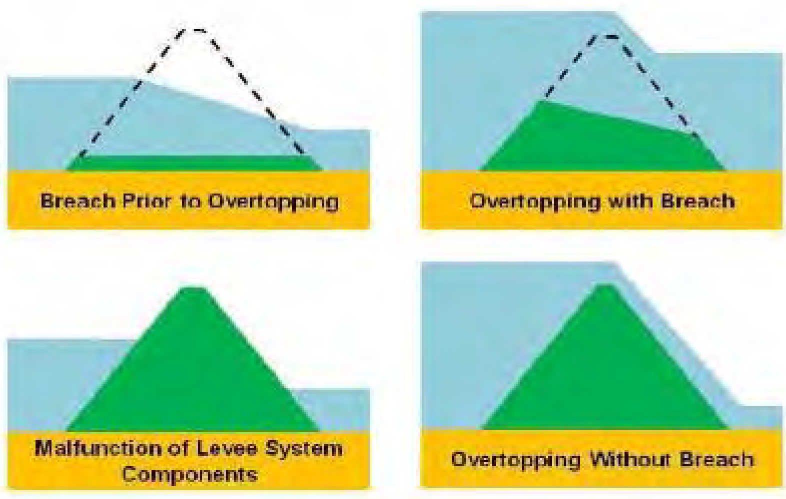


Levees are usually engineered to withstand a flood with a computed risk of occurrence. Many levees in Missouri were largely constructed to protect agricultural land and are not built to design standards established to protect people and property. Their presence can, in some cases, generate a false sense of security. If a larger flood occurs, then that structure will likely be overtopped. If during the overtopping the levee fails or is washed out, the water behind it can be released as a flash flood. Failed levees can create floods that are catastrophic to life and property in part because of the tremendous energy of the released water.

The 2013 USACE report “Hazard Mitigation Actions in Relation to State Hazard Mitigation Plans – Kansas and Missouri” presents a more refined classification scheme of levee inundation risk. In this report, a total of four scenarios are defined as posing inundation risk to the area landward of a levee system. Furthermore, the term “levee failure” was qualified as “non-desired performance.” The four inundation scenarios, as shown on **Figure 3.67** are:

- Overtopping without breach
- Breach due to overtopping
- Breach before overtopping
- Non-performance of a component (such as a gate) that lead to flooding of the protected area.

Figure 3.67. Inundation Scenarios



According to the NLD, levees in the State of Missouri that are accredited against the 0.2 % and 1% annual chance flood provide protection for close to 2,200 square miles of land. The multitude of privately-constructed and maintained levees provide protection for an even greater expanse of agricultural land. Should major flood events similar to the 1993 flood strike, the severity of damage to human lives and properties from all levee failures is expected to be high. While the US Army Corps of Engineers have done major levee reconstruction for levees that are in the PL84-99 program following the 1993 flood, proper inspection, diligent maintenance, and timely repair are key to controlling the severity of levee failure damage in the event of another catastrophic flood.

Flood severity categories defined by the National Weather Service would also apply to levee failure severity categories to describe the corresponding levee reaches. The first three of these flood categories—minor, moderate, and major flooding—are bounded by an upper and lower flood stage, with flood stage defined as an established gage height for a given location at which a rise in water surface level begins to create a hazard to lives, property, or commerce.

The severity of flooding at a given stage is not necessarily the same at all locations along a levee reach due to varying channel and bank characteristics. Therefore, the upper and lower stages for a given flood category are usually associated with water levels corresponding to the most significant flood impacts somewhere in the reach.

The flood severity categories are defined as:

- Minor Flooding - minimal or no property damage, but possibly some public threat (e.g., inundation of roads)

- Moderate Flooding - some inundation of structures and roads near stream, evacuations of people and/or transfer of property to higher elevations
- Major Flooding - extensive inundation of structures and roads, significant evacuations of people and/or transfer of property to higher elevations
- Record Flooding - flooding which equals or exceeds the highest stage or discharge observed at a given site during the period of record. The highest stage on record is not necessarily above the other three flood categories – it may be within any of them or even less than the lowest, particularly if the period of record is short (e.g., a few years)

The NWS has also defined three response levels for alerting the public as to the danger of floods, as described in **Table 3.27**.

Table 3.40. National Weather Service Flood Response Levels/Activities

Alert Level	Definition
Flood Watch	Atmospheric and hydrologic conditions are favorable for long duration areal or river flooding
Flood Warning	Long duration areal or river flooding is occurring or is imminent, which may result from excessive rainfall, rapid snow melt, ice jams on rivers or other similar causes
Flood Advisory	Thunderstorms have produced heavy rainfall that may result in ponding of water on roadways and in low-lying areas, as well as rises in small stream levels, none of which pose an immediate threat to life and property

Source: National Weather Service

Previous Occurrences

Table 3.41 below, provides a history of levee damage for the lower Missouri River for selected levee districts from 1942 through 1993 as noted in the Preliminary Report of the Scientific Assessment and Strategy Team (1994). Some of the text that follows this table is duplicated in the Flooding Section but is repeated here in the event that only this section is pulled out by the end user.

Table 3.41. History of Levee Damage in Missouri, 1942-1993

Levee District (Area) Name	Damage Years
Mittler et al	’45, ’46, ’52, ’53 ’58, ’66, ’73, ’82, ’86, ‘93
Darst Bottoms	’44, ’50, ’58 ’60, ’61, ’73, ’86 ‘93
Labadie Bottoms	’42, ’47, ’51, ’58, 66, ’73, ’86, ‘93
Pinckney-Peers	’42, 44, ’48, ’51, ’73, ’86, ‘93
Berger Bottoms	‘42, ‘44, ‘48, ’51, ‘57, ‘61, ’73, ’86, ‘93
Overton Bottoms	’42, ’47, ’48, ’51, ’57, ’65, ’73, ’82, ’86, ‘93
Lisbon Bottoms	’43, ’44, ’48, ’52, ’59, ’60, ’67. ’69, ’73, ’79, ’82, ’86, ‘93
Cambridge	’82, ’83, ’84, ’85, ‘93
Rhoades Island	’61, ’73, ’74, ’82, ’83, ’84, ’86, ‘93
Miami-DeWitt	’43, ’47, ’51, ’67, ‘93

Source: Preliminary Report of the Scientific Assessment and Strategy Team, 1994

Flood of 1993

In 1993, the Midwest Flood brought issues related to levees to the forefront. The flood approached or exceeded the 100-year threshold on most major rivers and resulted in overtopping or failure of large numbers of levees, most of them agricultural levees that provided various levels of damage/risk reduction. As a result of this flooding, 840 of Missouri's estimated 1,456 levees were damaged (http://www.sej.org/publications/tipsheet/levee-threats-gaining-attention).

Although only a few of the levee systems that were credited as providing 100-year protection were overtopped or failed, several levee systems protecting major urban areas, including parts of the City of St. Louis, were threatened. Had the flood been larger, these levee systems could also have been overtopped or failed. The single most costly levee failure during the Midwest Flood was the Monarch- Chesterfield Levee at Chesterfield, Missouri. This levee was an agricultural levee that had been upgraded during the early 1980s and was credited by FEMA as providing protection from the 100-year flood. Once the levee was credited, industrial and commercial development occurred. On July 30, an area of some 4,700 acres occupied by office and industrial parks, a large general aviation airport owned by St. Louis County government and a five-mile stretch of Interstate 64 disappeared under 10 feet of water. When floodwaters threatened the levee, most businesses bought flood insurance. When the levee failed, more than $13 million in claims were paid. This translated to 5 percent of the total claims for the entire Midwest Flood. This levee has since been rebuilt and upgraded to provide 500-year flood protection. Because the levee break was in the upstream portion of the valley contained by the Monarch Levee, the floodwaters were very slow to drain out of that basin even as the level of the river dropped. Flood damage was estimated at more than $320 million in 2006 dollars.

Table 3.42 provides the number of failed or overtopped federal and non-federal levees in each USACE District during the 1993 flood event throughout the Midwest. Please note, these levee failure statistics are for the entire Midwest region impacted by the 1993 floods, not just the State of Missouri.

Table 3.42. Number of Failed or Overtopped Federal and Non-Federal Levees by USACE District—1993 Midwest Floods

USACE District	Federal	Non-Federal
St. Paul	1 of 32	2 of 92
Rock Island	12 of 73	19 of 185
St. Louis	12 of 42	39 of 47
Kansas City	6 of 48	810 of 810
Omaha	9 of 31	173 of 210
Totals	40 of 226	1043 of 1345

Source: http://www.nwrfc.noaa.gov/floods/papers/oh_2/great.htm

In response to the effects of the flood of 1993, the White House established the Scientific Assessment and Strategy Team (SAST) to provide scientific advice and assistance to policymakers and officials responsible for flood recovery and river basin management in the Upper Mississippi River Basin. According to the SAST, approximately 5 to 7 percent of the floodplain (13,000 to 18,000 acres) was substantially damaged as a result of the levee breaches during the 1993 flood within the reach from Glasgow, Missouri to St. Louis, Missouri (about 225 river miles). Eyewitness accounts indicate that the majority of levee breaches were caused by overtopping, subsequent incision by gullies, and rapid flood- flow erosion. However, levee failures may have also been caused by underflow and piping beneath the levees, and by interflow piping within the levee structure itself.

2007 Flooding

According to a CBS news, at least 20 levees were overtopped as floodwaters made their way down Missouri streams and rivers. Nine levee breaks inundated the town of Big Lake, Missouri in Holt County. The broken levees included five on the Missouri River and four smaller levees along the Tarkio River and the Tarkio Creek (none of them operated by USACE. Levee breaks or overtopping were also reported in the following counties: Ray, Carroll, Clay, Chariton, Lafayette, Jackson, Saline and Platte. (Source: https://www.cbsnews.com/news/failing-levees-spur-major-missouri-floods/)

2008 Flooding

March— SEMA's situation report noted levee failures occurred on the Black River near Poplar Bluff, in Butler County, and in Stoddard County.

June—Several cities were wholly or partially flooded by levee failures or overtopping, including Clarksville, Winfield, Foley, and St. Charles. According to a news report, the Winfield case was especially illustrative of the fragility of some levees in the protection system, as the flood waters broke through a 3-inch tunnel dug by a muskrat and poured water out under pressure like a fire house. Many volunteers and National Guard troops were able to keep most other levees intact.

2011 Flooding

April— On April 26, 2011, the same levee that failed in the 2008 flooding near Poplar Bluff, Butler County, failed again in at least four locations along a two-mile stretch along the Black River. The threat of levee failure at another location prompted the evacuation of 1,000 people. This particular levee failed a federal inspection in 2008, receiving an "unacceptable" rating from the USACE. (Source: http://edition.cnn.com/2011/US/04/26/missouri.levee.failure/)

May – On Tuesday May 3, 2011 flooding occurred in Mississippi County when the USACE created a breach in the Birds Point-New Madrid floodway to relieve flooding in Cairo, IL by denotation of explosive along a reach of the levee. The explosion could be heard 20 miles away. Although the USACE said that flowage easements for the farmland affected by the breach allowed this action, it was an extremely controversial event that ended with a class action lawsuit being filed by many of the farmers flooded. The USACE contented that the floodway plan had not been needed since 1937 when the river had reached 59.5 feet at Cairo. It was predicted to crest at 63 feet by the National Weather Service. Breaching was predicted to drop the crest by 3-4 feet to relieve what USACE officials called "unprecedented pressure" on the system. Losses to Missouri residents totaled close to $1 billion dollars most of which was covered by crop insurance as if it were a natural disaster. (Source: http://www.stltoday.com/news/local/metro/missouri-farmland-swamped-after-levee-breach-to-help-cairo-ill/article_3c73c9f8-74ff-11e0-a74d-0019bb30f31a.html)

June— On June 13, 2011, two levees broke along the Missouri River in northwest Missouri. The first breach described by a local official and the USASCE as a "full breach" nearly 50 feet wide occurred in Atchison County. The second breach occurred in Holt County near the Atchison/Holt County lines. (Source: http://www.cnn.com/2011/US/06/13/missouri.levee.breach/index.html).

June – On June 19, 2011 a levee in Atchison County protecting Big Lake breached near Corning, Missouri with the river breaking the historic crest record for the area at 44.6 feet. The flooding was caused by record high snowfall in the Rocky Mountains coupled with near-record spring rainfall in Montana. (Source: https://web.archive.org/web/20110621210128/http://www.kansascity.com/2011/06/19/2961113/overtopped-levees-prompt-evacuations.html) Flooding and overtopping of levees occurred along the

Missouri River corridor from Council Bluff Iowa to Jefferson City Missouri throughout the month of June.

2013 Flooding

June — On June 3, 2013, residents of West Alton in St. Charles County experienced a levee overtopping on the Mississippi River near U. S. 67 and Lincoln Shields Access Rd. The breach was 100-150 foot section of the levee. The following day the Consolidated North County Levee on the Missouri River side breached. Approximately 500 residents were warned to evacuate. The Mississippi River hit about 40 feet and the Missouri River hit 34 feet. (Source: http://news.stlpublicradio.org/post/flooding-forces-evacuation-west-alton-communities-fight-rising-waters-across-region#stream/0)

2015 Flooding

December — On December 29, 2015, once again the residents of West Alton underwent evacuations as the levees were overtopped. The Mississippi river crested at 17 feet above flood stage, making it the second highest recorded crest behind only the 42.72 crest on August 1, 1993. (Source: http://fox2now.com/2015/12/29/west-alton-residents-evacuating-because-of-mississippi-flood-waters/)

2017 Flooding

May — On May 3, 2017 heavy rains in Randolph County and southern Missouri breached the Black River levee in Pocahontas Arkansas just across the Stateline after 10-15 inches of rain fell in a one week period. New water level records were set in the Midwest during this week of storms, 12 of them in Missouri. (Source: https://www.washingtonpost.com/news/capital-weather-gang/wp/2017/05/03/the-aerial-views-of-historic-missouri-and-arkansas-flooding-are-unreal/?utm_term=.8c11bd870aa1)

Probability of Future Hazard Events

Given the numerous levee systems constructed along the main stems and tributaries of Missouri River and Colorado River, the State of Missouri is susceptible to catastrophic levee failure and/or overtopping. Not counting the great flood of 1993, for the 70-year period from 1942 to 2017 for which levee failure statistics are available, over 100 levee failures/overtoppings were recorded. In the flood of 1993 alone, 840, or over 55% of the levees in the State sustained significant damages. The USACE through its Levee Safety Program Annual Inspection programs help to minimize this threat. The probability of future events is 100%.

Changing Future Conditions Considerations

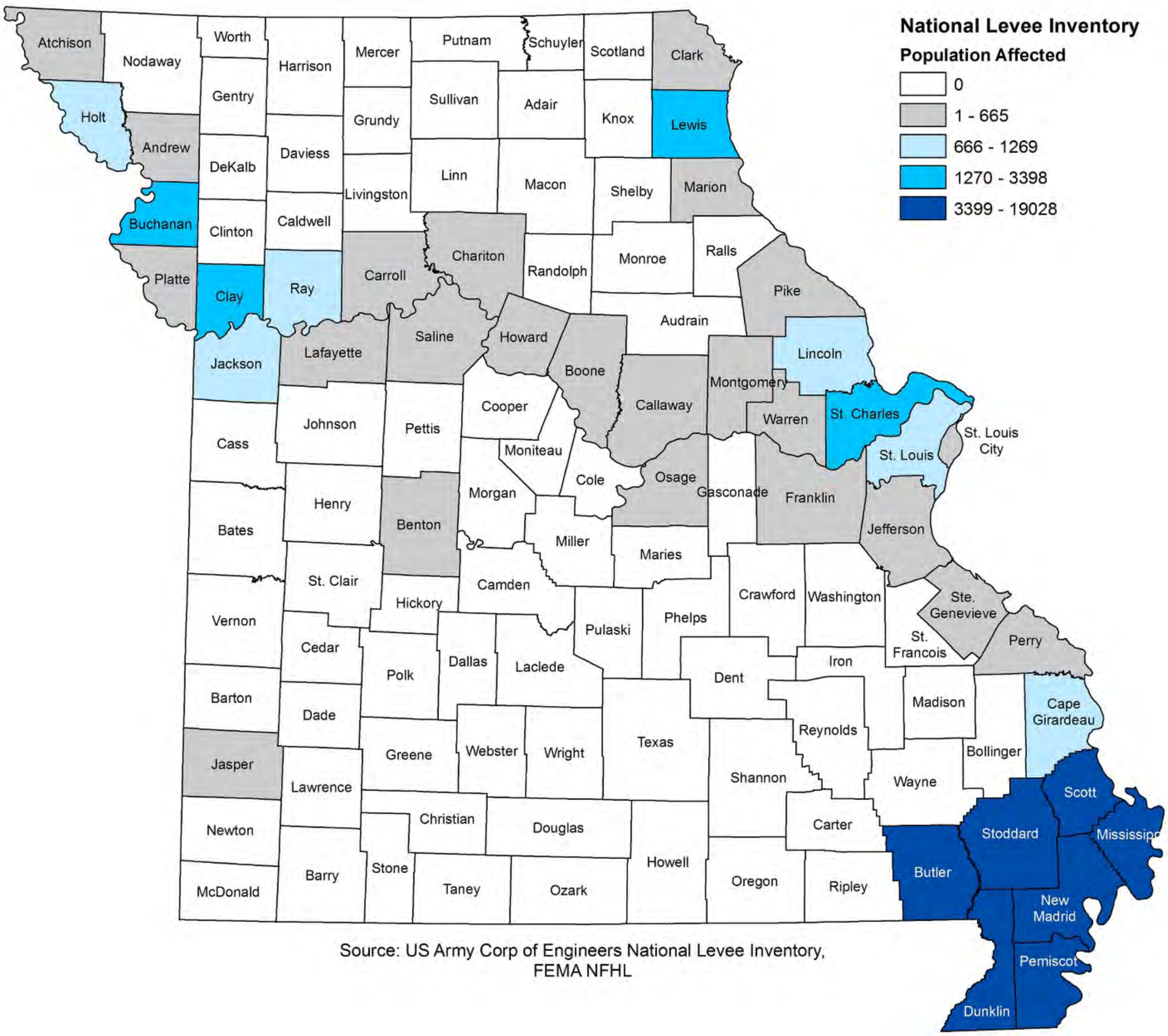
The impact of changing future conditions on levee failure will most likely be related to changes in precipitation and flood likelihood. Climate change projections suggest that precipitation may increase and occur in more extreme events, which may increase risk of flooding, putting stress on levees and increasing likelihood of levee failure. Furthermore, aging levee infrastructure and a lack of regular maintenance (including checking for seepage and removing trees, roots and other vegetation that can weaken a levee) coupled with more extreme weather events may increase risk of future levee failure.

State Vulnerability Overview

Levees have been constructed across the State of Missouri by public entities and private entities with varying levels of protection, inspection oversight and maintenance. The National Levee Safety Program Act of 2007 directed the development of a national levee safety program, in addition to the inventory and inspection of levees. As previously mentioned, two concurrent nation-wide levee inventory development efforts led by USACE and FEMA have captured the majority of levees in the State of Missouri, with the NLD focusing on the Corps' active PL84-99 program levees and the MLI focusing on levees that provide protection from 1 percent annual or higher base flood level. In fall of 2012, USACE and FEMA conducted a pilot project to integrate the NLD and MLI levees for FEMA Region VII into a single dataset, which covers the entire State of Missouri. This database continues to be further refined resulting in Missouri having a comprehensive levee GIS inventory that is spatially accurate and that reflects the best available information about levees from both federal agencies in the NLD. This data was used for high-level levee failure vulnerability analysis. **Table 3.38** is a summary of levee systems in the State of Missouri known to provide protection from 100-year or higher base flood on the FEMA FIRMs. As part of the Risk MAP program, FEMA requires levee owners seeking recognition of 1-percent or greater flood protection on the FIRM to provide proof that levees do indeed meet the levee requirements of 44 CFR 65.10. This levee accreditation process ensures that properties shown as protected by a levee are indeed provided the level of protection as indicated on the FIRM.)

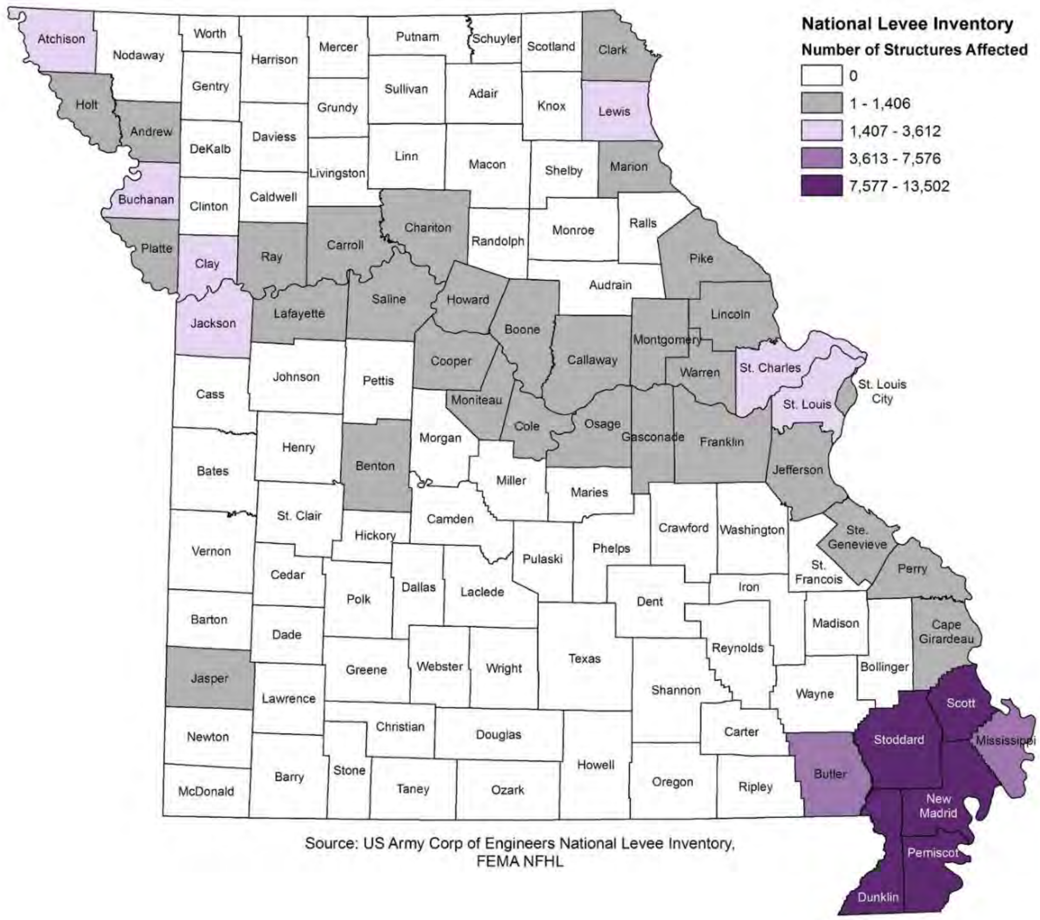
To determine the population and buildings vulnerable to damage if these levee segments were to fail, the "Area Protected by Levees" feature class from the FEMA National Flood Hazard Layer (NFHL) and the USACE leveed areas from the NLD (depicted in **Figure 3.68**) were compared against the MSDIS structure point file to determine the count of structures at risk. The value of structures at risk was calculated based on determining the average value of each building type for each county from Hazus and then applying that value to the buildings counts from the MSDIS structure comparison. Population at risk was determined based on the average household size per county applied to the number of residential structures in levee protected areas. **Figure 3.68 and Figure 3.69** provide the population and building exposure by county.

Figure 3.68. Population Exposure: Missouri Levees in USACE National Levee Inventory Providing 100-year or Greater Flood Protection



Source: US Army Corp of Engineers National Levee Inventory, FEMA NFHL

Figure 3.69. Residential Building Exposure: Missouri Levees in USACE National Levee Inventory Providing 1 percent annual chance or greater Flood Protection



State Estimates of Potential Losses

Utilizing an assumed depth-damage percentage of 50-percent, the building loss estimate for failure of levee segments designed to provide 1-percent-annual-chance flood protection is computed to be $29,818,812,980. A detailed breakdown by county is shown in **Table 3.43.** This data, including the MSDIS points, is available for export by county in the Missouri Hazard Mitigation Viewer at http://bit.ly/MoHazardMitigationPlanViewer2018.

Table 3.43. Building Loss from Levee Failure by County

County	Estimated Number of Structures	Estimated Structure Value	Estimated Population Affected
Andrew	**99**	**$24,014,886.45**	**70**
Agriculture	65	$14,095,426.36	
Commercial	3	$1,695,974.17	
Government	3	$2,191,500.00	
Residential	28	$6,031,985.92	70
Atchison	**1,619**	**$759,156,856.50**	**292**
Agriculture	1,424	$696,243,130.42	
Commercial	16	$10,081,936.84	
Industrial	42	$22,495,200.00	
Residential	137	$30,336,589.23	292

County	Estimated Number of Structures	Estimated Structure Value	Estimated Population Affected
Benton	**156**	**$52,584,899.54**	**228**
Commercial	56	$36,784,971.66	
Residential	100	$15,799,927.88	228
Boone	**85**	**$24,786,629.27**	**80**
Agriculture	51	$15,281,131.87	
Commercial	1	$891,844.85	
Residential	33	$8,613,652.55	80
Buchanan	**2,230**	**$1,001,358,534.02**	**2,356**
Agriculture	810	$196,588,928.61	
Commercial	31	$29,637,201.00	
Education	6	$6,942,187.50	
Government	115	$101,719,863.01	
Industrial	355	$461,793,887.81	
Residential	913	$204,676,466.09	2,356
Butler	**5,308**	**$1,041,395,803.37**	**13,077**
Industrial	98	$84,892,382.77	
Residential	5,210	$956,503,420.60	13,077
Callaway	**141**	**$56,692,626.99**	**28**
Agriculture	63	$12,200,192.31	
Commercial	27	$16,946,767.74	
Government	12	$7,741,384.62	
Industrial	28	$17,485,057.69	
Residential	11	$2,319,224.63	28
Cape Girardeau	**1,286**	**$386,634,065.97**	**1,111**
Agriculture	711	$177,618,465.00	
Commercial	93	$76,821,504.90	
Government	3	$2,286,468.75	
Industrial	33	$25,274,200.90	
Residential	446	$104,633,426.41	1,111
Carroll	**863**	**$532,122,179.05**	**226**
Agriculture	719	$464,649,755.52	
Commercial	8	$5,268,493.15	
Government	22	$16,992,627.45	
Industrial	23	$27,032,406.78	
Residential	91	$18,178,896.14	226
Chariton	**610**	**$535,287,828.83**	**249**
Agriculture	489	$501,895,110.93	
Commercial	21	$12,978,482.76	
Education	1	$2,320,272.73	
Residential	99	$18,093,962.42	249
Clark	**404**	**$236,218,907.48**	**235**
Agriculture	297	$214,615,500.00	
Commercial	8	$4,262,000.00	
Government	2	$853,764.71	
Residential	97	$16,487,642.77	235
Clay	**2,149**	**$1,291,995,856.96**	**2,980**
Agriculture	132	$31,039,830.98	
Commercial	513	$541,951,019.57	
Education	7	$13,504,155.97	
Government	17	$19,061,915.67	
Industrial	334	$372,286,484.46	

County	Estimated Number of Structures	Estimated Structure Value	Estimated Population Affected
Residential	1,146	$314,152,450.32	2,980
Cole	**20**	**$4,542,517.48**	
Agriculture	20	$4,542,517.48	
Cooper	**4**	**$897,398.60**	
Agriculture	4	$897,398.60	
Dunklin	**9,950**	**$2,166,392,241.14**	**18,512**
Agriculture	2,179	$806,455,970.36	
Commercial	127	$81,846,123.57	
Education	26	$35,610,000.01	
Government	25	$11,181,578.95	
Industrial	6	$2,915,672.73	
Residential	7,587	$1,228,382,895.53	18,512
Franklin	**77**	**$31,545,438.66**	**10**
Agriculture	36	$114,741.75	
Commercial	28	$12,891,148.57	
Industrial	9	$17,670,255.72	
Residential	4	$869,292.62	10
Gasconade	**5**	**$2,107,936.12**	
Agriculture	2	$454,000.00	
Commercial	3	$1,653,936.12	
Holt	**1,134**	**$265,599,490.91**	**865**
Agriculture	719	$193,258,021.25	
Government	3	$1,371,000.00	
Industrial	2	$1,081,025.64	
Residential	410	$69,889,444.03	865
Howard	**134**	**$30,735,873.61**	**40**
Agriculture	108	$23,380,285.72	
Commercial	9	$3,802,533.83	
Industrial	1	$429,617.65	
Residential	16	$3,123,436.41	40
Jackson	**1,956**	**$1,830,534,600.24**	**849**
Agriculture	200	$58,091,851.86	
Commercial	165	$183,346,066.86	
Education	4	$8,888,471.95	
Government	58	$82,933,866.44	
Industrial	1,181	$1,405,158,138.99	
Residential	348	$92,116,204.13	849
Jasper	**57**	**$44,689,094.53**	**18**
Agriculture	6	$1,868,583.73	
Commercial	1	$769,323.78	
Industrial	43	$40,679,331.86	
Residential	7	$1,371,855.16	18
Jefferson	**108**	**$40,529,807.66**	**56**
Commercial	83	$33,430,003.92	
Government	4	$2,914,616.82	
Residential	21	$4,185,186.91	56
Lafayette	**38**	**$3,395,890.30**	**10**
Agriculture	32	$1,234,763.45	
Commercial	1	$675,741.29	
Industrial	1	$595,866.34	
Residential	4	$889,519.22	10

County	Estimated Number of Structures	Estimated Structure Value	Estimated Population Affected
Lewis	**1,960**	**$605,833,107.18**	**3,398**
Agriculture	272	$194,256,571.42	
Commercial	251	$118,445,518.35	
Education	4	$5,808,444.44	
Government	12	$4,869,473.68	
Industrial	34	$27,105,846.15	
Residential	1,387	$255,347,253.14	3,398
Lincoln	**656**	**$146,544,664.73**	**1,079**
Agriculture	242	$651,852.80	
Commercial	37	$58,816,173.01	
Government	1	$1,374,650.00	
Residential	376	$85,701,988.92	1,079
Marion	**589**	**$271,393,062.53**	**340**
Agriculture	164	$36,436,700.00	
Commercial	136	$84,073,310.62	
Government	3	$2,150,516.13	
Industrial	146	$117,922,037.04	
Residential	140	$30,810,498.74	340
Mississippi	**7,576**	**$1,738,741,932.98**	**11,652**
Agriculture	2,491	$809,575,000.00	
Commercial	195	$88,661,625.00	
Education	26	$36,701,888.89	
Government	29	$17,882,961.54	
Residential	4,835	$785,920,457.55	11,652
Moniteau	**5**	**$1,081,822.92**	
Agriculture	5	$1,081,822.92	
Montgomery	**32**	**$7,979,156.57**	**7**
Agriculture	26	$5,868,508.47	
Commercial	3	$1,588,434.07	
Residential	3	$522,214.03	7
New Madrid	**13,502**	**$3,261,515,027.38**	**18,127**
Agriculture	5,686	$1,485,941,333.14	
Commercial	230	$127,569,711.28	
Education	65	$100,896,250.00	
Government	72	$34,860,857.14	
Industrial	169	$234,265,199.94	
Residential	7,280	$1,277,981,675.88	18,127
Osage	**80**	**$45,911,569.58**	**29**
Agriculture	69	$43,674,620.69	
Residential	11	$2,236,948.90	29
Pemiscot	**12,510**	**$2,848,942,988.27**	**19,028**
Agriculture	4,448	$1,124,454,400.00	
Commercial	352	$189,797,057.23	
Education	50	$85,412,500.00	
Government	60	$42,822,500.00	
Industrial	79	$90,472,015.42	
Residential	7,521	$1,315,984,515.63	19,028
Perry	**441**	**$10,847,893.65**	**56**
Agriculture	396	$2,067,302.83	
Commercial	23	$3,821,900.00	
Residential	22	$4,958,690.82	56

County	Estimated Number of Structures	Estimated Structure Value	Estimated Population Affected
Pike	**46**	**$1,365,845.96**	**15**
Agriculture	40	$186,545.66	
Residential	6	$1,179,300.30	15
Platte	**929**	**$518,180,287.40**	**467**
Agriculture	311	$77,555,345.32	
Commercial	129	$112,260,613.17	
Government	1	$1,186,759.26	
Industrial	298	$268,699,351.36	
Residential	190	$58,478,218.30	467
Ray	**902**	**$288,242,621.70**	**1,134**
Agriculture	397	$144,611,067.31	
Commercial	53	$29,462,578.00	
Education	1	$2,898,666.67	
Industrial	20	$13,503,600.00	
Residential	431	$97,766,709.72	1,134
Saline	**178**	**$71,407,766.36**	**52**
Agriculture	157	$66,644,191.17	
Residential	21	$4,763,575.18	52
Scott	**9,996**	**$2,295,574,040.20**	**15,891**
Agriculture	3,484	$952,546,556.26	
Commercial	145	$95,860,187.75	
Education	12	$42,724,421.05	
Government	8	$6,041,939.39	
Industrial	41	$37,745,203.46	
Residential	6,306	$1,160,655,732.28	15,891
St Charles	**2,155**	**$687,585,163.53**	**2,369**
Agriculture	949	$13,922,779.81	
Commercial	190	$163,683,700.72	
Education	1	$2,571,117.98	
Government	32	$49,350,831.46	
Industrial	89	$191,318,081.59	
Residential	894	$266,738,651.96	2,369
St Louis	**3,612**	**$2,304,863,480.55**	**1,269**
Agriculture	216	$37,058,166.95	
Commercial	2,301	$1,022,376,766.46	
Education	32	$50,584,876.62	
Government	94	$69,287,778.93	
Industrial	449	$999,889,199.81	
Residential	520	$125,666,691.78	1,269
St Louis City	**1,406**	**$1,939,228,667.22**	**394**
Commercial	108	$164,522,056.41	
Government	10	$273,329,727.27	
Industrial	1,109	$1,444,294,164.17	
Residential	179	$57,082,719.37	394
Ste Genevieve	**340**	**$110,095,112.42**	**665**
Agriculture	24	$50,970.50	
Commercial	42	$42,230,447.37	
Education	1	$5,853,500.00	
Government	2	$5,348,666.67	
Industrial	3	$2,125,623.85	
Residential	268	$54,485,904.03	665

County	Estimated Number of Structures	Estimated Structure Value	Estimated Population Affected
Stoddard	**9,343**	**$2,280,637,262.78**	**11,183**
Agriculture	4,486	$1,111,831,896.61	
Commercial	144	$248,040,000.00	
Education	14	$24,115,000.00	
Government	8	$5,149,500.00	
Industrial	89	$59,290,139.90	
Residential	4,602	$832,210,726.26	11,183
Warren	**391**	**$19,622,142.48**	**112**
Agriculture	342	$763,795.39	
Commercial	8	$9,517,792.00	
Residential	41	$9,340,555.09	112
Grand Total	**95,082**	**$29,818,812,980.08**	**128,558**

Hazard Impact on Future Growth and Development

The Bootheel Area of the Missouri the counties of Butler, Dunklin, New Madrid, Mississippi, Pemiscot and Stoddard were ranked high in both population and asset vulnerability for levee failure. The counties of Buchanan, Clay, Lewis and St. Charles Counties were ranked as medium-high. Development in these counties which have large areas protected by levees, could result in the potential for increased losses as a result of the increase in exposure.

As depicted in Table 3.8, the top ten counties experiencing population gains (Percent) are Platte, Boone, Christian, St. Charles, Clay, Taney, Greene, Lincoln, Cape Girardeau and Webster Counties. Among these counties, levees are present in five of the top ten: Platte, Boone, St. Charles, Lincoln and Cape Girardeau. Development in these counties could also result in the potential for increased losses.

EMAP Consequence Analysis

The impact of levee failure during a flooding event can be very similar to a dam failure in that the velocity of the water caused by sudden release as a result of levee breach can result in a flood surge or flood wave that can cause catastrophic damages (see **Table 3.44**). If the levee is overtopped as a result of flood waters in excess of the levee design, impactsare similar to flood impacts.

Table 3.44. EMAP Impact Analysis: Levee Failure

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

Risk Summary

Flooding is the most common hazard associated with levee failure, breach or overtopping. Levee failure, breach or overtopping can result not only in loss of life, but also considerable loss of capital investment, loss of income and property damage. Levees can provide a false sense of security by property owners and may lead to a misunderstanding of the true risk of assets in levee protected zones. While levees do provide flood protection, given enough time most will either overtop or fail leading to unsuspected damages. The Association of State Floodplain Managers (ASFPM) issued a position White Paper in 2007 calling levees the double-edged sword in which they discourage the building of new levees, development behind existing levees and increasing standards for levee construction. (Source: https://www.floods.org/PDF/ASFPM_Levee_Policy_Challenges_White_Paper_021907.pdf)

Problem Statement:

The top five counties most impacted for building loss from levee failure are Pemiscot, Dunklin, New Madrid, Scott and Butler counties. Focusing mitigation efforts and dollars in these five counties would most likely prove the most successful strategy.

The 2018 risk assessment data and mapping is available through the Missouri Hazard Mitigation Viewer: http://bit.ly/MoHazardMitigationPlanViewer2018.

3.3.3. Dam Failure

Probability	Severity
45% 19 events in 42 years	Moderate

Description/Location

A dam is generally defined as an artificial barrier, usually constructed across a stream channel, to impound water. Federal law and the Association of State Dam Safety Officials (ASDSO) define a dam as "any artificial barrier, including appurtenant works, which impounds or diverts water, and which (1) is twenty-five feet or more in height from the natural bed of the stream or watercourse measured at the downstream toe of the barrier, or from the lowest elevation of the outside limit of the barrier, if it is not across a stream channel or watercourse, to the maximum water storage elevation; or (2) has an impounding capacity at the maximum water storage elevation of fifty acre-feet or more." Based on this definition, there are more than 90,000 dams recorded in the United States Army Corps of Engineers (USACE) National Inventory of Dams (NID) in the United States as of February 2017. Over 96 percent of these dams are non-federal, with most being owned by state governments, municipalities, watershed districts, industries, lake associations, land developers, and private citizens. In Missouri, there are 5,113 total dams recorded in the NID. Dam owners have primary responsibility for the safe design, operation, and maintenance of their dams. They also have responsibility for providing early warning of problems at the dam, for developing an effective emergency action plan, and for coordinating that plan with local officials.

Dam construction varies widely throughout the State. The majority of dams in Missouri are earthen dams, which means they are constructed as a simple embankment of well-compacted earth. Missouri's mining industry has produced numerous tailing dams for the surface disposal of mine waste. These dams are made from mining material deposited in slurry form in an impoundment. Other types of earthen dams are reinforced with a core of concrete or asphalt. The largest dams in the State are built of reinforced concrete and are used for hydroelectric power.

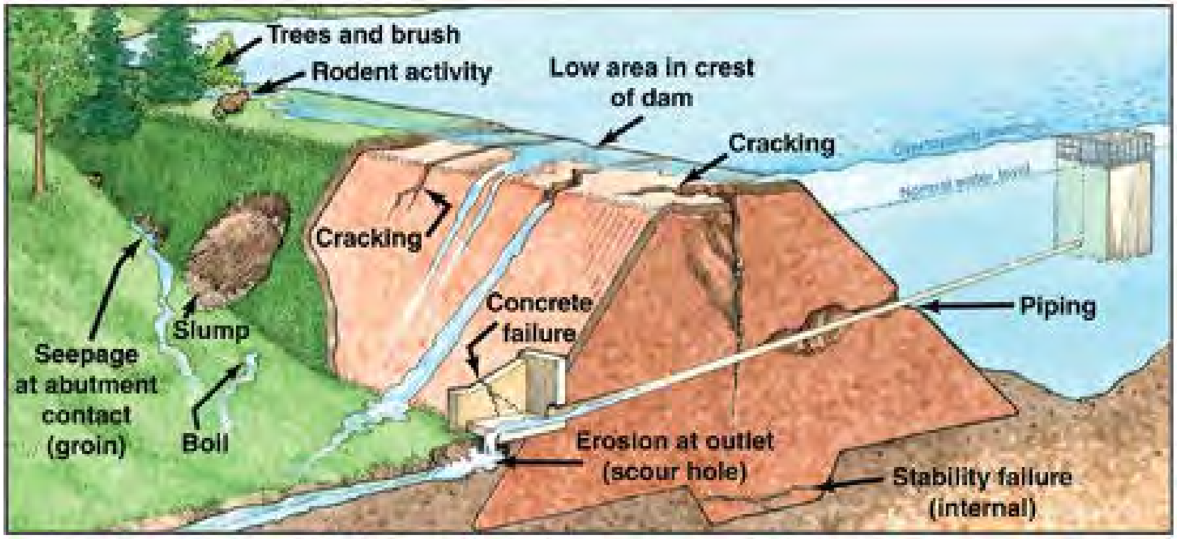
A dam failure is characterized by an uncontrolled release of water from behind a dam. Flooding, earthquakes, blockages, landslides, lack of maintenance, improper operation, poor construction, vandalism, and terrorism can all cause a dam to fail. When a dam failure occurs, an enormous amount of water is suddenly released, destroying infrastructure and flooding the area downstream of the dam.

The most common types of dam failures are as follows:

1) Overtopping – inadequate spillway design, debris blockage of spillways, or settlement of the dam crest;
2) Piping – internal erosion caused by embankment leakage, animal burrows, foundation leakage, and/or deterioration of pertinent structures appended to the dam;
3) Erosion – flow erosion, and/or inadequate slope protection;
4) Structural Failure – caused by an earthquake, slope instability, and/or faulty construction.

The four types of failures are often interrelated. For example, erosion, either on the surface or internal, may weaken the dam, which could lead to structural failure. Similarly, a structural failure could shorten the seepage path and lead to a piping failure. Observable defects that provide good evidence of potential dam failures are illustrated in **Figure 3.70.**

Figure 3.70. Possible Dam Failures



Source: United States Forest Service: https://www.fs.fed.us/eng/pubs/htmlpubs/htm12732805/page02.htm

Regulatory Framework

According to the National Inventory of Dams (NID), Missouri has 5,113 recorded dams. This data comes from the U.S. Army Corps of Engineer's NID provided to the Homeland Security Infrastructure Program Freedom Database, version 2015. With assistance from the Missouri Department of Natural Resources, the NID inventory was also supplemented with the State Hazard Classifications for state-regulated dams. The NID includes all regulated and unregulated dams for all types of dam owners (federal, state, local, or private) that fall into one of the four following categories:

1) High Hazard: Loss of at least one human life is likely if the dam fails
2) Significant Hazard: Possible loss of human life and likely significant property or environmental destruction.
3) Equal or exceed 25 feet in height and exceed 15 acre-feet in storage
4) Equal or exceed 50-acre feet storage and exceed 6 feet in height.

Low hazard dams are those in categories 3 and 4 that do not meet the separate criteria for categories 1 and 2. Low hazard dams which do not meet the criteria specified in categories 3 or 4 are not included in the NID even if they are regulated according to state criteria. Contact the State Hazard Mitigation Officer to obtain this data.

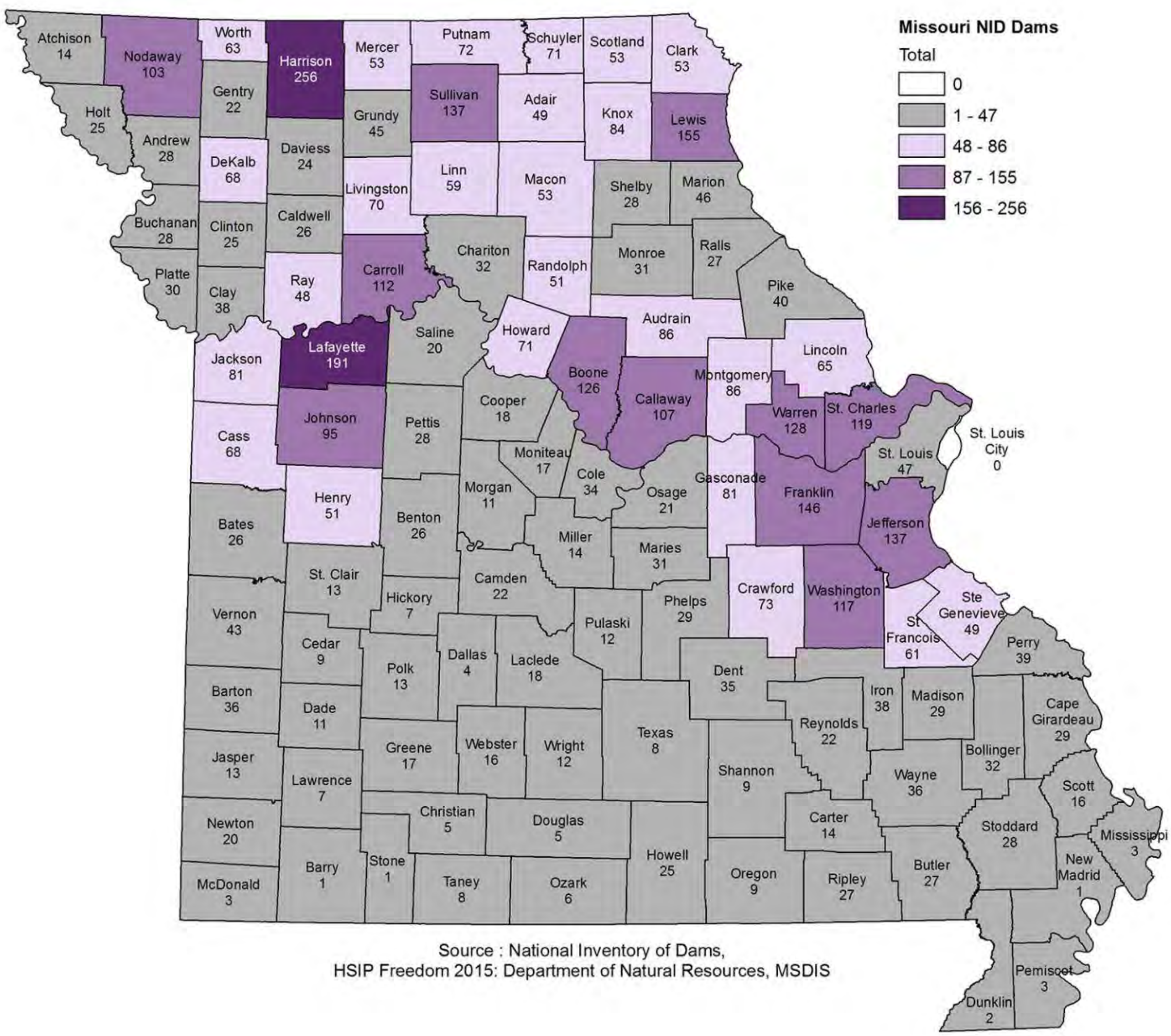
The hazard potential classifications above do not reflect in any way the current condition of a dam; it is simply a method to provide classifications according to the type of impacts that might occur in the event of failure.

When considering the Hazard Potential Classifications of the 5,113 recorded dams in the NID, 1,511 are High Hazard, 219 are Significant Hazard and 3,381 are Low Hazard. Two of the dams in the NID in Missouri did not indicate the Hazard class.

The topography of the State allows lakes to be built easily and inexpensively, contributing to the high number of dams. Despite the large number of total dams in the state, there are only 685 (about 13.4 percent) State-regulated dams, with an additional 57 federally regulated dams. The remaining 4,371 dams are un-regulated

Figure 3.71 provides the number of total recorded dams in Missouri according to the National Inventory of Dams by county. This figure is followed by **Figure 3.72**, **Figure 3.73**, and **Figure 3.74** that show the numbers of High, Significant, and Low Hazard dams respectively

Figure 3.71. Total Recorded Dams in Missouri by County



Source : National Inventory of Dams, HSIP Freedom 2015: Department of Natural Resources, MSDIS

Figure 3.72. High Hazard Dams in Missouri by County

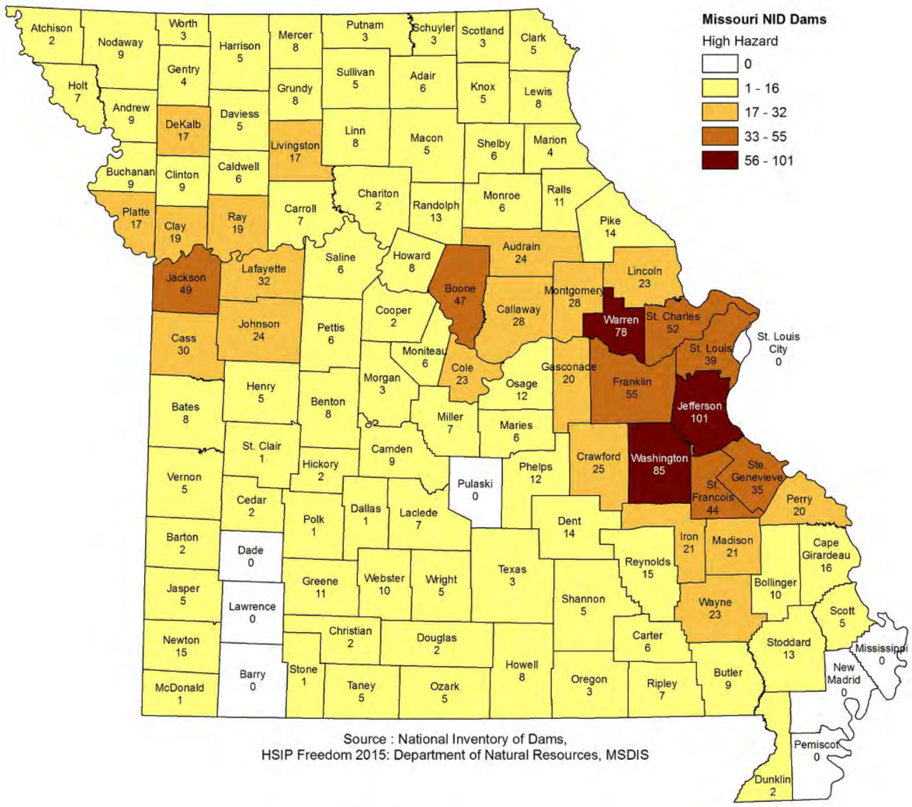


Figure 3.73. Significant Hazard Dams in Missouri by County

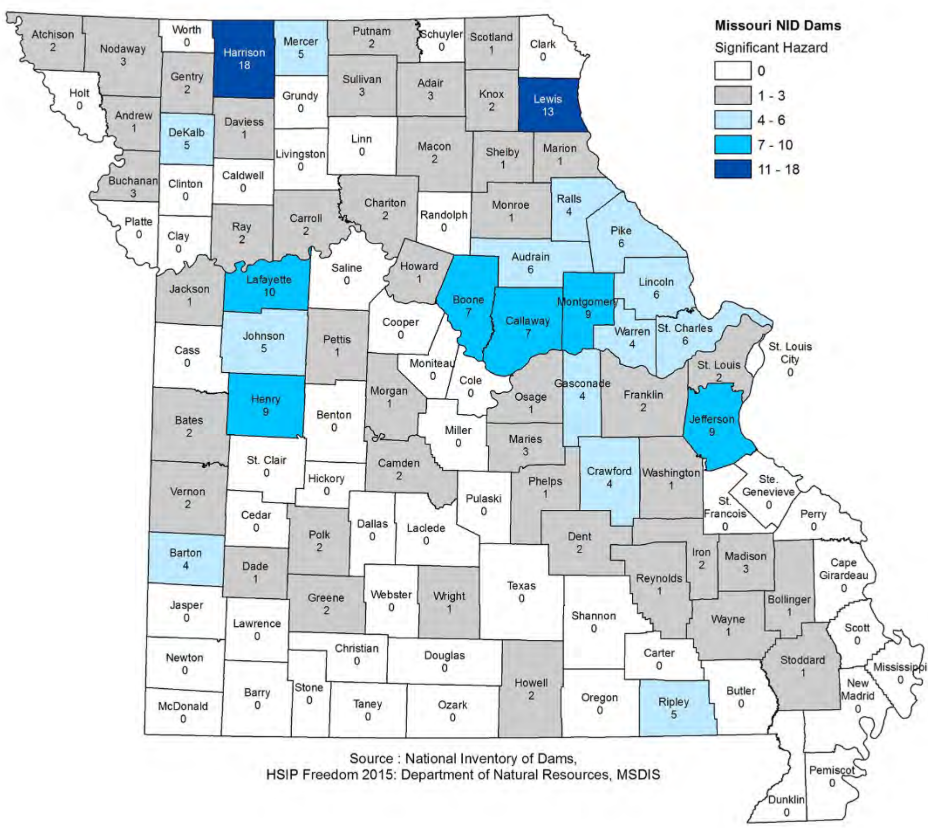
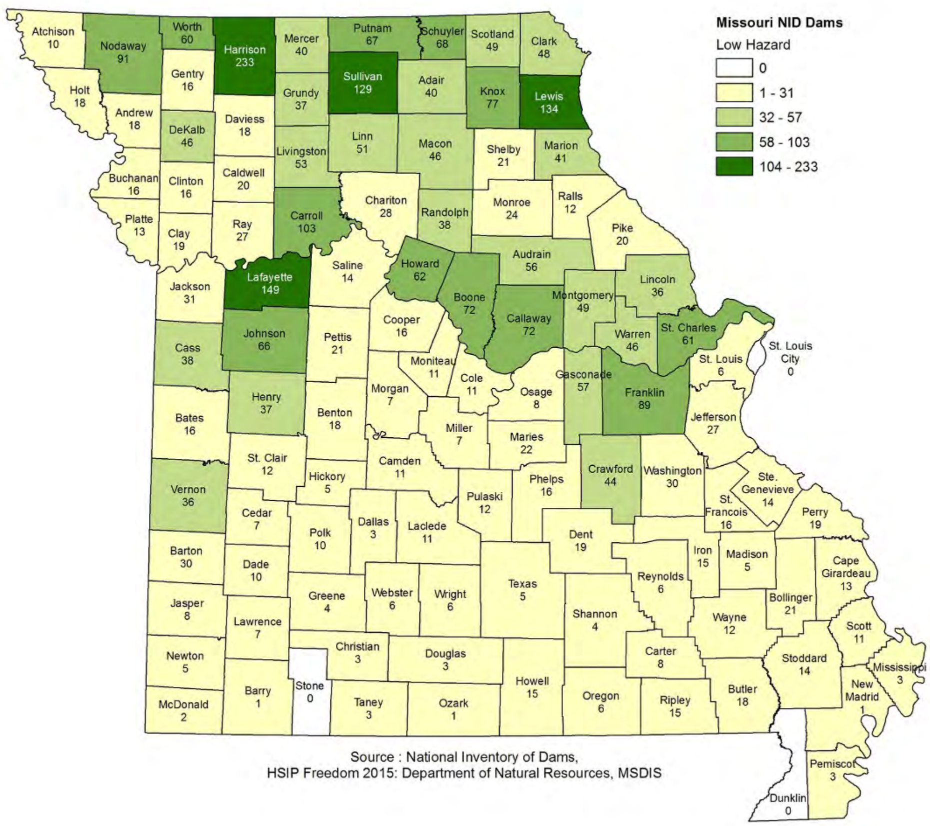


Figure 3.74. Low Hazard Dams in Missouri by County



State-Regulated Dams

Since the passage of the 1979 Missouri House Bill 603, Missouri defines any artificial or man-made barrier which does or may impound water and which impoundment is thirty-five feet or more in height as a dam that requires state regulation. The 1979 Missouri House Bill 603, as specified in Section 236.400 of the Revised Statutes of Missouri (RSMo), excluded certain dams from regulation – those less than 35 feet high, and allowed exemptions for others – those used primarily for agricultural purposes.

Dams that fall under state regulation are non-federally regulated dams that are more than 35 feet in height. Most non-federal dams are privately owned structures built either for agricultural, water supply or recreational use. Missouri also has more than 1,000 dams that were built as small watershed projects under Public Law-566 (Watershed Protection and Flood Prevention Act of 1953). These dams serve many functions, including flood control, erosion control, recreation, fish and wildlife habitat, water supply, and water quality improvement. Many of these PL-566 dams need ongoing maintenance to safely provide these functions. Another group of older dams in the State were originally built by railroad companies as holding ponds for water to be used in steam locomotives. Many of these are now used as drinking water reservoirs by nearby towns and cities. Finally, there are many mining dams that are no longer in use and have been sold to private individuals.

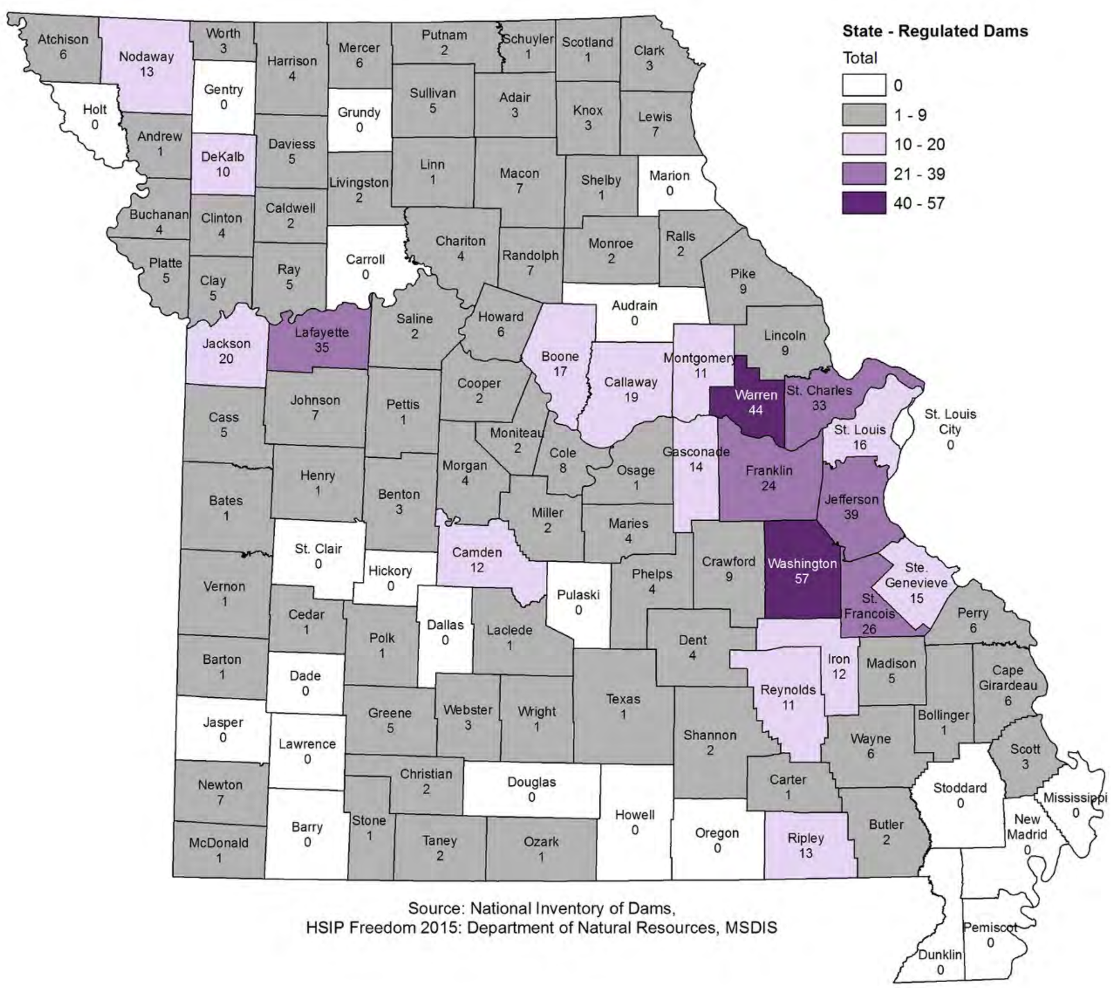
Within the State of Missouri, the Department of Natural Resources (MoDNR) Water Resources Center maintains a Dam and Reservoir Safety Program. The objective is to ensure that dams over 35 feet in height are safely constructed, operated, and maintained pursuant to Chapter 236 Revised Statutes of Missouri. These dams are inspected by a professional engineer once every 2-5 years, depending on the dam classification. MoDNR has three classifications for all state-regulated dams:

- Class 1: The area downstream from the dam that would be affected by inundation contains ten (10) or more permanent dwellings or any public building. Inspection of these dams must occur every two years.
- Class 2: The area downstream from the dam that would be affected by inundation contains one (1) to nine (9) permanent dwelling, or one (1) or more campgrounds with permanent water, sewer and electrical services or one (1) or more industrial buildings. Inspection Of these dams must occur once every three years.
- Class 3: 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 five years.

The breakdown of 685 state-regulated dams by class is as follows: 199 Class 1, 262 Class 2, and 216 Class 3. There are also 8 dams that are in the inventory that are indicated as state-regulated but are not built yet and have not been assigned a state class. See **Figure 3.75** through **Figure 3.78**.

There is not a direct correlation between the State hazard classification and the NID hazard classifications. However, most dams that are in the State's Classes 1 and 2 are considered NID High Hazard dams.

Figure 3.75. State Regulated Dams in Missouri, Total



Source: National Inventory of Dams,
HSIP Freedom 2015: Department of Natural Resources, MSDIS

Figure 3.76. Class 1 State-Regulated Dams in Missouri

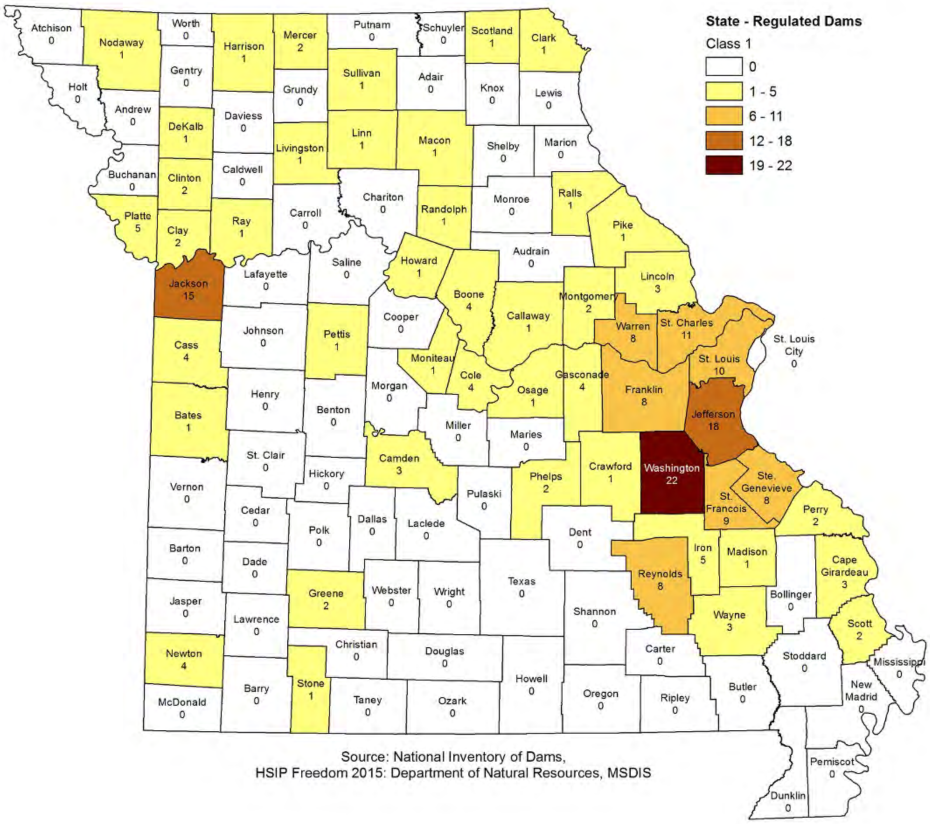


Figure 3.77. Class 2 State Regulated Dams in Missouri

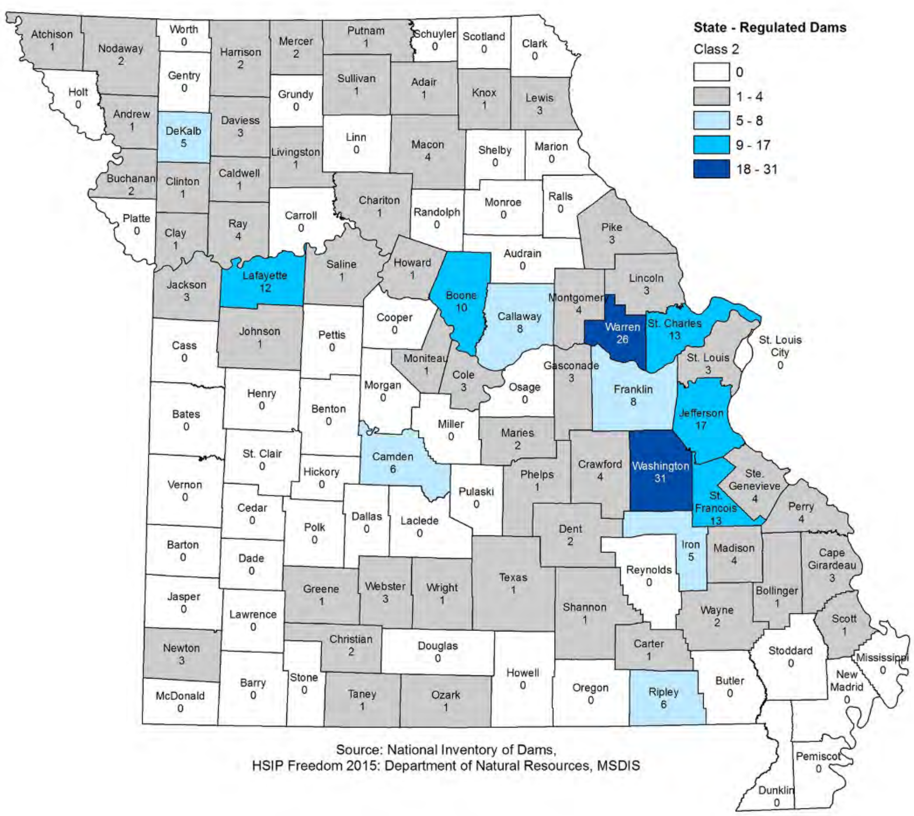
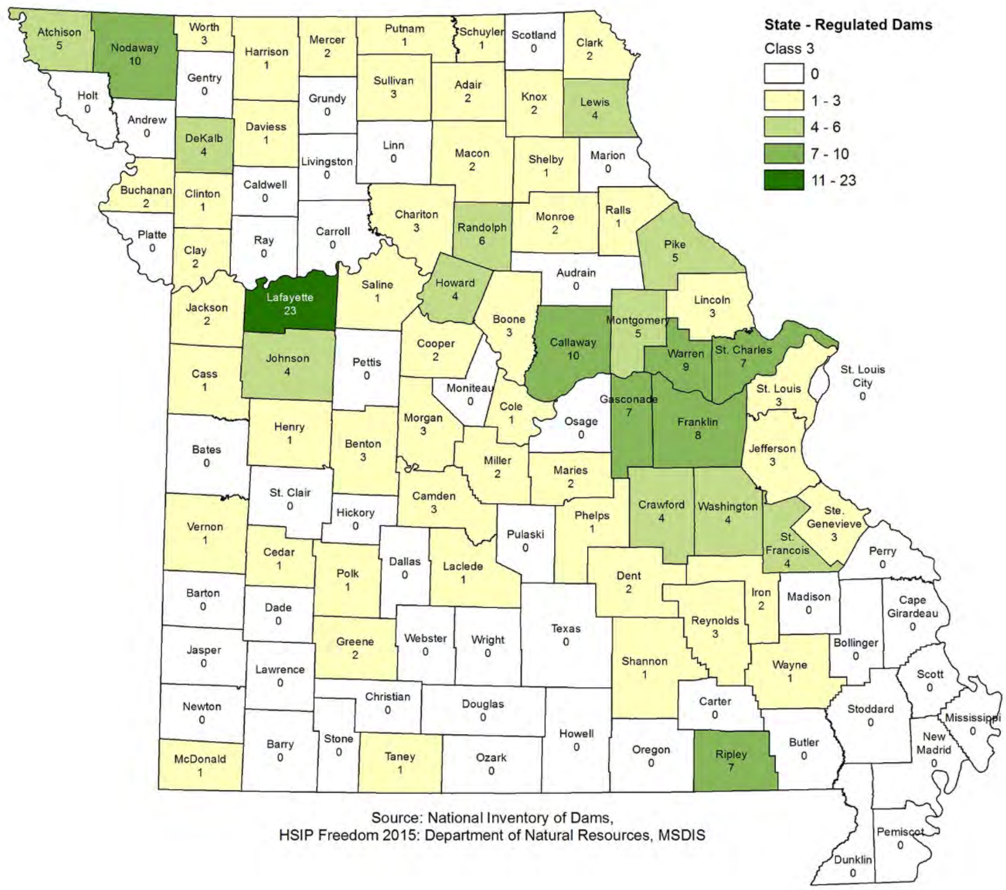


Figure 3.78. Class 3 State Regulated Dams in Missouri



Federally-regulated Dams

There are 57 federally-regulated dams in Missouri. All federally-regulated dams fall outside the regulatory authority of the Missouri Dam and Reservoir Safety Program. Federal dams in Missouri are primarily regulated by two federal agencies; the U.S. Army Corps of Engineers (USACE), and the U.S. Department of Agriculture Forest Service. The Federal Energy Regulatory Commission (FERC) regulates some dams under the 1920 Federal Power Act such as the facilities at Taum Sauk and the Bagnell Power Station at the Lake of the Ozarks. These dams are permitted under their FERC permits. Other federally regulated dams are owned by the Department of Defense, the Department of Interior, electric power providers, and other entities.

Extensive care is taken in the design, construction, and operation of the USACE dams. As a result, the USACE record for dam safety is considered excellent. In Missouri 25 dams are maintained and operated by the USACE (see **Table 3.45**). Several relevant USACE Civil Works programs overlap with the State Risk Management Team (SRMT) in Missouri. The Silver Jackets, for example, is the USACE Civil Works program that enables participation in the state hazard mitigation team through a collaborative effort between USACE, the Federal Emergency Management Agency, and other federal, state and local agencies to create an interagency team at the state level to develop and implement solutions to state natural hazard priorities. The lead coordinator for the Silver Jackets provides regular status updates and participates on the SRMT, representing all of the USACE districts within the state at the team meetings. Each district has a Silver Jacket Coordinator that is also encouraged to attend. The status updates provide detailed information on active USACE Civil Works projects and programs, including specific project information that is useful during the FEMA RiskMAP Discovery Phases.

Table 3.45. USACE Dams in Missouri

Dam Name	NID ID	County	River	City	Owner Name
Harry S Truman Dam	Mo20725	Benton	Osage River	Warsaw	USACE-CENWK-Kansas City District
Harry S Truman Dam - Sterett Creek Dike	Mo20725	Benton	Osage River	Warsaw	USACE-CENWK-Kansas City District
Stockton Dam	Mo30200	Cedar	Sac River	Caplinger Mills	USACE-CENWK-Kansas City District
Smithville Dam	Mo12084	Clay	Little Platte River	Smithville	USACE-CENWK-Kansas City District
Whitaker Dam	Mo20148	Henry	Tr Deep Water Creek	Deepwater	USACE-CENWK-Kansas City District
Clinton South Quad No.1 Dam	Mo20641	Henry	Trib-South Grand	Clinton	USACE-CENWK-Kansas City District
Re Mansfield Dam	Mo20642	Henry	Trib-South Grand	Clinton	USACE-CENWK-Kansas City District
Pomme De Terre Dam	Mo30201	Hickory	Pomme De Terre River	Hermitage	USACE-CENWK-Kansas City District
Blue Springs Dam	Mo12099	Jackson	East Fork Little Blue River	Independence	USACE-CENWK-Kansas City District
Longview South Dam	Mo20013	Jackson	Tr Mouse Creek	Lee's Summit	USACE-CENWK-Kansas City District
Longview No 2	Mo20236	Jackson	Tr Lumpkins Fork Offstream	Grandview	USACE-CENWK-Kansas City District
Blue Springs Quad No.1 Dam	Mo20575	Jackson	Trib-Blue River	Blue Springs	USACE-CENWK-Kansas City District
Commandeer Fishing Lake Dam	Mo30224	Jackson	Tr-Little Blue River	Independence	USACE-CENWK-Kansas City District
Longview Dam	Mo82202	Jackson	Little Blue River	Kansas City	USACE-CENWK-Kansas City District
Mississippi River Dam 20	Mo10303	Lewis	Mississippi River	Canton	USACE-CEMVR-Rock Island District
Lock & Dam 25	Mo10301	Lincoln	Mississippi River	Winfield	USACE-CEMVS-St. Louis District
Long Branch Dam	Mo11176	Macon	East Fork Little Chariton	Macon	USACE-CENWK-Kansas City District
Locks 27	Mo10302	Madison	Mississippi River	Granite City	USACE-CEMVS-St. Louis District
Mississippi River Dam 22	Mo10305	Ralls	Mississippi River	Ashburn	USACE-CEMVR-Rock Island District
Clarence Cannon Dam Re-Regulation Dam	Mo12086	Ralls	Salt River	New London	USACE-CEMVS-St. Louis District
Clarence Cannon Dam	Mo82201	Ralls	Salt River	New London	USACE-CEMVS-St. Louis District
Mills Lake Dam (Federal)	Mo20631	St. Clair	Tr To Salt Creek	Osceola	USACE-CENWK-Kansas City District
Table Rock Dam	Mo30202	Taney	White	Branson	USACE-CESWL-Little Rock District
Clearwater Dam	Mo30203	Wayne	Black	Leeper	USACE-CESWL-Little Rock District
Wappapello Lake Dam	Mo30204	Wayne	St. Francis River	Wappapello	USACE-CEMVS-St. Louis District

Source: National Inventory of Dams

The remaining 32 federal dams are owned by a combination of federal agencies (see Table **3.46**).

Table 3.46. Other Federal Dams in Missouri

Dam Name	NIDID	County	River	City	Owner Name
Swan Lake Levee #2 Dam	Mo10306	Chariton	Elk Creek		US Fish and Wildlife Service
Silver Lake Dam	Mo10307	Chariton	Elk Creek		US Fish and Wildlife Service
Swan Lake Dam	Mo10308	Chariton	Tough Branch		Us Fish and Wildlife Service
South Levee Dam	Mo12421	Holt	Offstream		Us Fish and Wildlife Service
Veterans Dam No. 95	Mo20130	Jackson	N/A	Buckner Mo	Lake City AAP
Loggers Lake Dam(Federal)	Mo30002	Shannon	Big Creek	Bunker	USDA FS
McCormack Lake Dam	Mo30004	Oregon	McCormack Hollow	Alton	USDA FS
Markham Spring	Mo30027	Wayne	Tr-Black River	Williamsville	USDA FS
Ripley County Lake Dam	Mo30053	Ripley	Briar Creek	Doniphan	USDA FS
Crane Lake	Mo30069	Iron	Crane Pond Lake	Des Arc	USDA FS
Timberlane Lake	Mo30206	Washington	Tr-Courtois Creek	Courtois	USDA FS
Markham Springs Dam(Federal)	Mo30207	Wayne	Tr Black River	Williamsville	USDA FS
Roby Lk-Embankment No. 2	Mo30209	Texas	Tr-Little Paddy Creek	Roby	USDA FS
Roby Lk-Embankment No. 1	Mo30210	Texas	Little Paddy Creek	Roby	USDA FS
Penn S Pond Dam	Mo30976	Pulaski	Roubidoux-Hurd Hollow Tr	Waynesville	Fort Leonard Wood
Red Lake Dam	Mo30977	Pulaski	Roubidoux-Smith Branch Tr	Waynesville	Fort Leonard Wood
Big Basin Dam	Mo30978	Pulaski	Roubidoux-Smith Branch Tr	Waynesville	Fort Leonard Wood
Fourche Creek Dam	Mo31227	Ripley	Fourche Creek	Gatewoods	USDA FS
Siloam Springs Quad No.1 Dam	Mo31326	Howell	Trib-Tabor Creek	Siloam Springs	USDA FS
Scotia Pond Dam	Mo31500	Dent	Trib-Meramec River	Gladden	USDA FS
Engineer Lake	Mo31551	Pulaski	Roubidoux-Smith Branch Tr	Waynesville	Fort Leonard Wood
Bloodland Quad No.2 Dam(Federal)	Mo31552	Pulaski	Trib-Roubidoux Creek	Waynesville	DOD USA
Pinewoods Lake	Mo31558	Carter	South Fork Hollow	Poplar Bluff	USDA FS
Bloodland Quad No.3 Dam(Federal)	Mo31752	Pulaski	Trib-Roubidoux Creek	Waynesville	DOD USA
Bloodland Lake Dam	Mo31753	Pulaski	Roubidoux-Smith Branch Tr	Waynesville	Fort Leonard Wood
Council Bluff Dam	Mo31755	Iron	Trib-Big River	Bixby	USDA FS
Sterling Hollow Dam	Mo32088	Howell	Sterling Hollow	Na	
Beaver Lake Dam	Mo40010	Butler	Trib To Hurricane Creek	Poplar Bluff	USDA FS
Mingo Refuge Fox Pond(Federal)	Mo40033	Wayne	Mingo Creek	McGee	DOI FWS
Puxico Quad No.1 Dam(Federal)	Mo40098	Wayne	Trib-St Francis River	Wappapello	DOI FWS
Sterling Hollow	Mo40183	Howell			USDA FS
Lofton Dam	Mo82901				DOI NPS

Source: National Inventory of Dams

Unregulated Dams

4,371 dams in Missouri (more than 85%) do not meet the height requirements for state-regulation and do not fall under federal regulation. Many of these dams have gone unchecked for decades because there is no legal authority or state allocated manpower available to inspect them. Dams that do not get regular attention can erode over the years, or may be damaged by floods. These dams can be considered vulnerable. If a dam fails, the owner is responsible for the damages that may be caused, regardless of whether or not the dam is regulated.

On the next several pages is provided an inventory of the numbers and types of dams in Missouri by County including the total in the NID, State-Regulated dams, Federally-Regulated dams, and Un-regulated dams.

Table 3.47. Numbers and Types of Dams in Missouri by County

	National Inventory of Dams					State-Regulated Dams					Federally-Regulated Dams				Un-regulated Dams				
County	H	S	L	Unrated	Total	1	2	3	Not Built	Total	H	S	L	Total	H	S	L	Unrated	Total
Adair	6	3	40	0	49	0	1	2	0	3	0	0	0	0	5	2	39	0	46
Andrew	9	1	18	0	28	0	1	0	0	1	0	0	0	0	8	1	18	0	27
Atchison	2	2	10	0	14	0	1	5	0	6	0	0	0	0	2	0	6	0	8
Audrain	24	6	56	0	86	0	0	0	0	0	0	0	0	0	24	6	56	0	86
Barry	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	1
Barton	2	4	30	0	36	0	0	0	1	1	0	0	0	0	2	3	30	0	35
Bates	8	2	16	0	26	1	0	0	0	1	0	0	0	0	7	2	16	0	25
Benton	8	0	18	0	26	0	0	3	0	3	2	0	0	2	6	0	15	0	21
Bollinger	10	1	21	0	32	0	1	0	0	1	0	0	0	0	9	1	21	0	31
Boone	47	7	72	0	126	4	10	3	0	17	0	0	0	0	34	6	69	0	109
Buchanan	9	3	16	0	28	0	2	2	0	4	0	0	0	0	9	1	14	0	24
Butler	9	0	18	0	27	0	0	0	0	0	0	0	1	1	9	0	17	0	26
Caldwell	6	0	20	0	26	0	1	0	1	2	0	0	0	0	4	0	20	0	24
Callaway	28	7	72	0	107	1	8	10	0	19	0	0	0	0	21	4	63	0	88
Camden	9	2	11	0	22	3	6	3	0	12	0	0	0	0	1	0	9	0	10
Cape Girardeau	16	0	13	0	29	3	3	0	0	6	0	0	0	0	10	0	13	0	23
Carroll	7	2	103	0	112	0	0	0	0	0	0	0	0	0	7	2	103	0	112
Carter	6	0	8	0	14	0	1	0	0	1	0	0	2	2	5	0	6	0	11
Cass	30	0	38	0	68	4	0	1	0	5	0	0	0	0	25	0	38	0	63
Cedar	2	0	7	0	9	0	0	1	0	1	1	0	0	1	1	0	6	0	7
Chariton	2	2	28	0	32	0	1	3	0	4	0	0	3	3	1	2	22	0	25
Christian	2	0	3	0	5	0	2	0	0	2	0	0	0	0	0	0	3	0	3
Clark	5	0	48	0	53	1	0	2	0	3	0	0	0	0	3	0	47	0	50
Clay	19	0	19	0	38	2	1	2	0	5	1	0	0	1	15	0	17	0	32
Clinton	9	0	16	0	25	2	1	1	0	4	0	0	0	0	6	0	15	0	21
Cole	23	0	11	0	34	4	3	1	0	8	0	0	0	0	16	0	10	0	26
Cooper	2	0	16	0	18	0	0	2	0	2	0	0	0	0	2	0	14	0	16
Crawford	25	4	44	0	73	1	4	4	0	9	0	0	0	0	20	3	41	0	64
Dade	0	1	10	0	11	0	0	0	0	0	0	0	0	0	0	1	10	0	11
Dallas	1	0	3	0	4	0	0	0	0	0	0	0	0	0	1	0	3	0	4
Daviess	5	1	18	0	24	0	3	1	1	5	0	0	0	0	2	1	16	0	19
Dekalb	17	5	46	0	68	1	5	4	0	10	0	0	0	0	11	5	42	0	58
Dent	14	2	19	0	35	0	2	2	0	4	0	0	1	1	11	2	17	0	30
Douglas	2	0	3	0	5	0	0	0	0	0	0	0	0	0	2	0	3	0	5
Dunklin	2	0	0	0	2	0	0	0	0	0	0	0	0	0	2	0	0	0	2
Franklin	55	2	89	0	146	8	8	8	0	24	0	0	0	0	37	2	83	0	122
Gasconade	20	4	57	0	81	4	3	7	0	14	0	0	0	0	13	1	53	0	67
Gentry	4	2	16	0	22	0	0	0	0	0	0	0	0	0	4	2	16	0	22
Greene	11	2	4	0	17	2	1	2	0	5	0	0	0	0	8	0	4	0	12
Grundy	8	0	37	0	45	0	0	0	0	0	0	0	0	0	8	0	37	0	45

	National Inventory of Dams					State-Regulated Dams					Federally-Regulated Dams				Un-regulated Dams				
County	H	S	L	Unrated	Total	1	2	3	Not Built	Total	H	S	L	Total	H	S	L	Unrated	Total
Harrison	5	18	233	0	256	1	2	1	0	4	0	0	0	0	2	18	232	0	252
Henry	5	9	37	0	51	0	0	1	0	1	0	0	3	3	5	9	33	0	47
Hickory	2	0	5	0	7	0	0	0	0	0	1	0	0	1	1	0	5	0	6
Holt	7	0	18	0	25	0	0	0	0	0	0	0	1	1	7	0	17	0	24
Howard	8	1	62	0	71	1	1	4	0	6	0	0	0	0	6	0	59	0	65
Howell	8	2	15	0	25	0	0	0	0	0	0	2	1	3	8	0	14	0	22
Iron	21	2	15	0	38	5	5	2	0	12	0	1	1	2	11	0	13	0	24
Jackson	49	1	31	0	81	15	3	2	0	20	3	0	4	7	29	0	25	0	54
Jasper	5	0	8	0	13	0	0	0	0	0	0	0	0	0	5	0	8	0	13
Jefferson	101	9	27	0	137	18	17	3	1	39	0	0	0	0	65	8	25	0	98
Johnson	24	5	66	0	95	2	1	4	0	7	0	0	0	0	21	4	63	0	88
Knox	5	2	77	0	84	0	1	2	0	3	0	0	0	0	4	2	75	0	81
Laclede	7	0	11	0	18	0	0	1	0	1	0	0	0	0	7	0	10	0	17
Lafayette	32	10	149	0	191	0	12	23	0	35	0	0	0	0	19	8	129	0	156
Lawrence	0	0	7	0	7	0	0	0	0	0	0	0	0	0	0	0	7	0	7
Lewis	8	13	134	0	155	0	3	4	0	7	0	1	0	1	4	10	133	0	147
Lincoln	23	6	36	0	65	3	3	3	0	9	0	1	0	1	18	5	32	0	55
Linn	8	0	51	0	59	1	0	0	0	1	0	0	0	0	7	0	51	0	58
Livingston	17	0	53	0	70	1	1	0	0	2	0	0	0	0	15	0	53	0	68
Macon	5	2	46	0	53	1	4	2	0	7	1	0	0	1	2	0	43	0	45
Madison	21	3	5	0	29	1	4	0	0	5	0	1	0	1	16	2	5	0	23
Maries	6	3	22	0	31	0	2	2	0	4	0	0	0	0	3	2	22	0	27
Marion	4	1	41	0	46	0	0	0	0	0	0	0	0	0	4	1	41	0	46
Mcdonald	1	0	2	0	3	0	0	1	0	1	0	0	0	0	1	0	1	0	2
Mercer	8	5	40	0	53	2	2	2	0	6	0	0	0	0	5	4	38	0	47
Miller	7	0	7	0	14	0	0	2	0	2	0	0	0	0	7	0	5	0	12
Mississippi	0	0	3	0	3	0	0	0	0	0	0	0	0	0	0	0	3	0	3
Moniteau	6	0	11	0	17	1	1	0	0	2	0	0	0	0	4	0	11	0	15
Monroe	6	1	24	0	31	0	0	2	0	2	0	0	0	0	6	1	22	0	29
Montgomery	28	9	49	0	86	2	4	5	0	11	0	0	0	0	22	9	44	0	75
Morgan	3	1	7	0	11	0	0	3	1	4	0	0	0	0	1	0	6	0	7
New Madrid	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	1
Newton	15	0	5	0	20	4	3	0	0	7	0	0	0	0	8	0	5	0	13
Nodaway	9	3	91	0	103	1	2	10	0	13	0	0	0	0	7	2	81	0	90
Oregon	3	0	6	0	9	0	0	0	0	0	1	0	0	1	2	0	6	0	8
Osage	12	1	8	0	21	1	0	0	0	1	0	0	0	0	11	1	8	0	20
Ozark	5	0	1	0	6	0	1	0	0	1	0	0	0	0	4	0	1	0	5
Pemiscot	0	0	3	0	3	0	0	0	0	0	0	0	0	0	0	0	3	0	3
Perry	20	0	19	0	39	2	4	0	0	6	0	0	0	0	15	0	18	0	33
Pettis	6	1	21	0	28	1	0	0	0	1	0	0	0	0	5	1	21	0	27
Phelps	12	1	16	0	29	2	1	1	0	4	0	0	0	0	9	0	16	0	25
Pike	14	6	20	0	40	1	3	5	0	9	0	0	0	0	10	5	16	0	31
Platte	17	0	13	0	30	5	0	0	0	5	0	0	0	0	12	0	13	0	25
Polk	1	2	10	0	13	0	0	1	0	1	0	0	0	0	1	2	9	0	12

	National Inventory of Dams					State-Regulated Dams					Federally-Regulated Dams				Un-regulated Dams				
County	**H**	**S**	**L**	**Unrated**	**Total**	**1**	**2**	**3**	**Not Built**	**Total**	**H**	**S**	**L**	**Total**	**H**	**S**	**L**	**Unrated**	**Total**
Pulaski	0	0	12	0	12	0	0	0	0	0	0	0	7	7	0	0	5	0	5
Putnam	3	2	67	0	72	0	1	1	0	2	0	0	0	0	2	1	67	0	70
Ralls	11	4	12	0	27	1	0	1	0	2	0	3	0	3	10	0	12	0	22
Randolph	13	0	38	0	51	1	0	6	0	7	0	0	0	0	12	0	32	0	44
Ray	19	2	27	0	48	1	4	0	0	5	0	0	0	0	14	2	27	0	43
Reynolds	15	1	6	0	22	8	0	3	0	11	0	0	0	0	7	0	4	0	11
Ripley	7	5	15	0	27	0	6	7	0	13	0	2	0	2	2	2	8	0	12
Saline	6	0	14	0	20	0	1	1	0	2	0	0	0	0	5	0	13	0	18
Schuyler	3	0	68	0	71	0	0	1	0	1	0	0	0	0	3	0	67	0	70
Scotland	3	1	49	0	53	1	0	0	0	1	0	0	0	0	2	1	49	0	52
Scott	5	0	11	0	16	2	1	0	0	3	0	0	0	0	2	0	11	0	13
Shannon	5	0	4	0	9	0	1	1	0	2	1	0	0	1	3	0	3	0	6
Shelby	6	1	21	0	28	0	0	1	0	1	0	0	0	0	6	0	21	0	27
St. Charles	52	6	61	0	119	11	13	7	2	33	0	0	0	0	25	2	59	0	86
St. Clair	1	0	12	0	13	0	0	0	0	0	0	0	1	1	1	0	11	0	12
St. Francois	44	0	16	1	61	9	13	4	0	26	0	0	0	0	23	0	11	1	35
St. Louis	39	2	6	0	47	10	3	3	0	16	0	0	0	0	26	0	5	0	31
Ste. Genevieve	35	0	14	0	49	8	4	3	0	15	0	0	0	0	23	0	11	0	34
Stoddard	13	1	14	0	28	0	0	0	0	0	0	0	0	0	13	1	14	0	28
Stone	1	0	0	0	1	1	0	0	0	1	0	0	0	0	0	0		0	0
Sullivan	5	3	129	0	137	1	1	3	0	5	0	0	0	0	3	3	126	0	132
Taney	5	0	3	0	8	0	1	1	0	2	1	0	0	1	3	0	2	0	5
Texas	3	0	5	0	8	0	1	0	0	1	0	0	2	2	2	0	3	0	5
Vernon	5	2	36	0	43	0	0	1	0	1	0	0	0	0	5	1	36	0	42
Warren	78	4	46	0	128	8	26	9	1	44	0	0	0	0	44	2	38	0	84
Washington	85	1	30	1	117	22	31	4	0	57	0	0	1	1	32	0	26	1	59
Wayne	23	1	12	0	36	3	2	1	0	6	2	0	4	6	17	1	6	0	24
Webster	10	0	6	0	16	0	3	0	0	3	0	0	0	0	7	0	6	0	13
Worth	3	0	60	0	63	0	0	3	0	3	0	0	0	0	3	0	57	0	60
Wright	5	1	6	0	12	0	1	0	0	1	0	0	0	0	4	1	6	0	11
Grand Total	**1,511**	**219**	**3,381**	**2**	**5,113**	**199**	**262**	**216**	**8**	**685**	**14**	**11**	**32**	**57**	**1,039**	**158**	**3172**	**2**	**4,371**

Source: NID in HSIP Freedom 2015, MoDNR dam data in MSDIS supplemented by direct consultation with MoDNR Dam Safety Program Officials.

Dams Outside State Boundaries that Could Impact Missouri

Dams located outside of the State's boundaries could impact Missouri as well. Of particular concern is the Tuttle Creek Dam in Riley, Pottawatomie, and Marshall Counties in northeast Kansas on the Big Blue River, nine miles upstream from the confluence of the Blue and Kansas Rivers. It is situated near the Humboldt fault line, which is associated with the Nemaha Uplift. Earthquake models show that the dam could be significantly damaged to the point that the lake could wash out the dam. Efforts have been made to shore up the dam to withstand a moderate to large earthquake.

The Gavins Point Dam located on the Missouri River in South Dakota is another dam outside of Missouri's boundaries that has the possibility of impacting the State in the case of failure. There are a number of reports that focus on past and future spring pulse releases from this structure in addition to studies on possible water storage increases within the system. The USACE's Missouri River Master Manual provides additional information. Other upstream USACE dams that have inundation areas that extend into Missouri are listed in **Table 3.48**.

Table 3.48. Out-of-State USACE Dams with Inundation Areas Extending into Missouri

Dam Name	State (Origin)
Fort Peck Dam	Montana
Fort Randall Dam	South Dakota
Garrison Dam	North Dakota
Gavins Point Dam	Nebraska
Oahe Dam	South Dakota
Tuttle Creek Dam	Kansas
Milford Dam	Kansas
Big Bend Dam	South Dakota
Rathbun Dam	Iowa
Harlan County Dam	Nebraska
Clinton Dam	Kansas
Perry Dam	Kansas
Saylorville Dam/Big Creek	Iowa
Hillsdale Dam	Kansas
Melvern Dam	Kansas
Pomona Dam	Kansas
Red Rock Dam	Iowa

Source: U.S. Army Corps of Engineers

Locations in Missouri at Risk to Dam Failure

Locations at risk to dam failure in Missouri can be defined as any areas within the dam inundation areas (also referred to as dam breach areas). The State Vulnerability Overview section provides information about the number of mapped dam inundation areas in the State.

Although efforts are being made on a continuing basis, there are still many dams in Missouri that do not have identified inundation areas. As described above, there are 4,371 dams in Missouri that are not regulated by a state or federal agency. Of those, 1,039 are high hazard dams. Although areas downstream of those dams are at risk in the event of failure, the specific locations at risk have not been identified.

Extent

The extent (strength or magnitude) of dam failure hazard is based on the dam height and reservoir volume. Both of these factors impact the height of the downstream flood wave and the extent of wave propagation. Additional details on the extent of dam failure are excerpted below from FEMA's *Federal guidelines for Dam Safety*, April 2004.

The area affected by dam failure during a given flow condition on a river is the additional area inundated by the incremental increase in flood elevation due to failure over that which would occur normally by flooding without dam failure. The area affected by a flood wave resulting from a theoretical dam breach is a function of the height of the flood wave and the downstream distance and width of the river at a particular location. An associated and important factor is the flood wave travel time. These elements are primarily a function of the rate and extent of dam failure, but also are functions of channel and floodplain geometry and roughness and channel slope.

Previous Occurrences

Over the years, dam failures have injured or killed thousands of people and caused billions of dollars in property damage in the United States. Among the most catastrophic were the failures of the Teton dam in Idaho in 1976, which killed 14 people and caused more than $1 billion in damage, and the Kelly-Barnes Dam in Georgia in 1977, which left 39 dead and $30 million in property damage.

The problem of unsafe dams in Missouri was underscored by dam failures at Lawrenceton in 1968, Washington County in 1975, Fredericktown in 1977, and the December 14, 2005 collapse of the Upper Reservoir of AmerenUE's Taum Sauk hydroelectric complex in Reynolds County. Many of Missouri's smaller dams are becoming a greater concern as they continue to age and deteriorate. Hundreds of dams are in need of rehabilitation. However, a lack of funding and questions of ownership have made it difficult to implement the necessary maintenance.

According to Stanford University's National Performance of Dams Program and additional research, there have been 86 dam failure incidents in Missouri. One failure was recorded to be in 1917. All others in this repository of data occurred between 1975 and 2016.

Table 3.49. Dam Incidents in Missouri, 1917-2016

Dam Name	Incident Date	Incident Type	Dam Failure	NPDP ID
Powersite Dam	5/1/1917	Sliding	Unknown	
Dresser No.4 Dam (Failed)	8/15/1975	Piping	Yes	MO30474
Dresser No.4 Dam (Failed)	8/15/1975	Piping	No	MO30474
Unnamed Dam (MOS00014)	1/1/1977	Inflow Flood - Hydrologic Event	No	MOS00014
Pinkston	1/1/1978	Piping	Yes	MOS00013
Richardet Dam	12/1/1985	Seepage; Embankment Slide	Yes	MO31374
Marschke Lake Dam	4/19/1988	Not Known	Yes	MO31923
St. Joe State Park Sediment Impoundment	2/15/1990	Inflow Flood - Hydrologic Event; Inadequate Spillway Capacity	Yes	MOS00004
Bass Lake Dam	5/15/1990	Inflow Flood - Hydrologic Event	No	MO11224
Bullard Lake Dam	5/15/1990	Inflow Flood - Hydrologic Event	No	MO10620
Allen Dale Subdivision Dam	5/21/1990	Inflow Flood - Hydrologic Event	No	MOS00006
Rogue Creek Upper Dam (Incomplete)	5/25/1990	Inflow Flood - Hydrologic Event	No	MO31849
Pinnacle Lake Dam	6/7/1990	Inflow Flood - Hydrologic Event	No	MO30923
Woodridge Lake Dam	6/8/1990	Embankment Erosion	No	MO11005
Hester Lake Dam	6/27/1990	Not Known	Yes	MO12279
Brushy Creek Tailings Dam	1/9/1991	Toe Berm Erosion	No	MO30951
Hester Lake Dam	4/9/1991	Piping	Yes	MO12279
Brays Lake Dam	5/13/1991	Inflow Flood - Hydrologic Event	No	MO30098
Mcnulty Lake Dam	5/13/1991	Inflow Flood - Hydrologic Event	No	MO31915
Lake Viking Dam	10/28/1991	Not Known	No	MO10414
Miller Lake Dam	4/2/1992	Embankment Slide	No	MO31725
No Name (owned by Lonnie Hollaway)	5/25/1992	Embankment Slide	No	MOS00001

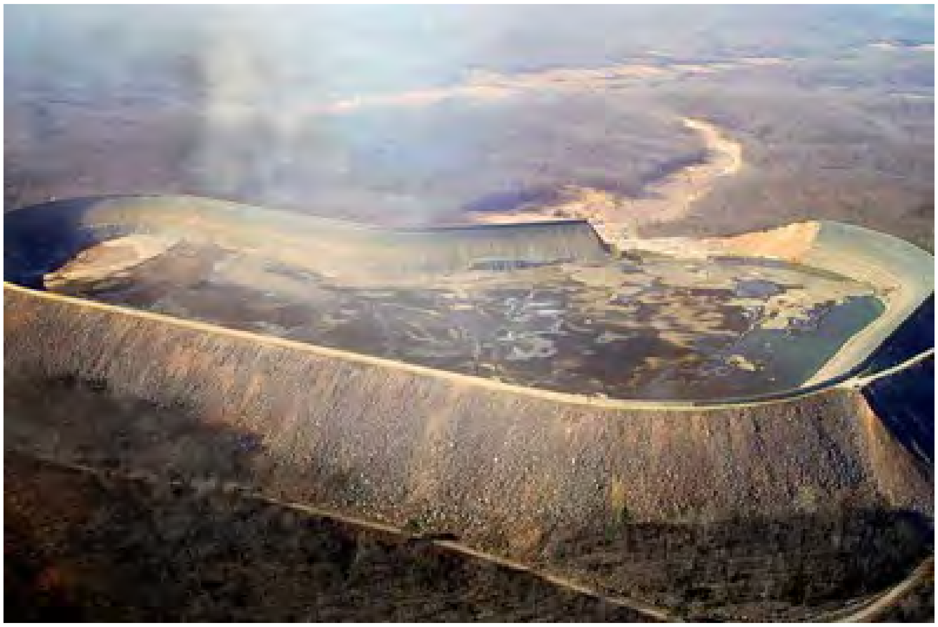
Dam Name	Incident Date	Incident Type	Dam Failure	NPDP ID
ISP Minerals, Inc. Plant	6/3/1992	Not Known	Yes	MO31988
ISP Minerals, Inc. Plant	6/3/1992	Tailings Pile Failure	No	MO31988
Unnamed Dam (MOS00015)	6/5/1992	Erosion	Yes	MOS00015
Harrison County Lake (aka West Fork of Big Creek C1 Dam)	1/3/1993	Inflow Flood - Hydrologic Event	Yes	MO12370
Las Brisas Lake Dam	5/24/1993	Seepage; Embankment Erosion	No	MO30541
Norman Swinney's Dam	5/26/1993	Inadequate Compaction	Yes	MOS00002
Robbins Lake Dam	5/26/1993	Embankment Slide	No	MO11260
Stevens Lake Dam	6/1/1993	Inflow Flood - Hydrologic Event	Yes	MO10107
City of Higbee Dam	6/18/1993	Seepage	No	MO10660
Bockelman Lake Dam	7/1/1993	Inflow Flood - Hydrologic Event	Yes	MO31526
Lake Marie Dam	7/8/1993	Embankment Erosion	No	MO10154
Carp and Commandeer Dams	7/14/1993	Inflow Flood - Hydrologic Event	No	MO20166
Trenton Lower Lake Dam	7/14/1993	Inflow Flood - Hydrologic Event	No	MO10366
Hidden Lake Dam	7/16/1993	Embankment Erosion	No	MO31452
Lake Viking Dam	7/22/1993	Inflow Flood - Hydrologic Event	No	MO10414
Lake Viking Dam	8/9/1993	Inflow Flood - Hydrologic Event	No	MO10414
Mozingo Creek Dam	8/10/1993	Inflow Flood - Hydrologic Event	No	MO12277
Trenton Lower Lake Dam	8/10/1993	Inflow Flood - Hydrologic Event	No	MO10366
F.E.M., Inc. Lake Dam (aka Claysville Lake Dam)	8/11/1993	Inflow Flood - Hydrologic Event	No	MO12234
Sunny Mount Dam	9/23/1993	Animal Attack	No	MO30832
Boyd Lake Dam	9/25/1993	Embankment Slide	Yes	MO31996
Freddies Lake Dam	9/26/1993	Inflow Flood - Hydrologic Event	Yes	MO32026
Lake Arrowhead Dam	10/5/1993	Inflow Flood - Hydrologic Event	No	MO10581
Lac Shayne Dam	10/7/1993	Embankment Slide	No	MO31835
Fellows Lake Dam	10/28/1993	Concrete Deterioration	No	MO20036
Holiday Acres Lake Dam	1/3/1994	Seepage; Embankment Slide	No	MO10135
Dresser #11 Tailings Pond Dam	2/17/1994	Concrete Deterioration	No	MO31422
Four Winds Way Dam	3/1/1994	Concrete Deterioration	No	
Prairie Lee Lake Dam	4/22/1994	Embankment Slide	No	MO10044
Goose Creek Dam	4/27/1994	Concrete Deterioration	No	MO31743
Bettison	5/26/1994	Embankment Slide	No	MOS00003
Seven Lakes #1	6/21/1994	Concrete Cracking	No	MO30347
Silver Creek Lake Dam	6/21/1994	Concrete Deterioration	No	MO31846
Mozingo Creek Dam	7/7/1994	Inflow Flood - Hydrologic Event	No	MO12277
Unnamed Dam	7/14/1994	Debris - Reservoir	No	MOS00007
Shatto Lake Mill Dam	7/21/1994	Inflow Flood - Hydrologic Event	No	MO20754
Seven Lakes #1	8/24/1994	Embankment Slide	No	MO30347
Unnamed Dam	8/30/1994	Seepage; Piping	No	MOS00008
Nehai Tonkayea Lake Dam	11/14/1994	Embankment Slide	No	MO10627
Lake Arrowhead Dam	11/15/1994	Embankment Slide	No	MO10581
City of Higbee Dam	3/23/1995	Embankment Slide	No	MO10660
Lake Arrowhead Dam	5/17/1995	Inflow Flood - Hydrologic Event	No	MO30572
Sunny Shores Dam	6/21/1995	Seepage	No	MO20237
Bowling Green #1 Dam	6/26/1995	Seepage; Piping	No	MO10262
Unnamed Dam	8/24/1995	Inflow Flood - Hydrologic Event	No	MOS00009
Owl Creek Estates Dam No. 3	8/31/1995	Embankment Slide	No	MO31960
Wells Lake Dam	12/7/1995	Cracks/Tree Growth	No	MO20447
Nehai Tonkayea Lake Dam	12/10/1995	Embankment Slide	No	MO10627
Iron Mountain Lake Dam	4/22/1996	Embankment Erosion	No	MO30057
Block Lake Dam	4/28/1996	Inflow Flood - Hydrologic Event	No	MO32038
Macon Lake Dam	5/7/1996	Inflow Flood - Hydrologic Event	No	MO10153
Tamarack Dam	5/31/1996	Inflow Flood - Hydrologic Event	No	MO30452
102 Riv Trib Wtrshd Strctr Lt-36	12/4/1996	Debris - Reservoir	No	MO11258
Lake Venita Dam	2/21/1997	Seepage; Piping	Yes	MO20164
Schacktenberg Company Dam	2/26/1997	Animal Attack	No	MO20805
Carp Lake Dam	3/2/1997	Embankment Slide	No	MO30217
Unnamed Dam	3/5/1997	Inflow Flood - Hydrologic Event	No	MOS00011

Dam Name	Incident Date	Incident Type	Dam Failure	NPDP ID
Unnamed Dam (Schacktenberg Company Dam?)	8/2/1997	Seepage; Piping	No	MOS00010
Christiansen Lake Dam	5/1/1999	Embankment Erosion	Yes	MO20145
Lake Flamingo Dam	6/6/2001	Seepage/Piping	No	MO11241
T-69 Watershed Site	8/22/2001	Concrete Deterioration	No	MOS00012
Junior Lake Dam	11/14/2001	Swallow Hole	No	MO11526
Taum Sauk	12/14/2005	Suspected Instrumentation Failure	Yes	Not Reported
Moon Valley Lake Dam	3/17/2008	Unknown	Yes	Not Reported
Glover Spring Lake Dam	8/2016	Overtopping/some damage	No	Not Reported

Source: Stanford University National Performance of Dams Program, https://npdp.stanford.edu/dam_incidents

The most notable dam failure in recent history was the December 14, 2005 breech in the Taum Sauk reservoir dam owned by AmerenUE of St. Louis. A 600-foot breech in the northwest side of the retention facility released 1.5 billion galls of stored water into the Johnson Shut-Ins State Park in 10 minutes' time. The waters destroyed the park and the park Superintendent's house and swept the Superintendent's family out of their house. All five family members survived. The lower reservoir was overtopped by the flow of the east fork of the Black River. As a precautionary measure, the City of Lesterville (Reynolds County) evacuated 100-150 people to higher ground. If the dam had failed during the summer months during the park's peak use, it is likely that many lives would have been lost.

Figure 3.79. 2005 Failure of AmerenUE's Taum Sauk Reservoir Dam



Source: State of Missouri Attorney General's Office

The 2011 floods in Missouri led to the Corps of Engineers having to release record levels of water through the Gavin Point Dam. This release did cause downstream flooding; however, the reservoirs upstream were at 100% capacity. The difficult choice to release so much water was supported by local officials. In Wyatt, Missouri during the same event, the Corps of Engineers breached the Bird's Point Levee in order to reduce pressure on a floodwall protecting the town. Although these events were not dam failures, they represent examples of intentional releases that caused downstream flooding to avoid potential failure, overtopping or pressure on upstream areas.

Although not included in the Stanford University National Performance of Dams incidents, there was a dam incident in Callaway County, Missouri in August of 2016. Glover Spring Lake, a man-made lake created in 1956 east of Fulton overflowed after 8 inches of rain fell. Increased water levels split the dam and floodwaters rushed under a bridge on County Road 101 and into Crows Fork and Auxvasse Creeks. County Road 101 was closed to traffic after rainfall and the overflow washed away road sections on both sides of the bridge. Routes UU and O were also impacted. The dam did not completely fail and there were no known injuries. No homes or farms downstream were flooded. If the dam had fully collapsed, there would have been additional damages.

Probability of Future Hazard Events

For the 42-year period from 1975 to 2016 for which dam failure statistics are available, 19 dam failures and 68 incidents are recorded. According to this data, annual probability calculates to a 45 percent annual probability of a dam failure somewhere in the state and a 100 percent annual probability of dam incidents. In should be noted that historical dam failures and incidents include events from all hazard classes and all dams (whether regulated or un-regulated). Failures and incidents for regulated dams that have higher inspection frequencies should be less probable. The probability of future events is 45%.

Changing Future Conditions Considerations

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

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

State Vulnerability Overview

The downstream hazard classification system utilized by the National Inventory of Dams provides the Hazard Classification system as a means to determine overall vulnerability in the event of dam failure. According to the NID, of the 5,113 recorded dams, 1,511 (29.5%) are High Hazard, 219 (4.3%) are Significant Hazard and 3,381 (66.1%) are Low Hazard, and 2 are unrated. If any of the 29.5% High Hazard dams in the state were to fail, loss of human life is likely. If any of the 4.3% Significant Hazard dams were to fail, loss of human life is possible. Failure of any of the 66.1% low hazard dams can result in loss of property. But, loss of life is unlikely.

The dam hazard classification system is a means to classify dams 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.

Inspection of Dams

State and Federal-regulated dams are inspected regularly with the frequency of inspection based on the hazard class. Results of inspections may result in necessary corrective actions. For State-regulated dams in Missouri, Class 1 dams are inspected every two years, Class 2 dams are inspected every three years, and Class 3 dams are inspected every five years.

Table 3.50 below provides the summary of the inspection findings provided in the National Inventory of Dams for State regulated dams.

Table 3.50. Inspection Rating Summary, State-Regulated Dams

Ratings	Class 1	Class 2	Class 3	Not Built	Total
Not Rated	2	18	35	5	60
Satisfactory	192	234	175	3	604
Unsatisfactory	5	10	6	0	21
Total	**199**	**262**	**216**	**8**	**685**

Source: National Inventory of Dams, HSIP Freedom 2015

A summary of the unsatisfactory ratings by county is provided in **Table 3.51.**

Table 3.51. Unsatisfactory Ratings by County, State-Regulated Dams

County	Class 1	Class 2	Class 3	Total
Boone	1	1	0	2
Crawford	0	1	1	2
Greene	0	1	0	1
Jefferson	0	1	0	1
Montgomery	0	0	1	1
Morgan	0	0	1	1
Platte	1	0	0	1
Polk	0	0	1	1
Ripley	0	2	0	2
St. Louis	1	0	1	2
Washington	2	4	1	7
Total	**5**	**10**	**6**	**21**

Source: National Inventory of Dams, HSIP Freedom 2015

For federally-regulated dams regulated by USACE, two types of dam inspections and completed. The first one is the Annual Inspection, which is performed on an annual basis to ensure the dam is being properly operated and maintained. The Periodic Inspection is the next level of inspection and is conducted by a multidisciplinary team led by a professional engineer. It includes a more detailed, comprehensive evaluation of the condition of the dam and will be conducted every five years. Components of the Periodic Inspection include evaluating annual inspection items; verifying proper operation and maintenance; evaluating operational adequacy, structural stability, and safety of the system; and comparing current design and construction criteria with those in place when the dam was built (http://www.usace.army.mil/Missions/Civil-Works/Dam-Safety-Program/Program-Activities/).

In 2005, the USACE started Screening for Portfolio Risk Analysis (SPRA). This analysis screened every one of the approximately 694 dams in the USACE inventory based on available information, to expeditiously identify and classify the highest risk dams requiring urgent and compelling action (Dam Safety Action Classification Classes I and II Dams). This screening has yielded a clear but basic understanding of where the greatest risks and priorities are located.

Completing SPRA has allowed USACE to develop a Portfolio Investment Plan for more than 300 dams within the portfolio determined to be "actionable," or posing moderate to extremely high risks.

The Dam Safety Action Classification System (DSAC) is intended to provide consistent and systematic guidelines for appropriate actions to address the dam safety issues and deficiencies of USACE dams. USACE dams are placed into a DSAC class based on their individual dam safety risk considered as a combination of probability of failure and potential life safety, economic, environmental, or other consequences. The DSAC table presents different levels and urgencies of actions that are commensurate with the different classes of the safety status of USACE dams. These actions range from immediate recognition of an urgent and compelling situation requiring extraordinary and immediate action for unsafe dams through normal operations and dam safety activities for safe dams.

1) DSAC Class I (Very High Urgency) – Dams where progression toward failure is confirmed to be taking place under normal operations and the dam is almost certain to fail under normal operations within a time frame from immediately to within a few years without intervention; or, the combination of life or economic consequences with probability of failure is extremely high.
2) DSAC Class II (High Urgency) – Dams where failure could begin during normal operations or be initiated as the consequence of an event. The likelihood of failure from one of these occurrences, prior to remediation, is too high to assure public safety; or, the combination of life or economic consequences with probability of failure is very high.
3) DSAC Class III (Moderate Urgency) – Dams that have issues where the dam is significantly inadequate or the combination of life, economic, or environmental consequences with probability of failure is moderate to high.
4) DSAC Class IV (Low Urgency) – Dams are inadequate with low risk such that the combination of life, economic, or environmental consequences with a probability of failure is low and the dam may not meet all essential USACE engineering guidelines.
5) DSAC Class V (Normal) – Dams considered adequately safe, meeting all essential agency guidelines and the residual risk is considered tolerable.

Due to their sensitive nature, the DSAC Classes of USACE dams are not available for publication.

The USACE is actively engaged in a program to assess and communicate risk associated with dams and levees. Actions to reduce inundation risks associated with USACE programs have been termed interim risk reduction measures (IRRMs). IRRMs are temporary actions taken to reduce inundation risks posed by dams and/or levees while longer term solutions are planned and implemented. The IRRMS do not preclude or in any way replace long term measures needed to reduce any risk. IRRMs are a critical part of responsible, adaptive flood risk management and recognize the dynamic nature of flood risk. In establishing IRRMs, the prevention of loss of life is the highest priority. **Table 3.52** provides a summary of risk evaluations for USACE dams in Missouri.

Table 3.52. Risk Evaluations for USACE Dams

Dam Name	Owner	Risk Evaluation Concerns	Interim Risk Reduction Measures
Lock and Dam No. 20	USACE-MVR	Miter gate failure due to barge impact Instability due to scour Miter gate anchorage failure Spillway gate due to barge impact	Update EAP Scour monitoring Regular inspections Risk assessment in FY16 New miter gates
Lock and Dam No. 21	USACE-MVR	Miter gate failure due to barge impact Instability due to scour Miter gate anchorage failure Spillway gate due to barge impact	Update EAP Scour monitoring Regular inspections New miter gates

Dam Name	Owner	Risk Evaluation Concerns	Interim Risk Reduction Measures
Lock and Dam No. 22	USACE-MVR	Miter gate failure due to barge impact Miter gate anchorage failure Spillway gate due to barge impact	Update EAP Regular inspections New miter gates Designing new Tainter gates
Bear Creek Dam	City of Hannibal	Seepage along the conduit concentrated leak erosion between the embankment fill and shale backward erosion piping	Removed vegetation from abutments Routinely operate and grease gates Remove sediment and debris from the intake
Red Rock Dam	USACE-MVR	Seepage and piping through the soluble gypsum layer Concentrated leak erosion between the embankment fill and bed rock Slope stability of the embankment Concentrated leak erosion at the spillway/ embankment interface Failure of Tainter gates	Red Rock Hydropower Project under construction Red Rock foundation investigation Regular inspections Regular Tainter gate operations and maintenance Instrumentation monitoring
Blue Springs Dam	USACE-NWK	Blue Springs Dam is considered low risk within the USACE portfolio. Concerns at the dam include low confidence in the hydrologic adequacy of the dam and the need to communicate risk to recent downstream developments.	None
Clinton Dam	USACE-NWK	Clinton Dam is considered low risk within the USACE portfolio. Concerns at the dam include the need to communicate risk to the downstream community and spillway erosion during rare flood events.	None
Harlan County Dam	USACE-NWK	Harlan County Dam is considered moderate risk within the USACE portfolio. Concerns at the dam include the bearing friction of the spillway tainter gates and potential sliding of the spillway along the foundation rock.	The tainter gates and sluiceway gates are currently under construction to replace gate bearings and structurally strengthen the tainter gates. Irrigation lines have been inspected and/or replaced. The dam surveillance plan and emergency action plan have been updated.
Hillsdale Dam	USACE-NWK	Hillsdale Dam is considered low risk within the USACE portfolio. Concerns at the dam include the elevation of the chimney drain and possible erosion on the upstream clay blanket.	None
Kanopolis Dam	USACE-NWK	Kanopolis Dam is considered moderate risk within the USACE portfolio. Concerns at the dam include overtopping during the probably maximum flood, erosion through the buried collector system, and erosion along the construction shutdown interface.	USACE will be communicating the risk of overtopping to the population within the inundation area and updating the dam surveillance plan and emergency action plan.
Harry Truman Dam	USACE-NWK	Harry Truman Dam is considered low risk within the USACE portfolio. Concerns at the dam include the spillway potentially being undersized for extremely rare loading conditions.	None
Long Branch Dam	USACE-NWK	Long Branch Dam is considered low risk within the USACE portfolio. Concerns at the dam include the potential for spillway erosion during rare flood events and the lack of a drain within the upper portion of the embankment.	None
Longview Dam	USACE-NWK	Longview Dam is considered low risk within the USACE portfolio. Concerns at the dam include the potential for spillway erosion during rare flood events.	None

Dam Name	Owner	Risk Evaluation Concerns	Interim Risk Reduction Measures
Melvern Dam	USACE-NWK	Melvern Dam is considered low risk within the USACE portfolio. Concerns at the dam include seepage and potential piping within the left abutment.	None
Milford Dam	USACE-NWK	Milford Dam is considered low risk within the USACE portfolio. Concerns at the dam include overtopping due to wind/wave action during an extremely rare flood event, contact erosion along the closure section, seepage through the right abutment, and erosion within the spillway.	None
Perry Dam	USACE-NWK	Perry Dam is considered low risk within the USACE portfolio. Concerns at the dam include the stability of the stilling basin and seepage through the foundation.	None
Pomme de Terre Dam	USACE-NWK	Pomme de Terre Dam is considered low risk within the USACE portfolio. Concerns at the dam include erosion within the rock-fill embankment.	None
Pomona Dam	USACE-NWK	Pomona Dam is considered low risk within the USACE portfolio. Concerns at the dam include erosion within the foundation and abutments and the breakdown of the upstream riprap embankment protection.	None
Rathbun Dam	USACE-NWK	Rathbun Dam is considered moderate risk within the USACE portfolio. Concerns at the dam include seepage through the foundation sands during high pool events and inadequacy of the stilling basin for large releases.	Thresholds have been established for piezometers in the abutments and valley. USACE has communicated the risks associated with the dam to local communities. The dam surveillance plan and emergency action plan have been updated to reflect potential problem areas.
Smithville Dam	USACE-NWK	Smithville Dam is considered moderate risk within the USACE portfolio. Concerns at the dam include instability of the abutment during rare and unusual flood events.	USACE is completing a stability analysis on the left abutment. USACE has communicated the risks associated with the dam to local communities. New instrumentation has been installed on the dam. The dam surveillance plan and emergency action plan have been updated.
Stockton Dam	USACE-NWK	Stockton Dam is considered low risk within the USACE portfolio. Concerns at the dam include seepage and erosion into the foundation.	None
Tuttle Creek Dam	USACE-NWK	Tuttle Creek Dam is considered low risk within the USACE portfolio. Concerns at the dam include spillway erosion and seismic failure.	None
Wilson Dam	USACE-NWK	Wilson Dam is considered low risk within the USACE portfolio. Concerns at the dam include overtopping, spillway erosion, and potential for settlement during rare flood events.	None

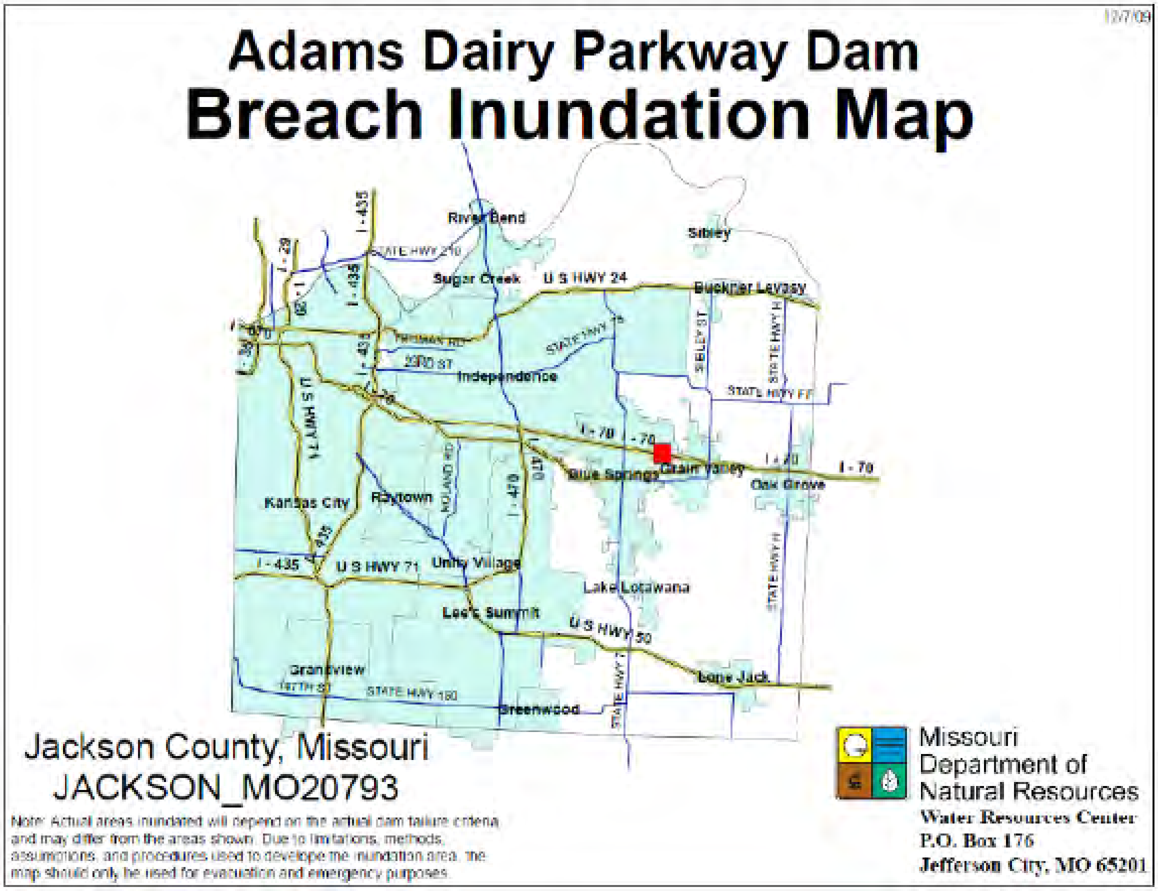
Source: U.S. Army Corps of Engineers

Missouri dams regulated by other federal agencies are inspected by the regulatory federal agency.

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). **Figure 3.80** provides an example inundation map for Adams Dairy Parkway Dam in Jackson County, Missouri.

Figure 3.80. Sample Inundation Map, Adams Dairy Parkway Dam, MoDNR



Source: Missouri Department of Natural Resources

Each 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.

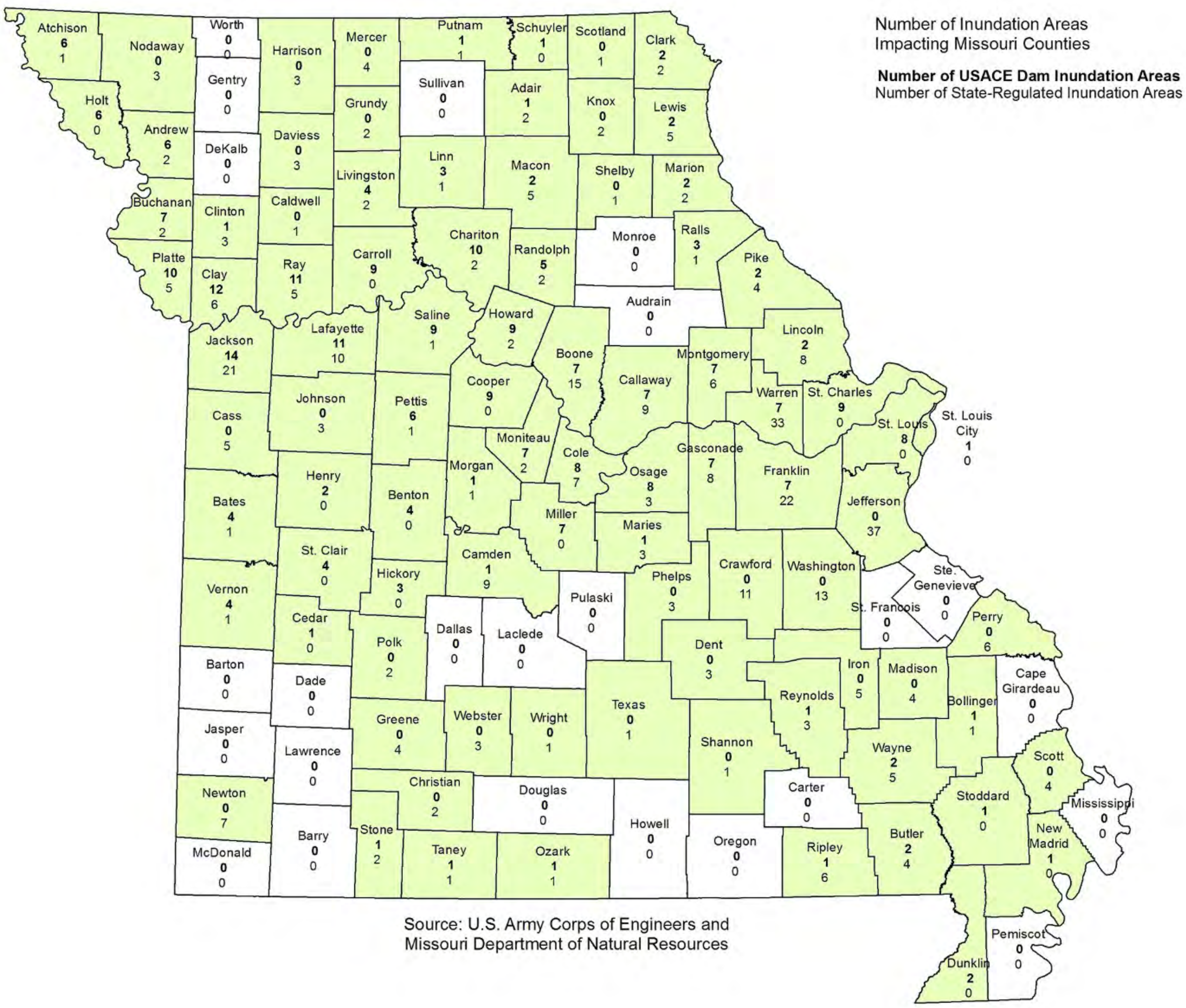
When a dam fails, the stored water can be suddenly released and have catastrophic effects on life and property downstream. Homes, bridges, and roads can be demolished in minutes. Residents near High Hazard or Significant Hazard dams should become familiar with the dam's emergency action plans, if available.

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.

Figure 3.81 provides the number by county of all state and USACE-regulated dams in Missouri for which inundation areas were made available for the State Hazard Mitigation Plan Vulnerability Analysis.

Figure 3.81. State and Federally-regulated Dams with Provided Inundation Areas



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

For State-regulated Class 1 and Class 2 dams that have available inundation maps as well as USACE dams for which inundation maps were made available, GIS comparative analysis was accomplished against the building exposure data to determine the types, numbers, and estimated values of buildings at risk to dam failure. The building exposure data was based on the structure inventory data layer available from the Missouri Spatial Data Inventory Service (MSDIS). The available dam inundation areas were compared against the structure inventory to determine the numbers and types of structures at risk to dam failure. To calculate estimated values of buildings at risk, buildings values available in the HAZUS census block data were used to determine an average value for each property type. This average value per property type was then applied to the number of structures in dam inundation areas by type to calculate an overall estimated value of buildings at risk by type.

In addition to counts and values of structures at risk, an estimated population impacted for each county was calculated based on the number of residential properties in inundation areas multiplied by the average household size.

Table 3.53 provides the results of the inundation area analysis with the numbers and values of various types of structures, and population within the mapped inundation areas for State-Regulated Dams. **Table 3.54** that follows provides the same analysis results of the inundation area analysis of available USACE dams. Error! Reference source not found. to **Figure 3.87** provide thematic maps of the analysis results for number of structures, value of structures, and population at risk. Note: Counties not included in table did not have structures in available dam inundation areas.

Table 3.53. Estimated Numbers and Values of Structures and Population Vulnerable to Failure of State-Regulated Dams with Available Inundation Areas

County	Number of Structures	Value of Structures	Population
Adair	**6**	**$2,161,414**	**5**
Agriculture	4	$1,735,758	0
Residential	2	$425,656	5
Andrew	**109**	**$25,626,397**	**191**
Agriculture	26	$5,638,171	0
Commercial	4	$2,261,299	0
Government	1	$730,500	0
Industrial	2	$623,895	0
Residential	76	$16,372,533	191
Atchison	**2**	**$977,870**	**0**
Agriculture	2	$977,870	0
Bollinger	**8**	**$5,351,385**	**0**
Agriculture	8	$5,351,385	0
Boone	**61**	**$18,508,925**	**104**
Agriculture	13	$3,895,190	0
Commercial	2	$1,783,690	0
Industrial	3	$1,606,194	0
Residential	43	$11,223,850	104
Buchanan	**3**	**$672,540**	**8**
Residential	3	$672,540	8
Butler	**18**	**$4,979,581**	**20**
Agriculture	10	$3,510,862	0
Residential	8	$1,468,719	20
Caldwell	**1**	**$184,997**	**2**
Residential	1	$184,997	2
Callaway	**19**	**$6,383,365**	**15**
Agriculture	7	$1,355,577	0
Commercial	5	$3,138,290	0
Industrial	1	$624,466	0
Residential	6	$1,265,032	15

County	Number of Structures	Value of Structures	Population
Camden	**16**	**$5,968,159**	**23**
Agriculture	3	$718,463	0
Commercial	4	$3,226,996	0
Residential	9	$2,022,700	23
Cass	**150**	**$48,894,441**	**153**
Agriculture	59	$15,964,094	0
Commercial	33	$17,994,619	0
Residential	58	$14,935,728	153
Chariton	**28**	**$26,207,561**	**8**
Agriculture	25	$25,659,259	0
Residential	3	$548,302	8
Christian	**49**	**$19,105,353**	**32**
Agriculture	19	$3,891,789	0
Commercial	11	$5,527,272	0
Industrial	7	$6,905,290	0
Residential	12	$2,781,003	32
Clark	**2**	**$1,255,361**	**0**
Agriculture	1	$722,611	0
Commercial	1	$532,750	0
Clay	**133**	**$76,148,793**	**195**
Agriculture	7	$1,646,052	0
Commercial	50	$52,821,737	0
Government	1	$1,121,289	0
Residential	75	$20,559,715	195
Clinton	**33**	**$11,150,593**	**40**
Agriculture	3	$532,806	0
Commercial	13	$6,269,961	0
Government	1	$577,800	0
Residential	16	$3,770,026	40
Cole	**23**	**$5,952,157**	**51**
Agriculture	2	$454,252	0
Residential	21	$5,497,905	51
Crawford	**30**	**$5,811,747**	**50**
Agriculture	10	$2,067,000	0
Commercial	1	$554,899	0
Residential	19	$3,189,848	50
Daviess	**13**	**$4,674,946**	**5**
Agriculture	8	$1,610,411	0
Industrial	3	$2,695,068	0
Residential	2	$369,466	5
Dekalb	**38**	**$16,262,268**	**7**
Agriculture	11	$2,259,500	0
Commercial	24	$13,295,778	0
Residential	3	$706,990	7
Dent	**12**	**$5,571,450**	**3**
Agriculture	10	$4,637,059	0
Commercial	1	$769,535	0
Residential	1	$164,856	3
Franklin	**147**	**$33,080,876**	**360**
Agriculture	14	$44,622	0

County	Number of Structures	Value of Structures	Population
Commercial	17	$7,826,769	0
Residential	116	$25,209,486	360
Gasconade	**38**	**$10,701,837**	**7**
Agriculture	29	$6,583,000	0
Commercial	5	$2,756,560	0
Government	1	$799,579	0
Residential	3	$562,698	7
Greene	**144**	**$50,247,447**	**150**
Agriculture	57	$14,472,284	0
Commercial	8	$6,865,363	0
Government	14	$13,122,667	0
Residential	65	$15,787,134	150
Grundy	**21**	**$4,442,095**	**2**
Agriculture	20	$4,249,348	0
Residential	1	$192,747	2
Harrison	**10**	**$1,952,385**	**0**
Agriculture	10	$1,952,385	0
Howard	**14**	**$4,324,030**	**18**
Commercial	7	$2,957,526	0
Residential	7	$1,366,503	18
Iron	**74**	**$17,498,203**	**133**
Agriculture	13	$3,621,429	0
Commercial	2	$998,599	0
Government	2	$1,082,800	0
Industrial	3	$3,322,468	0
Residential	54	$8,472,907	133
Jackson	**1,813**	**$1,218,255,315**	**2,230**
Agriculture	33	$9,585,156	0
Commercial	862	$957,844,301	0
Education	4	$8,888,472	0
Residential	914	$241,937,387	2,230
Jefferson	**9**	**$2,101,117**	**3**
Agriculture	8	$1,930,655	0
Residential	1	$170,462	3
Johnson	**16**	**$4,090,214**	**32**
Agriculture	2	$404,296	0
Commercial	1	$633,883	0
Residential	13	$3,052,034	32
Knox	**1**	**$1,261,385**	**0**
Agriculture	1	$1,261,385	0
Lafayette	**27**	**$7,152,667**	**20**
Agriculture	19	$5,373,629	0
Residential	8	$1,779,038	20
Lewis	**44**	**$29,303,544**	**10**
Agriculture	40	$28,567,143	0
Residential	4	$736,402	10
Lincoln	**49**	**$1,820,251**	**86**
Agriculture	13	$2,694	0
Commercial	5	$1,589,626	0
Residential	31	$227,931	86

County	Number of Structures	Value of Structures	Population
Linn	**25**	**$9,250,987**	**33**
Agriculture	1	$224,299	0
Commercial	11	$6,577,406	0
Residential	13	$2,449,282	33
Livingston	**23**	**$5,845,313**	**5**
Agriculture	21	$5,456,080	0
Residential	2	$389,233	5
Macon	**10**	**$2,182,696**	**19**
Agriculture	1	$206,381	0
Commercial	1	$591,282	0
Residential	8	$1,385,033	19
Madison	**23**	**$5,632,283**	**45**
Agriculture	2	$480,240	0
Commercial	3	$1,774,760	0
Industrial	1	$775,723	0
Residential	17	$2,601,560	45
Maries	**18**	**$4,477,553**	**34**
Agriculture	1	$206,381	0
Commercial	3	$1,773,845	0
Residential	14	$2,497,327	34
Marion	**708**	**$270,673,794**	**1,035**
Commercial	264	$163,201,132	0
Government	9	$6,451,548	0
Industrial	9	$7,269,167	0
Residential	426	$93,751,946	1,035
Mercer	**2**	**$991,978**	**2**
Agriculture	1	$749,875	0
Residential	1	$242,103	2
Moniteau	**1**	**$203,419**	**3**
Residential	1	$203,419	3
Montgomery	**39**	**$8,544,560**	**12**
Agriculture	34	$7,674,203	0
Residential	5	$870,357	12
Morgan	**2**	**$382,111**	**3**
Agriculture	1	$222,965	0
Residential	1	$159,146	3
Newton	**466**	**$135,365,952**	**846**
Agriculture	59	$11,022,527	0
Commercial	79	$50,191,761	0
Education	5	$15,965,921	0
Residential	323	$58,185,743	846
Nodaway	**39**	**$11,350,283**	**21**
Agriculture	30	$9,171,356	0
Residential	9	$2,178,927	21
Osage	**36**	**$22,357,152**	**3**
Agriculture	35	$22,153,793	0
Residential	1	$203,359	3
Perry	**62**	**$230,615**	**59**
Agriculture	39	$5,220	0
Residential	23	$225,395	59

County	Number of Structures	Value of Structures	Population
Pettis	**5**	**$1,386,806**	**0**
Agriculture	5	$1,386,806	0
Phelps	**52**	**$10,702,801**	**96**
Agriculture	14	$2,650,614	0
Residential	38	$8,052,187	96
Pike	**27**	**$1664397**	**28**
Agriculture	4	$4,664	0
Commercial	5	$353,791	0
Industrial	7	$260,942	0
Residential	11	$1,045,000	28
Platte	**175**	**$89,225,679**	**261**
Agriculture	8	$1,994,993	0
Commercial	56	$48,733,289	0
Education	1	$1,695,836	0
Government	2	$2,373,519	0
Industrial	2	$1,803,351	0
Residential	106	$32,624,690	261
Polk	**10**	**$2,113,195**	**8**
Agriculture	7	$1,596,000	0
Residential	3	$517,195	8
Putnam	**16**	**$11,598,585**	**2**
Agriculture	15	$11,449,167	0
Residential	1	$149,418	2
Ralls	**185**	**$86,430,306**	**271**
Agriculture	5	$1,070,244	0
Commercial	33	$13,654,315	0
Industrial	40	$51,877,753	0
Residential	107	$19,827,994	271
Randolph	**4**	**$1,900,727**	**0**
Agriculture	4	$1,900,727	0
Ray	**12**	**$5,437,737**	**5**
Agriculture	3	$1,092,779	0
Commercial	7	$3,891,284	0
Residential	2	$453,674	5
Ripley	**23**	**$1,128,290**	**21**
Agriculture	15	$20,590	0
Residential	8	$1,107,700	21
Saline	**6**	**$2,546,912**	**0**
Agriculture	6	$2,546,912	0
Scotland	**27**	**$19,094,984**	**0**
Agriculture	4	$3,932,800	0
Commercial	20	$13,718,261	0
Government	3	$1,443,923	0
Scott	**41**	**$8,886,540**	**66**
Agriculture	15	$4,101,090	0
Residential	26	$4,785,450	66
Shelby	**1**	**$244,937**	**0**
Agriculture	1	$244,937	0
Ste Genevieve	**17**	**$923,786**	**16**
Agriculture	11	$137,786	0

County	Number of Structures	Value of Structures	Population
Residential	6	$786,000	16
St Louis	**6**	**$1,029,394**	**0**
Agriculture	6	$1,029,394	0
Stone	**205**	**$70,381,819**	**240**
Agriculture	11	$2,898,641	0
Commercial	83	$44,127,238	0
Government	4	$2,056,000	0
Industrial	8	$3,017,128	0
Residential	99	$18,282,812	240
Taney	**3**	**$1,613,938**	**0**
Agriculture	1	$210,197	0
Commercial	2	$1,403,741	0
Warren	**215**	**$11,071,840**	**135**
Agriculture	162	$2,684,178	0
Commercial	2	$594,862	0
Residential	51	$7,792,800	135
Washington	**48**	**$1,314,354**	**16**
Agriculture	37	$125,874	0
Commercial	5	$710,280	0
Residential	6	$478,200	16
Wayne	**40**	**$7,575,929**	**41**
Agriculture	23	$5,288,722	0
Residential	17	$2,287,206	41
Webster	**2**	**$408,359**	**3**
Agriculture	1	$240,275	0
Residential	1	$168,085	3
Grand Total	**5,735**	**$2,492,250,679**	**7,292**

Source: Missouri Department of Natural Resources, MSDIS Structure Inventory, HAZUS Building Exposure

Table 3.54. Estimated Numbers and Values of Structures and Population Vulnerable to Failure of USACE Dams with Available Inundation Areas

County	Number of Structures	Value of Structures	Population
Adair	**255**	**$89,268,465**	**250**
Agriculture	136	$59,015,758	0
Commercial	12	$7,098,223	0
Government	1	$594,720	0
Residential	106	$22,559,765	250
Andrew	**494**	**$117,900,851**	**638**
Agriculture	213	$46,189,628	0
Commercial	14	$7,914,546	0
Government	12	$8,766,000	0
Industrial	1	$311,947	0
Residential	254	$54,718,729	638
Atchison	**2,595**	**$1,195,605,532**	**731**
Agriculture	2,058	$1,006,227,783	0
Commercial	106	$66,792,832	0
Government	8	$3,784,727	0
Industrial	80	$42,848,000	0
Residential	343	$75,952,191	731

County	Number of Structures	Value of Structures	Population
Bates	**64**	**$40,002,133**	**32**
Agriculture	43	$33,309,892	0
Commercial	5	$2,976,462	0
Education	3	$1,416,842	0
Residential	13	$2,298,936	32
Benton	**3,505**	**$1,289,245,325**	**4,640**
Agriculture	4	$3,695,429	0
Commercial	1,454	$955,095,514	0
Government	11	$7,977,588	0
Industrial	1	$948,262	0
Residential	2,035	$321,528,532	4,640
Bollinger	**8**	**$5,351,385**	**0**
Agriculture	8	$5,351,385	0
Boone	**2,189**	**$635,372,467**	**4,422**
Agriculture	304	$91,087,531	0
Commercial	19	$16,945,052	0
Education	8	$25,793,609	0
Government	20	$20,968,794	0
Industrial	3	$1,606,194	0
Residential	1,835	$478,971,286	4,422
Buchanan	**6,038**	**$2,773,093,273**	**9,079**
Agriculture	1,019	$247,313,726	0
Commercial	475	$454,118,402	0
Education	13	$15,041,406	0
Government	117	$103,488,904	0
Industrial	895	$1,164,240,928	0
Residential	3,519	$788,889,906	9,079
Butler	**18**	**$4,979,581**	**20**
Agriculture	10	$3,510,862	0
Residential	8	$1,468,719	20
Callaway	**1,001**	**$240,413,767**	**887**
Agriculture	556	$107,671,539	0
Commercial	38	$23,851,006	0
Government	16	$10,321,846	0
Industrial	39	$24,354,188	0
Residential	352	$74,215,188	887
Camden	**25,253**	**$14,451,939,002**	**26,341**
Agriculture	43	$10,297,976	0
Commercial	15,073	$12,160,125,927	0
Government	6	$4,629,188	0
Residential	10,131	$2,276,885,912	26,341
Carroll	**3,514**	**$1,793,812,723**	**2,812**
Agriculture	2,194	$1,417,860,311	0
Commercial	113	$74,417,466	0
Education	4	$4,376,889	0
Government	26	$20,082,196	0
Industrial	43	$50,538,847	0
Residential	1,134	$226,537,014	2,812
Cedar	**190**	**$54,466,087**	**110**
Agriculture	141	$45,895,500	0

County	Number of Structures	Value of Structures	Population
Industrial	2	$1,706,937	0
Residential	47	$6,863,650	110
Chariton	**3,082**	**$2,390,415,507**	**2,145**
Agriculture	2,097	$2,152,298,666	0
Commercial	117	$72,308,690	0
Education	1	$2,320,273	0
Government	7	$2,404,000	0
Industrial	9	$5,548,909	0
Residential	851	$155,534,970	2,145
Clark	**488**	**$276,592,800**	**315**
Agriculture	337	$243,519,944	0
Commercial	19	$10,122,250	0
Government	2	$853,765	0
Residential	130	$22,096,841	315
Clay	**3,797**	**$1,974,980,232**	**5,975**
Agriculture	335	$78,775,329	0
Commercial	666	$703,585,534	0
Education	9	$17,362,486	0
Government	38	$42,608,988	0
Industrial	451	$502,698,217	0
Residential	2,298	$629,949,678	5,975
Cole	**2,460**	**$749,496,484**	**4,221**
Agriculture	518	$117,651,203	0
Commercial	98	$78,378,729	0
Education	11	$17,468,887	0
Government	23	$32,339,646	0
Industrial	80	$50,735,342	0
Residential	1,730	$452,922,678	4,221
Cooper	**1,060**	**$259,365,988**	**1,279**
Agriculture	426	$95,572,951	0
Commercial	95	$49,873,774	0
Government	11	$4,627,333	0
Industrial	10	$6,957,909	0
Residential	518	$102,334,020	1,279
Franklin	**2948**	**$762,218,127**	**4,951**
Agriculture	906	$2,887,667	0
Commercial	294	$135,357,060	0
Education	11	$9,462,612	0
Government	5	$2,391,875	0
Industrial	135	$265,053,836	0
Residential	1597	$347,065,078	4,951
Gasconade	**1,493**	**$403,197,647**	**1,535**
Agriculture	611	$138,697,000	0
Commercial	205	$113,018,968	0
Education	11	$18,698,900	0
Government	6	$4,797,474	0
Industrial	7	$5,504,722	0
Residential	653	$122,480,583	1,535
Hickory	**248**	**$61,659,180**	**394**
Agriculture	22	$7,410,000	0

County	Number of Structures	Value of Structures	Population
Commercial	40	$24,442,759	0
Education	3	$5,050,200	0
Government	8	$4,778,400	0
Residential	175	$19,977,821	394
Holt	**3,344**	**$851,718,125**	**2,222**
Agriculture	2,036	$547,250,808	0
Commercial	146	$66,527,906	0
Education	2	$3,196,889	0
Government	31	$14,167,000	0
Industrial	76	$41,078,974	0
Residential	1,053	$179,496,548	2,222
Howard	**787**	**$189,102,241**	**982**
Agriculture	269	$58,234,230	0
Commercial	102	$43,095,383	0
Industrial	28	$12,029,294	0
Residential	388	$75,743,333	982
Iron	**74**	**$17,498,203**	**133**
Agriculture	13	$3,621,429	0
Commercial	2	$998,599	0
Government	2	$1,082,800	0
Industrial	3	$3,322,468	0
Residential	54	$8,472,907	133
Jackson	**7,312**	**$4,415,812,408**	**9,967**
Agriculture	510	$148,134,222	0
Commercial	807	$896,728,945	0
Education	11	$24,443,298	0
Government	24	$34,317,462	0
Industrial	1,875	$2,230,881,889	0
Residential	4,085	$1,081,306,592	9,967
Lafayette	**443**	**$90,875,060**	**315**
Agriculture	279	$39,271,450	0
Commercial	16	$10,811,861	0
Education	1	$1,975,026	0
Government	1	$539,128	0
Industrial	17	$10,129,728	0
Residential	129	$28,686,995	315
Lewis	**1,739**	**$548,588,237**	**2,913**
Agriculture	184	$131,408,857	0
Commercial	275	$129,770,986	0
Education	4	$5,808,444	0
Government	17	$6,898,421	0
Industrial	70	$55,806,154	0
Residential	1,189	$218,895,374	2,913
Lincoln	**460**	**$58,674,549**	**706**
Agriculture	205	$552,189	0
Residential	255	$58,122,360	706
Linn	**41**	**$9,246,863**	**23**
Agriculture	31	$6,953,260	0
Commercial	1	$597,946	0
Residential	9	$1,695,657	23

County	Number of Structures	Value of Structures	Population
Livingston	**168**	**$42,171,838**	**74**
Agriculture	136	$35,334,613	0
Commercial	1	$804,118	0
Residential	31	$6,033,107	74
Macon	**239**	**$50,156,004**	**141**
Agriculture	176	$36,323,108	0
Commercial	1	$591,282	0
Government	4	$3,200,125	0
Residential	58	$10,041,489	141
Madison	**23**	**$5,632,283**	**45**
Agriculture	2	$480,240	0
Commercial	3	$1,774,760	0
Industrial	1	$775,723	0
Residential	17	$2,601,560	45
Marion	**528**	**$175,265,504**	**544**
Agriculture	169	$37,547,575	0
Commercial	104	$64,291,355	0
Government	10	$7,168,387	0
Industrial	21	$16,961,389	0
Residential	224	$49,296,798	544
Miller	**2,434**	**$844,876,121**	**2,438**
Agriculture	406	$97,795,877	0
Commercial	1,068	$576,040,541	0
Government	6	$3,120,000	0
Industrial	20	$10,687,861	0
Residential	934	$157,231,842	2,438
Moniteau	**487**	**$104,480,588**	**233**
Agriculture	397	$85,896,740	0
Commercial	1	$479,522	0
Residential	89	$18,104,326	233
Montgomery	**1,166**	**$257,890,796**	**533**
Agriculture	925	$208,783,475	0
Commercial	10	$5,294,780	0
Industrial	6	$4,646,489	0
Residential	225	$39,166,052	533
Morgan	**10,228**	**$4,100,169,616**	**10,904**
Agriculture	87	$19,397,947	0
Commercial	5,861	$3,398,194,249	0
Education	1	$651,833	0
Industrial	3	$1,417,148	0
Residential	4,276	$680,508,438	10,904
Osage	**1,557**	**$857,380,131**	**1,195**
Agriculture	983	$622,205,103	0
Commercial	60	$38,288,045	0
Education	9	$29,793,600	0
Government	2	$1,344,118	0
Industrial	47	$73,017,565	0
Residential	456	$92,731,700	1,195
Ozark	**172**	**$92,595,467**	**24**
Agriculture	7	$2,822,000	0

County	Number of Structures	Value of Structures	Population
Commercial	154	$88,217,412	0
Residential	11	$1,556,055	24
Pettis	**21**	**$5,824,583**	**0**
Agriculture	21	$5,824,583	0
Pike	**459**	**$58,699,043**	**658**
Agriculture	97	$452,373	0
Commercial	83	$29,364,691	0
Government	8	$1,809,444	0
Industrial	8	$2,087,534	0
Residential	263	$24,985,000	658
Platte	**3,285**	**$1,459,413,930**	**4,640**
Agriculture	600	$149,624,460	0
Commercial	434	$377,682,993	0
Education	14	$23,741,709	0
Government	40	$47,470,370	0
Industrial	311	$280,421,135	0
Residential	1,886	$580,473,262	4,640
Putnam	**88**	**$55,606,201**	**40**
Agriculture	68	$51,902,889	0
Commercial	2	$1,013,783	0
Residential	18	$2,689,529	40
Ralls	**464**	**$110,392,719**	**344**
Agriculture	295	$63,144,390	0
Commercial	20	$8,275,342	0
Government	5	$3,395,500	0
Industrial	8	$10,375,551	0
Residential	136	$25,201,936	344
Randolph	**31**	**$12,672,548**	**19**
Agriculture	24	$11,404,364	0
Residential	7	$1,268,184	19
Ray	**2,053**	**$696,848,076**	**2,601**
Agriculture	899	$327,469,394	0
Commercial	92	$51,142,588	0
Education	20	$57,973,333	0
Government	7	$4,862,773	0
Industrial	46	$31,058,280	0
Residential	989	$224,341,708	2,601
Ripley	**23**	**$1,128,290**	**21**
Agriculture	15	$20,590	0
Residential	8	$1,107,700	21
Saline	**796**	**$320,175,296**	**508**
Agriculture	555	$235,589,338	0
Commercial	4	$2,538,547	0
Education	1	$1,684,056	0
Government	1	$539,128	0
Industrial	30	$33,322,660	0
Residential	205	$46,501,567	508
Schuyler	**60**	**$40,765,079**	**10**
Agriculture	56	$40,096,000	0
Residential	4	$669,079	10

County	Number of Structures	Value of Structures	Population
Scott	**41**	**$8,886,540**	**66**
Agriculture	15	$4,101,090	0
Residential	26	$4,785,450	66
St Charles	**8,323**	**$2,856,006,746**	**15,971**
Agriculture	2,194	$32,188,176	0
Commercial	847	$729,684,708	0
Education	6	$15,426,708	0
Government	38	$58,604,112	0
Industrial	247	$530,961,418	0
Residential	4,991	$1,489,141,624	15,971
St Clair	**177**	**$70,723,004**	**106**
Agriculture	118	$55,080,714	0
Commercial	10	$7,009,290	0
Government	3	$2,285,438	0
Residential	46	$6,347,562	106
St Louis	**5,799**	**$3,063,026,253**	**7477**
Agriculture	326	$55,930,382	0
Commercial	2,366	$1,051,257,466	0
Education	33	$52,165,654	0
Government	103	$75,921,715	0
Industrial	559	$1,244,850,919	0
Residential	2,412	$582,900,117	7477
St Louis City	**6**	**$7,935,660**	**3**
Commercial	5	$7,616,762	0
Residential	1	$318,898	3
Taney	**4,065**	**$1,329,495,344**	**7,069**
Agriculture	221	$46,453,530	0
Commercial	863	$605,714,222	0
Government	44	$31,152,000	0
Industrial	28	$9,960,558	0
Residential	2,909	$636,215,033	7,069
Vernon	**2**	**$1,268,194**	**0**
Agriculture	2	$1,268,194	0
Warren	**1,509**	**$126,008,297**	**810**
Agriculture	1,188	$4,357,647	0
Commercial	13	$78,224,353	0
Government	1	$3,239,897	0
Residential	307	$40,186,400	810
Wayne	**40**	**$7,575,929**	**41**
Agriculture	23	$5,288,722	0
Residential	17	$2,287,206	41
Grand Total	**119,144**	**$52,513,962,319**	**144553**

Source: U.S. Army Corps of Engineers, MSDIS Structure Inventory, HAZUS Building Exposure

Figure 3.82. Number of Structures in State-Regulated Dam Inundation Areas by County

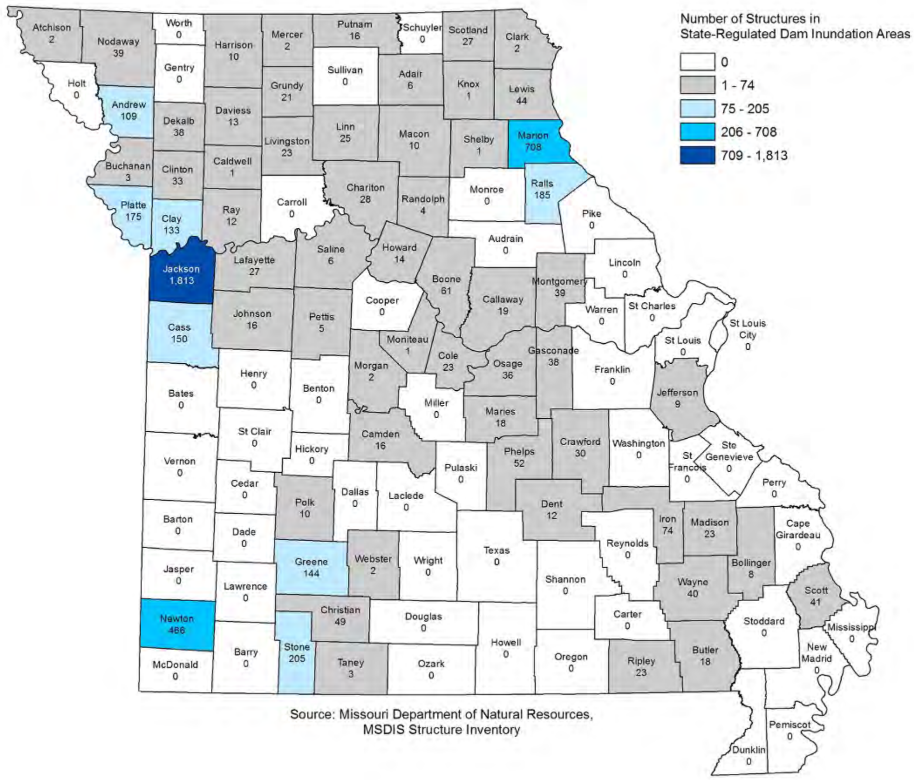


Figure 3.83. Value of Structures in State-Regulated Dam Inundation Areas by County

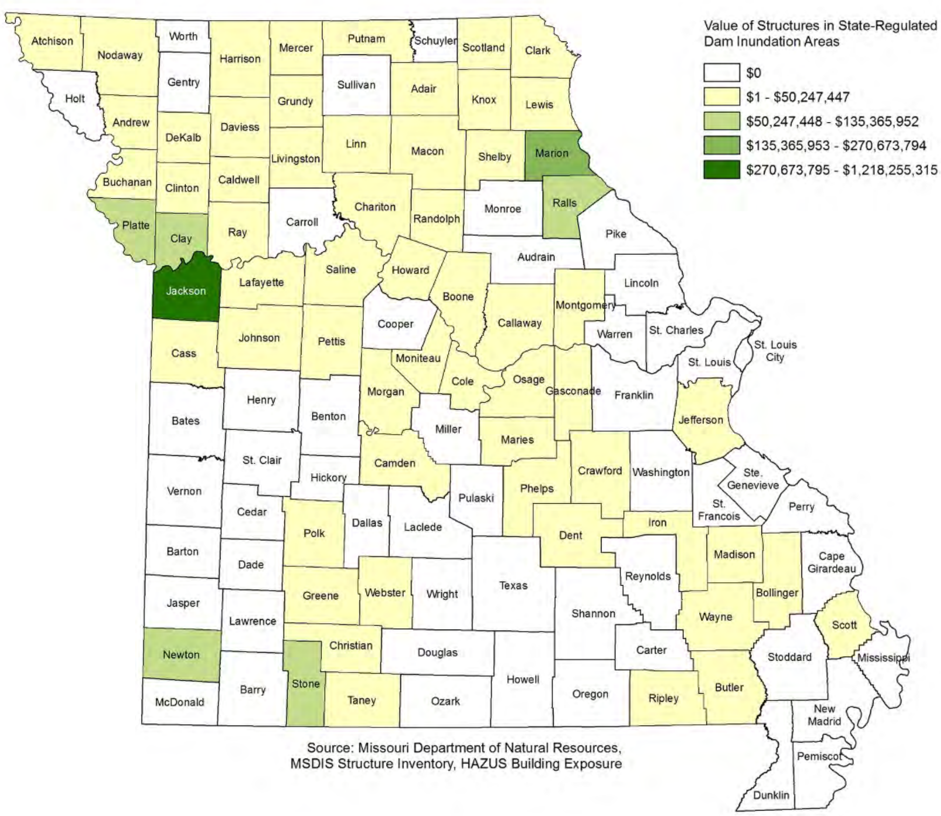


Figure 3.84. Number of Structures in USACE Dam Inundation Areas by County

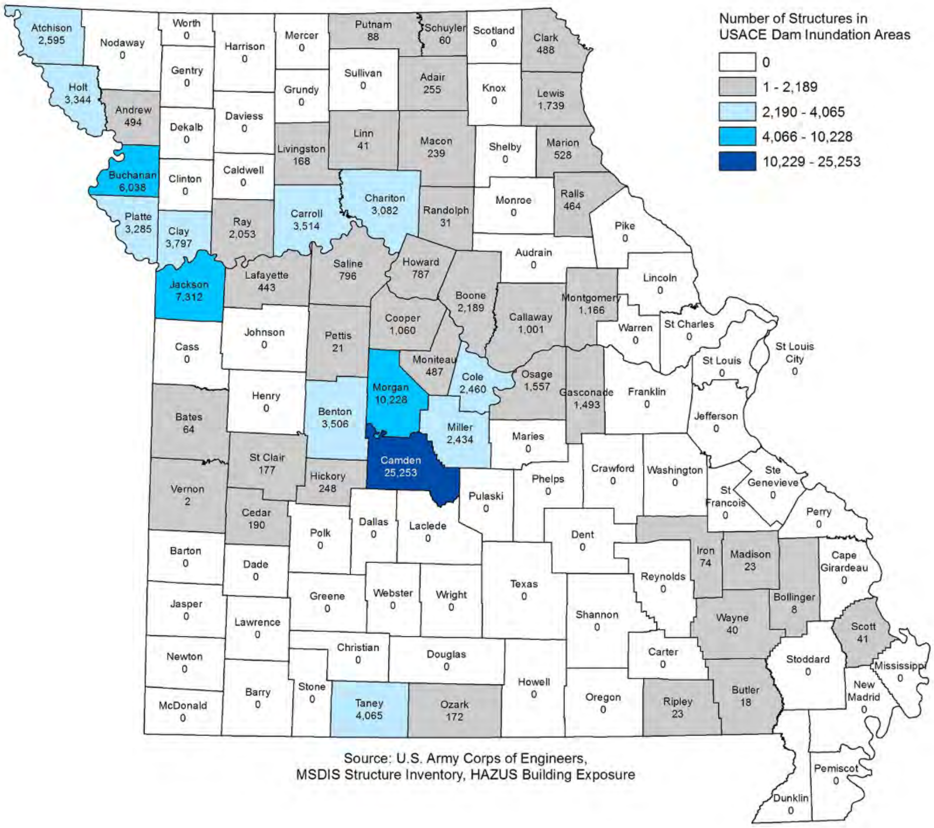
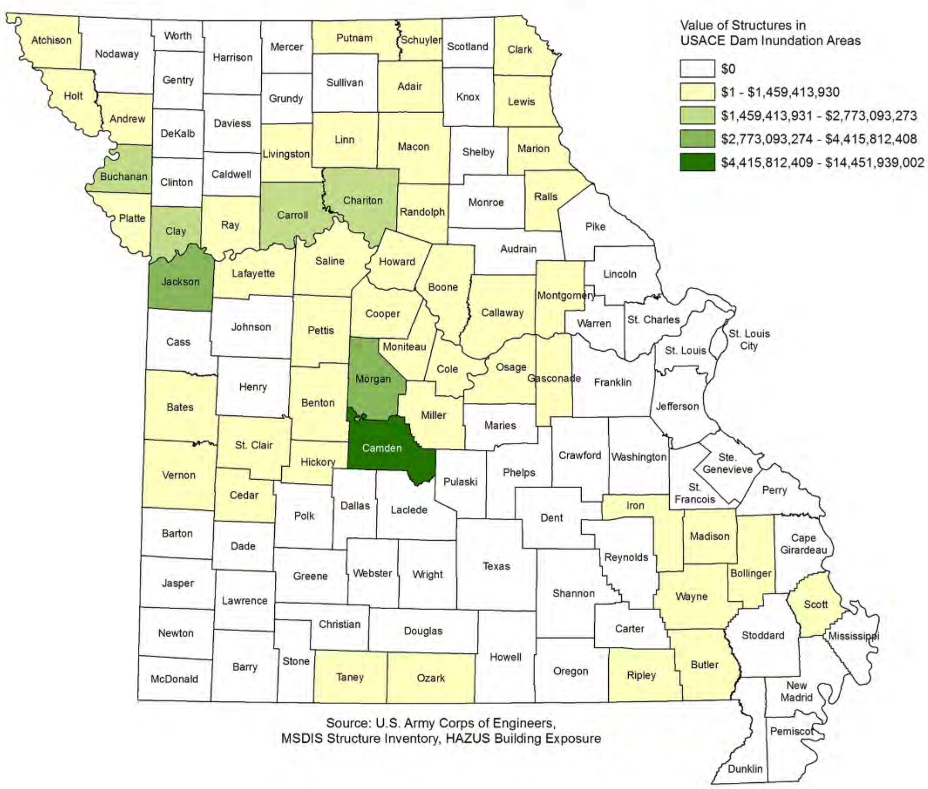


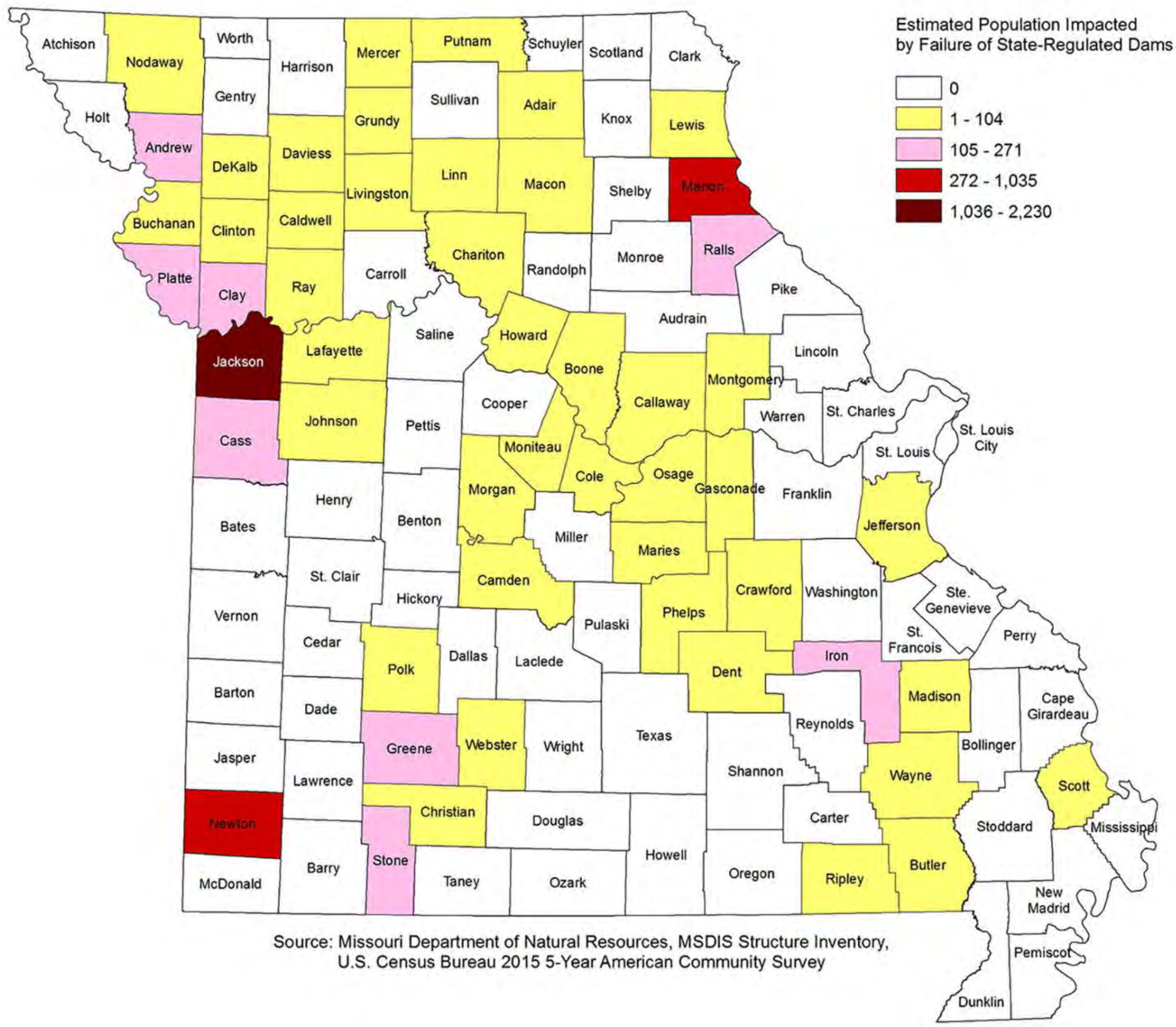
Figure 3.85. Value of Structures in USACE Dam Inundation Areas by County



3 Risk Assessment

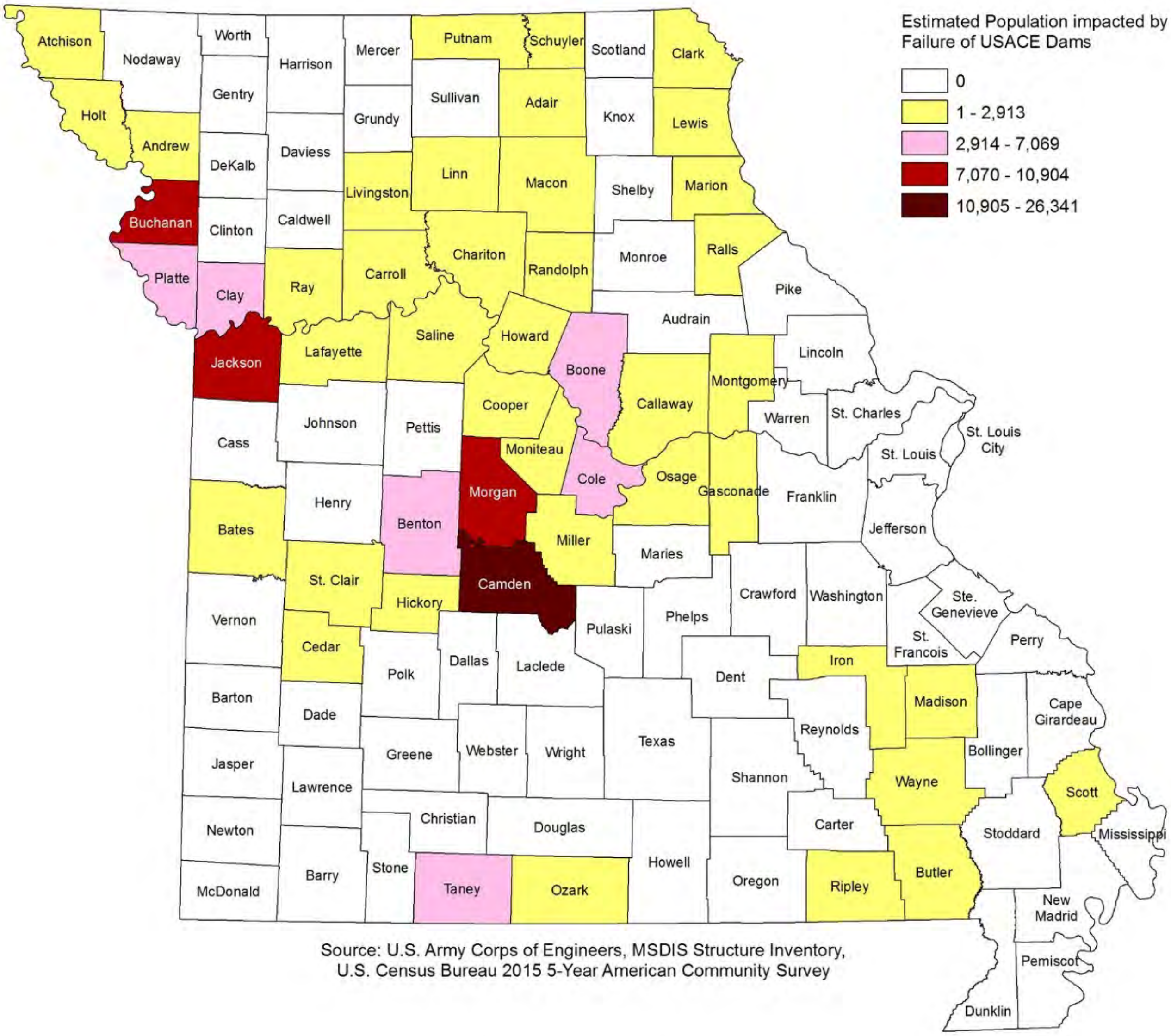
Figure 3.86 provides the estimated population at risk to dam failure based on the average household size and the number of residential structures at risk to dam inundation by county.

Figure 3.86. Population at Risk to Dam Failure in Available State-Regulated Inundation Areas



Source: Missouri Department of Natural Resources, MSDIS Structure Inventory, U.S. Census Bureau 2015 5-Year American Community Survey

Figure 3.87. Population at Risk to Dam Failure in Available USACE Inundation Areas



Source: U.S. Army Corps of Engineers, MSDIS Structure Inventory,
U.S. Census Bureau 2015 5-Year American Community Survey

State Estimates of Potential Losses

To determine state estimates of potential loss, a damage estimation of 20 percent of the total structure value in dam inundation areas was used. This damage amount is based on FIA depth-damage curves for a one-story structure with no basement flooded to two feet. **Table 3.55** provides the results.

Table 3.55. State Estimates of Potential Loss as a Result of Dam Failure (Combined State-Regulated and USACE)

County	Loss Estimates
Adair	$18,285,976
Andrew	$28,705,450
Atchison	$239,316,680
Bates	$8,000,427
Benton	$257,849,065
Bollinger	$2,140,554
Boone	$130,776,278
Buchanan	$554,753,163
Butler	$1,991,833
Caldwell	$36,999
Callaway	$49,359,426
Camden	$2,891,581,432
Carroll	$358,762,545
Cass	$9,778,888
Cedar	$10,893,217
Chariton	$483,324,614
Christian	$3,821,071
Clark	$55,569,632
Clay	$410,225,805
Clinton	$2,230,119
Cole	$151,089,728
Cooper	$51,873,198
Crawford	$1,162,349
Daviess	$934,989
Dekalb	$3,252,454
Dent	$1,114,290
Gasconade	$82,779,897
Greene	$10,049,489
Grundy	$888,419
Harrison	$390,477
Hickory	$12,331,836
Holt	$170,343,625
Howard	$38,685,254
Iron	$6,999,281
Jackson	$1,126,813,545
Jefferson	$420,223
Johnson	$818,043
Knox	$252,277
Lafayette	$19,605,545
Lewis	$115,578,356
Linn	$3,699,570
Livingston	$9,603,430
Macon	$10,467,740
Madison	$2,252,913
Maries	$895,511
Marion	$89,187,860
Mercer	$198,396
Miller	$168,975,224
Moniteau	$20,936,801
Montgomery	$53,287,071
Morgan	$820,110,345
Newton	$27,073,190
Nodaway	$2,270,057
Osage	$175,947,457
Ozark	$18,519,093
Pettis	$1,442,278
Phelps	$2,140,560
Platte	$309,727,922
Polk	$422,639
Putnam	$13,440,957
Ralls	$39,364,605
Randolph	$2,914,655
Ray	$140,457,163
Ripley	$451,316
Saline	$64,544,442
Schuyler	$8,153,016
Scotland	$3,818,997
Scott	$3,554,616
Shelby	$48,987
St Clair	$14,144,601
Stone	$14,076,364
Taney	$266,221,856
Vernon	$253,639
Wayne	$3,030,371
Webster	$81,672
Total	**$9,604,501,762**

It should be noted that dam failures are generally isolated incidents and do not often occur in conjunction with failure at additional dam sites. Since it is unknown which dams, if any might fail at any given time, this analysis provides for a state-wide view of dam failure. It is nearly certain that not all dams would fail simultaneously. So, this analysis should be viewed in light of these considerations.

Hazard Impact on Future Growth and Development

Of the top 10 counties with highest percent increase in populations, the following are also in the top 10 for potential population impacted by dam failure: Boone, Clay, and Platte. Of the top 10 counties with highest number increase in housing units, the following are also in the top 10 for number of structures impacted by dam failure: Jackson, Clay, and Platte. If growth in these counties is occurring in dam inundation areas, the vulnerable populations and structures will increase as well.

EMAP Consequence Analysis

The information in **Table 3.127** provides the Impact Analysis of Potential for Detrimental Impacts of Hazards completed for the Emergency Management Accreditation Program.

Table 3.56. EMAP Impact Analysis: Dam Failure

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

Risk Summary

Dam breaks are caused most often by failure of the structure itself. However, flooding is the most common hazard associated with dam failure. Prolonged rains and flooding can saturate earthen dams, for example, producing much the same breaching effect as occurs with earthen levees. Flooding can also result in overtopping of dams when the spillway and reservoir storage capacities are exceeded. A large slide may develop in either the upstream or downstream slope of the embankment and threaten to release the impounded water. Complete structural collapse can occur, especially as a result of an earthquake.

Actual dam failure can result not only in loss of life, but also considerable loss of capital investment, loss of income, and property damage. Loss of the reservoir itself can cause hardship for those dependent on it for their livelihood or water supply.

The majority of dams in Missouri are less than 35 feet high and/or not owned by a federal entity and are therefore not regulated by the State or a federal entity. While the State has encouraged dam owners to have these unregulated dams inspected, the MoDNR lacks the authority to assess the condition of these dams and any downstream hazards.

Flood risk is a shared responsibility including communities within the floodplain, owners and operators of dams and levees, owners and operators of infrastructure within the floodplain and agencies with jurisdiction for emergency management and evacuation authority. Local residents are expected to know their risk. One key public message is that flood risk mitigation projects (including dams and levees) reduce risk; they do not eliminate it.

Problem Statement:

Using the indicators of potential residential losses due from either State or USACE dam failure, the top five counties affected are Jackson, Greene, Clay, Boone and Cass counties. Mitigation efforts and dollars would most likely prove most successful in these areas of highest impact.

2018 risk assessment data and mapping is available through the Missouri Hazard Mitigation Viewer: http://bit.ly/MoHazardMitigationPlanViewer2018. Note that the inundation layers are only available through a direct request to MODNR.

3.3.4. Earthquakes

Probability	Severity
72% 31 events in 43 years	High

Description/Location

Earthquakes are defined as shifts in the earth's crust causing the surface to become unstable. This instability can manifest itself in intensity from slight tremors to large shocks. The duration can be from a few seconds up to five minutes. The period of tremors (and shocks) can last up to several months. The larger shocks can cause ground failure, landslides, liquefaction, uplifts, and sand blows.

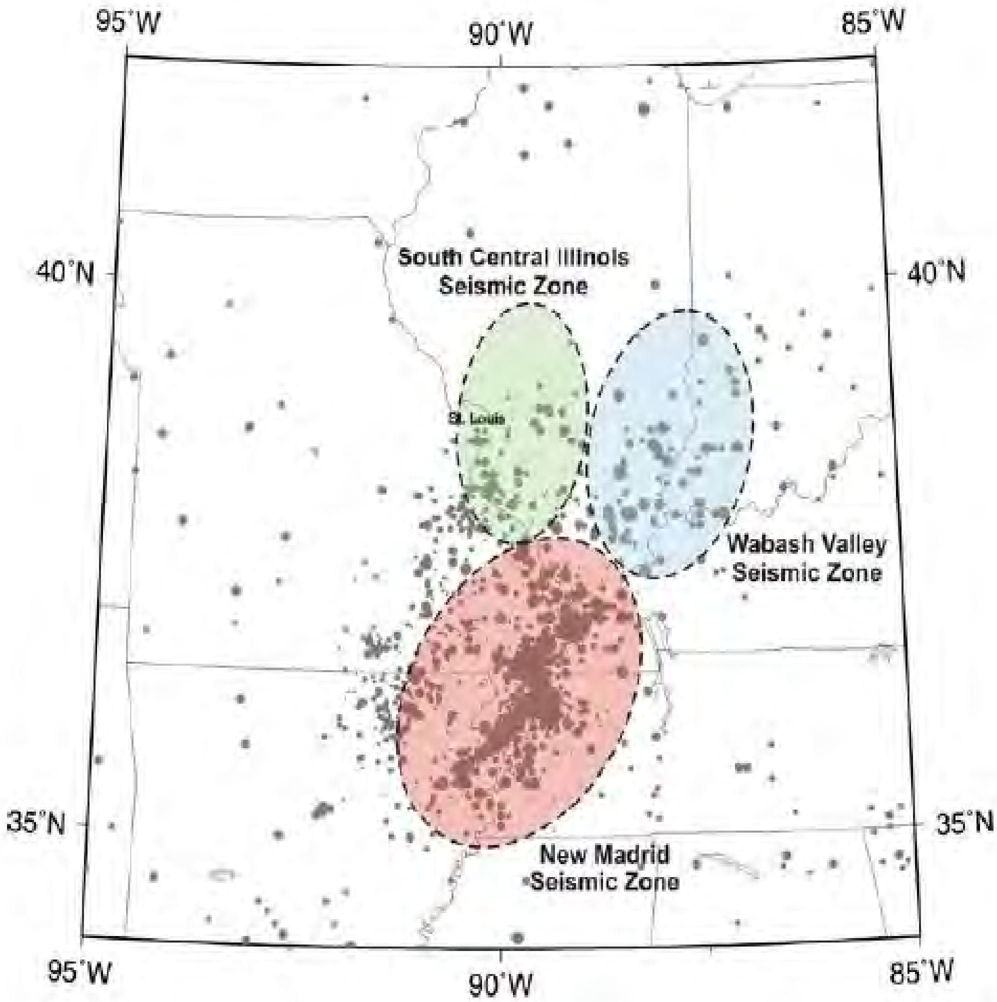
The earth's crust is made up of gigantic plates, commonly referred to as tectonic plates. These plates form what is known as the lithosphere, which varies in thickness from 6.5 miles (beneath oceans) to 40 miles (beneath mountain ranges), and has an average thickness of 20 miles. These plates "float" over a partly melted layer of crust called the asthenosphere. These plates are in constant motion, and areas where one plate joins another are referred to as "plate boundaries." Areas where the plates are moving toward each other are called convergent plate boundaries, areas where they are moving away from each other are called divergent plate boundaries, and areas where they are neither moving away nor towards each other are called transform boundaries. The San Andreas Fault in California is one such transform boundary where the Pacific Plate is moving to the north while the North American Plate is moving to the west.

Plate movements release built-up energy in the form of earthquakes, tremors, and volcanic activity. Fault lines such as the San Andreas come all the way to the surface and can be readily seen and identified. Some fault lines do not come all the way to the surface, yet all faults store and release energy when they move. Many of the faults in the central United States are characterized this way.

Subterranean faults, faults that do not make it to the surface, were formed many millions of years ago on or near the surface of the earth. Subsequent to that time, these ancient faults subsided, while the adjacent areas were pushed up. As this fault zone (also known as a rift) sank, sediments filled in the lower areas. Under pressure, sediments hardened into limestone, sandstone, and shale, thus burying the rifts. With the pressure on the North Atlantic Ridge affecting the eastern side of the North American Plate, and the movements along the San Andreas Fault by the Pacific Plate, one such rift system in the Mississippi embayment has reactivated. This particular rift system is now called the Reelfoot Rift.

Eight earthquake seismic zones are located in the central United States, two of which are located in Missouri. The most active zone is the New Madrid Seismic Zone, which is also the most active seismic area in the United States east of the Rocky Mountains according to the U.S. Geological Survey. The New Madrid Zone is by some measures as high a risk for tremors as seismic zones in California. It runs from northern Arkansas through southeast Missouri and western Tennessee and Kentucky to the Illinois side of the Ohio River Valley (see **Figure 3.88)**.

Figure 3.88. New Madrid, South Central Illinois, and Wabash Valley Seismic Zones



Source: Rogers, Karadeniz, and Cramer (in press 2007)

The southeastern (Bootheel) section of Missouri is most susceptible to earthquakes because it overlies the New Madrid Seismic Zone. It is at risk to strong ground motions and has a high potential for soil liquefaction due to the presence of sandy, loosely consolidated sediments and a high water table. The immediate vicinity of the Ozarks is also at risk from earthquakes in the New Madrid Seismic Zone because, like in the Bootheel, subsurface conditions of the Mississippi and Missouri river valleys tend to amplify earthquake ground shaking. Earthquake hazards in the western part of the State also exist because of the historical earthquakes in eastern Kansas and Nebraska. No area of Missouri is immune from the danger of earthquakes. Minor, but potentially damaging, earthquakes can occur anywhere in the State.

In addition to the New Madrid Seismic Zone, other seismic zones that affect Missourians include the Wabash Valley Seismic Zone, the South Central Illinois Seismic Zone, and the Nemaha Uplift. The Wabash and Illinois seismic zones are not as active as the New Madrid Seismic Zone based on microseismic activity, but they are considered capable of producing earthquakes in the range of M 6.0 to 6.8. An earthquake of this magnitude on the South Central Illinois Seismic Zone could potentially cause more damage to the St. Louis metropolitan area than a New Madrid Seismic Zone event because it is closer to the area. The Nemaha Uplift is of concern to Missourians because it runs parallel to the Missouri/Kansas border from Lincoln, Nebraska, to Oklahoma City, Oklahoma. Earthquakes from the Nemaha Uplift are not as severe as those associated with the historic New Madrid Seismic Zone.

Large earthquakes in Missouri could trigger additional hazards such as soil liquefaction, lateral spreading, landslides, and sinkhole collapse (specifically in the karst topography present in much of southeast Missouri). Liquefaction is a site soil response to strong earthquake ground motion. Strong earthquake waves cause water pressure to increase within sandy soils; force sand grains apart, and the material will behave as a dense liquid. Sandblows form in the areas where liquefied sand is overlain by heavier clay rich silts, causing a geyser-like eruption of sand onto the land surface. Liquefaction causes land to lose its load-bearing capacity, which can lead to differential settlement and associated building foundation failures. Lateral spreading can occur even on gentle slopes and seriously damage buried utilities and road networks. Landslides could be triggered in steep slopes and road cuts through unstable geologic materials, potentially damaging and closing roads and railroads. As noted earlier, these risk areas and any identified mitigation fall under the jurisdiction of MoDOT. Earthquake shaking will exacerbate existing problems and cause even more slides where none have existed before. It is possible that housing developments on certain shale bedrock units could be affected by landslides as well, with potentially catastrophic results.

Extent

The amount of energy released during an earthquake is usually expressed as a magnitude and is measured directly from the earthquake as recorded on seismographs. Seismologists have developed several magnitude scales; one of the first was the Richter Scale, developed in 1932 by the late Dr. Charles F. Richter of the California Institute of Technology. The Richter Magnitude Scale is used to quantify the magnitude or strength of the seismic energy released by an earthquake. The moment magnitude scale (abbreviated as MMS; denoted as M_W or M) is used by seismologists to measure the size of earthquakes in terms of the energy released. The scale was developed in the 1970s to succeed the Richter magnitude scale. Even though the formulas are different, the new scale retains a similar continuum of magnitude values to that defined by the older one. As with the Richter magnitude scale, an increase of one step on this logarithmic scale corresponds to a 101.5 (about 32) times increase in the amount of energy released, and an increase of two steps corresponds to a 103 (1,000) times increase in energy. Thus, an earthquake of Mw of 7.0 releases about 32 times as much energy as one of 6.0 and 1,000 times that of 5.0.

Another measure of earthquake severity is Intensity. Intensity is an expression of the amount of shaking at any given location on the ground surface based on felt or observed effects. Seismic shaking is typically the greatest cause of losses to structures during earthquakes. Intensity is measured with the Modified Mercalli Intensity Scale. **Table 3.57** describes the typical effects and Intensities associated with earthquakes of various magnitudes. The intensity and effects depend on several factors (earthquake depth, epicenter location, site geology, population density, to name a few) and can vary widely.

Table 3.57. Richter Magnitude and Modified Mercalli Intensity Scales and Effects

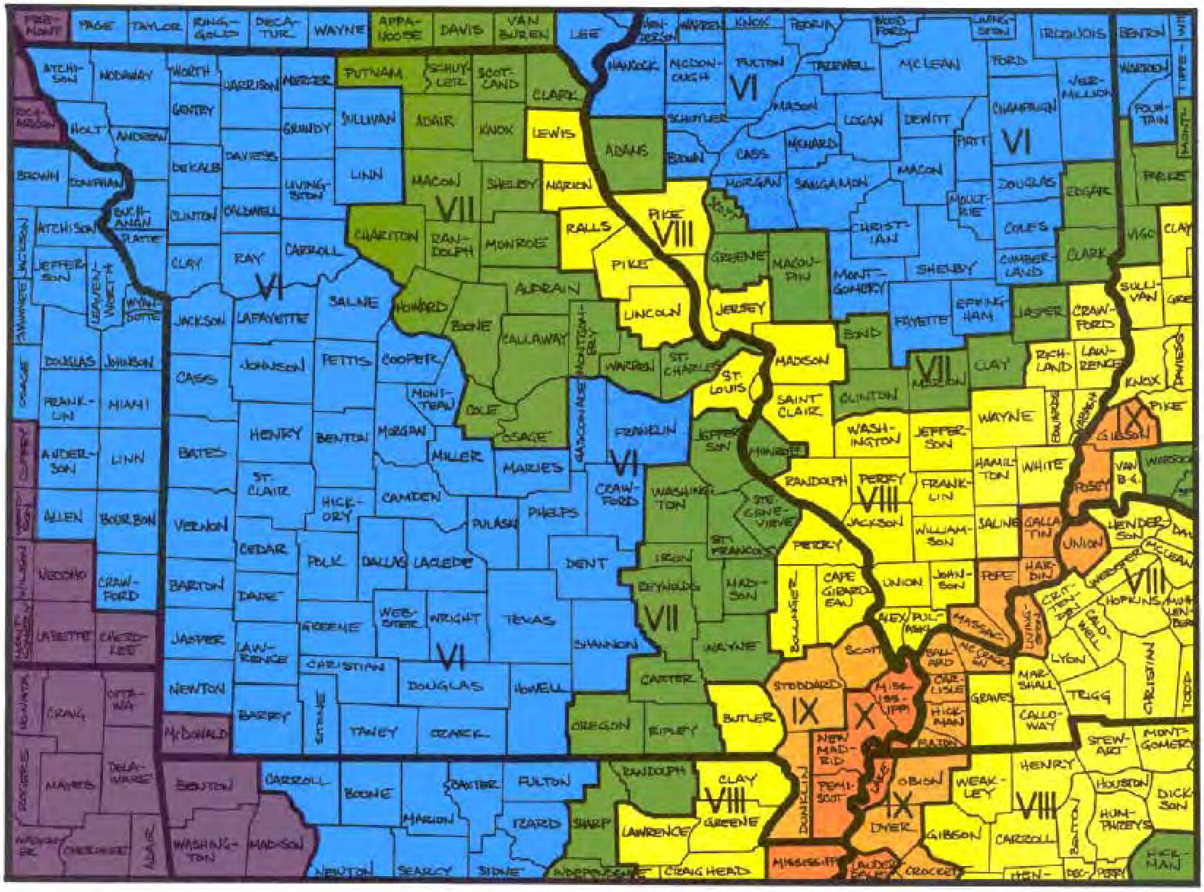
Magnitude	Mercalli Intensity	Effects
Less than 2.0	I	Microearthquakes, not felt or rarely felt; recorded by seismographs.
2.0-2.9	I	Felt slightly by some people; damages to buildings.
3.0-3.9	II to III	Often felt by people; rarely causes damage; shaking of indoor objects noticeable.
4.0-4.9	IV to V	Noticeable shaking of indoor objects and rattling noises; felt by most people in the affected area; slightly felt outside; generally no to minimal damage.
5.0-5.9	VI to VII	Can cause damage of varying severity to poorly constructed buildings; at most, none to slight damage to all other buildings. Felt by everyone.
6.0-6.9	VII to IX	Damage to a moderate number of well-built structures in populated areas; earthquake-resistant structures survive with slight to moderate damage; poorly

Magnitude	Mercalli Intensity	Effects
		designed structures receive moderate to severe damage; felt in wider areas; up to hundreds of miles/kilometers from the epicenter; strong to violent shaking in epicentral area.
7.0-7.9	VIII or higher	Causes damage to most buildings, some to partially or completely collapse or receive severe damage; well-designed structures are likely to receive damage; felt across great distances with major damage mostly limited to 250 km from epicenter.
8.0-8.9	VIII or higher	Major damage to buildings, structures likely to be destroyed; will cause moderate to heavy damage to sturdy or earthquake-resistant buildings; damaging in large areas; felt in extremely large regions.
9.0 and Greater	VIII or higher	At or near total destruction - severe damage or collapse to all buildings; heavy damage and shaking extends to distant locations; permanent changes in ground topography.

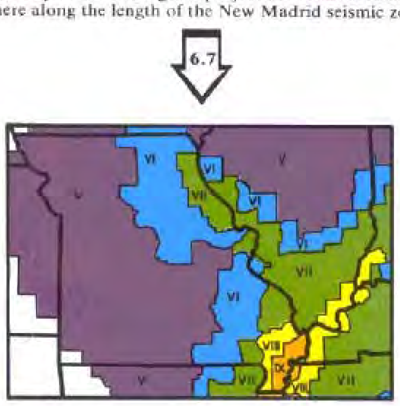
Source: USGS

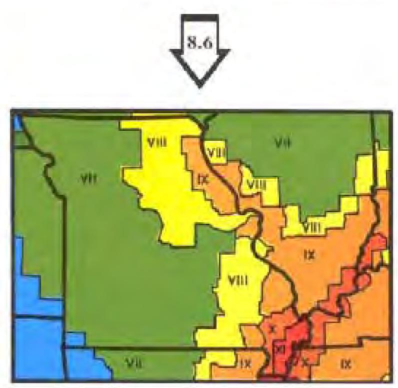
The map in **Figure 3.89** shows the highest projected Modified Mercalli intensities by county from a potential magnitude 7.6 earthquake whose epicenter could be anywhere along the length of the New Madrid Seismic Zone. The secondary maps show the same regional Intensities for a 6.7 and an 8.6 earthquake, respectively. **Figure 3.90** describes the projected earthquake intensities for each level of the Modified Mercalli Intensity Scale. Based on this information the highest extent earthquake in Modified Mercalli Intensity could be Intensity X in the extreme southeastern bootheel region counties.

Figure 3.89. Projected Earthquake Intensities



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





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

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

Figure 3.90. Modified Mercalli Intensity Scale

I People do not feel any Earth movement.

II A few people might notice movement.

III Many people indoors feel movement. Hanging objects swing.

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

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

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

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

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

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

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

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

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

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

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Previous Occurrences

Several earthquakes have affected Missouri in the past. Small earthquakes occur often in Missouri. About 200 are detected every year in the New Madrid Seismic Zone. Most can only be detected by sensitive instruments, but southeast Missouri experiences an earthquake once or twice every 18 months that is strong enough to crack plaster in buildings.

The most severe earthquakes occurred in the New Madrid Seismic Zone during a period between December 16, 1811, and March 12, 1812. The earthquakes on December 16, 1811 (M7.5), January 23, 1812 (M7.3) and February 7, 1812 (M7.5), rank among the United States' largest earthquakes. The shocks from these earthquakes could be easily felt as far away as Detroit, Michigan, and Charleston, South Carolina. The area between the St. Francois River and Mississippi River south of New Madrid to Marked Tree, Arkansas, showed numerous sand blows from liquefaction. Because there were no seismographs in North America at that time, and very few people in the New Madrid region, the estimated magnitudes of this series of earthquakes vary considerably and depend on modern researchers' interpretations of journals, newspaper reports, and other accounts of the ground shaking and damage. The magnitudes of the three principal earthquakes of 1811-1812 described previously are the preferred values taken from research involved with producing the 2014 USGS National Seismic Hazard Map (source https://earthquake.usgs.gov/earthquakes/states/events/1811-1812.php#december_16).

Areas uplifted as well as subsided (dropped) along the Mississippi River during the 1811-1812 events, creating new landforms. The area around Tiptonville, Tennessee, formed a dome (uplift of several yards). Immediately adjacent to the Tiptonville Dome, an area subsided to form a lake 18 miles long and 5 miles wide. It is now known as Reelfoot Lake and is a tourist and recreation area. Ground failure and landslides were apparent throughout the bluffs (Chickasaw Bluffs) alongside the Mississippi River in Kentucky and Tennessee. Many fissures were made throughout the region, and one local observer recorded that the earth seemed to be rolling in waves a few feet in height. These swells would burst, leaving wide and long fissures. The damage to the area was so severe that Congress passed, and President James Madison signed into law, the first disaster relief act, giving government lands in other territories to people wanting to move out of the area.

The following is excerpted directly from Carl A. von Hake's "Missouri Earthquake History" in Earthquake Information Bulletin, Volume 6, Number 3, May–June 1974 and provides a more detailed perspective of the 1811-1812 events:

Whatever the seismic history of the region may have been before the first Europeans arrived, after December 16, 1811, there could be no doubt about the area's potential to generate severe earthquakes. On that date, shortly after 2 AM, the first tremor of the most violent series of earthquakes in the United States history struck southeast Missouri. In the small town of New Madrid, about 290 kilometers south of St. Louis, residents were aroused from their sleep by the rocking of their cabins, the cracking of timbers, the clatter of breaking dishes and tumbling furniture, the rattling of falling chimneys, and the crashing of falling trees. A terrifying roaring noise was created as the earthquake waves swept across the ground. Large fissures suddenly opened and swallowed large quantities of river and marsh water. As the fissures closed again, great volumes of mud and sand were ejected along with the water.

The earthquake generated great waves on the Mississippi River that overwhelmed many boats and washed others high upon the shore. The waves broke off thousands of trees and carried them into the river. High river banks caved in, sand bars gave way, and entire islands disappeared. The violence of the earthquake was manifested by great topographic changes that affected an area of 78,000 to 130,000 square kilometers.

On January 23, 1812, a second major shock, seemingly more violent than the first, occurred. A third great earthquake, perhaps the most severe of the series, struck on February 7, 1812.

The three main shocks probably reached intensity XII, the maximum on the Modified Mercalli scale, although it is difficult to assign intensities, due to the scarcity of settlements at the time. Aftershocks continued to be felt for several years after the initial tremor. Later evidence indicates that the epicenter of the first earthquake (December 16, 1811) was probably in northeast Arkansas. Based on historical accounts, the epicenter of the February 7, 1812, shocks was probably close to the town of New Madrid.

Although the death toll from the 1811-12 series of earthquakes has never been tabulated, the loss of life was very slight. It is likely that if at the time of the earthquakes the New Madrid area had been as heavily populated as at present, thousands of persons would have perished. The main shocks were felt over an area covering at least 5,180,000 square kilometers. Chimneys were knocked down in Cincinnati, Ohio, and bricks were reported to have fallen from chimneys in Georgia and South Carolina. The first shock was felt distinctly in Washington, D.C., 700 miles away, and people there were frightened badly. Other points that reported feeling this earthquake included New Orleans, 804 kilometers away; Detroit, 965 kilometers away; and Boston, 1,769 kilometers away.

The New Madrid seismic zone has experienced numerous earthquakes since the 1811-12 series, and at least 35 shocks of intensity V or greater have been recorded in Missouri since 1811. Numerous earthquakes originating outside of the State's boundaries have also affected Missouri. Five of the strongest earthquakes that have affected Missouri since the 1811-12 series are described below.

On January 4, 1843, a severe earthquake in the New Madrid area cracked chimneys and walls at Memphis, Tennessee. One building reportedly collapsed. The earth sank at some places near New Madrid; there was an unverified report that two hunters were drowned during the formation of a lake. The total felt area included at least 1,036,000 square kilometers.

The October 31, 1895, earthquake near Charleston, Missouri, probably ranks second in intensity to the 1811-12 series. Every building in the commercial area of Charleston was damaged. Cairo, Illinois, and Memphis, Tennessee, also suffered significant damage. Near Charleston, 4 acres of ground sank and a lake was formed. The shock was felt over all or portions of 23 states and at some places in Canada.

A moderate earthquake on April 9, 1917, in the Ste. Genevieve–St. Mary's area was reportedly felt over a 518,000 square kilometer area from Kansas to Ohio and Wisconsin to Mississippi. In the epicentral area people ran into the street, windows were broken, and plaster cracked. A second shock of lesser intensity was felt in the southern part of the area.

The small railroad town of Rodney, Missouri, experienced a strong earthquake on August 19, 1934. At nearby Charleston, windows were broken, chimneys were overthrown or damaged, and articles were knocked from shelves. Similar effects were observed at Cairo, Mounds and Mound City, Illinois, and at Wickliff, Kentucky. The area of destructive intensity included more than 596 square kilometers.

The November 9, 1968, earthquake centered in southern Illinois was the strongest in the central United States since 1895. The magnitude 5.5 shock caused moderate damage to chimneys and walls at Hermann, St. Charles, St. Louis, and Sikeston, Missouri. The felt areas include all or portions of 23 states.

Along the Nemaha Seismic Zone, an earthquake of 3.1 Richter magnitude occurred on March 31, 1993, close to the Cooper Nuclear Power Station in Brownville, Nebraska. Another 3.1 occurred on March 23, 2007, near Effingham, Kansas. No damage resulted from either event; however, the earthquake was felt across the Missouri River into Missouri.

From 1811-2016 in the central united states, there have been 55 recorded earthquakes with a magnitude greater than 4. Of those 55 events, 5% have been over M7, 4% have a recorded magnitude of 6-6.9, 35% have a recorded magnitude of 5-5.9, and the remaining 56% have a recorded magnitude of 4-4.9.

Table 3.58 lists moderate/large earthquakes in the Central United States.

Table 3.58. Earthquakes M>4 in the Central United States

Date	Locality	Magnitude	Maximum Intensity	Source Zone
December 16, 1811	New Madrid, Missouri	7.5	XII	New Madrid Fault
January 23, 1812	New Madrid, Missouri	7.3	XII	New Madrid Fault
February 7, 1812	New Madrid, Missouri	7.5	XII	New Madrid Fault
June 9, 1838	Southern Illinois	5.7	VI	Illinois Basin
January 4, 1843	Western Tennessee	6.3	VIII	New Madrid Fault
Unknown, 1860	Central Minnesota	5.0	Unknown	Colorado Lineament
August. 17, 1865	Southeastern Missouri	5.3	VII	New Madrid Fault
April 24, 1867	Lawrence, Kansas	5.1	VII	Nemaha Uplift
June 18, 1875	Western Ohio	5.3	VII	Cincinnati Arch
November 15, 1877	Eastern Nebraska	5.0	VII	Nemaha Uplift
October 22, 1882	Arkansas, Texas	5.5	VI–VII	Ouchita, Wichita Fault
July 26, 1891	Illinois, Indiana	5.9	VI	Wabash Valley Fault
October 31, 1895	Charleston, Missouri	6.7	VIII	New Madrid Fault
May 26, 1909	Illinois	5.1	VII	Cincinnati Arch
April 9, 1917	Eastern Missouri	5.0	VI	St. Francois Uplift
March 8, 1937	Western Ohio	5.0	VII–VIII	Cincinnati Arch
April 9, 1952	Enid, Oklahoma	5.1	VII	Nemaha Uplift
November 9, 1968	South Central Illinois	5.5	VII	Wabash Valley Fault
January 8, 1974	Tennessee	4.1	IV-V	New Madrid Fault
April 3, 1974	Illinois	4.5	IV-V	Wabash Valley Fault
May 13, 1974	Missouri	4.3	IV-V	New Madrid Fault
June 5, 1974	Illinois	4	IV-V	South Central Fault
June 13, 1975	8 km SW of Lilbourn, Missouri	4.3	IV-V	New Madrid Fault
March 24, 1976	Marked Tree, Arkansas	5.0	V–VI	New Madrid Fault
March 25, 1976	8 km NW of Marked Tree, Arkansas	5	VI	New Madrid Fault
December 11, 1976	Missouri	4.2	IV-V	South Central Fault
July 27, 1980	North Central Kentucky	5.2	VII	Cincinnati Arch
August 7, 1981	11 km SE of Newbern, Tennessee	4	IV-V	New Madrid Fault
January 21, 1982	11 km NW of Vilonia, Arkansas	4.1	IV-V	New Madrid Fault
March 1, 1982	15 km NE of Vilonia, Arkansas	4.1	IV-V	New Madrid Fault

Date	Locality	Magnitude	Maximum Intensity	Source Zone
May 15, 1983	9 km ENE of Highland, Illinois	4.3	IV-V	South Central Fault
January 31, 1986	Anna, Ohio	5.0	VI	Cincinnati Arch
June 9, 1987	Lawrenceville, Illinois	5.2	V–VI	Wabash Valley Fault
June 13, 1987	10 km W of Lilbourn, Missouri	4.1	IV-V	New Madrid Fault
September 29, 1987	6 km SSE of Cairo, Illinois	4.3	IV-V	New Madrid Fault
April 27, 1989	4 km E of Steele, Missouri	4.3	IV-V	New Madrid Fault
September 26, 1990	Chaffee, Missouri	3.0	IV–V	New Madrid Fault
May 3, 1991	Risco, Missouri	4.6	IV–V	New Madrid Fault
May 4, 1991	12 km E of Malden, Missouri	4.5	IV-V	New Madrid Fault
June 26, 2000	Harrison, Arkansas	3.9	VIII	Ouchita, Wichita Fault
May 4, 2001	Conway, Arkansas	4.4	VI	Ouchita, Wichita Fault
June 18, 2002	Evansville, Indiana	4.6	VI	Wabash Valley Fault
November 3, 2002	O’Neill, Nebraska	4.3	V	Nemaha Uplift
April 30, 2003	1 km N of Blytheville, Arkansas	4	IV-V	New Madrid Fault
June 6, 2003	Cairo, Illinois	4.0	VI	New Madrid Fault
August 16, 2003	West Plains, Missouri	4.0	V	New Madrid Fault
June 28, 2004	Ottawa, Illinois	4.2	VI	Illinois Basin
February 10, 2005	Blytheville, Arkansas	4.1	V	New Madrid Fault
May 1, 2005	Blytheville, Arkansas	4.1	V	New Madrid Fault
June 2, 2005	Dyersburg, Tennessee	4.0	IV	New Madrid Fault
April 18, 2008	Gards Point, IL	5.2	VII	Wabash Valley Fault
April 18, 2008	Ogden, IL	4.6	VI	Wabash Valley Fault
April 21, 2008	Gards Point, IL	4.0	V	Wabash Valley Fault
April 21, 2008	Ogden, IL	4.2	V	Wabash Valley Fault
October 11, 2010	10 km NE of Greenbrier, Arkansas	4.1	IV-V	New Madrid Fault
February 18, 2011	4 km NNE of Greenbrier, Arkansas	4.1	IV-V	New Madrid Fault
February 28, 2011	4 km NE of Greenbrier, Arkansas	4.7	IV-V	New Madrid Fault
There have been no earthquakes greater than 4.0 since February 2011 registered in Missouri.				

Source: State Hazard Analysis, July 2018, USGS Earthquake Catalog, https://earthquake.usgs.gov/earthquakes/search/

Table 3.59 is based on a USGS data query of any recent quakes in the Central United States recorded since 1973. Earthquakes in the region occur every year, though most of them are below M 4.0. Thirty-one earthquakes greater than or equal to M 4.0 have occurred in this timeframe.

Table 3.59. USGS Recorded Events by Magnitude in Central United States

	Magnitude		
Year	**2.5-2.9**	**3-3.9**	**4>**
1973-1979	43	30	8
1980-1989	142	77	8
1990-1999	105	36	3
2000-2009	144	23	9
2010	51	14	1
2011	131	38	2
2012	14	5	0
2013	21	3	0
2014	18	3	0
2015	18	7	0
2016	15	3	0
Totals	**702**	**239**	**31**

Source: USGS Earthquake Events Database, Accessed July 2018

Probability of Future Hazard Events

There have been 31 recorded earthquake events greater than or equal to M 4.0 in the 43-year period from 1973 to 2018. According to this data, annual probability calculates to a 72 percent. Additionally, the USGS estimated in 2006 that the probability of a repeat of the 1811–1812 earthquakes (magnitude 7.5–8.0) was 7–10% in a 50-year time period (Source: http://pubs.usgs.gov/fs/2006/3125*)*. Given the historical frequency of earthquake events, this hazard is determined to have a high probability of occurrence within the State.

Changing Future Conditions Considerations

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

State Vulnerability Overview

The impacts and severity of earthquakes on Missouri can be significant. The New Madrid earthquakes of 1811–1812 are among the largest that have happened on the North American continent. Although losses were limited because of the sparse population of the time, many Native Americans died and property was damaged to the point that resettlement became a national policy.

The most important direct earthquake hazard is ground shaking. Ground shaking affects structures close to the earthquake epicenter but can also affect those at great distances, particularly where thick clay-rich soils can amplify ground motions. Certain types of buildings are more vulnerable to ground shaking than others. Unreinforced masonry structures, tall structures without adequate lateral resistance, and poorly maintained structures are specifically susceptible to large earthquakes.

According to MoDNR's Missouri Geological Survey, damage from earthquakes in the New Madrid Seismic Zone will vary depending on the earthquake magnitude, the character of the land, and the degree of urbanization. The Bootheel area is dominantly rural with scattered small to medium-sized towns. Damage to the land could be extensive and significantly affect the area's farming industry. The more distant, densely populated urban area of St. Louis is not likely to have damage to the land, but its huge stock of structures and their contents could receive significant damage from shaking and earthquake-triggered landslides and sinkhole collapse. Shaking would be most severe to development built on thick, clay-rich soils. Roads and railroads in southeast Missouri and Saint Louis area could be severely damaged by earthquake triggered slope failures, rockfalls, and liquefaction.

During most earthquakes, liquefaction happens in relatively small isolated patches. The New Madrid Seismic Zone is unique because it is in a vast area with ideal conditions for liquefaction. Liquefaction could be an enormous problem in a large earthquake and even for a magnitude 6–6.5 earthquake occurring in a portion of the Bootheel. Infrastructure (roads, bridges, power lines, gas lines, water lines, petroleum pipelines, telephone lines, ports, etc.) will be severely damaged and disrupted by liquefaction. This will make it difficult to perform rescue and recovery operations because these infrastructure facilities will be needed but will take a long time to repair.

Several studies indicate the need to prepare for earthquakes, as scholars estimate that the New Madrid Seismic Zone has the capability of generating Mercalli intensities of X (ten) in southeast Missouri. The late Dr. Otto Nuttli of St. Louis University stated in his book, *The Effects of Earthquakes in the Central United States*, that surface-wave magnitudes of 7.6 (Richter) would create the largest possible earthquake that could occur anywhere along the New Madrid Seismic Zone in the near future. Information on preparedness and predictions related to the New Madrid Seismic Zone is provided on the U.S. Geological Survey Earthquake Hazards Program web site at www.usgs.gov/hazards, and the Center for Earthquake Research and Information web site at www.ceri.memphis.edu/usgs.

Another report, *Impact of Earthquakes on the Central USA,* dated September 2008 presents the findings of a two-year study on the impact of a 7.7 magnitude earthquake on states in the New Madrid Seismic Zone (NMSZ). The study was conducted for FEMA by the Mid-America Earthquake (MAE) Center at the University of Illinois in partnership with the Central United States Earthquake Consortium (CUSEC), the U.S. Geological Survey (USGS), USACE, and George Washington University's Institute for Crisis, Disaster and Risk Management. It is primarily intended to provide scientific data upon which to base response and recovery planning for the devastating earthquakes that have long been predicted for the New Madrid region, which includes areas of Alabama, Arkansas, Illinois, Indiana, Kentucky, Mississippi, Missouri and Tennessee. The study is also available for download at https://www.ideals.illinois.edu/handle/2142/8971.

Earthquake Insurance Analysis

The Missouri Department of Insurance, Financial Institutions & Professional Registration (DIFP) prepared a report in August 2015 on the state of earthquake coverage in Missouri presenting the market trends over the past 15 years. The report notes that earthquake coverage has become less available and less affordable over the last 15 years with the following highlights:

- On average, earthquake insurance premiums in the six counties that comprise the New Madrid area have increased by nearly 500 percent between 2000 and 2014, and in one county by almost 700 percent.

- Insurance rates have increased throughout the state with the rates in the highest risk areas having increased much more rapidly, widening the costs between high and low risk areas. In 2000, the average annual premium in the New Madrid area was only 64 percent higher than the lowest risk counties of Missouri. By 2015, premiums were nearly 330 percent higher.
- In 2000, over 60 percent of residences in the New Madrid area had earthquake insurance. By 2014, the rate of coverage had significantly decreased to only 20 percent.
- In high risk areas outside of the New Madrid zone, take-up rates also substantially decreased, from 67.6 percent in 2000 to 52.1 percent in 2014.
- Homeowners who are able to obtain earthquake insurance must still “self-insure” to a significant degree. No insurer (among those surveyed in the 2015 report) offers a deductible of less than 10 percent of the insured value of the residence. Over 40 percent of the insurance market requires a deductible of 20 percent or higher. Often, deductibles are “stacked,” such that they apply separately to the building and contents.

The full earthquake coverage report is included in Appendix C.

Overview and Analysis of Vulnerability

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). A second scenario, based on an event with a 2% probability of exceedance in 50 years, was done to model a worst case earthquake using a level of ground shaking recognized in earthquake-resistant design.

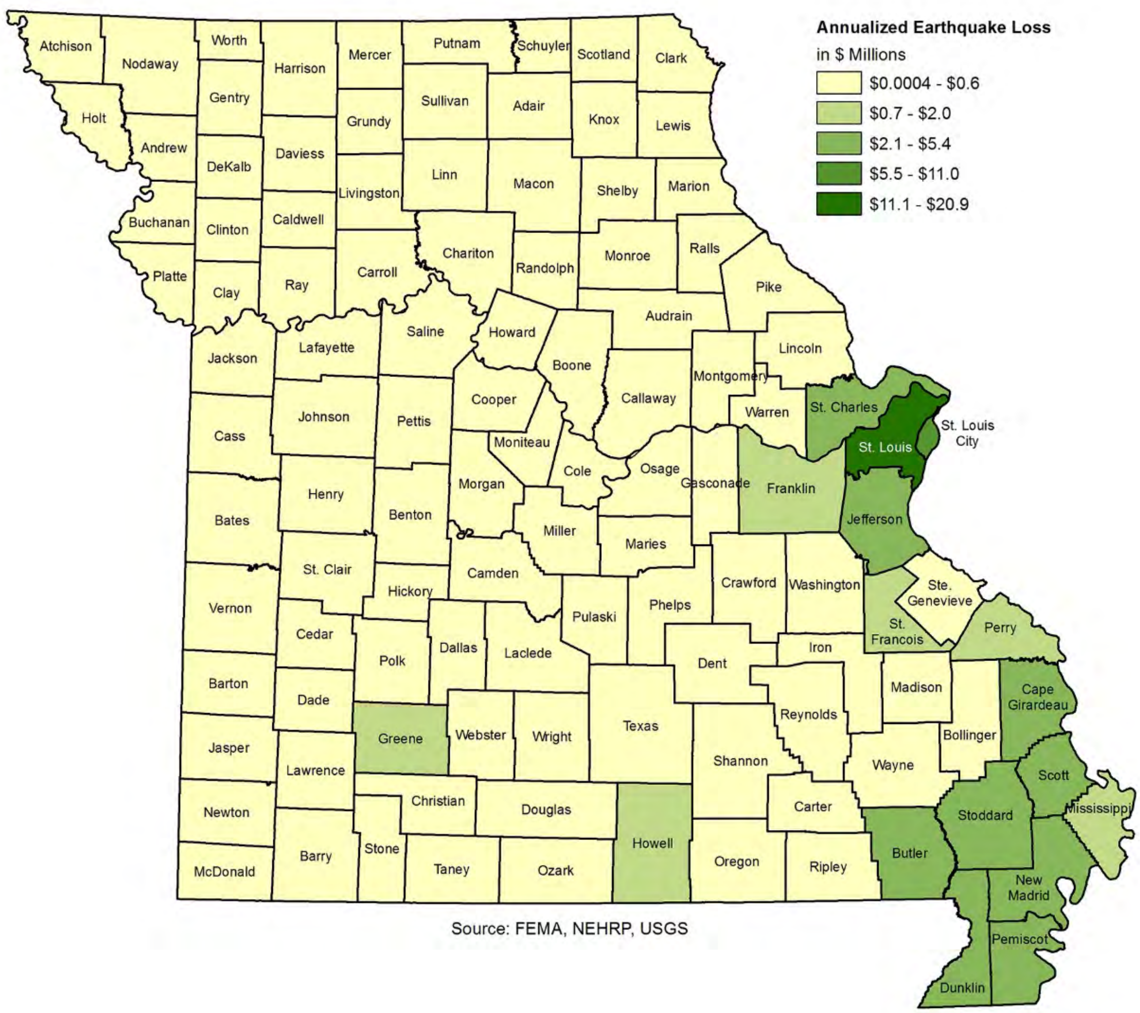
The Central United States Earthquake Consortium provided state-wide National Earthquake Hazards Reduction Program (NEHRP) site classification and soil liquefaction characteristics. Furthermore, the Missouri Department of Natural Resources provided more detailed, quad-based NEHRP site classification and 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 re-attributed as “D” since in these instances Hazus does not allow the data in its original format.

State Estimates of Potential Losses

Annualized Loss Scenario

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 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.

Figure 3.91. HAZUS-MH Earthquake Loss Estimation: Annualized Loss Scenario—Direct Economic Losses to Buildings



The total annualized expected losses (including building and income losses) are presented in **Table 3.60** and ranked from highest total losses to lowest. Included in the table are the annualized loss ratio and a ranking based on this loss ratio. The loss-ratio column in Table 3.60 represents the ratio of the average annualized losses divided by the entire building inventory by county as calculated by HAZUS-MH. The loss ratio is an indication of the economic impacts an earthquake could have, and how difficult it could be for a particular community to recover from an event. The top 10 counties in terms of the highest annualized loss ratio are highlighted. Loss per capita is also shown in the table. The table indicates that the highest risk is to the counties closest to the New Madrid Seismic Zone, which are likely to have considerable portions of the building inventory damaged during an earthquake.

Table 3.60. HAZUS-MH Earthquake Loss Estimation: Annualized Loss Scenario

County	Total Losses, in $ Thousands	Loss Per Capita, in $ Thousands	Loss Ratio, in $ per Million
St. Louis	$20,877	$0.0209	$150
St. Louis City	$11,025	$0.0345	$235
Cape Girardeau	$5,394	$0.0713	$613
Scott	$5,204	$0.1328	$1,289
St. Charles	$4,846	$0.0134	$116
Dunklin	$3,943	$0.1234	$1,325
New Madrid	$3,571	$0.1884	$2,023
Pemiscot	$3,170	$0.1733	$1,930
Jefferson	$3,128	$0.0143	$141
Stoddard	$2,655	$0.0886	$888
Butler	$2,554	$0.0597	$616
Mississippi	$2,043	$0.1423	$1,833
St. Francois	$1,400	$0.0214	$227
Greene	$1,337	$0.0049	$42
Franklin	$947	$0.0093	$83
Perry	$941	$0.0496	$421
Howell	$678	$0.0168	$191
Boone	$552	$0.0034	$30
Ste. Genevieve	$484	$0.0267	$224
Jackson	$478	$0.0007	$5
Ripley	$430	$0.0305	$380
Cole	$372	$0.0049	$35
Wayne	$361	$0.0267	$288
Pulaski	$342	$0.0065	$64
Phelps	$334	$0.0074	$70
Bollinger	$319	$0.0258	$308
Madison	$297	$0.0243	$262
Washington	$265	$0.0105	$153
Crawford	$260	$0.0105	$109
Christian	$248	$0.0032	$32
Lincoln	$240	$0.0046	$51
Iron	$222	$0.0208	$226
Camden	$217	$0.0049	$26
Warren	$210	$0.0065	$60
Jasper	$191	$0.0016	$16
Taney	$189	$0.0037	$31
Laclede	$182	$0.0051	$57
Oregon	$178	$0.0164	$200
Dent	$177	$0.0113	$122
Texas	$172	$0.0066	$75
Reynolds	$167	$0.0249	$249
Callaway	$158	$0.0036	$36
Carter	$157	$0.0251	$302
Shannon	$154	$0.0182	$226
Clay	$149	$0.0007	$5
Webster	$124	$0.0034	$45
Wright	$118	$0.0063	$74
Audrain	$118	$0.0046	$44
Gasconade	$114	$0.0075	$60
Barry	$107	$0.0030	$29
Lawrence	$92	$0.0024	$26
Newton	$92	$0.0016	$17
Stone	$83	$0.0026	$21
Pettis	$81	$0.0019	$18

County	Total Losses, in $ Thousands	Loss Per Capita, in $ Thousands	Loss Ratio, in $ per Million
Polk	$78	$0.0025	$29
Miller	$72	$0.0029	$30
Montgomery	$70	$0.0057	$50
Ozark	$67	$0.0069	$73
Pike	$67	$0.0036	$36
Johnson	$66	$0.0013	$11
Morgan	$63	$0.0031	$22
Cass	$62	$0.0006	$6
Douglas	$61	$0.0045	$59
Osage	$58	$0.0042	$36
Platte	$52	$0.0006	$5
Cooper	$50	$0.0028	$28
Maries	$48	$0.0053	$51
Dallas	$48	$0.0029	$35
Buchanan	$48	$0.0005	$5
Randolph	$47	$0.0019	$20
Benton	$46	$0.0024	$19
Henry	$44	$0.0020	$17
Marion	$37	$0.0013	$12
Saline	$36	$0.0015	$15
Vernon	$33	$0.0016	$15
Moniteau	$32	$0.0020	$21
Lafayette	$32	$0.0009	$8
Barton	$26	$0.0021	$18
Ralls	$25	$0.0024	$21
Macon	$20	$0.0013	$12
Cedar	$20	$0.0014	$15
Ray	$20	$0.0008	$8
Adair	$19	$0.0008	$7
Monroe	$19	$0.0022	$20
Howard	$19	$0.0018	$17
Dade	$19	$0.0024	$25
Bates	$16	$0.0009	$9
Lewis	$15	$0.0015	$15
Shelby	$14	$0.0022	$18
Livingston	$14	$0.0009	$8
McDonald	$14	$0.0006	$8
St. Clair	$13	$0.0013	$14
Hickory	$12	$0.0012	$14
Clinton	$12	$0.0006	$5
Linn	$11	$0.0009	$7
Carroll	$11	$0.0012	$9
Clark	$8	$0.0012	$12
Nodaway	$8	$0.0004	$3
Chariton	$7	$0.0009	$8
Andrew	$6	$0.0003	$3
Grundy	$6	$0.0005	$5
Scotland	$5	$0.0011	$10
Caldwell	$5	$0.0005	$5
Knox	$4	$0.0010	$9
Daviess	$4	$0.0005	$4
DeKalb	$4	$0.0003	$4
Harrison	$4	$0.0004	$4
Sullivan	$3	$0.0005	$5
Gentry	$3	$0.0004	$4
Putnam	$3	$0.0005	$5

County	Total Losses, in $ Thousands	Loss Per Capita, in $ Thousands	Loss Ratio, in $ per Million
Holt	$3	$0.0005	$4
Schuyler	$2	$0.0005	$5
Atchison	$2	$0.0003	$2
Mercer	$1	$0.0004	$4
Worth	$0	$0.0002	$2
Total	$83,762		

2% Probability of Exceedance in 50 Years Earthquake Scenario

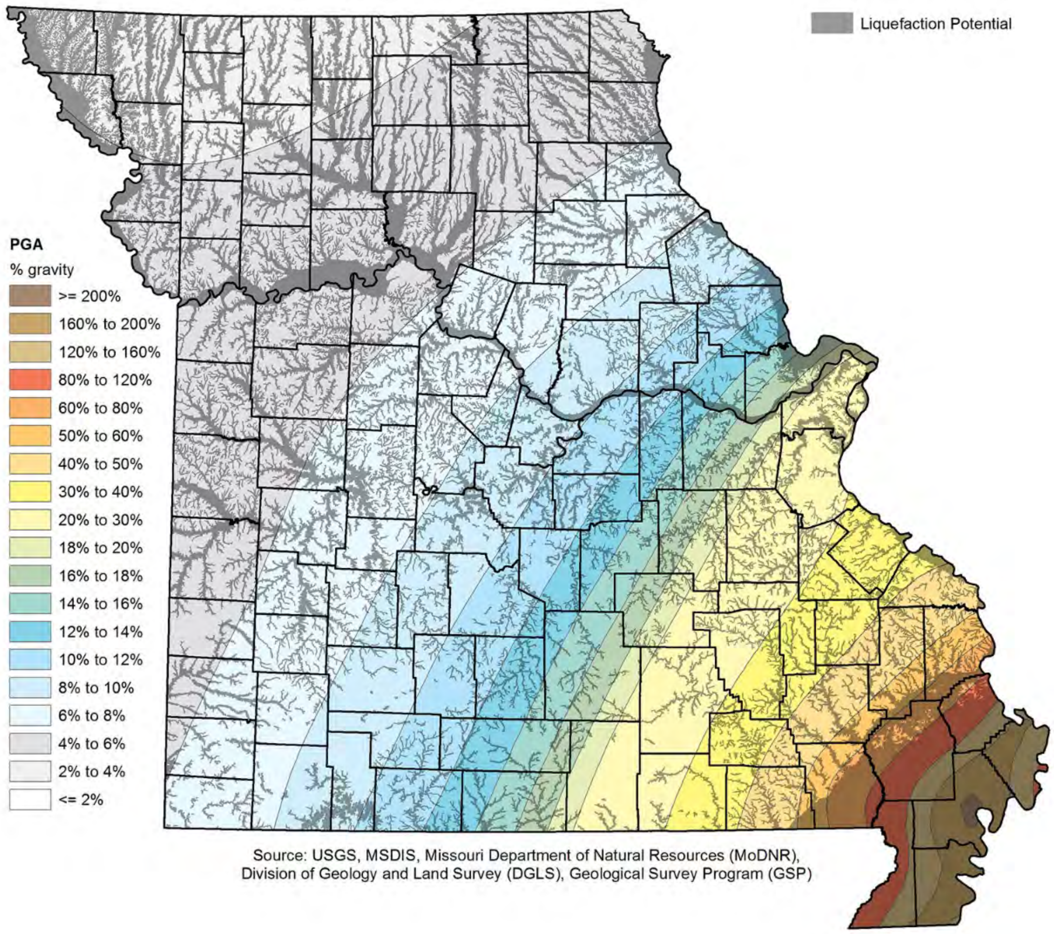
A second scenario, based on an event with a 2% probability of exceedance in 50 years, was done to model a worst-case scenario. This scenario is equivalent to the 2,500 year earthquake scenario in HAZUS-MH. The methodology is based on probabilistic seismic hazard shaking grids developed by the U.S. Geological Survey (USGS) for the National Seismic Hazard Maps that are included with HAZUS-MH. The USGS updated this mapping in 2014. The USGS maps provide estimates of peak ground acceleration and spectral acceleration at periods of 0.3 second and 1.0 second, respectively, which have a 2% probability of exceedance in the next 50 years. The International Building Code uses this level of ground shaking for building design in seismic areas. This scenario used a 7.7 driving magnitude in HAZUS-MH, which is the magnitude used for typical New Madrid fault planning scenarios in Missouri. While the 2% probability of exceedance in the next 50 years ground motion maps incorporate the shaking potential from all faults with earthquake potential in and around Missouri, the most severe shaking is predominately generated by the New Madrid Fault. This pattern of shaking can be seen in **Figure 3.92,** with corresponding potential for damage and areas with soils potentially susceptible to liquefaction.

During the 2017-18 update an enhanced analysis was performed for bridges, hazardous materials facilities and essential facilities (schools, fire and medical facilities) to further refine the vulnerability assessment to identify areas that may warrant further analysis or targeted mitigation. This enhanced analysis is presented in two separate reports: the *Missouri Earthquake Risk Assessment Enhancements: Bridges and Hazardous Materials Facilities* Report as prepared for the Central United States Earthquake Consortium (CUSEC) in coordination with SEMA; and the *Missouri Earthquake Risk Assessment Enhancements: Essential Facilities Analysis* Report as prepared for SEMA. Both detailed reports can be referenced in Appendix C.

For the enhanced analysis, default Hazus inventories for bridges and hazardous materials facilities were replaced with data supplied by the State of Missouri and the Homeland Security Infrastructure Program (HSIP) data. Schools, fire and medical facilities from HSIP and the bridges data set were formatted for use in Hazus using the Hazus Comprehensive Data Management System (CDMS) tool. Results of these analyses are presented in the following locations:

- Bridges – Section 3.5, State Owned and Operated Facilities; and Appendix C
- Hazardous Materials – Appendix C
- Essential Facilitates (Schools, fire, and medical facilities) – Section 7.6, Commitment to a Comprehensive Mitigation Program, Mitigation of Risks to Post-Disaster Response and Recovery Operations

Figure 3.92. HAZUS- MH Earthquake 2% Probability of Exceedance in 50 Years —Ground Shaking and Liquefaction Potential



Scenario Results

The results of this probabilistic scenario include total losses exceeding $51.4 billion in building and income losses, with overall economic losses exceeding $63 billion on. summarizes the results from the HAZUS-MH run for the entire state (HAZUS-MH Earthquake Event Summary Report). **Table 3.61** summarizes the building related losses by county. HAZUS estimates direct damage to structural and non-structural building components separately. Structural components are the walls, columns, beams and flood systems that are responsible for holding up the building. In other words, the structural components are the gravity and lateral load resisting systems. Non-structural building components include building mechanical/electrical systems and architectural components such as partition walls, ceilings, windows and exterior cladding that are not designed as part of the building load carrying system. Equipment that is not an integral part of the building, such as computers, is considered building contents.

Damage to structural components affects other losses differently than damage to non-structural components. For example, if the ceiling tiles fall down in a building, business operations can probably resume once the debris is removed. On the other hand, if a column in a building is damaged, there is a life safety hazard until the column is repaired or temporarily shored, possibly resulting in a long-term disruption. Summary of building damage counts by occupancy class and county for the 2% probability of exceedance in 50 years scenario are shown in.

Table 3.61. Hazus Earthquake Loss Estimation 2% Probability of Exceedance in 50 Years Scenario Results – Summary of Overall Impacts in Missouri

Type of Impact	Summary of Modeled Impacts
Total Buildings Damaged	Slight: 372,790 Moderate: 223,225 Extensive: 88,883 Complete: 47,549
Building and Income Related Losses	$51.4 billion
Total Economic Losses (includes building, income and lifeline losses)	$63.4 billion
Casualties (based on 2 a.m. time of occurrence)	Without requiring hospitalization: 15,454 Requiring hospitalization: 3,855 Life threatening: 512 Fatalities: 999
Casualties (based on 2 p.m. time of occurrence)	Without requiring hospitalization: 21,732 Requiring hospitalization: 5,727 Life threatening: 833 Fatalities: 1,606
Casualties (based on 5 p.m. time of occurrence)	Without requiring hospitalization: 15,480 Requiring hospitalization: 4,020 Life threatening: 574 Fatalities: 1,090
Damage to Schools	339 with at least moderate damage*
Damage to Medical Facilities	159 with at least moderate damage*
Damage to Fire Stations	194 with at least moderate damage*
Damage to Transportation Systems	819 highway bridges, at least moderate damage* 464 highway bridges, complete damage* 4 railroad bridges, moderate damage 12 airport facilities, moderate damage
Households without Power/Water Service (based on 2,375,611 households)	Power loss, Day 1: 364,335 Water loss, Day 1: 753,546 Water loss, Day 3: 730,857 Water loss, Day 7: 687,407 Water loss, Day 30: 549,352 Water loss, Day 90: 254,958
Displaced Households	48,730
Shelter Requirements	32,237 people out of 5,988,927 total population
Debris Generation	16.2 million tons

Table 3.62. Hazus Earthquake Loss Estimation 2% Probability of Exceedance in 50 Years Scenario Results – Summary of by Occupancy Class (Millions of Dollars)

Category	Area	Single Family	Other Residential	Commercial	Industrial	Others	Total
Income Losses	Wage	$0.00	$137.35	$1,494.55	$82.36	$119.30	$1,833.52
	Capital-Related	$0.00	$58.59	$1,217.03	$50.99	$30.64	$1,357.23
	Rental	$610.67	$425.50	$666.99	$30.81	$55.85	$1,789.81
	Relocation	$2,089.36	$380.76	$1,107.27	$147.23	$460.23	$4,184.85
	Subtotal	**$2,700.03**	**$1,002.20**	**$4,485.84**	**$311.39**	**$666.02**	**$9,165.41**
Capital Stock Losses	Structural	$3,581.98	$879.63	$2,018.83	$573.42	$605.33	$7,659.20
	Non-Structural	$12,295.72	$3,928.15	$5,230.69	$1,737.85	$1,559.66	$24,752.07
	Content	$3,915.69	$1,007.10	$2,641.24	$1,170.28	$799.40	$9,533.72
	Inventory	$0.00	$0.00	$72.52	$199.57	$15.57	$287.66
	Subtotal	**$19,793.39**	**$5,814.88**	**$9,963.28**	**$3,681.12**	**$2,979.96**	**$42,232.65**
	Total	**$22,493.42**	**$6,817.08**	**$14,449.12**	**$3,992.51**	**$3,645.98**	**$51,398.06**

Figure 3.93 depicts a map of the modeled earthquake impacts by county based on building losses, including structural and nonstructural damage, content and inventory loss, and wage and income loss. **Figure 3.93** depicts loss ratio by county, which is the ratio of the building structure and nonstructural damage to the value of the entire building inventory. The loss ratio is a measure of the disaster impact to community sustainability, which is generally considered at risk when losses exceed 10 percent of the built environment (FEMA). The loss-ratio map depicts considerable losses in southeastern Missouri, which is consistent with being in close proximity to the New Madrid Seismic Zone and high liquefaction potential.

Table 3.63 ranks the counties by the total building losses. The loss ratio is included and the top 10 counties ranked by loss ratio are highlighted.

Table 3.63. HAZUS-MH Earthquake Loss Estimation 2% Probability of Exceedance in 50 Years Scenario Direct Economic Losses Results Summary by County (All values in thousands)

County	Cost Structural Damage	Cost Non-Structural Damage	Cost Contents Damage	Inventory Loss	Loss Ratio %	Relocation Loss	Capital Related Loss	Wages Losses	Rental Income Loss	Total Loss
St. Louis City	$1,949,201	$6,160,589	$2,539,227	$75,332	5.84	$1,013,089	$384,393	$486,441	$454,429	$13,062,699
St. Louis	$743,887	$2,487,176	$1,080,057	$37,022	6.89	$409,797	$193,220	$239,233	$227,973	$5,418,365
Cape Girardeau	$597,637	$2,140,986	$813,363	$22,777	31.15	$305,430	$119,890	$174,133	$135,755	$4,309,971
Jefferson	$435,917	$1,412,097	$526,453	$11,707	8.31	$239,233	$61,970	$81,642	$83,896	$2,852,915
Scott	$393,622	$1,440,264	$560,141	$22,085	45.43	$201,209	$61,559	$83,504	$78,304	$2,840,689
St. Charles	$369,881	$1,162,593	$449,190	$9,511	3.66	$200,216	$72,356	$93,926	$83,171	$2,440,845
Dunklin	$301,286	$1,037,400	$387,954	$10,944	44.98	$158,495	$43,029	$62,375	$63,834	$2,065,316
Stoddard	$247,347	$878,094	$325,448	$10,685	37.65	$130,329	$29,682	$44,860	$50,290	$1,716,735
New Madrid	$246,570	$896,091	$303,785	$10,619	64.73	$121,245	$25,553	$40,446	$53,425	$1,697,734
Butler	$217,447	$744,680	$290,800	$10,735	23.22	$122,494	$32,442	$50,255	$50,408	$1,519,262
Pemiscot	$205,587	$777,124	$273,217	$6,792	59.84	$109,562	$23,084	$35,869	$44,994	$1,476,230
St. Francois	$172,068	$548,759	$202,485	$6,189	11.66	$100,863	$29,410	$43,291	$39,573	$1,142,637
Mississippi	$140,944	$505,577	$171,275	$3,913	58.01	$74,421	$15,553	$21,429	$30,046	$963,156
Franklin	$129,283	$367,029	$146,775	$6,325	4.35	$70,946	$24,439	$31,243	$26,988	$803,029
Greene	$106,340	$282,704	$101,638	$2,653	1.21	$66,754	$23,549	$32,699	$28,904	$645,241
Perry	$96,805	$307,216	$124,522	$6,226	18.09	$52,059	$12,896	$20,875	$19,112	$639,711
Ste. Genevieve	$73,391	$236,053	$91,675	$3,933	14.31	$39,222	$10,158	$16,311	$14,418	$485,160
Jackson	$85,597	$179,993	$53,610	$1,622	0.30	$47,990	$16,440	$20,654	$22,788	$428,693
Wayne	$57,036	$188,917	$62,927	$1,587	19.57	$36,248	$5,629	$8,523	$12,004	$372,871
Ripley	$54,859	$179,711	$65,791	$2,589	20.73	$34,006	$6,191	$9,758	$10,983	$363,888
Howell	$55,995	$158,220	$59,731	$2,049	6.03	$36,564	$11,636	$16,469	$14,442	$355,107
Bollinger	$51,293	$169,434	$55,111	$1,009	21.32	$30,534	$3,756	$5,080	$9,951	$326,167
Boone	$47,799	$129,199	$44,304	$679	0.96	$29,990	$11,430	$15,490	$14,373	$293,265
Madison	$44,290	$140,643	$52,254	$1,795	16.29	$26,861	$5,610	$8,290	$9,236	$288,979
Cole	$43,457	$120,094	$44,103	$541	1.53	$32,126	$7,001	$14,911	$13,288	$275,521
Phelps	$38,019	$108,793	$40,517	$843	3.10	$24,804	$9,319	$14,269	$10,713	$247,276
Pulaski	$37,007	$98,954	$30,192	$359	2.55	$16,823	$4,313	$5,918	$11,663	$205,229
Washington	$32,398	$98,709	$32,139	$436	7.57	$22,252	$3,321	$5,511	$7,078	$201,844
Taney	$27,344	$81,222	$26,710	$427	1.77	$17,890	$11,503	$14,074	$12,376	$191,546
Iron	$28,245	$89,400	$31,563	$931	12.02	$17,368	$3,032	$4,929	$6,510	$181,978
Crawford	$27,361	$77,077	$28,333	$904	4.37	$17,082	$4,787	$6,210	$6,205	$167,959
Lincoln	$27,994	$76,171	$26,846	$605	2.21	$17,350	$3,618	$5,112	$5,630	$163,327

County	Cost Structural Damage	Cost Non-Structural Damage	Cost Contents Damage	Inventory Loss	Loss Ratio %	Relocation Loss	Capital Related Loss	Wages Losses	Rental Income Loss	Total Loss
Camden	$25,407	$75,023	$23,467	$351	1.21	$15,754	$4,940	$6,219	$7,906	$159,068
Christian	$27,084	$75,350	$25,272	$573	1.32	$16,278	$3,693	$4,400	$6,180	$158,829
Oregon	$24,137	$72,964	$24,754	$447	10.90	$15,933	$3,444	$4,615	$5,410	$151,703
Texas	$23,223	$62,179	$22,454	$639	3.72	$15,051	$3,764	$5,474	$5,464	$138,246
Carter	$19,483	$63,654	$21,883	$695	16.01	$12,804	$3,052	$4,158	$4,515	$130,244
Reynolds	$19,472	$62,211	$21,814	$829	12.20	$12,608	$2,126	$4,132	$4,495	$127,687
Clay	$25,868	$52,452	$15,023	$474	0.28	$13,597	$3,751	$4,842	$5,989	$121,996
Warren	$20,203	$57,360	$21,109	$607	2.23	$12,135	$2,777	$3,508	$4,219	$121,919
Dent	$18,897	$52,441	$19,313	$513	4.91	$12,100	$3,244	$4,674	$4,095	$115,277
Jasper	$19,922	$45,641	$15,083	$527	0.54	$12,951	$4,334	$5,902	$5,320	$109,681
Laclede	$15,737	$39,201	$13,915	$528	1.71	$10,311	$3,080	$3,950	$4,089	$90,812
Callaway	$15,892	$41,449	$13,755	$296	1.30	$9,598	$2,252	$3,189	$3,876	$90,307
Shannon	$13,888	$43,013	$14,536	$330	8.38	$9,252	$1,358	$2,230	$3,344	$87,951
Stone	$14,359	$40,589	$12,805	$135	1.40	$9,678	$1,891	$2,461	$3,604	$85,522
Gasconade	$12,743	$34,070	$12,792	$382	2.48	$8,034	$2,282	$3,146	$2,855	$76,305
Webster	$12,530	$33,048	$11,254	$271	1.64	$8,408	$1,746	$2,188	$2,931	$72,376
Wright	$12,043	$30,999	$11,141	$333	2.69	$8,262	$2,096	$2,842	$2,914	$70,630
Barry	$10,373	$25,784	$9,524	$471	0.97	$6,844	$1,520	$2,266	$2,343	$59,125
Newton	$10,400	$23,237	$7,455	$243	0.61	$6,695	$1,813	$2,592	$2,581	$55,016
Marion	$8,643	$22,001	$7,606	$195	0.95	$5,458	$2,224	$3,050	$2,482	$51,658
Miller	$8,681	$22,383	$7,412	$187	1.29	$5,847	$1,528	$1,852	$2,189	$50,078
Lawrence	$8,919	$21,698	$7,374	$264	0.88	$5,744	$1,262	$1,788	$2,115	$49,165
Cass	$10,550	$22,676	$5,872	$111	0.30	$5,612	$933	$1,276	$2,125	$49,155
Ozark	$8,178	$22,834	$7,801	$190	3.35	$5,651	$836	$1,368	$1,921	$48,779
Osage	$8,207	$21,758	$8,325	$408	1.86	$4,981	$920	$1,450	$1,614	$47,663
Pettis	$8,569	$19,374	$6,821	$267	0.63	$5,430	$1,539	$2,237	$2,228	$46,464
Platte	$9,435	$20,250	$5,295	$108	0.26	$4,819	$1,290	$1,588	$2,327	$45,111
Johnson	$8,031	$19,889	$6,809	$115	0.46	$5,590	$1,064	$1,585	$1,998	$45,082
Audrain	$7,885	$19,102	$6,903	$227	1.00	$4,908	$1,414	$2,176	$1,879	$44,495
Buchanan	$8,580	$16,843	$5,189	$199	0.24	$5,166	$2,025	$2,853	$2,173	$43,028
Polk	$7,744	$18,811	$6,147	$148	0.98	$5,063	$1,163	$1,721	$1,911	$42,707
Douglas	$7,074	$19,431	$6,529	$151	2.53	$5,119	$830	$1,149	$1,671	$41,953
Morgan	$7,694	$18,730	$5,831	$140	0.92	$5,133	$1,024	$1,305	$1,794	$41,651
Pike	$7,013	$17,351	$6,186	$174	1.31	$4,375	$1,150	$1,618	$1,836	$39,703
Montgomery	$6,777	$16,153	$5,990	$282	1.64	$4,076	$907	$1,247	$1,536	$36,967

County	Cost Structural Damage	Cost Non-Structural Damage	Cost Contents Damage	Inventory Loss	Loss Ratio %	Relocation Loss	Capital Related Loss	Wages Losses	Rental Income Loss	Total Loss
Maries	$5,576	$14,984	$5,419	$178	2.15	$3,465	$561	$790	$1,077	$32,050
Benton	$5,156	$12,675	$3,594	$48	0.72	$3,522	$586	$733	$1,139	$27,455
Dallas	$4,739	$11,846	$3,743	$89	1.22	$3,232	$501	$675	$1,043	$25,868
Henry	$4,504	$9,915	$3,347	$135	0.57	$2,723	$709	$1,059	$1,098	$23,491
Randolph	$4,277	$9,777	$3,143	$101	0.58	$2,744	$800	$1,097	$1,103	$23,041
Moniteau	$4,192	$10,239	$3,495	$120	0.96	$2,489	$454	$625	$883	$22,496
Cooper	$4,182	$9,485	$3,163	$121	0.76	$2,443	$608	$876	$1,041	$21,917
Lafayette	$4,625	$9,384	$2,730	$76	0.36	$2,549	$544	$742	$1,017	$21,668
Saline	$3,685	$8,283	$2,585	$78	0.49	$2,257	$611	$806	$956	$19,261
Ralls	$3,325	$8,067	$2,776	$121	0.99	$1,981	$302	$429	$666	$17,668
McDonald	$3,280	$7,802	$2,252	$59	0.66	$2,245	$289	$412	$708	$17,047
Vernon	$3,000	$6,737	$2,131	$59	0.43	$1,984	$518	$798	$754	$15,981
Cedar	$2,513	$5,822	$1,841	$60	0.64	$1,754	$441	$632	$651	$13,715
Barton	$2,531	$5,399	$1,998	$75	0.56	$1,582	$373	$524	$537	$13,019
Adair	$2,456	$5,252	$1,421	$26	0.30	$1,559	$512	$775	$841	$12,841
Hickory	$2,281	$5,461	$1,479	$19	0.89	$1,764	$181	$287	$501	$11,974
Monroe	$2,187	$5,058	$1,621	$55	0.74	$1,408	$312	$418	$486	$11,545
Ray	$2,485	$5,114	$1,346	$26	0.30	$1,401	$231	$317	$502	$11,421
Macon	$2,229	$4,725	$1,408	$34	0.43	$1,450	$399	$588	$569	$11,401
Howard	$2,257	$4,984	$1,548	$40	0.67	$1,327	$241	$365	$512	$11,274
Bates	$2,137	$4,491	$1,315	$28	0.40	$1,346	$225	$345	$463	$10,349
St. Clair	$1,837	$4,177	$1,255	$19	0.64	$1,309	$220	$385	$400	$9,602
Dade	$1,727	$3,985	$1,310	$51	0.77	$1,147	$229	$307	$394	$9,149
Linn	$1,848	$3,661	$1,086	$29	0.36	$1,145	$298	$411	$419	$8,898
Lewis	$1,750	$3,777	$1,131	$40	0.56	$1,026	$261	$313	$421	$8,719
Livingston	$1,744	$3,341	$984	$45	0.30	$1,033	$325	$441	$458	$8,371
Carroll	$1,588	$3,304	$1,070	$45	0.41	$981	$211	$381	$349	$7,931
Chariton	$1,632	$3,358	$1,031	$30	0.53	$962	$198	$281	$364	$7,855
Clinton	$1,721	$3,410	$813	$17	0.22	$979	$206	$274	$382	$7,801
Shelby	$1,430	$2,980	$1,004	$33	0.56	$876	$216	$265	$322	$7,125
Nodaway	$1,535	$2,783	$684	$19	0.18	$817	$205	$293	$423	$6,759
Grundy	$1,179	$2,215	$599	$17	0.29	$720	$154	$260	$299	$5,444
Andrew	$1,172	$2,194	$513	$9	0.20	$663	$137	$169	$257	$5,114
Clark	$890	$1,842	$515	$12	0.38	$580	$133	$179	$206	$4,357
Caldwell	$895	$1,677	$410	$8	0.26	$545	$73	$115	$189	$3,911

County	Cost Structural Damage	Cost Non-Structural Damage	Cost Contents Damage	Inventory Loss	Loss Ratio %	Relocation Loss	Capital Related Loss	Wages Losses	Rental Income Loss	Total Loss
Daviess	$859	$1,628	$441	$24	0.26	$521	$94	$143	$172	$3,882
Harrison	$813	$1,479	$378	$7	0.22	$520	$167	$224	$209	$3,797
DeKalb	$829	$1,511	$347	$6	0.21	$436	$85	$112	$225	$3,550
Sullivan	$613	$1,168	$326	$13	0.29	$401	$80	$139	$145	$2,886
Scotland	$608	$1,146	$326	$10	0.32	$365	$81	$136	$147	$2,818
Knox	$574	$1,101	$312	$8	0.38	$360	$74	$103	$134	$2,666
Gentry	$519	$875	$230	$7	0.20	$324	$74	$117	$127	$2,273
Holt	$499	$881	$252	$8	0.22	$301	$87	$103	$115	$2,246
Atchison	$508	$873	$236	$6	0.17	$293	$68	$93	$118	$2,194
Putnam	$445	$793	$190	$5	0.23	$289	$52	$74	$104	$1,953
Schuyler	$358	$664	$163	$3	0.25	$229	$34	$66	$89	$1,607
Mercer	$293	$539	$121	$2	0.21	$191	$27	$41	$69	$1,282
Worth	$170	$299	$68	$1	0.17	$101	$12	$25	$38	$715
Total	$7,659,201	$24,752,079	$9,533,725	$287,656		$4,184,856	$1,357,240	$1,833,524	$1,789,811	$51,398,085

Source: Hazus MH/Wood E&IS

Figure 3.93. HAZUS-MH Earthquake Loss Estimation with a 2% Probability of Exceedance in 50 Years Scenario—Total Building Loss

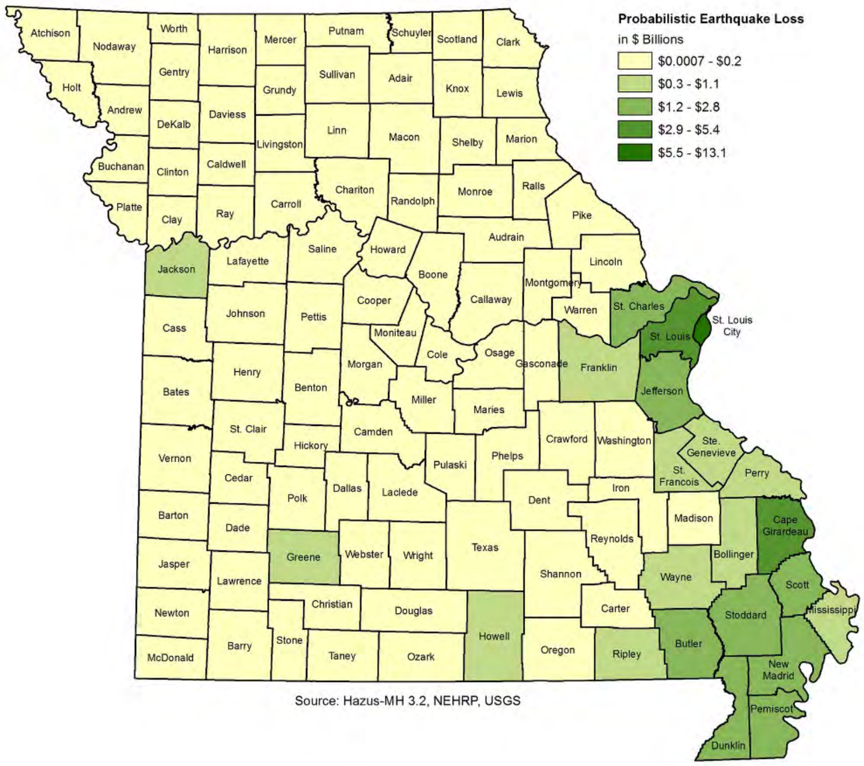
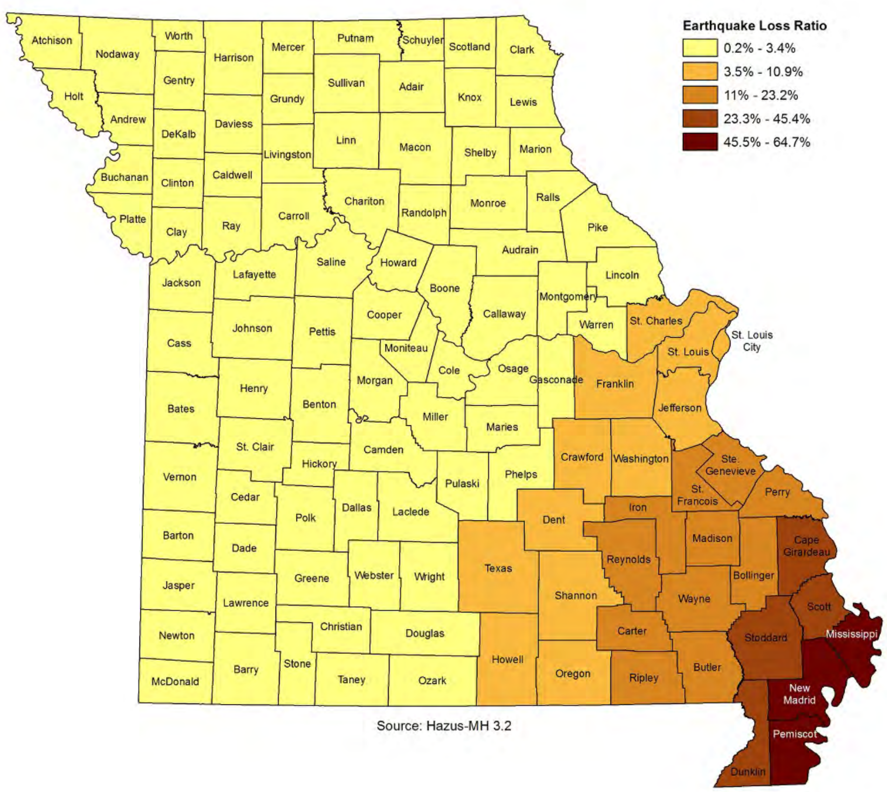


Figure 3.94. HAZUS-MH Earthquake Loss Estimation with a 2% Probability of Exceedance in 50 Years Scenario—Loss Ratio



Hazard Impact on Future Growth and Development

According to the population trends analysis is generally not significant development and growth occurring in high vulnerable areas. The exception to this is Cape Girardeau County which experienced 6.6% population growth between 2010 and 2015. To some extent modern building codes will help to reduce damage and casualties associated with future structures from earthquakes. Future state facilities in the high-risk areas of southeast Missouri should be built to account for potential earth shaking and earthquake impacts.

EMAP Consequence Analysis

The information in **Table 3.64** is from the Impact Analysis of Potential for Detrimental Impacts of Hazards done for the Emergency Management Accreditation Program.

Table 3.64. EMAP Impact Analysis: Earthquakes

Subject	Detrimental Impacts
Public	Adverse impact expected to be severe for unprotected personnel and moderate to light for protected personnel.
Responders	Adverse impact expected to be severe for unprotected personnel and moderate to light for protected personnel.
Continuity of Operations including continued delivery of services	Damage to facilities/personnel in the area of the incident may require relocation of operations and lines of succession execution. Disruption of lines of communication and destruction of facilities may extensively postpone delivery of services.
Property, Facilities, and Infrastructure	Damage to facilities and infrastructure in the area of the incident may be extensive for facilities, people, infrastructure, and HazMat.
Environment	May cause extensive damage, creating denial or delays in the use of some areas. Remediation needed.
Economic Condition of Jurisdiction	Local economy and finances adversely affected, possibly for an extended period of time.
Public Confidence in the Jurisdiction's Governance	Ability to respond and recover may be questioned and challenged if planning, response, and recovery not timely and effective.

Risk Summary

The exact timing is unknown, but the State is overdue for a damaging earthquake. The New Madrid Seismic Zone is considered as seismically active as some areas of California and has been the source of some of the strongest earthquakes felt anywhere in the country. Based on HAZUS modeling and historic incidents the earthquake could have significant impacts on the citizens of Missouri, particularly in the southeastern and eastern parts of the state and surrounding states. Earthquakes also have secondary effects such as soil liquefaction, fires, building collapse, transportation infrastructure damage, utility disruptions, dam failures, flooding, hazardous material releases, environmental impacts, and long term economic disruptions or losses.

Problem Statement:

Using the loss ratio for the 2% probability of exceedance in 50 years as the key indicator, the data suggests that it would most feasible to concentrate mitigation efforts and dollars first in Mississippi, New Madrid and Pemiscot. Following next would be concentration of resources on Scott, Stoddard and Dunklin Counties with a general focus of remaining resources in the remaining southeast area of the State.

2018 risk assessment data and mapping is available through the Missouri Hazard Mitigation Viewer: http://bit.ly/MoHazardMitigationPlanViewer2018

3.3.5. Land Subsidence/Sinkholes

Probability	Severity
100% 12 events in 12 years	Low

Description/Location

Land subsidence is a geological hazard caused by the sinking of the earth's surface due to the movement of earth materials below the surface. This sinking can be sudden or gradual and is generally attributed to the removal of subsurface water or the draining of organic soils. In Missouri, subsidence is primarily associated with sinkholes but they can also occur from void space left by mining and natural caves.

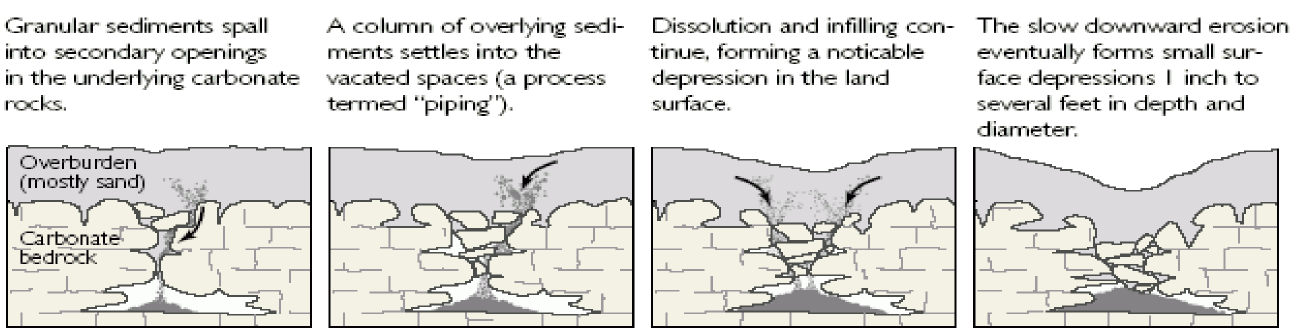
Sinkholes

Sinkholes can be natural or artificial, and can develop in several different ways and vary in size and shape. Natural sinkholes develop in areas where the rock below the surface is limestone, carbonate rock (as found in Missouri), salt beds or any type of rock that can naturally be dissolved by groundwater circulating through it. This process of the dissolution of rock is known as the karst process. As the rock dissolves, spaces and caverns develop which potentially lead to sinkholes forming above these voids. Natural sinkholes can vary from a few square feet in area to hundreds of acres and can be from one foot deep to hundreds of feet deep. Naturally occurring sinkholes are typically permanent and have flood risk associated with them which need to be assessed.

Artificial sinkholes are created by man-made events. Examples of artificial sinkholes include groundwater pumping, water main and sewer collapses and even mine collapses. Artificial sinkholes can also be linked to land-use and development practices. Unlike natural sinkholes, artificial sinkholes typically are not permanent and do not have flood risk associated with them. In most cases, if an artificial sinkhole is created, the issues causing the sinkhole are dealt with and the sinkhole filled in.

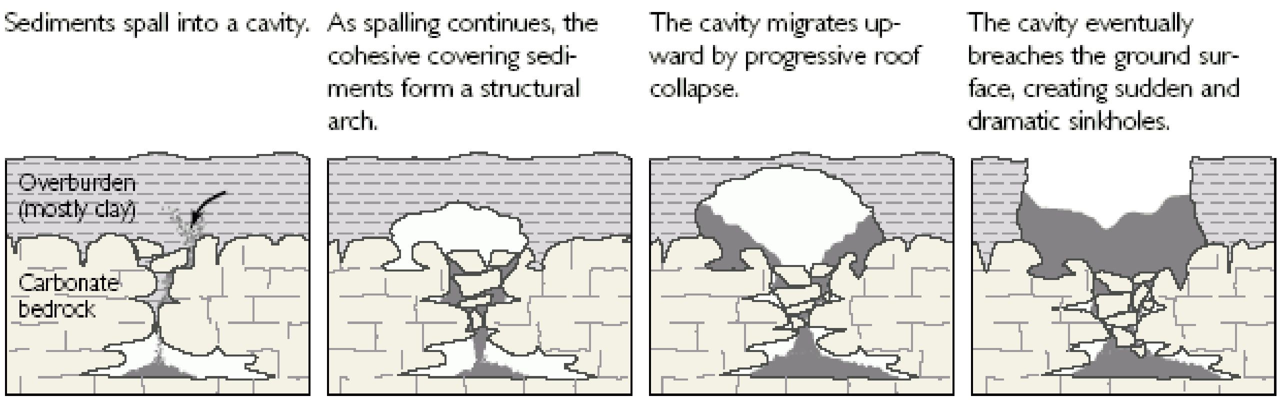
There are two ways that a naturally occurring sinkhole is formed, by cover-subsidence or by cover-collapse. Cover subsidence is a relatively slow process as observed from the surface. The overlying earth above an underground void slowly settles and fills the void. This process can go undetected for long periods and can be hard to detect in rolling terrain. Cover collapse occurs much more rapidly; this is where the earth above a void cannot support itself any longer and collapses into the void. Both processes are depicted in **Figures 3.95 and 3.96**.

Figure 3.95. Depiction of the cover-subsidence process



Source: water.usgs.gov

Figure 3.96. Depiction of the cover-collapse process

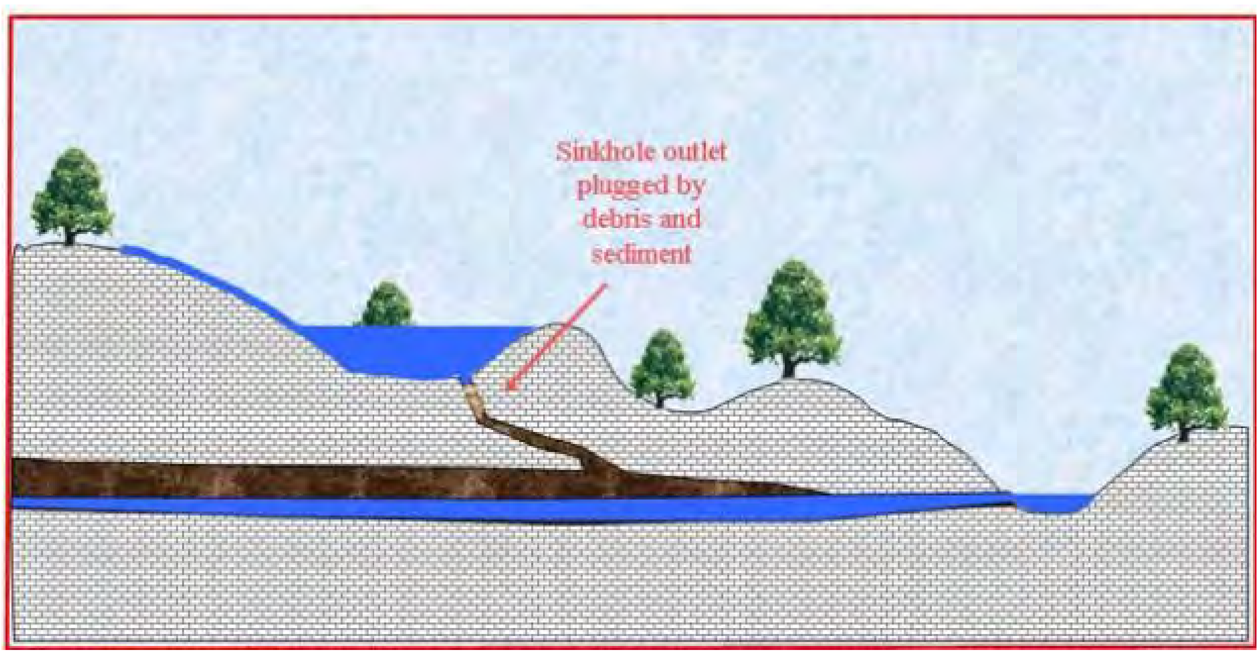


Source: water.usgs.gov

Once formed, there are four main ways sinkholes can subsequently fill with water and cause a flooding hazard. Two flood situations are created when the rate of run-off water flowing into the sink is greater than the rate of flow out of the sink. These are caused by either (1) a plugged throat; or (2) an insufficient outlet size. The other two flood situations are caused by the reversal of groundwater flow when backwater backs up into the sink from underground. These two are caused by either (1) backwater from a river; or (2) from another sinkhole.

Flooding in a sinkhole can occur when the throat or the outlet of the sinkhole is plugged with debris and cannot drain the sinkhole at the rate run-off is filling the sinkhole. This flooding can be seen in **Figure 3.97** below.

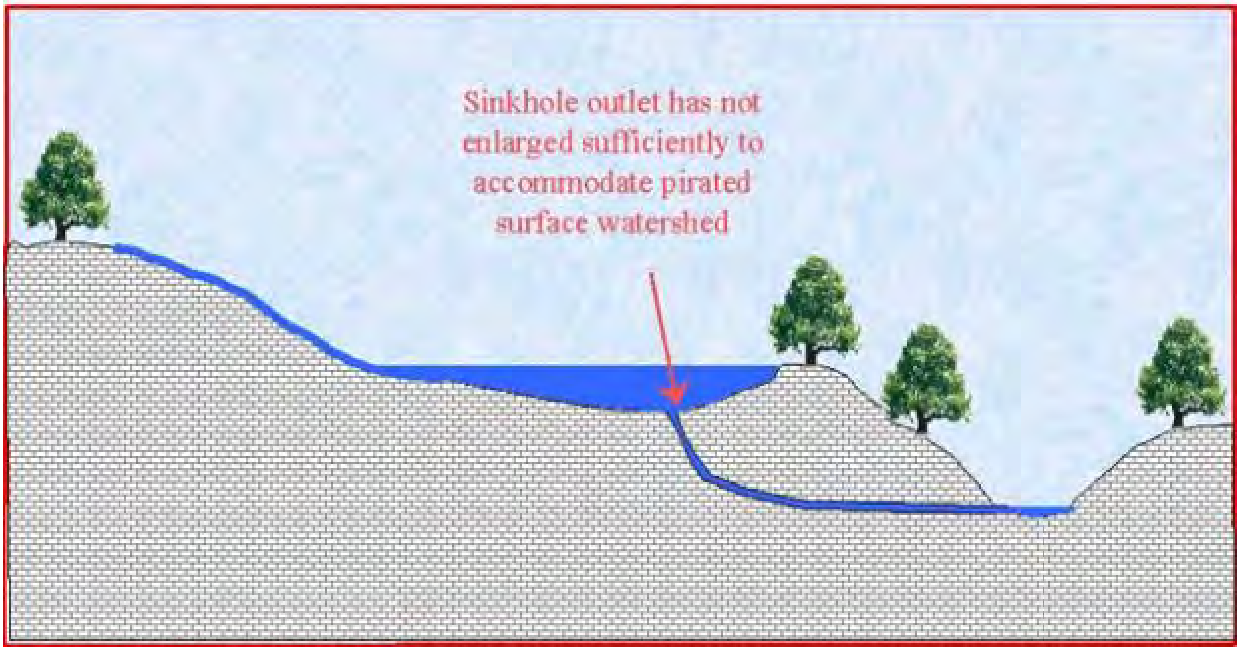
Figure 3.97. Flooding Caused By Plugged Throat



Source: www.uky.edu

Flooding in a sinkhole can occur when the throat or the outlet of the sinkhole is not large enough to drain the sinkhole at the rate run-off is filling the sinkhole. This flooding can be seen in **Figure 3.98** below.

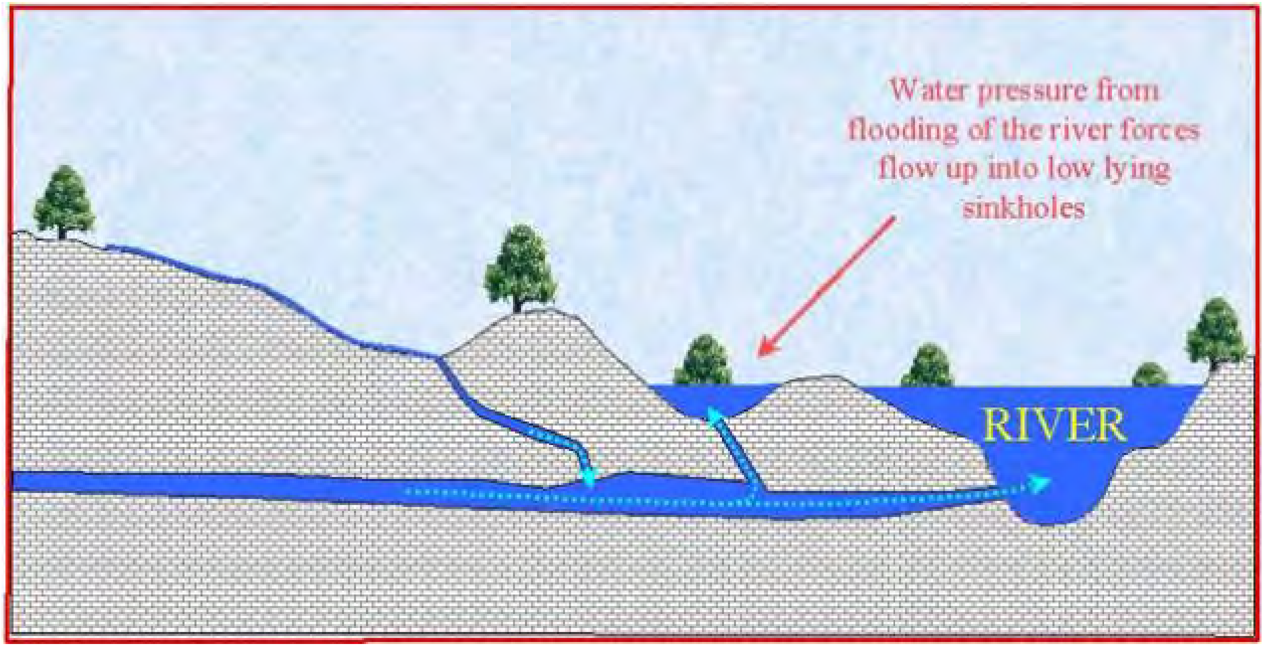
Figure 3.98.   Flooding Caused By Plugged Throat



Source: www.uky.edu

Flooding in a sinkhole can occur when there is flooding on a nearby stream or river which causes water to back up under ground and fill the sink hole by reversing the flow of water through its throat. This flooding can be seen in **Figure 3.99** below.

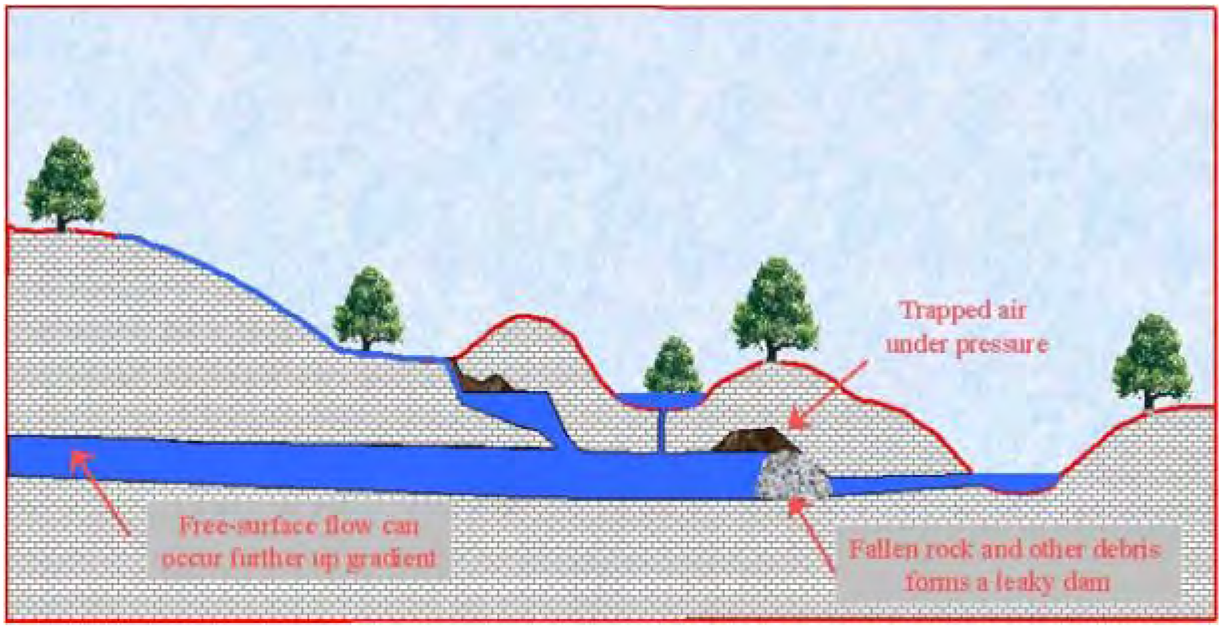
Figure 3.99.   Flooding Caused By Riverine Backwater



Source: www.uky.edu

Flooding in a sinkhole can occur when there is flooding in a nearby sinkhole which cannot drain fast enough to a river which ultimately causes water to back up under ground and fill the sink hole by reversing the flow of water through its throat. This flooding can be seen **Figure 3.110** below.

Figure 3.100. Flooding Caused By Sinkhole Backwater



Source: www.uky.edu

There are many ways to locate sinkholes varying from observation to computer processing. Communities may have their own inventory of sinkholes which have been documented over time based on observation. The MoDRN's Missouri Geological Survey has created a statewide inventory of sinkholes which documents 15,981 larger more well-known sinkholes. Whereas, Greene County has developed its own inventory of sinkholes which documents more than 7,000 sinks in Greene County alone. The largest known sinkhole is approximately 700 acres in western Boone County southeast of where I-70 crosses the Missouri River.

Mining

Mining activity in Missouri has been occurring since the early 1740s. Missouri has a vast amount of minerals hidden beneath the surface. Minerals founds include lead, vast supplies of zinc, copper, nickel, and cobalt, tripoli, stone, clay, industrial sand, lime, barite, and coal were extracted from Missouri's mines.

Natural Caves

A cave is a natural underground opening large enough to explore, therefore, a cave may be a rock shelter, or a pit opening in the bottom of a sinkhole, or a cavernous, many-roomed passage that extends deep into the earth. Missouri is known for their more than 6,300 natural caves through the State.

Location

According to the U.S. Geological Survey, the most damage from sinkholes tends to occur in Florida, Texas, Alabama, Missouri, Kentucky, Tennessee and Pennsylvania. Fifty-nine percent of Missouri is underlain by thick, carbonate rock that makes Missouri vulnerable to sinkholes. Sinkholes occur in Missouri on a frequent basis. Most of Missouri's sinkholes occur naturally in the State's karst regions (areas with soluble bedrock). They are a common geologic hazard in southern Missouri, but also occur in the central and northeastern parts of the State.

Figure 3.101. Sinkhole areas as delineated by the MoDNR

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

Figure 3.102. Sinkhole Counts per county

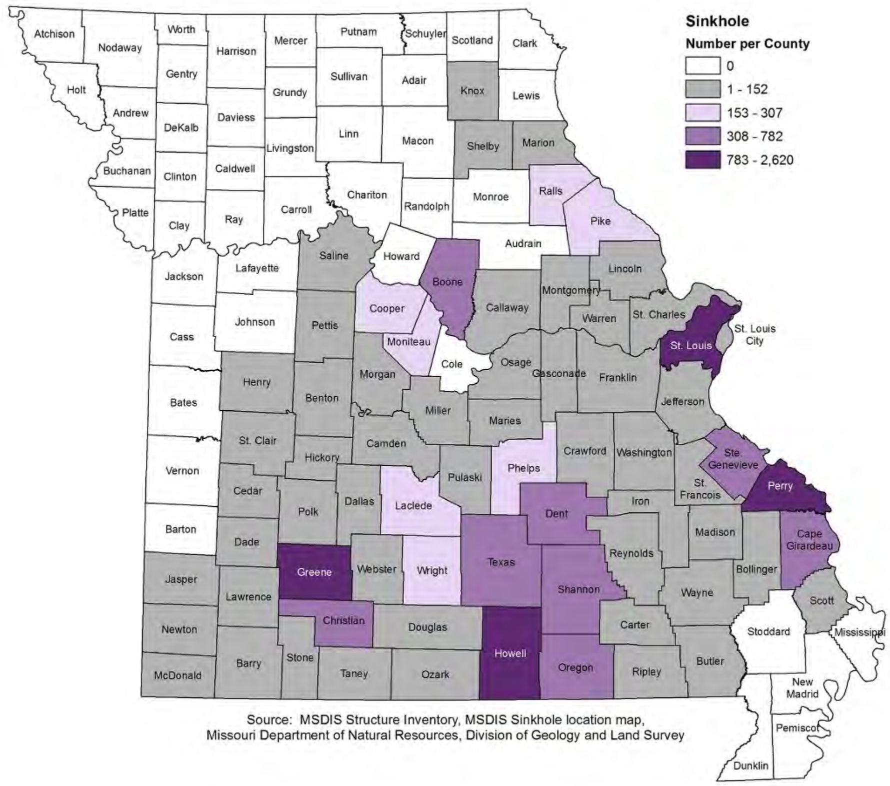


Figure 3.103. Mine Counts per county

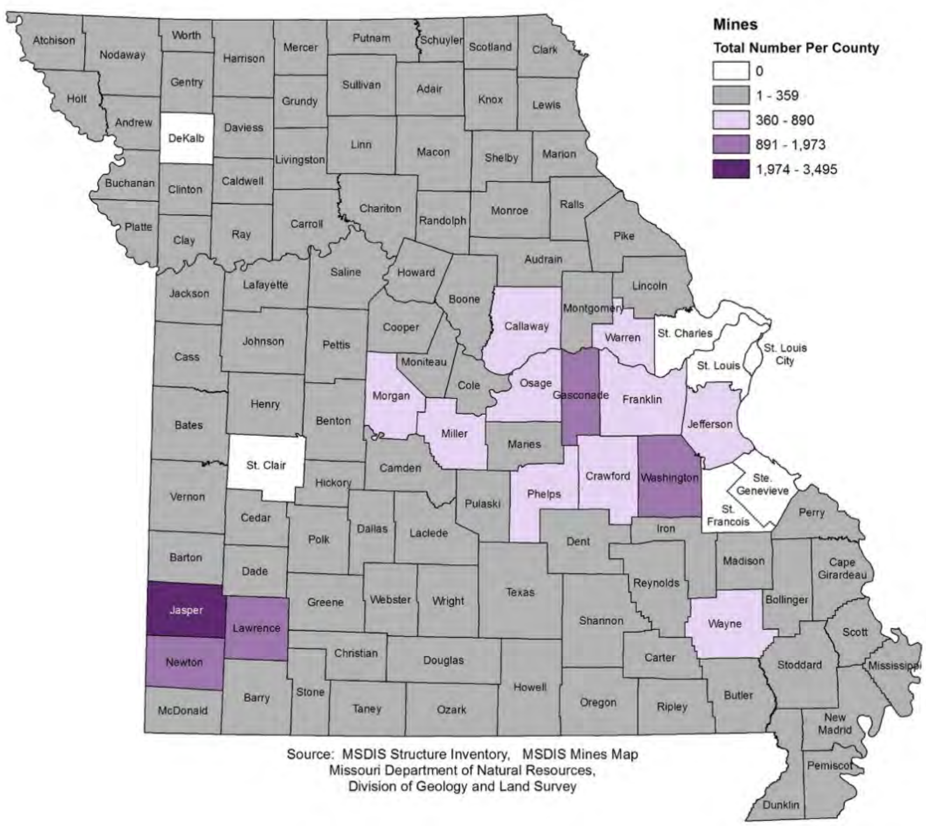


Table 3.65. Sinkhole and Mine Counts per county

County	Number of Sinkholes Per County	Number of Mines Per County
Adair	0	120
Andrew	0	95
Atchison	0	14
Audrain	0	94
Barry	51	176
Barton	0	128
Bates	0	181
Benton	1	137
Bollinger	3	121
Boone	397	200
Buchanan	0	80
Butler	3	95
Caldwell	0	39
Callaway	5	423
Camden	82	167
Cape Girardeau	426	81
Carroll	0	71
Carter	72	97
Cass	0	91
Cedar	7	83
Chariton	0	83
Christian	534	237
Clark	0	43
Clay	0	133
Clinton	0	85
Cole	0	249
Cooper	234	106
Crawford	57	546
Dade	85	109
Dallas	18	44
Daviess	0	79
Dekalb	0	0
Dent	432	156
Douglas	90	77
Dunklin	0	10
Franklin	17	764
Gasconade	2	1366
Gentry	0	84
Greene	1292	359
Grundy	0	55
Harrison	0	84
Henry	1	224
Hickory	19	132
Holt	0	40
Howard	0	76
Howell	1286	306
Iron	4	193
Jackson	0	231
Jasper	101	3495
Jefferson	20	389
Johnson	0	143
Knox	1	19
Laclede	298	77
Livingston	0	107
Macon	0	202
Madison	4	217
Maries	9	243
Marion	44	46
McDonald	4	45
Mercer	0	74
Miller	10	890
Mississippi	0	2
Moniteau	187	347
Monroe	0	71
Montgomery	2	329
Morgan	3	685
New Madrid	0	29
Newton	28	1973
Nodaway	0	85
Oregon	463	159
Osage	1	387
Ozark	105	146
Pemiscot	0	8
Perry	2620	59
Pettis	7	85
Phelps	212	372
Pike	307	82
Platte	0	137
Polk	75	52
Pulaski	94	86
Putnam	0	92
Ralls	181	96
Randolph	0	255
Ray	0	132
Reynolds	56	107
Ripley	33	72
Saline	17	118
Schuyler	0	14
Scotland	0	11
Scott	13	51
Shannon	782	145
Shelby	3	31
St Charles	45	0
St Clair	5	0
St Francois	59	0
St Louis	1361	0
St Louis City	108	0
Ste Genevieve	734	0
Stoddard	0	165
Stone	17	57
Sullivan	0	53
Taney	52	77
Texas	418	144
Vernon	0	205
Warren	7	408
Washington	15	1566

County	Number of Sinkholes Per County	Number of Mines Per County
Lafayette	0	201
Lawrence	72	1198
Lewis	0	33
Lincoln	152	68
Linn	0	44
Wayne	17	405
Webster	38	117
Worth	0	28
Wright	292	126
Grand Total	**14,190**	**25,424**

Extent

Unlike earthquakes or other geologic hazards, there currently is no scale for measuring or determining the severity of sinkholes. However, geological and mining parameters can affect the magnitude and extent of sinkhole subsidence. As previously noted, natural sinkholes develop in areas where the rock below the surface is limestone, carbonate rock (as found in Missouri), salt beds or any type of rock that can naturally be dissolved by groundwater circulating through it. Artificial sinkholes develop due to groundwater pumping, water main and sewer collapses, and mine collapses.

Previous Occurrences

Sinkholes are a regular occurrence in Missouri, but rarely are the events of any significance. However, there have been occasional damages related to sinkholes. The following events are from Jim Vandike's "That Sinking Feeling—A Void, a Collapse" in the Spring/Summer 2003 issue of Missouri's Department of Natural Resources' Missouri Resources:

In 1948, a well-drilling rig was constructing a mineral-test hole on the St. Francis River floodplain in St. Francois County when sinkholes began developing around the rig. By the time the well was cased, there were approximately 20 sinkholes up to 90 feet long and 20 feet wide within 500 feet of the rig.

A lake in northern Howell County was built in the 1960s on a tributary of the Eleven Point River in an area characterized by deeply weathered bedrock, losing streams, and sinkholes. A sinkhole formed in the floor of the lake and quickly drained it. Efforts to stop the leak failed and the lake will only hold water for short periods following heavy rainfall.

Sinkhole collapses have occurred in sewage lagoons at several southern Missouri towns including West Plains and Republic. In most instances, the lagoons were abandoned and new lagoons were constructed on better sites or the towns switched wastewater-treatment methods.

Mining-related collapses have occurred in the Joplin area where lead and zinc were once mined; southeastern Missouri (Washington, Iron, St. Francois, and Reynolds Counties), where lead has been mined since the 1700s; northern and western Missouri (and part of St. Louis) where coal was mined underground prior to the 1940s; and throughout Missouri where underground limestone quarries are common.

Other notable events include the following:

- In May 2017, Missouri State Highway Patrol spotted a newly formed giant sinkhole near West Plains, Missouri which was swallowing the recent floodwaters.
- In April 2016, a garbage truck fell in to sinkhole while picking up trash on its route in Boone County and a dump truck fell into a sinkhole suddenly along in Clayton, Missouri near Central Avenue and Maryland Avenue.
- In March 2016, a U.S. Marine at Fort Leonard Wood died while hunting in south central Missouri after falling into an unseen sinkhole in Pulaski County.

- In May 2015, a sinkhole was discovered near the entrance to Top of the Rock golf course in Branson Missouri that was 80 feet wide and 35 feet deep. Nearly 7,000 cubic feet of material was displaced by the hole which has since been filled in.
- In April 2014, sinkholes in Reynolds County appeared near the West Fork mine at the Doe Run lead mining facility. A sinkhole more than 100 feet wide opened near the historic West Fork Sutterfield Cemetery. It is possible that mining operations may have been linked to this event.
- In August 2013, City of Springfield Utility crews discovered a 50 foot wide 25 foot deep sinkhole near Walnut Lawn at Cox while installing water mains.
- In June 2013, sinkhole damage caused road closures on south Sprigg Street at La Cruz Street. One sinkhole was about 15 feet deep and the other was about 8 feet deep.
- In January 2013, the owner of a used car company in Sugar Creek, Missouri experienced damage from a sinkhole appearing in the parking lot.
- August 6, 2012, a sinkhole caused a road to collapse near Springfield-Branson National Airport. A water main snapped when the concrete collapsed. The hole likely formed after heavy rains.
- In July 2010, MODOT had to close a section of I-470 in Kansas City because of damage from a sinkhole at the Three Trails Crossing intersection.
- In 2009 a sinkhole approximately 70' by 30' at the bottom of a rain runoff area in Battlefield, Greene County, had to be patched as it threatened a city sewer lift station. (News-Leader, 2009)
- In August 2006, a sinkhole collapse in the City of Nixa in Christian County severely destroyed a residence and vehicle and threatened adjacent homes and city utilities. No one was injured in this event.

Figure 3.104. Sinkhole Example from the Southwest Missouri town of Nixa in 2006

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

- In February 2005, a sinkhole appeared in a pasture in Barry County and grew to be the size of a football field.
- In June 2004, a sinkhole drained 23-acre Lake Chesterfield in St. Louis County.

Probability of Future Hazard Events

Since 2006, 12 notable sinkhole events have occurred within the State. Historically sinkholes occur in areas away from development and typically do not cause serious damage. The probability of future events is 100%.

Changing Future Conditions Considerations

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

State 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, pollutants captured in sinkholes (or dumped) can affect a community's groundwater system. Sinkhole collapse could be triggered by large earthquakes, which could be particularly problematic for the St. Louis metropolitan area. Sinkholes located in floodplains can absorb floodwaters but make detailed flood hazard studies difficult to model.

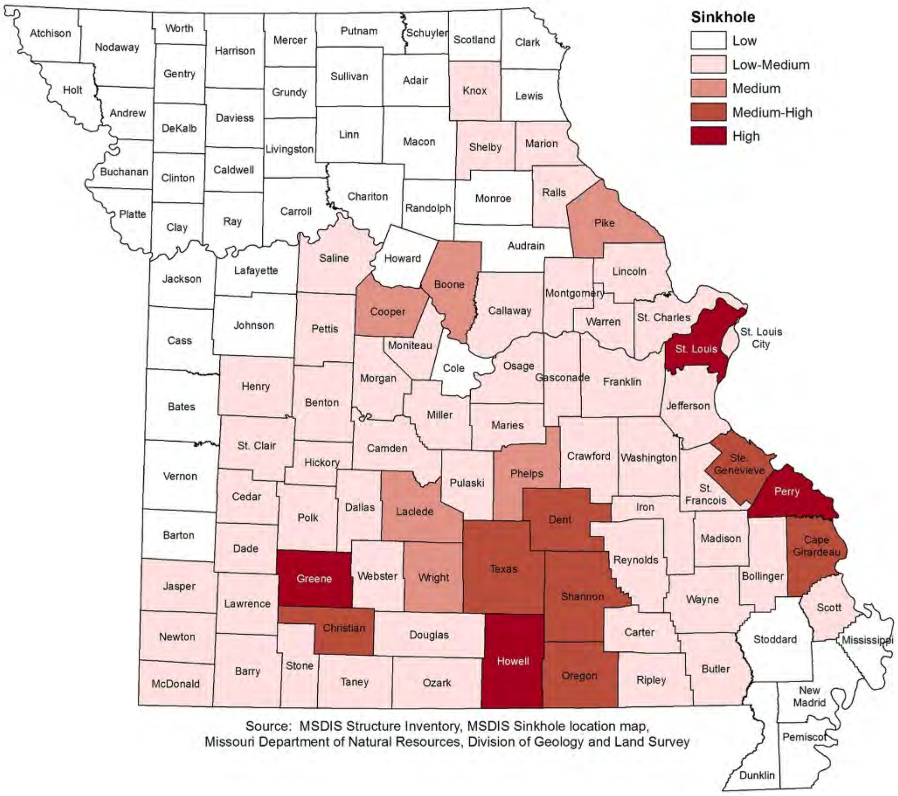
A statewide sinkhole inventory has been created by MoDNR's Missouri Geological Survey that will be used in addition to new data being developed for some newly mapped floodplain areas. The new data is being developed using the methods outlined in the Missouri Sinkhole Analysis Policy paper "Analysis and Communication of Flood Risk for Sinkholes in Missouri" funded in 2016 by SEMA. These inventories are polygon features which will be used for count analysis within ArcGIS.

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.

Table 3.66. Sinkhole Rating Values

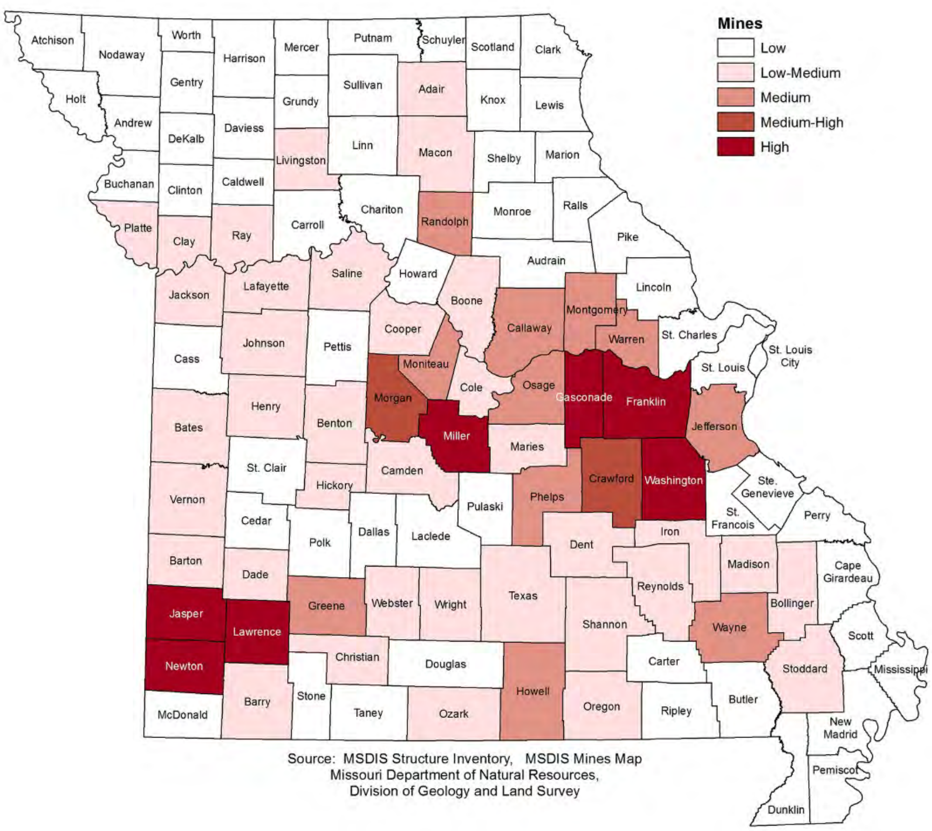
Factor	1 (Low)	2 (Low-medium)	3 (Medium)	4 (Medium-high)	5 (High)
Sinkholes per county	0	1 – 200	201 – 400	401 – 800	801+
Mines per county	0 - 100	101 - 250	251 – 500	501 – 750	751 +

Figure 3.105. Sinkhole Rating Value By County



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

Figure 3.106. Mine Rating Value By County

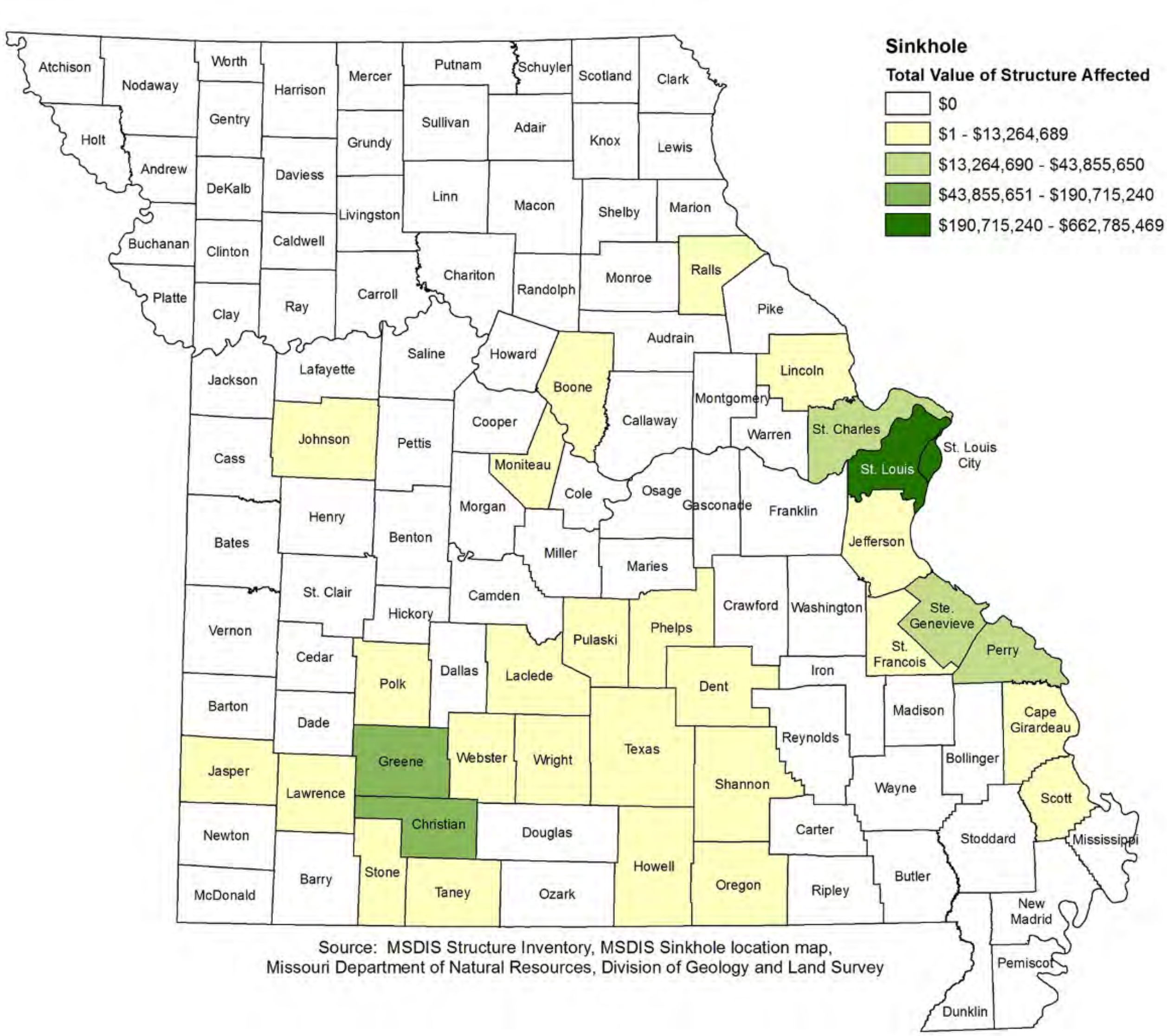


Source: MSDIS Structure Inventory, MSDIS Mines Map
Missouri Department of Natural Resources,
Division of Geology and Land Survey

State Estimates of Potential Losses

From the GIS data collected and analysis performed, **Figure 3.107** shows the potential for losses due to sinkholes while **Table 3.67 and Figure 3.108** shows the number of structures, the value of the structures and the population potentially impacted by sinkholes.

Figure 3.107. Ranking of Structures Potentially Impacted By Sinkholes By County



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

3 Risk Assessment

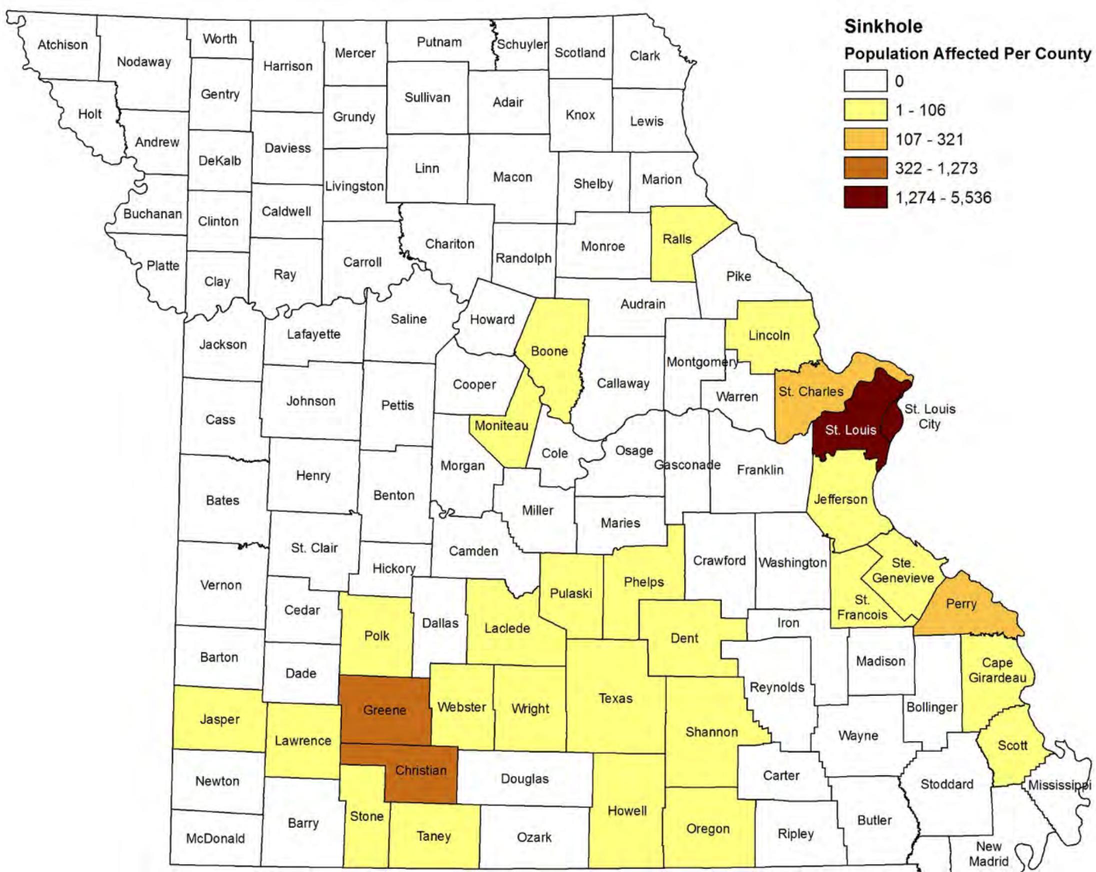
Table 3.67. Number and Value of Structures with Population Potentially Impacted By County (note that Population affected is zero when residential structure impact is not predicted)

County	Number of Structures	Value of Structures	Population
Barry	**3**	**$821,578.95**	**0**
Agriculture	3	$821,578.95	
Boone	**37**	**$9,966,613.75**	**69.89**
Agriculture	8	$2,397,040.29	
Residential	29	$7,569,573.45	
Cape Girardeau	**46**	**$13,264,689.89**	**77.19**
Agriculture	11	$2,747,965.00	
Commercial	3	$2,478,113.06	
Industrial	1	$765,884.88	
Residential	31	$7,272,726.95	
Carter	**1**	**$338,000.00**	**0**
Agriculture	1	$338,000.00	
Christian	**202**	**$52,652,001.94**	427.71
Agriculture	26	$5,325,605.63	
Commercial	13	$6,532,230.23	
Industrial	4	$3,945,880.00	
Residential	159	$36,848,286.08	
Cooper	**1**	**$224,349.65**	**0**
Agriculture	1	$224,349.65	
Crawford	**3**	**$620,100.00**	
Agriculture	3	$620,100.00	
Dent	**16**	**$6,828,573.35**	**7.8**
Agriculture	12	$5,564,470.59	
Commercial	1	$769,534.98	
Residential	3	$494,567.78	
Douglas	**1**	**$879,250.00**	**0**
Agriculture	1	$879,250.00	
Greene	**676**	**$190,715,240.29**	**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	
Howell	**55**	**$12,819,608.45**	**53.9**
Agriculture	25	$4,547,661.87	
Commercial	6	$3,460,607.04	
Industrial	2	$1,359,084.62	
Residential	22	$3,452,254.92	
Jasper	**8**	**$1,567,834.47**	**20.16**
Residential	8	$1,567,834.47	
Jefferson	**3**	**$913,802.14**	**10.72**
Residential	3	$913,802.14	

County	Number of Structures	Value of Structures	Population
Laclede	**42**	**$7,747,113.16**	**98.8**
Agriculture	3	$653,112.00	
Industrial	1	$859,443.95	
Residential	38	$6,234,557.21	
Lawrence	**6**	**$1,064,833.68**	**15.6**
Residential	6	$1,064,833.68	
Lincoln	**4**	**$686,486.07**	**8.52**
Agriculture	1	$2,693.61	
Residential	3	$683,792.46	
Moniteau	**18**	**$3,816,891.36**	**15.72**
Agriculture	12	$2,596,375.00	
Residential	6	$1,220,516.36	
Montgomery	**11**	**$2,482,830.51**	**0**
Agriculture	11	$2,482,830.51	
Newton	**1**	**$635,338.75**	
Commercial	1	$635,338.75	
Oregon	**6**	**$2,886,769.61**	**2.48**
Agriculture	5	$2,748,666.67	
Residential	1	$138,102.94	
Ozark	**1**	**$403,142.86**	
Agriculture	1	$403,142.86	
Perry	**268**	**$27,701,581.87**	**299.72**
Agriculture	148	$772,628.33	
Commercial	2	$332,339.13	
Residential	118	$26,596,614.41	
Phelps	**5**	**$1,547,576.93**	**10.16**
Commercial	1	$699,978.26	
Residential	4	$847,598.67	
Polk	**4**	**$689,593.96**	**10.08**
Residential	4	$689,593.96	
Pulaski	**15**	**$9,551,088.58**	**17.29**
Government	8	$7,535,200.00	
Residential	7	$2,015,888.58	
Ralls	**6**	**$1,169,330.98**	**11.36**
Agriculture	2	$428,097.56	
Residential	4	$741,233.42	
Scott	**2**	**$368,111.55**	**5.06**
Residential	2	$368,111.55	
Shannon	**7**	**$160,649.80**	**2.52**
Agriculture	6	$8,886.32	
Residential	1	$151,763.48	
St Charles	**130**	**$43,855,649.74**	**302.5**
Commercial	9	$7,753,438.46	

County	Number of Structures	Value of Structures	Population
Residential	121	$36,102,211.28	
St Francois	**6**	**$1,706,816.40**	**5.3**
Agriculture	3	$615,989.36	
Commercial	1	$720,288.19	
Residential	2	$370,538.84	
St Louis	**2563**	**$660,196,984.48**	**5,536.1**
Agriculture	6	$1,029,393.53	
Commercial	177	$78,644,366.65	
Education	4	$6,323,109.58	
Residential	2376	$574,200,114.73	
St Louis City	**1554**	**$662,785,468.87**	**3,508.7**
Commercial	102	$155,381,942.17	
Education	7	$13,681,376.65	
Government	1	$27,332,972.73	
Industrial	6	$7,814,035.15	
Residential	1438	$458,575,142.17	
Ste Genevieve	**142**	**$39,347,337.83**	**105.6**
Agriculture	76	$15,354,451.61	
Commercial	14	$9,725,800.00	
Industrial	4	$4,444,949.64	
Residential	48	$9,822,136.58	
Stone	**13**	**$4,214,504.21**	**17.36**
Agriculture	1	$263,512.82	
Commercial	5	$2,658,267.33	
Residential	7	$1,292,724.06	
Taney	**7**	**$2,005,596.21**	**12.1**
Agriculture	1	$210,196.97	
Commercial	1	$701,870.48	
Residential	5	$1,093,528.76	
Texas	**9**	**$1,098,395.21**	**9.72**
Agriculture	4	$7,443.68	
Commercial	1	$341,928.95	
Residential	4	$749,022.58	
Webster	**14**	**$2,353,183.60**	**37.38**
Residential	14	$2,353,183.60	
Wright	**20**	**$691,895.37**	**11.12**
Agriculture	16	$35,183.89	
Residential	4	$656,711.48	
Grand Total	**5,906**	**$1,770,778,814.42**	**11,983.36**

Figure 3.108. Ranking of Population Potentially Impacted By Sinkholes By County



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

Hazard Impact on Future Growth and Development

St. Louis City, St. Louis, Greene, Howell and Perry County ranked high in both population and asset vulnerability for sinkholes. Greene County is one of the top 10 counties with greatest housing unit gains between 2010 and 2015. St. Louis County is one of the top 10 counties with the greatest estimated population gains between 2010 and 2015.

Christian, Cape Girardeau, Dent, Oregon, Ste. Genevieve, Shannon and Texas County ranked medium-high for both population and asset vulnerability for sinkholes. Christian County is one of the top 10 counties with greatest housing unit gains and estimated population gains between 2010 and 2015.

With growing population and increased development, this is some potential for increased losses as a result of the increase in exposure but it is considered a low risk at this time.

EMAP Consequence Analysis

Table 3.68. EMAP Impact Analysis: Land Subsidence/Sinkholes

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

Risk Summary

Most of Missouri's sinkholes are naturally occurring. Since it is possible to determine the geographical extent of this hazard in most cases, mitigation can be targeted. Avoiding the hazard is much more cost effective than altering or mitigating the sinkhole itself. Some counties, such as Greene and Christian, limit construction in areas near sinkholes with building code and floodplain management practices.

Problem Statement:

Using the total value of structures exposed to risk in the karst areas of the state as a key indicator, the data suggests that St. Louis City and St. Louis County, Greene, Christian, St. Charles, Perry and Ste. Genevieve counties would prove the most likely areas affected by sinkhole damage. Mitigation efforts and dollars focused in these areas would be most feasible.

2018 risk assessment data and mapping is available through the Missouri Hazard Mitigation Viewer: http://bit.ly/MoHazardMitigationPlanViewer2018.

3.3.6. Drought

Probability	Severity
6-11%	High

Description/Location

Droughts are regional climatic events which can impact large areas ranging from several counties in Missouri to the entire Midwestern region. Areas with extensive agricultural land use can experience particularly significant impacts. Drought is not a hazard that affects just farmers, but can impact the nation's entire economy. Its outcome can adversely affect a small town's water supply, homeowners, small business owners, commodity markets, and tourism.

The National Weather Service defines drought as "a deficiency in precipitation over an extended period, usually a season or more, resulting in a water shortage causing adverse impacts on vegetation, animals, and/or people." The Missouri Drought Response Plan distinguishes between five categories of drought, as follows:

- **Agricultural Drought**—Defined by soil moisture deficiencies
- **Hydrological Drought**—Defined by declining surface and groundwater supplies
- **Meteorological Drought**—Defined by precipitation deficiencies
- **Hydrological Drought and Land Use**—Defined as a meteorological drought in one area that has hydrological impacts in another area
- **Socioeconomic Drought**—Defined as drought that impacts supply and demand of some economic commodity

Each of these definitions relates the occurrence of drought to water shortfall in some component of the hydrological cycle. Each affects patterns of water and land use, and each refers to a repetitive climatic condition. In urban areas, drought can affect those communities that depend on reservoirs for water, and decreased water levels due to insufficient rain can lead to restricted water use. In agricultural areas, drought during the planting and growing season can have a significant impact on yield.

Regardless of the specific definition, droughts are difficult to predict or forecast, both as to when they will occur and how long they will last. According to Dr. Grant Darkow, Department of Atmospheric Science, University of Missouri–Columbia, there is a recognizable *"upper air-flow pattern and simultaneous surface pattern associated with abnormal dryness over Missouri."* When the upper air-flow pattern is typified by air flowing in a broad arc over the central plains with higher speeds in southern Canada than over the United States, then the air over the southern plains will be *"characterized by a weak clockwise circulation."* Storm systems coming off the Pacific Ocean will cross the extreme northwestern states and southern Canada, thus bypassing the Midwestern states. When this flow pattern persists, the result can be a prolonged period of drought.

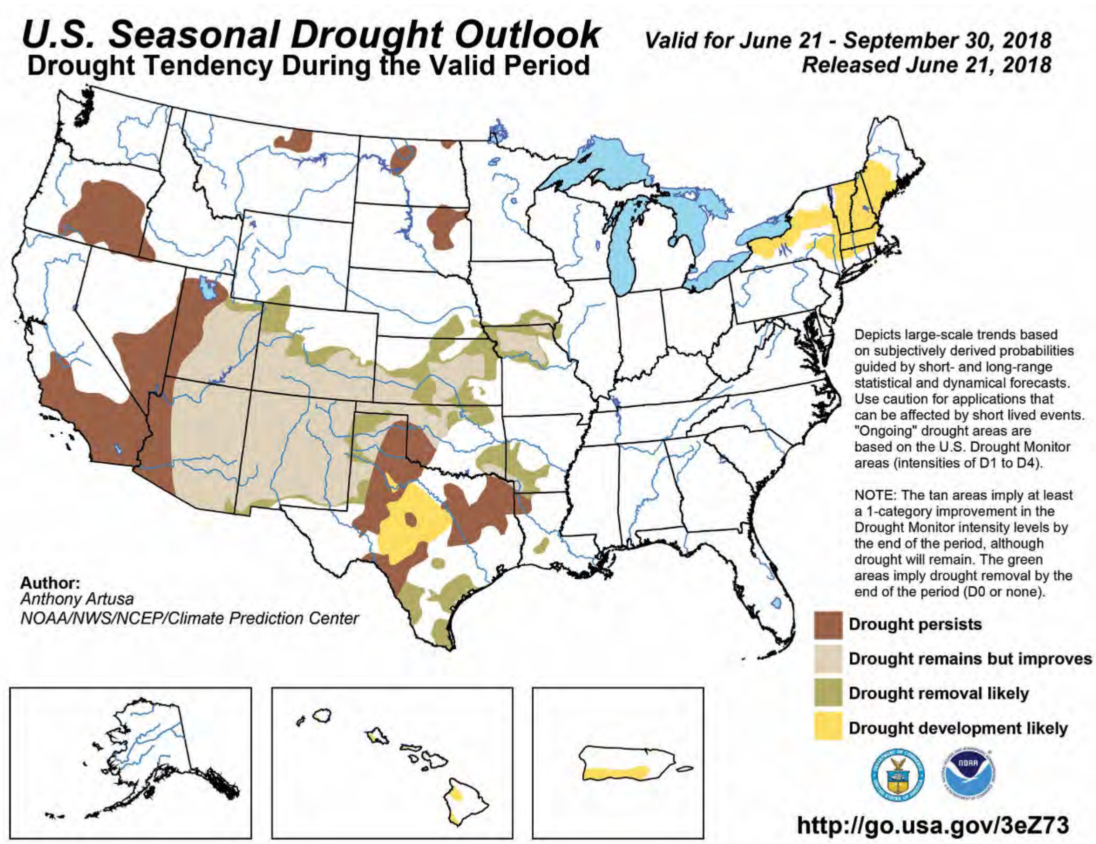
According to the Missouri Climatic Atlas for Design of Land Application Systems (MDNR-WP-1400) Missouri's average annual rainfall ranges from about 33.6 inches in the northwest to about 51 inches in the southern tier of the Missouri bootheel. Even the driest areas of Missouri have more rainfall than most western states; however, lack of rainfall impacts certain parts of the State more than others because of alternate source availability and usage patterns.

Southern Missouri—Most of the southern portions of Missouri are less susceptible to problems caused by prolonged periods without rain because of abundant groundwater resources in the region. Even with decreased stream flows or lowered reservoir levels, groundwater is still a viable resource in southern

Missouri. Row-crop farming is not extensive; therefore agricultural needs aren't as great as in other parts of the State. The only exception is in the southwestern and southeastern areas where irrigation is used.

Northern and West Central Missouri—Most of the northern and west-central portions of Missouri are underlain by rocks that are not conducive to water-bearing formations. They yield only small amounts of water, even during periods of normal and above-normal rainfall. Under drought conditions, adequate amounts of water cannot be pumped from the rock formations of northern Missouri to supply even domestic needs. Most streams in northern Missouri do not receive appreciable groundwater recharge. During periods of drought, these streams are generally reduced to a series of pools, or may become completely dry. Streams and water impoundments are the only localized sources of water during droughts, and even these limited resources are at risk when the drought is prolonged. Agriculture in west-central and northern Missouri is usually the first to feel the effects of drought. Although row-cropping is more extensive in this part of the State, irrigation is generally not feasible except on the floodplains of major rivers.

Figure 3.109. Drought Footprint



Extent

One of the most common and longest-used indicators of drought severity is the Palmer Drought Severity Index (PDSI), which is published jointly by the National Oceanic and Atmospheric Administration (NOAA) and the U.S. Department of Agriculture (USDA) (see **Table 3.69**). The PDSI measures the difference between water supply (in terms of precipitation and stored soil moisture) and demand (the amount of water required to recharge soil and keep rivers, lakes, and reservoirs at normal levels). The result is a scale from +4 to -4, at 1.0 and 0.5 intervals. By relating the PDSI to a regional index, one can compile data that reflects long-term wet or dry tendencies. Missouri has been susceptible to all levels of PDSI drought, including extreme drought.

Table 3.69. Palmer Drought Severity Index

PDSI Number	Long-Term Tendency
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 -.9	Mild drought
-2.0 to -2.9	Moderate drought
-3.0 to -3.9	Severe drought
Below -4.0	Extreme drought

Source: NOAA

Missouri's Drought Response System outlined in the state's Drought Response Plan is divided into four phases, based on the PDSI:

Phase I: Advisory Phase—Requires a drought monitoring and assessment system to provide enough lead time for state and local planners to take appropriate action.

Phase II: Drought Alert—When the PDSI reads -1.0 to -2.0, and stream flows, reservoir levels, and groundwater levels are below normal over a several month period, or when the Drought Assessment Committee (DAC) determines that Phase II conditions exist based on other drought determination methods.

Phase III: Conservation Phase—When the PDSI reads -2.0 to -4.0, and stream flows, reservoir levels, and groundwater levels continue to decline, along with forecasts indicating an extended period of below-normal precipitation, or when the DAC determines that Phase III conditions exist based on other drought determination models.

Phase IV: Drought Emergency—When the PDSI is lower than -4.0, or when the DAC determines that Phase IV conditions exist based on other drought determination methods.

For PDSI reporting purposes, Missouri is divided into six regions of similar climatic conditions: Northwest, Northeast, West Central, Southwest, Southeast, and Bootheel.

One difficulty with recognizing or predicting drought is that no single indicator can be reliably used to predict onset. Regional indicators such as the PDSI are limited in that they respond slowly to deteriorating conditions, whereas observations of surface conditions and groundwater measurements or rainfall may only provide a "snapshot" of a very small area.

The U.S. Drought Portal, a product of the National Integrated Drought Information System (NIDIS), is also used in Missouri to monitor drought.

The U.S. Drought Portal is part of an interactive system to:

- Provide early warning about emerging and anticipated droughts
- Assimilate and quality control data about droughts and models

- Provide information about risk and impact of droughts to different agencies and stakeholders
- Provide information about past droughts for comparison and to understand current conditions
- Explain how to plan for and manage the impacts of droughts
- Provide a forum for different stakeholders to discuss drought-related issues

A major component of this portal is the **U.S. Drought Monitor.** The Drought Monitor concept was developed jointly by the NOAA's Climate Prediction Center, the National Drought Mitigation Center, and the USDA's Joint Agricultural Weather Facility in the late 1990s as a process that synthesizes multiple indices, outlooks and local impacts into an assessment that best represents drought conditions in a given year. The final outcome of each Drought Monitor is a consensus of federal, state, and academic scientists who are intimately familiar with the conditions in their respective regions.

Drought intensity is summarized in five categories (D0-Abonormally Dry to D4-Exceptional Drought), based on a synthesis of the various drought indicators. Descriptions of the Drought Monitor categories, possible impacts, and comparisons with the PDSI and Standardized Precipitation Index are noted in **Table 3.70**.

Table 3.70. Drought Monitor Categories and Description

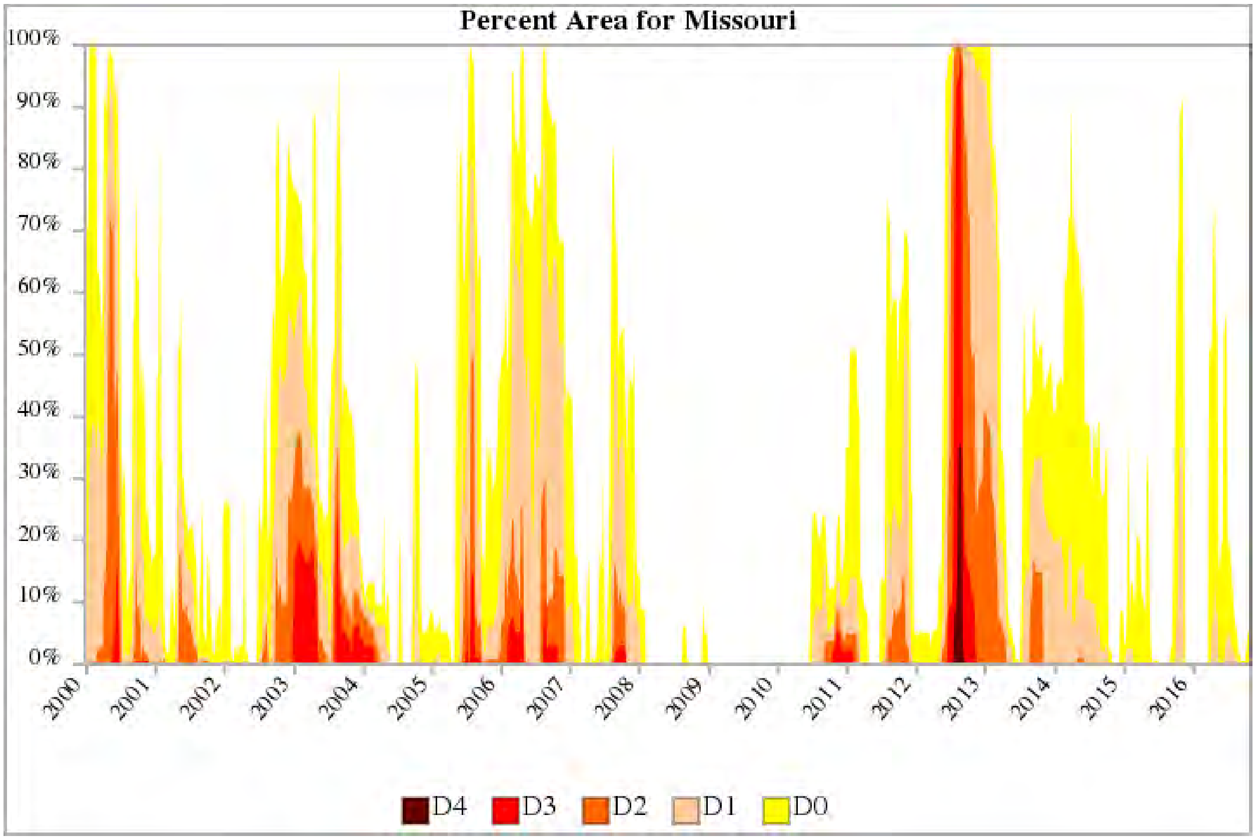
Category	Description	Possible Impacts	Palmer Drought Severity Index (PDSI)	Standardized Precipitation Index (SPI)
D0	Abnormally Dry	Going into drought: - Short-term dryness slowing planting, growth of crops or pastures Coming out of drought: - Some lingering water deficits - Pastures or crops not fully recovered	-1.0 to -1.9	-0.5 to -0.7
D1	Moderate Drought	- Some damage to crops, pastures - Streams, reservoirs or wells low, some water - Shortages developing or imminent - Voluntary water-use restrictions requested	-2.0 to -2.9	-0.8 to -1.2
D2	Severe Drought	- Crop or pasture losses likely - Water shortages common - Water restrictions imposed	-3.0 to -3.9	-1.3 to -1.5
D3	Extreme Drought	- Major crop/pasture losses - Widespread water shortages or restrictions	-4.0 to -4.9	-1.6 to -1.9
D4	Exceptional Drought	- Exceptional and widespread crop/pasture losses - Shortages of water in reservoirs, streams and wells creating water emergencies	-5.0 or less	-2.0 or less

Source: United States Drought Monitor

Previous Occurrences

The National Drought Monitor provides an indication of when and how extensive drought has been statewide since it was initiated in 2000. **Figure 3.110 i**s a time series graphic of National Drought Monitor drought categories, which shows the cyclical nature and variable extent of drought conditions across the state. The 2012-2013 drought was the most severe and most extensive in that time period based on the figure below.

Figure 3.110. Percent of Missouri in Drought 2000-2016



Summaries of recent droughts, since 1999, in Missouri are noted in the following table from various sources including the 2013 Missouri Hazard Mitigation Plan and NOAA documents **Table 3.71**. The 2012-2013 drought was a significant event that impacted the entire state as well as much of the Midwestern United States. An analysis of NOAA Palmer Drought Severity Index data between 1895-2016 showed that significant droughts have also occurred in 1918, 1934 ('dust bowl' drought), 1954-56, 1964, and 1980.

Table 3.71. Summaries of Recent Missouri Droughts

DATE	DESCRIPTION
July 1999 to November 1999	In September 1999, a Phase I Drought Advisory was declared for the state of Missouri. Governor Carnahan declared an agricultural emergency for the entire state. Agricultural reporting showed a 50 percent crop loss from the drought in 50 counties, with severe damage to pastures for livestock, corn crops, and Missouri's top cash crop—soybeans. On October 13, 1999, Dan Glickman, USDA secretary declared all Missouri counties agricultural disaster areas, making low-interest loans available to farmers in Missouri and contiguous states. The drought intensity increased through autumn and peaked at the end of November 1999. In fact, the five-month span between July and November became the second driest July-November period in Missouri since 1895, averaging only 9.38 inches of rain.

DATE	DESCRIPTION
March 2000 to May 2000	A wetter-than-normal winter diminished dry conditions in central and southern Missouri, but long- term moisture deficits continued to exist. At the same time, the remainder of the State (roughly north of the Missouri River) continued under drought conditions. Overall dry conditions returned through much of the State in March 2000, and costly wildfires and brush fires (70) erupted in many counties. By May, the entire state was under a Phase II Drought Alert level, and on May 23, Governor Carnahan announced activation of the Missouri Drought Assessment Committee (DAC), made up of state and federal agencies and chaired by Jeff Stake the MoDNR deputy director.
May 2000 to July 2000	At a May 25, 2000, meeting, the DAC selected a subcommittee (guided by the Missouri Drought Plan) to determine the drought status of each county. In June, based on observations across the State and projections of future rainfall, the committee upgraded the drought status for 27 northern Missouri counties to Phase III Conservation. This was based on concerns for water supplies and agricultural impacts. The City of Milan in Sullivan County was among the most severely affected in terms of water supplies. In June, a total of 80 Missouri counties remained under the Phase II Alert level, while 7 counties in southeast Missouri (Butler, Dunklin, Mississippi, New Madrid, Pemiscot, Scott, and Stoddard) remained under Phase I Advisory conditions. By mid-July 2000, some areas of northern Missouri benefited from additional rainfall, while drier conditions prevailed in other areas. At its July 12 meeting, the DAC revised its assessment, placing 30 counties under Phase III Conservation conditions, including 10 counties in the south-central area. The remaining 84 counties in the State were under Phase II Drought Alert conditions. This included seven counties in northern Missouri, which were downgraded from Phase III Conservation, and seven counties in Southeast Missouri, which were previously assessed as Phase I Advisory. To ease the agricultural impact of the drought during the summer months, Governor Carnahan gained release of over one million acres from the Conservation Reserve Program (CRP) to provide farmers and ranchers in 21 counties additional sources to cut hay for livestock feed. Also, livestock producers in 16 counties were released from CRP contracts to allow cattle grazing on certain idle lands.
2002 to June 2004	The drought of 2002 caused tremendous financial hardships to many Missouri crop and livestock producers. The financial impact of the drought on producers in turn impacted the local communities and the State in terms of reduced economic activity. This drought cost an estimated $46 million in 2002 and $575 million for 2003 in terms of Missouri’s agricultural and economic productivity. Drought conditions encompassed most of the northwestern quarter of Missouri. Severe drought conditions affected the northwest, west-central, and some portions of southwest Missouri, causing water conservation measures to be taken and restrictions to be imposed. For some areas, this was the second driest year since 1914. The only drier year was in 1988. 2002 had the driest November– December period on record for northwestern and north-central Missouri. The drought continued through 2003 and 2004 with conditions improving in 2004. As of March 3, 2004, drought conditions still encompassed most of the northwestern quarter of Missouri with 18 counties designated as being in Phase III Conservation. The drought conditions improved due to an increase in precipitation between March and June 2004. In June 2004, Missouri was considered drought-free for the first time in three years.
July 2005 to September 2005	The drought of 2005, as in the previous drought of 2003-2004, caused tremendous hardships to many Missouri crop and livestock producers. According to the University of Missouri’s Food and Agriculture Institute, the estimated losses to the corn and hay crops alone will likely top $370 million. For some Missouri farmers, this will be a drier year than 1988. By late July, the drought conditions encompassed all but nine counties in the northwestern corner of the State. Severe drought conditions affected counties in the southwest through the northeast part of the State. Effective August 23, 2005, due to the secretarial disaster designation, 114 Missouri counties and St. Louis City were designated as natural disasters for physical and/or production-loss loan assistance from Farm Service Agency (FSA). The drought conditions began to improve by late August and into September.
September 2006 to December 2006	The drought of 2006 has had a tremendous agricultural impact on Missouri farmers. As of September 2006, FSA reported that 26 counties had requested Emergency Conservation Program (ECP) funds with two additional counties pending. The livestock industry is feeling severe effects from the current drought. Hay supplies are short, and water supplies for livestock continue to decline. USDA reported that the new $50 million program for livestock producers, called the Livestock Assistance Grant Program, will provide this money in Section 32 to states in block grant form. The drought has also had an impact on local water supplies with several communities issuing mandatory conservation measures. On September 19, 2006, only 10 counties in the southeastern portion of the State were free of drought. By November 28, 2006, 5 more counties were drought-free and 11 more had entered Phase III for a total of 49 counties in the Conservation Phase. In October 2006, the USDA designated 85 Missouri counties as a primary natural disaster area (and extended assistance eligibility to 20 contiguous counties) due to losses caused by the drought beginning January 1, 2006. Only the southeast corner and the extreme northwest corner were not eligible for assistance. According to Pat Guinan, University of Missouri climatologist, a snowstorm in late November/early December put a dent in the drought, but more rain and snow are needed for conditions to return to normal.

DATE	DESCRIPTION
February 2007 to October 2007	No serious drought conditions have been reported since 2006. The Interim Drought Status map (February 13, 2007) indicates that there were 76 counties in Phase I—Advisory Phase, and 38 counties with no drought. The U.S. Drought Monitor map (July 31, 2007) indicates that several counties north of I-70 and all counties along the Mississippi River to the south had abnormally dry conditions. The Palmer Drought Severity Index map for October 16, 2007, forecasts moderate to extreme drought for most of the counties in Missouri. On October 23, 2007 (see Fig. 3.22) shows that there were 61 counties with no drought, 33 counties in Phase I—Advisory Phase, and 20 counties Phase II—Drought Alert.
June 2010 to March 2011	Starting in July 2010, precipitation levels dropped as temperatures remained high, stressing crops in southeast Missouri. Rainfall in late July and August and Tropical Storm Hermine in September gave little relief as water shortage continued. Continued lack of rainfall led to severe (D2) drought conditions in September and extreme (D3) conditions in October the Bootheel region of Missouri. The drought expanded north and west during October and wildfire risk increased due to the dry conditions. Several wildfires occurred in November in Wayne and Carter counties. Precipitation in February provided some relief from the drought and reduced conditions back to severe, then additional rainfall in March further improved the drought status in Missouri.
July 2011 to November 2011	The south west region of Missouri experienced severe (D2) drought at the end of July 2011. Crops were hard hit, and many failures were reported. Crop damages up to $10 million were recorded along with reports of impacts to livestock and their feed. Rainfall in November was double the normal amount for the month and helped to reduce the level of drought to moderate (D1) or abnormally dry (D0).
May 2012 to January 2013	May of 2012 brought below average rainfall and resulted in crop damage, low soil moisture levels, and reduced stream flows. By the end of the month, the southern and Bootheel regions of Missouri reached a severe (D2) level drought. In June the drought worsened, meriting an upgrade to an extreme (D3) drought. Fire warnings were high, soybean, corn, and sorghum crops became stressed, and soils moisture levels continued to drop. The drought expanded further into the Ozarks, East Central, Northeast, and Southeast Missouri by the end of June. During July, the drought level was heightened to exceptional (D4) conditions. Crops continued to decline and more livestock had to switch to hay bales for feed. Fourth of July fireworks were canceled due to the dangerously dry conditions. The drought continued for the remainder of 2012 and into early 2013. The majority of the state remained at a severe (D2) drought condition as of January 2013 until conditions improved in the remainder of 2013. All counties in Missouri were declared disaster areas due to the drought.

Probability of Future Hazard Events

Because of its geographical location and characteristic weather patterns, Missouri is vulnerable to drought conditions. Agricultural droughts are the most common on record, particularly those inflicting damage to corn crop yields. Throughout much of the previous 122 years, these droughts have occurred with common regularity (on the average of once every five years), according to the Missouri Crop and Livestock Reporting Service. **Figure 3.111** depicts the percent of time in extreme or severe drought, based on 122 years of PDSI data (1895-2016). North of the Missouri River the state can be expected to be in extreme or severe drought between 9-10.72% of the time; south of the River 5.87-8% of the time.

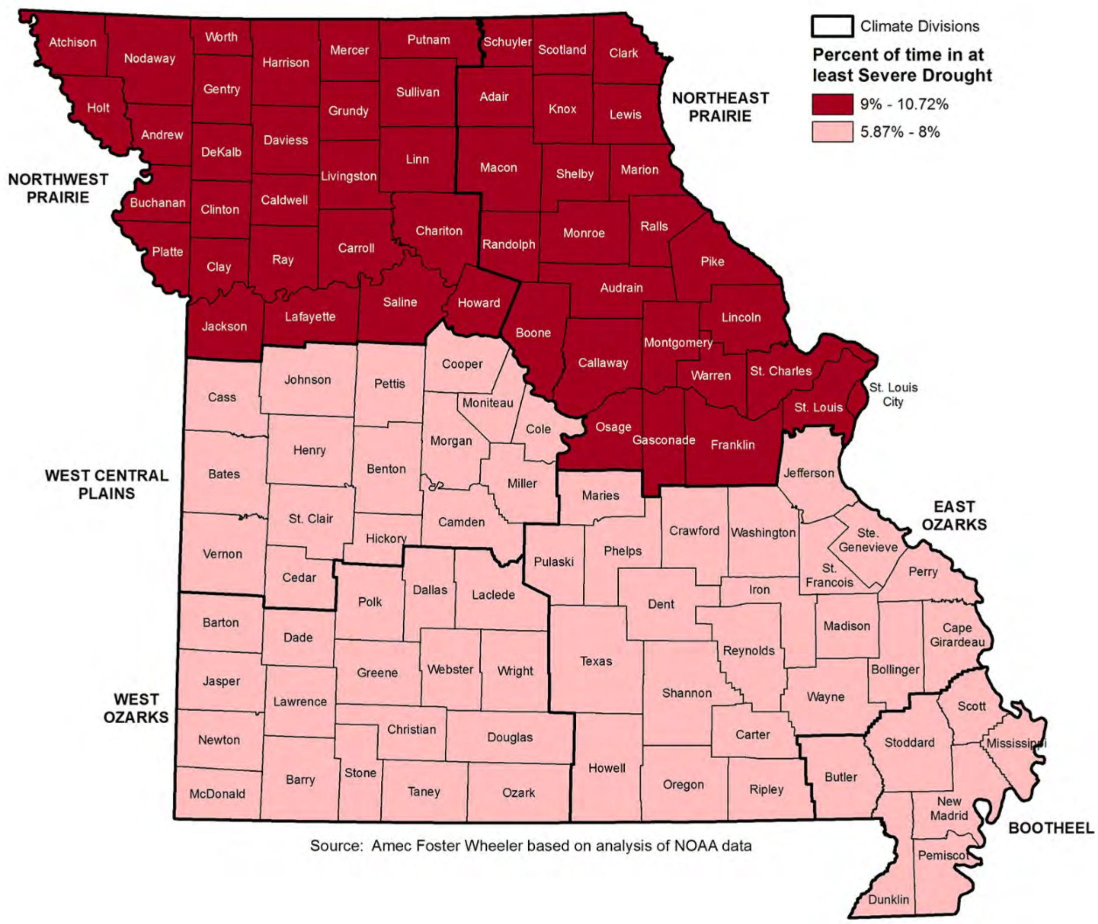
Changing Future Conditions Considerations

Severe drought, a natural part of Missouri's climate, is a risk to this agriculture-dependent state. Future increases in evaporation rates due to higher temperatures may increase the intensity of naturally-occurring droughts.

Although springtime in Missouri is likely to be wetter, summer droughts are likely to be more severe. Higher evaporation and lower summer rainfall are likely to reduce river flows. The drought of 2012 narrowed navigation channels, forced lock closures, and caused dozens of barges to run aground on the Mississippi River along the Missouri shoreline. The resulting impact on navigation cost the region more than $275 million. The drought of 2012–2013 also threatened municipal and industrial water users along the Missouri River.

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. Higher temperatures and increased evapotranspiration increase the likelihood of drought. This could lead to agricultural drought and suppressed crop yields.

Figure 3.111. Drought Probability By Climate Division Based on Palmer Drought Severity Index 1895-2016



Source: Amec Foster Wheeler based on analysis of NOAA data

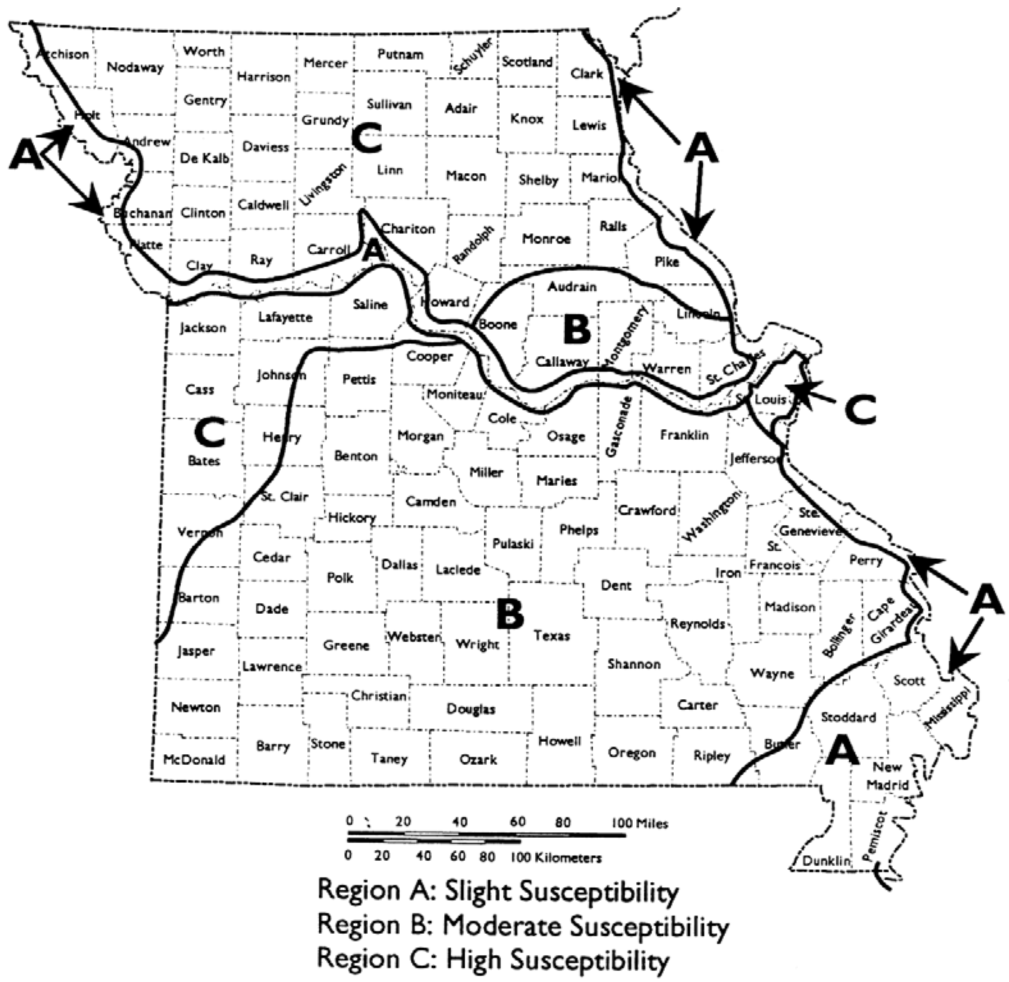
State Vulnerability Overview

The impacts and severity of drought on Missouri can be significant. The Missouri Drought Plan divides the State into three regions, which are prioritized according to drought susceptibility (see **Figure 3.112**). The regions are identified as having slight, moderate, and severe susceptibility to drought conditions. Descriptions of drought susceptibility for the three regions are as follows:

- **Region A (mostly southeast Missouri)** has very little drought susceptibility. It is a region underlain by sands and gravel (alluvial deposits). Surface and groundwater resources are generally adequate for domestic, municipal, and agricultural needs.
- **Region B (central, east-central Missouri)** 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.
- **Region C (northern, west-central Missouri; St. Louis County)** has severe drought vulnerability. Surface water sources usually become inadequate during extended drought. The groundwater resources are normally poor, and typically supply enough water only for domestic needs. Irrigation is

generally not feasible. When irrigation is practical, groundwater withdrawal may affect other uses. Surface water sources are used to supplement irrigation supplied by groundwater sources.

Figure 3.112. Missouri Drought Susceptibility



Source: Missouri Drought Plan, 2002

The National Drought Mitigation Center launched the Drought Impact Reporter (DIR) in July 2005 as the nation's first comprehensive database of drought impacts. The DIR summarizes information from media reports, user-supplied reports, National Weather Service Drought Information Statements, Community Collaborative Rain, Hail and Snow network, and other agency reports. A report is defined as 'An observable loss or change that occurred at a specific place and time because of drought.' Reports are collected at state and county levels, where possible, and data can be accessed and queried through an online map service.

The Drought Impact Reporter contains information on 460 drought impacts from droughts that affected Missouri between January 1, 1980 and December 2016.   Most of the impacts, 240 were classified as "agriculture." Other impacts include "water supply and quality" (121), "relief, response, and restrictions" (104), "plants and wildlife" (83), "fire" (57), "society and public health" (24)", "business and industry" (7), "tourism and recreation" (4) and "energy" (3). In many cases the recorded impact includes several of the above categories. These categories are described as follows:

- **Agriculture**—Drought effects associated with agriculture, farming, aquaculture, horticulture, forestry, or ranching. Examples of drought-induced agricultural impacts include damage to crop quality; income loss for farmers due to reduced crop yields; reduced productivity of cropland; insect infestation; plant disease; increased irrigation costs; cost of new or supplemental water resource development (wells, dams, pipelines) for agriculture; reduced productivity of rangeland; forced reduction of foundation stock; closure/limitation of public lands to grazing; high cost or unavailability of water for livestock, Christmas tree farms, forestry, raising domesticated horses, bees, fish, shellfish or horticulture.

- **Business & Industry**—This category tracks drought's effects on non-agriculture and non-tourism businesses, such as lawn care, recreational vehicles or gear dealers, and plant nurseries. Typical impacts include reduction or loss of demand for goods or services, reduction in employment, variation in number of calls for service, late opening or early closure for the season, bankruptcy, permanent store closure, and other economic impacts.
- **Energy**—This category concerns drought's effects on power production, rates, and revenue. Examples include production changes for both hydropower and non-hydropower providers, changes in electricity rates, revenue shortfalls and/or windfall profits, and purchase of electricity when hydropower generation is down.
- **Fire**—Drought often contributes to forest, range, rural, or urban fires, fire danger, and burning restrictions. Specific impacts include enacting or easing burning restrictions, fireworks bans, increased fire risk, occurrence of fire (number of acres burned, number of wildland fires compared to average, people displaced, etc.), state of emergency during periods of high fire danger, closure of roads or land due to fire occurrence or risk, and expenses to state and county governments of paying firefighters overtime and paying equipment (helicopter) costs.
- General Awareness
- **Plants & Wildlife**—Drought effects associated with unmanaged plants and wildlife, both aquatic and terrestrial, include loss of biodiversity of plants or wildlife; loss of trees from rural or urban landscapes, shelterbelts, or wooded conservation areas; reduction and degradation of fish and wildlife habitat; lack of feed and drinking water; greater mortality due to increased contact with agricultural producers, as animals seek food from farms and producers are less tolerant of the intrusion; disease; increased vulnerability to predation (from species concentrated near water); migration and concentration (loss of wildlife in some areas and too much wildlife in others); increased stress on endangered species; salinity levels affecting wildlife; wildlife encroaching into urban areas; and loss of wetlands.
- Relief, Response and Restrictions
- **Society & Public Health**—Drought effects associated with human, public and social health include health-related problems related to reduced water quantity and/or quality, such as increased concentration of contaminants; loss of human life (e.g. from heat stress, suicide); increased respiratory ailments; increased disease caused by wildland fire concentrations; increased human disease caused by changes in insect carrier populations; population migration (rural to urban areas, migrants into the United States); loss of aesthetic values; change in daily activities (non-recreational, like putting a bucket in the shower to catch water); elevated stress levels; meetings to discuss drought; communities creating drought plans; lawmakers altering penalties for violation of water restrictions; demand for higher water rates; cultural/historical discoveries form low water levels; prayer meetings; cancellations of fundraising events; cancellation/alteration of festivals or holiday traditions; stockpiling water; public service announcements and drought information websites; protests; and conflicts within the community due to competition for water.
- **Tourism & Recreation**—Drought effects associated with recreational activities and tourism include closure of state hiking trails and hunting areas due to fire danger; water access or navigation

problems for recreation; bans on recreational activities; reduced license, permit, or ticket sales (e.g. hunting, fishing, ski lifts, etc.); losses related to curtailed activities (e.g. bird watching, hunting and fishing, boating, etc.); reduced park visitation; and cancellation or postponement of sporting events.

- **Water Supply & Quality**—Drought effects associated with water supply and water quality include dry wells, voluntary and mandatory water restrictions, changes in water rates, easing of water restrictions, increases in requests for new well permits, changes in water use due to water restrictions, greater water demand, decreases in water allocation or allotments, installation or alteration of water pumps or water intakes, changes to allowable water contaminants, water line damage or repairs due to drought stress, drinking water turbidity, change in water color or odor, declaration of drought watches or warnings, and mitigation activities.

The DIR data indicates that the agricultural sector suffers the greatest impacts during times of drought in Missouri. This is supported by analysis of drought-related crop losses discussed later in this section.

While data on structure impacts from drought is sparse, areas prone to expansive soils can have greater movement during drought conditions that can impact foundations and infrastructure. A DIR report submitted August 15, 2012 sourced from the St. Louis Post-Dispatch noted that basement repair businesses in the St. Louis area received a high volume of phone calls from homeowners needing repairs as the drought causes soil to shift, damaging home foundations. The wait for repairs, which can run in the tens of thousands of dollars, was two months or longer for some businesses. One repairman had never seen as many problems with foundations as this in his 28 years of work. One repair firm said they had twice to three times the usual number of jobs lined up. Much of the soil in the St. Louis area is high in clay, which shrinks as the soil dries, triggering cracking in walls.

Other economic impacts can result from the need to deepen existing wells or drill additional wells. This was observed by the Missouri Department of Natural Resources (MoDNR) during the 2006 drought in southwest Missouri because the drought was so extreme there. Drillers in southwestern Missouri must make wells 500 to 600 feet deep to find adequate water supplies that once were found at a depth of 300 feet. Drought has impacted barge traffic on the Missouri and Mississippi Rivers as underwater obstructions pose problems for navigation due to low water levels.

Drought, as it affects the health and safety of Missouri citizens, is primarily a problem of rural water supply. With some exceptions, larger municipalities have not experienced major problems at levels that have caused impacts to some smaller communities. Most seriously affected are those supplied by small water supply structures. In its scope, a drought may be limited to a localized problem, or even a regional problem. Based on severity and duration, it may even become a statewide problem, at least in terms of overall impact, such as the commitment and shifting of resources and other response issues. Good water quality and a plentiful supply are two factors that are often taken for granted. But when good water becomes a scarce commodity and people must compete for the available supply, the importance of these two factors increases dramatically. Missouri’s Resources Plan (*RSMo 640.415*), which is a provision of the Water Resources Law enacted by the Missouri Legislature in 1989, requires MoDNR to ensure that the quality and quantity of Missouri’s water resources are maintained at the highest possible level to support present and future beneficial uses. The provision was established to provide for the development, maintenance, and periodic updating of a long-range comprehensive statewide plan for the use of surface water and groundwater. It includes existing and future requirements for drinking water supplies, agriculture, industry, recreation, environmental protection, and related needs. The State Water Plan addresses water resources planning further and is undergoing a major update beginning in 2016; see additional discussion in the Development in Hazard Prone Areas subsection.

The method used to determine vulnerability to drought across Missouri was a statistical analysis of data from several sources: USDA Risk Management Agency's insured crop losses as a result of drought (2007-2016), USDA crop exposure by county, the calculated Social Vulnerability Index for Missouri Counties from the Hazards and Vulnerability Research Institute in the Department of Geography at the University of South Carolina, and storm events data (1950 to December 31, 2016) and probability of severe drought based on historic Palmer Drought Severity Index. The USDA crop exposure by county is from the 2012 Agricultural Census and assumes that the larger the exposure, the greater potential for loss and impact on the local economy.

From the statistical data collected, four factors were considered in determining overall vulnerability to drought as follows: social vulnerability, crop exposure ratio, annualized crop claims paid, and likelihood of occurrence. Based on natural breaks in the statistical data, a rating value of 1 through 5 was assigned to each factor. These rating values correspond to the following descriptive terms:

1) Low
2) Low-medium
3) Medium
4) Medium-high
5) High

Table 3.72 provides the factors considered and the ranges for the rating values assigned. Once the ranges were determined and applied to all factors considered in the analysis, the ratings were combed to determine an overall vulnerability rating for drought.

Table 3.72. Ranges for Drought Vulnerability Factor Ratings

Factors Considered	Low (1)	Low-medium (2)	Medium (3)	Medium-high-4	High (5)
Social Vulnerability Index	1	2	3	4	5
Crop Exposure Ratio Rating	\$886,000 - \$10,669,000	\$10,669,001 - \$33,252,000	\$33,252,001 - \$73,277,000	\$73,277,001 - \$155,369,000	\$155,369,001 - \$256,080,000
Annualized USDA Crop Claims Paid	< \$340,000	\$670,000-\$669,999	\$670,000-\$999,999	\$1M-\$1,299,999	> \$1,300,000
Likelihood of Occurrence of severe or extreme drought	1-1.9%	2-3.9%	4-5.9%	6-8.9%	9-10.72%
Total Drought Vulnerability Rating	7-8	9-10	11-12	13-14	15-17

Table 3.73. Vulnerability of Missouri Counties to Drought (alphabetized)

County	SOVI Index Rating	USDA RMA Total Drought Crop Claims	Average Annualized Crop Claims	USDA Claims Rating	2012 Crop Exposure	Crop Exposure Rating	Likeli-hood of Severe Drought (%)	Drought Occurrence Rating	Total Rating	Total Rating (Text) Drought
Adair	1	\$11,949,408	\$1,327,712	3	\$20,148,000	2	10.72	5	11	Medium
Andrew	1	\$17,775,965	\$1,975,107	3	\$46,225,000	3	9.70	5	12	Medium
Atchison	5	\$15,348,138	\$1,705,349	3	\$147,023,000	4	9.70	5	17	High
Audrain	1	\$65,477,602	\$7,275,289	5	\$89,658,000	4	10.72	5	15	High
Barry	1	\$11,032,114	\$1,225,790	2	\$6,279,000	1	5.87	4	8	Low
Barton	2	\$38,695,542	\$4,299,505	5	\$73,277,000	3	5.87	4	14	Medium-High
Bates	1	\$50,509,360	\$5,612,151	5	\$63,996,000	3	7.65	4	13	Medium-High
Benton	1	\$7,723,403	\$858,156	2	\$13,012,000	2	7.65	4	9	Low-medium
Bollinger	1	\$2,222,795	\$246,977	1	\$16,490,000	2	6.42	4	8	Low
Boone	3	\$10,882,471	\$1,209,163	2	\$34,419,000	3	10.72	5	13	Medium-High

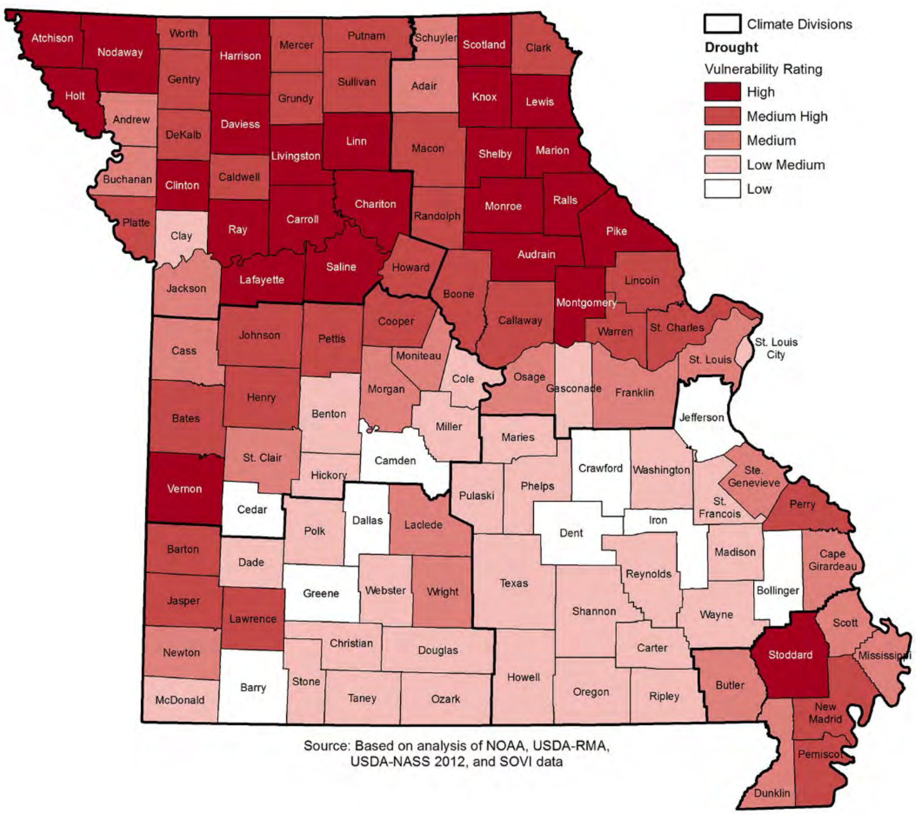
County	SOVI Index Rating	USDA RMA Total Drought Crop Claims	Average Annualized Crop Claims	USDA Claims Rating	2012 Crop Exposure	Crop Exposure Rating	Likeli-hood of Severe Drought (%)	Drought Occurrence Rating	Total Rating	Total Rating (Text) Drought
Buchanan	2	$5,905,518	$656,169	2	$60,492,000	3	9.70	5	12	Medium
Butler	3	$403,870	$44,874	1	$123,103,000	4	7.86	4	12	Medium
Caldwell	3	$17,699,811	$1,966,646	3	$24,241,000	2	9.70	5	13	Medium-High
Callaway	3	$17,328,395	$1,925,377	3	$34,075,000	3	10.72	5	14	Medium-High
Camden	2	$0	$0	1	$1,930,000	1	7.65	4	8	Low
Cape Girardeau	3	$9,458,824	$1,050,980	2	$52,149,000	3	6.42	4	12	Medium
Carroll	2	$24,892,277	$2,765,809	4	$111,305,000	4	9.70	5	15	High
Carter	3	$0	$0	1	$1,046,000	1	6.42	4	9	Low-medium
Cass	2	$17,531,326	$1,947,925	3	$60,217,000	3	7.65	4	12	Medium
Cedar	2	$2,943,061	$327,007	1	$6,811,000	1	7.65	4	8	Low
Chariton	2	$23,791,891	$2,643,543	4	$89,250,000	4	9.70	5	15	High
Christian	3	$854,107	$94,901	1	$3,459,000	1	5.87	4	9	Low-medium
Clark	2	$22,275,063	$2,475,007	4	$51,825,000	3	10.72	5	14	Medium-High
Clay	1	$4,952,050	$550,228	2	$19,447,000	2	9.70	5	10	Low-medium
Clinton	3	$24,832,781	$2,759,198	4	$38,632,000	3	9.70	5	15	High
Cole	3	$1,227,825	$136,425	1	$10,516,000	1	7.65	4	9	Low-medium
Cooper	3	$30,881,654	$3,431,295	4	$45,029,000	3	7.65	4	14	Medium-High
Crawford	2	$245,293	$27,255	1	$3,112,000	1	6.42	4	8	Low
Dade	2	$6,902,175	$766,908	2	$33,252,000	2	5.87	4	10	Low-medium
Dallas	1	$808,310	$89,812	1	$5,489,000	1	5.87	4	7	Low
Daviess	5	$27,823,846	$3,091,538	4	$38,660,000	3	9.70	5	17	High
DeKalb	2	$23,749,485	$2,638,832	4	$36,441,000	3	9.70	5	14	Medium-High
Dent	2	$0	$0	1	$1,852,000	1	6.42	4	8	Low
Douglas	4	$6,112	$679	1	$2,928,000	1	5.87	4	10	Low-medium
Dunklin	1	$2,311,017	$256,780	1	$196,914,000	5	7.86	4	11	Medium
Franklin	2	$4,558,014	$506,446	2	$27,586,000	2	10.72	5	11	Medium
Gasconade	2	$1,759,655	$195,517	1	$9,253,000	1	10.72	5	9	Low-medium
Gentry	2	$25,903,593	$2,878,177	4	$35,570,000	3	9.70	5	14	Medium-High
Greene	2	$2,884,918	$320,546	1	$7,208,000	1	5.87	4	8	Low
Grundy	3	$19,380,026	$2,153,336	3	$28,332,000	2	9.70	5	13	Medium-High
Harrison	2	$39,360,588	$4,373,399	5	$58,835,000	3	9.70	5	15	High
Henry	3	$19,420,806	$2,157,867	3	$34,984,000	3	7.65	4	13	Medium-High
Hickory	3	$2,010,216	$223,357	1	$4,202,000	1	7.65	4	9	Low-medium
Holt	4	$11,456,099	$1,272,900	2	$90,958,000	4	9.70	5	15	High
Howard	4	$6,232,634	$692,515	2	$37,015,000	3	9.70	5	14	Medium-High
Howell	3	$0	$0	1	$2,431,000	1	6.42	4	9	Low-medium
Iron	2	$0	$0	1	$886,000	1	6.42	4	8	Low
Jackson	3	$5,449,878	$605,542	2	$25,426,000	2	9.70	5	12	Medium
Jasper	3	$23,757,378	$2,639,709	4	$32,605,000	2	5.87	4	13	Medium-High

County	SOVI Index Rating	USDA RMA Total Drought Crop Claims	Average Annualized Crop Claims	USDA Claims Rating	2012 Crop Exposure	Crop Exposure Rating	Likeli-hood of Severe Drought (%)	Drought Occurrence Rating	Total Rating	Total Rating (Text) Drought
Jefferson	2	$644,985	$71,665	1	$6,949,000	1	6.42	4	8	Low
Johnson	2	$21,889,350	$2,432,150	4	$46,190,000	3	7.65	4	13	Medium-High
Knox	4	$54,204,968	$6,022,774	5	$37,762,000	3	10.72	5	17	High
Laclede	5	$2,172,056	$241,340	1	$7,618,000	1	5.87	4	11	Medium
Lafayette	5	$25,612,396	$2,845,822	4	$115,469,000	4	9.70	5	18	High
Lawrence	4	$13,511,940	$1,501,327	3	$15,166,000	2	5.87	4	13	Medium-High
Lewis	4	$60,157,109	$6,684,123	5	$51,946,000	3	10.72	5	17	High
Lincoln	2	$17,232,944	$1,914,772	3	$47,855,000	3	10.72	5	13	Medium-High
Linn	4	$24,891,176	$2,765,686	4	$39,327,000	3	9.70	5	16	High
Livingston	3	$22,316,164	$2,479,574	4	$49,960,000	3	9.70	5	15	High
Macon	2	$34,324,215	$3,813,802	4	$35,836,000	3	10.72	5	14	Medium-High
Madison	3	$132,467	$14,719	1	$1,793,000	1	6.42	4	9	Low-medium
Maries	4	$485,209	$53,912	1	$4,576,000	1	6.42	4	10	Low-medium
Marion	3	$26,387,111	$2,931,901	4	$53,674,000	3	10.72	5	15	High
McDonald	3	$1,509,665	$167,741	1	$3,651,000	1	5.87	4	9	Low-medium
Mercer	3	$14,969,266	$1,663,252	3	$19,068,000	2	9.70	5	13	Medium-High
Miller	4	$509,203	$56,578	1	$4,809,000	1	7.65	4	10	Low-medium
Mississippi	3	$2,820,140	$313,349	1	$153,775,000	4	7.86	4	12	Medium
Moniteau	3	$8,339,644	$926,627	2	$16,298,000	2	7.65	4	11	Medium
Monroe	4	$45,129,905	$5,014,434	5	$49,947,000	3	10.72	5	17	High
Montgomery	3	$24,459,283	$2,717,698	4	$47,349,000	3	10.72	5	15	High
Morgan	3	$4,638,261	$515,362	2	$12,472,000	2	7.65	4	11	Medium
New Madrid	3	$1,569,367	$174,374	1	$216,974,000	5	7.86	4	13	Medium-High
Newton	4	$10,058,373	$1,117,597	2	$15,032,000	2	5.87	4	12	Medium
Nodaway	2	$31,619,521	$3,513,280	4	$114,630,000	4	9.70	5	15	High
Oregon	3	$0	$0	1	$1,183,000	1	6.42	4	9	Low-medium
Osage	3	$1,244,528	$138,281	1	$13,940,000	2	10.72	5	11	Medium
Ozark	4	$0	$0	1	$2,072,000	1	5.87	4	10	Low-medium
Pemiscot	2	$5,270,118	$585,569	2	$185,947,000	5	7.86	4	13	Medium-High
Perry	5	$8,761,103	$973,456	2	$31,753,000	2	6.42	4	13	Medium-High
Pettis	3	$33,635,149	$3,737,239	4	$54,467,000	3	7.65	4	14	Medium-High
Phelps	4	$0	$0	1	$1,857,000	1	6.42	4	10	Low-medium
Pike	4	$35,530,600	$3,947,844	4	$54,922,000	3	10.72	5	16	High
Platte	3	$7,186,832	$798,537	2	$37,545,000	3	9.70	5	13	Medium-High
Polk	3	$1,297,446	$144,161	1	$9,057,000	1	5.87	4	9	Low-medium
Pulaski	4	$100,579	$11,175	1	$2,008,000	1	6.42	4	10	Low-medium
Putnam	3	$13,782,791	$1,531,421	3	$16,606,000	2	9.70	5	13	Medium-High
Ralls	3	$36,139,291	$4,015,477	4	$41,953,000	3	10.72	5	15	High
Randolph	4	$14,450,278	$1,605,586	3	$21,478,000	2	10.72	5	14	Medium-High

County	SOVI Index Rating	USDA RMA Total Drought Crop Claims	Average Annualized Crop Claims	USDA Claims Rating	2012 Crop Exposure	Crop Exposure Rating	Likeli-hood of Severe Drought (%)	Drought Occurrence Rating	Total Rating	Total Rating (Text) Drought
Ray	4	$11,979,425	$1,331,047	3	$53,423,000	3	9.70	5	15	High
Reynolds	3	$0	$0	1	$1,222,000	1	6.42	4	9	Low-medium
Ripley	4	$110,248	$12,250	1	$10,669,000	1	6.42	4	10	Low-medium
Saline	4	$34,213,625	$3,801,514	4	$155,369,000	4	9.70	5	17	High
Schuyler	3	$8,181,908	$909,101	2	$14,841,000	2	10.72	5	12	Medium
Scotland	4	$23,735,156	$2,637,240	4	$36,718,000	3	10.72	5	16	High
Scott	3	$2,608,380	$289,820	1	$130,314,000	4	7.86	4	12	Medium
Shannon	4	$0	$0	1	$1,204,000	1	6.42	4	10	Low-medium
Shelby	4	$45,113,919	$5,012,658	5	$59,084,000	3	10.72	5	17	High
St. Charles	4	$8,462,773	$940,308	2	$52,979,000	3	10.72	5	14	Medium-High
St. Clair	3	$11,184,481	$1,242,720	2	$14,351,000	2	7.65	4	11	Medium
St. Francois	3	$468,928	$52,103	1	$4,604,000	1	6.42	4	9	Low-medium
St. Louis	4	$577,537	$64,171	1	$18,532,000	2	10.72	5	12	Medium
St. Louis City	3	$0	$0	1	$0	1	10.72	5	10	Low-medium
Ste. Genevieve	4	$3,037,903	$337,545	1	$15,592,000	2	6.42	4	11	Medium
Stoddard	4	$5,194,088	$577,121	2	$256,080,000	5	7.86	4	15	High
Stone	3	$0	$0	1	$3,672,000	1	5.87	4	9	Low-medium
Sullivan	4	$13,963,040	$1,551,449	3	$18,229,000	2	9.70	5	14	Medium-High
Taney	4	$0	$0	1	$1,269,000	1	5.87	4	10	Low-medium
Texas	4	$0	$0	1	$3,703,000	1	6.42	4	10	Low-medium
Vernon	4	$39,019,848	$4,335,539	5	$62,212,000	3	7.65	4	16	High
Warren	4	$7,132,587	$792,510	2	$24,694,000	2	10.72	5	13	Medium-High
Washington	3	$0	$0	1	$2,301,000	1	6.42	4	9	Low-medium
Wayne	4	$174,091	$19,343	1	$1,555,000	1	6.42	4	10	Low-medium
Webster	4	$2,575,416	$286,157	1	$6,423,000	1	5.87	4	10	Low-medium
Worth	4	$8,301,031	$922,337	2	$13,752,000	2	9.70	5	13	Medium-High
Wright	5	$1,559,792	$173,310	1	$3,256,000	1	5.87	4	11	Medium

Figure 3.113 shows the darker shaded counties are generally consistent with the Region B & C susceptibility counties shown previously.

Figure 3.113. Missouri Drought Vulnerability by County



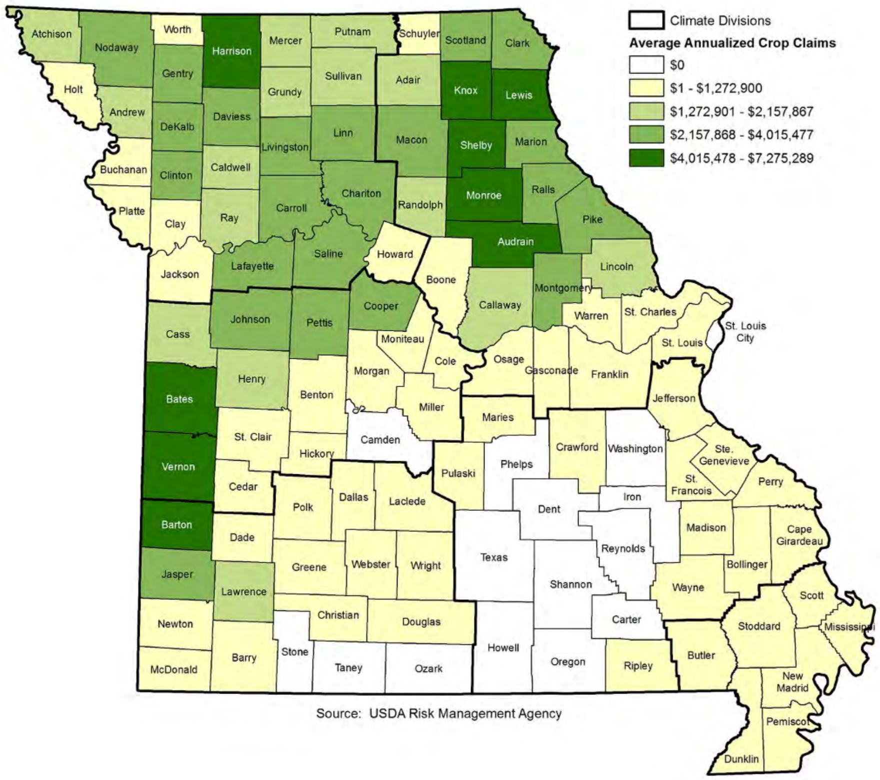
According to this analysis, the counties with a high vulnerability to drought are: Audrain, Atchison, Carroll, Chariton, Clinton, Daviess, Harrison, Holt, Knox, Lafayette, Lewis, Linn, Livingston, Marion, Monroe, Montgomery, Nodaway, Pike, Ralls, Ray, Saline, Scotland, Shelby, Stoddard, and Vernon.

State Estimates of Potential Losses

Determining the direct and indirect costs associated with drought is difficult because of the broad impacts of drought and the difficulty in establishing when droughts begin and end. The impacts of drought have been assessed through the vantage point of agricultural losses, primarily due to the excellent agricultural statistical and insurance data that is available and the fact that agricultural impacts are noted as the most prevalent impact from the Drought Impact Reporter Analysis. As part of the update process, SEMA revisited available data sets to determine if additional assessments are possible, but determined that data to support drought losses to other sectors was not readily available for analysis.

The drought loss estimation methodology uses USDA Risk Management Agency's crop insurance claims paid in Missouri from 2007-2016 and the USDA's crop exposure value by county to determine the Annualized Drought Crop Insurance Claims Paid as mapped in Figure 3.114 below. USDA Risk Management Agency's crop insurance claims paid as a result of drought conditions during this time period totaled $1,495,192,901. This results in a statewide annualized loss of $49,519,290. This data is provided for all Missouri counties. Crop insurance claims data were obtained for all hazards that resulted in payment of claims.

Figure 3.114. Annualized Drought Crop Insurance Claims Paid from 2007-2016



The Central US 2012 Drought Assessment report contains a state-by state assessment of the drought conditions and impacts. An income assessment on the effects of the 2012 drought on Missouri agriculture noted in this report concludes a loss of $1.07 billion dollars in farm income within the state.

Hazard Impact on Future Growth and Development

As counties experience significant increases in population it will create greater demands on water resources and potentially increase drought vulnerability. Of the counties that were determined to be highly vulnerable to drought as a result of this analysis, only Clinton County is in the group of Missouri Counties with a population growth rate of 5% or more (11.1%). In southwest Missouri growth and development alone could strain existing surface and ground water resources according to a study done in 2014 by the Missouri Department of Natural Resources and Army Corp of Engineers. The exact findings in the 16-county region in Southwest Missouri vary with weather and population models, but there is a consensus that a prolonged drought coupled with expected population growth means additional water sources will be needed, perhaps as early as 2030.

The update to the state water plan in 2017-2018 will be addressing the following items that relate to water resources and availability of a sustainable supply, including during times of drought:

- Develop an updated evaluation of current groundwater and surface water availability and develop projected water supply demands.
- Produce an in-depth analysis of current and future consumptive and non-consumptive water demands, and identify gaps in water availability based on water demand projections.
- Identify municipal, agricultural, industrial and environmental infrastructure needs
- Help the department understand the areas where developing new and more sustainable water sources, better infrastructure, and more integrated water supplies, can help sustain water delivery in a dynamic climate.

- Help the state better understand regionally where future water gaps may exist, as studies have revealed in parts of southwest and northern Missouri.

Areas that appear to be the most vulnerable to drought and water supply shortages should be the focus of future drought planning, management, and mitigation activities, and should be considered in the next Missouri Drought Plan update.

EMAP Consequence Analysis

The information in **Table 3.74** is from the Impact Analysis of Potential for Detrimental Impacts of Hazards done for the Emergency Management Accreditation Program.

Table 3.74. EMAP Impact Analysis: Drought

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

Risk Summary

In Missouri, drought losses to crops alone have averaged about $50M annually over the past ten years. Sector impacts beyond agriculture include water supply and quality, relief, response, and restrictions, plants and wildlife, business and industry and tourism and recreation. The impacts of drought are so diffuse and far-reaching that financial estimates of loss beyond agriculture are difficult to quantify.

In addition to damage to crops, produce, livestock, and soil, and the resulting economic consequences, the arid conditions created by drought pose an increased risk of fire. The danger is especially high for brush fires, grass fires, and fires in wooded areas, which can threaten homes and other structures in their path. Lack of water resources in rural areas can complicate the firefighting efforts.

Severe drought also poses health threats to citizens due to water shortages and can be exacerbated by extreme heat. Particularly vulnerable are children, the elderly, and those with respiratory problems. Contaminated or poor water quality for drinking and sanitation measures can also cause serious illnesses.

Problem Statement:

Using Annualized Drought Crop Insurance claims paid as a key indicator, the counties most likely to be impacted by drought are Knox, Lewis, Shelby, Monroe, Audrain, Harrison, Bates, Vernon and Barton. The data suggests that mitigation efforts and dollars allocated to these counties would be most beneficial.

2018 risk assessment data and mapping is available through the Missouri Hazard Mitigation Viewer: http://bit.ly/MoHazardMitigationPlanViewer2018.

3.3.7. Extreme Temperatures

Probability	Severity
100% Heat – 151 events per year average Cold – 32 events per year average	Moderate

Description/Location

Missouri has a continental type of climate marked by strong seasonality. Frequent changes in temperature are known to occur mainly because of the State's inland location. Prolonged periods of extremely cold weather or heat are unusual, however temperatures above 100° F have occurred, as well as, temperatures below 0° F, which average 2 to 5 days per year in northern counties and 1 to 2 days per year in southern counties.

Extreme Heat/Heat Wave

Extreme heat can be described as temperatures that hover 10°F or more above the average high temperature for a region during the summer months. A heat wave is a period of excessive heat, which can lead to illness and other stress to people with prolonged exposure to these conditions. High humidity, which often accompanies heat in Missouri, can make the effects of heat even more harmful. While heat-related illness and death can occur from exposure to intense heat in just one afternoon, heat stress on the body has a cumulative effect. Consequently, the persistence of a heat wave increases the threat to public health. The National Weather Service (NWS) defines a heat wave as three consecutive days of temperatures of 90 degrees Fahrenheit (°F) and above. These high temperatures generally occur from June through September, but are most prevalent in the months of July and August.

Ambient temperature is not the only factor considered when assessing the likely effects of heat. Relative humidity is also considered along with duration of exposure, wind, and activity. The NWS has stepped up its efforts to more effectively alert the general public and appropriate authorities to the hazards of heat waves. The NWS has devised a Heat Index (HI), which is a combination of air temperature and relative humidity that more accurately reflects the heat intensity. The HI, given in degrees Fahrenheit, is an accurate measure of how hot it really feels when the relative humidity is added to the actual air temperature. The Heat Index Chart is presented in **Figure 3.115.** As an example, if the air temperature is 96°F (found at the top of the table), and the relative humidity is 55 percent (found on the left of the table), the HI is 112°F (the intersection of the 96°F row and the 55 percent column). Because HI values were devised for shady, light wind conditions, exposure to full sunshine can increase HI values by up to 15°F. Also, strong winds, particularly with very hot, dry air, can be extremely hazardous.

Along with humans, animals also can be affected by high temperatures and humidity. For instance, cattle and other farm animals respond to heat by reducing feed intake, increasing their respiration rate, and increasing their body temperature. These responses assist the animal in cooling itself, but this is usually not sufficient. The hotter the animal is, the more it will begin to shut down body processes not vital to its survival, such as milk production, reproduction, or muscle (meat) building.

Figure 3.115. Heat Index Chart

NWS Heat Index

Temperature (°F)

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

Likelihood of Heat Disorders with Prolonged Exposure or Strenuous Activity

Caution | Extreme Caution | Danger | Extreme Danger

Risk Level	Possible Heat Disorder:
Caution	Fatigue possible with prolonged exposure and physical activity.
Extreme Caution	Sunstroke, heat cramps and heat exhaustion possible.
Danger	Sunstroke, heat cramps, and heat exhaustion likely, and heat stroke possible.
Extreme Danger	Heat stroke highly likely with continued exposure.

Source: National Weather Service; http://www.nws.noaa.gov/om/heat/heat_index.shtml
Note: The red area without numbers indicates extreme danger.

Heat waves are often a major contributing factor to power outages (brownouts, etc.), as the high temperatures result in a tremendous demand for electricity for cooling purposes. Power outages for prolonged periods increase the risk of heat stroke and subsequent fatalities due to loss of cooling and proper ventilation.

Other related hazards include water shortages brought on by drought-like conditions and high demand. Local advisories, which list priorities for water use and rationing, are common during heat waves. Government authorities report that civil disturbances and riots are also more likely to occur during heat waves, as well as incidents of domestic violence and abuse. In cities, pollution becomes a problem because the heat traps pollutants in densely developed urban areas. Adding pollution to the stresses of the heat magnifies the health threat to the urban population.

Extreme Cold

Extreme cold temperatures drop well below what is considered normal for an area during the winter months and often accompany winter storm events. Combined with increases in wind speed, defined as wind chill, such temperatures can be life threatening to those exposed for extended periods of time. Wind chill is determined by factoring cold temperatures and wind speed to determine the overall chill factor. For example when the temperature is 20°F and the wind speed is 15 miles per hour, the resulting wind chill (what it really feels like) is 6°F. This type of situation can be dangerous to people outdoors because their bodies can experience rapid heat loss, resulting in hypothermia (abnormally low body temperature). Hypothermia or frostbite may be considered the most direct cause of death and injury that can be attributed to winter storms or severe cold.

The NWS Wind Chill Temperature (WCT) Index makes use of advances in science, technology, and computer modeling to provide a more accurate, understandable, and useful formula for calculating the dangers from winter winds and freezing temperatures, see Figure 3.86.

In addition, clinical trials were conducted, and the results of those trials have been used to improve the accuracy of the WCT Index and determine frostbite threshold values. The current WCT Index, implemented in 2001, uses wind speed calculated at the average height of the human body's face (5 feet), is based on a human face model; incorporates modern heat transfer theory (heat loss from the body to its surroundings during cold and breezy/windy days); lowers the calm wind threshold to 3 miles per hour; uses a consistent standard for skin tissue resistance; and assumes the worst-case scenario for solar radiation (clear night sky).

An indirect winter hazard that affects Missourians every year is carbon monoxide (CO) poisoning. Improperly vented gas and kerosene heaters or the indoor use of charcoal briquettes creates dangerous levels of carbon monoxide. Between 1993 and 2015, there were 1,759 cases of CO poisoning, including 1,104 fatalities, in Missouri according to the Missouri Department of Health and Senior Services, see **Figure 3.116** below.

Figure 3.116. Wind Chill Chart

Wind Chill Chart

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

Frostbite Times: 30 minutes, 10 minutes, 5 minutes

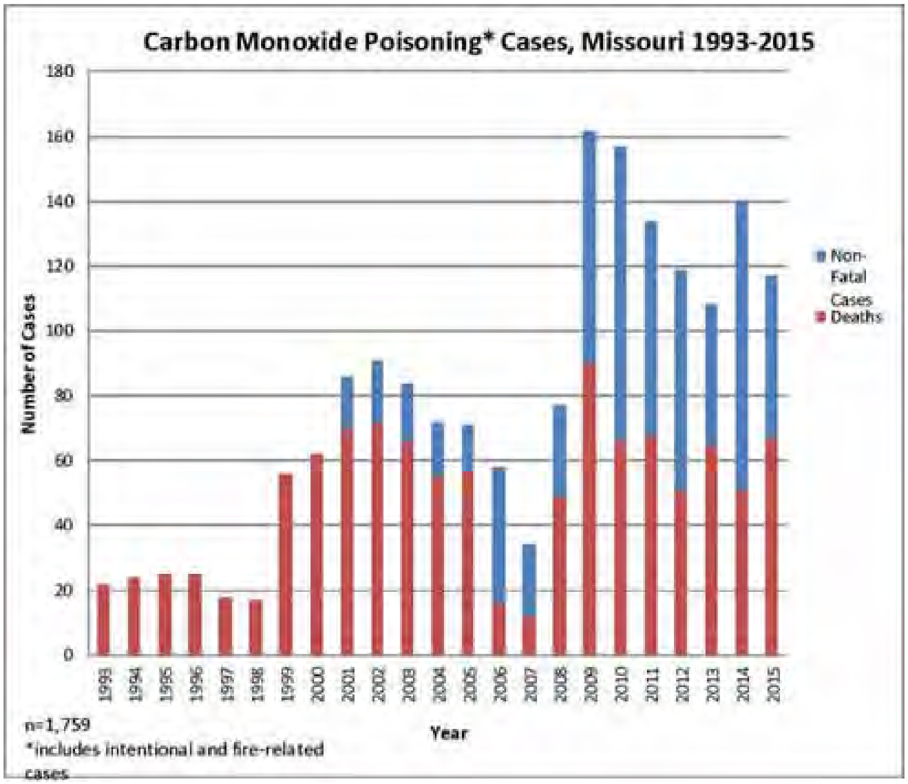
$$\text{Wind Chill (°F)} = 35.74 + 0.6215T - 35.75(V^{0.16}) + 0.4275T(V^{0.16})$$

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

Effective 11/01/01

Source: National Weather Service; http://www.nws.noaa.gov/om/cold/wind_chill.shtml

Figure 3.117. Carbon Monoxide Poisoning Cases, Missouri, 1993-2015



Source: Missouri DHSS; http://health.mo.gov/living/environment/carbonmonoxide/reports.php

Extent

Extreme Heat/Heat Wave

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

- **Excessive Heat Warning —** An Excessive Heat Warning is issued within 12 hours of the onset of extremely dangerous heat conditions. The general rule of thumb for this Warning is when the maximum heat index temperature is expected to be 105° or higher for at least 2 days and night time air temperatures will not drop below 75°; however, these criteria vary across the country, especially for areas not used to extreme heat conditions. If you don't take precautions immediately when conditions are extreme, you may become seriously ill or even die.
- **Excessive Heat Watches —** Heat watches are issued when conditions are favorable for an Excessive Heat event in the next 24 to 72 hours. A Watch is used when the risk of a heat wave has increased but its occurrence and timing is still uncertain.
- **Heat Advisory—** A Heat Advisory is issued within 12 hours of the onset of extremely dangerous heat conditions. The general rule of thumb for this Advisory is when the maximum heat index temperature is expected to be 100° or higher for at least 2 days, and night time air temperatures will not drop below 75°; however, these criteria vary across the country, especially for areas that are not used to dangerous heat conditions. Take precautions to avoid heat illness. If you don't take precautions, you may become seriously ill or even die.

- **Excessive Heat Outlooks** are issued when the potential exists for an Excessive Heat event in the next 3-7 days. An Outlook provides information to those who need considerable lead-time to prepare for the event.

Extreme Cold

The National Weather Service issues some or all of the following wind chill and frost/freeze products as conditions warrant across the State of Missouri.

- **Wind Chill Warning:** NWS issues a wind chill warning when dangerously cold wind chill values are expected or occurring. If you are in an area with a wind chill warning, avoid going outside during the coldest parts of the day. If you do go outside, dress in layers, cover exposed skin, and make sure at least one other person knows your whereabouts. Update them when you arrive safely at your destination.
- **Wind Chill Watch:** NWS issues a wind chill watch when dangerously cold wind chill values are *possible*. As with a warning, adjust your plans to avoid being outside during the coldest parts of the day. Make sure your car has at least a half a tank of gas, and update your winter survival kit.
- **Wind Chill Advisory:** NWS issues a wind chill advisory when seasonably cold wind chill values but not extremely cold values are expected or occurring. Be sure you and your loved ones dress appropriately and cover exposed skin when venturing outdoors.
- **Hard Freeze Warning:** NWS issues a hard freeze warning when temperatures are expected to drop below 28°F for an extended period of time, killing most types of commercial crops and residential plants.
- **Freeze Warning:** When temperatures are forecasted to go below 32°F for a long period of time, NWS issues a freeze warning. This temperature threshold kills some types of commercial crops and residential plants.
- **Freeze Watch**: NWS issues a freeze watch when there is a potential for significant, widespread freezing temperatures within the next 24-36 hours. A freeze watch is issued in the autumn until the end of the growing season and in the spring at the start of the growing season.
- **Frost Advisory:** A frost advisory means areas of frost are expected or occurring, posing a threat to sensitive vegetation.

For both extreme heat and extreme cold temperatures, the following population groups in Missouri are at a greater risk to injury and/or illness:

- Those vulnerable to heat stress due to physical condition:
  - Older people
  - Children
  - People overweight or underweight
  - People with limited independence due to physical or mental disorders
  - People in institutional settings without air conditioning/heat
  - People working in heat under stress (firefighters, police, emergency medical technicians)
  - People in urban environments where heat retention in asphalt, concrete, and masonry is a factor (heat island effect)
  - People with low income who lack resources for air conditioning, transportation, medical care, etc
- Those with increased risk from work or leisure activities:
  - People who work outdoors (utility crews, construction crews, etc.)
  - Military personnel and trainees
  - Athletes

- Those more difficult to reach through normal communications:
  - People who live alone
  - People who are homeless
  - People who do not speak English
  - People who cannot read
  - People who are culturally, socially, or geographically isolated

Previous Occurrences

Missouri experiences about 40 days per year above 90 ºF, based on a 30 year average compiled by the NWS from 1961 through 1990. July leads this statewide mean with 15 days above 90°F, followed by August with an average of 12 days over 90°F. June and September average 6 days and 4 days, respectively, for temperatures above 90°F. The 30-year climatic data was collected from NWS stations at Kansas City, Columbia, Springfield, and St. Louis. As these regional locations indicate, all of Missouri is subject to heat wave during the summer months.

The Missouri Department of Health and Senior Services (DHSS) monitor high temperatures and humidity across the State to prevent heat-related illness and death. The elderly and the chronically ill are more vulnerable to the effects of high temperatures. They perspire less and are more likely to have health problems requiring medications that can impair the body's response to heat. Many prescription medications make individuals more sensitive to the heat. Some of these medications include heart drugs, some anti-Parkinsonian agents, antihistamines, over-the-counter sleeping pills, antidepressants, anti-psychotics and major tranquilizers.

DHSS initiated statewide hyperthermia death surveillance in 1980 in response to a summer heat wave that resulted in the death of 295 individuals. The program defines hyperthermia as physician-diagnosed heat exhaustion, heat stroke, or hot weather/natural environment as a contributing factor in a death. In 2005, 25 Missourians died from heat-related illnesses. Missouri's heat-related deaths are primarily in the urban, more densely populated areas of St. Louis City, St. Louis County, and Jackson County (Kansas City). DHSS provides statistics on heat related emergency room visits and heat related hospitalizations for 1999 through 2010. **Table 3.75** displays a summary of this data.

Table 3.75. Heat-Related Emergency Rooms and Hospitalizations in Missouri 1999-2010

Year	Heat Emergency Room Visits	Heat Related Hospitalizations
1999	1,176	209
2000	1,356	168
2001	1,422	254
2002	1,267	217
2003	1,063	191
2004	815	114
2005	1,340	228
2006	1,377	298
2007	1,315	227
2008	957	143
2009	939	186
2010	1,772	379

Source: Missouri DHSS, http://health.mo.gov/living/healthcondiseases/hyperthermia/data.php

3 Risk Assessment

The NCEI Storm Events Database provides information on previous heat and Excessive Heat events in Missouri. **Table 3.76** lists the annual total of events, deaths, injuries, property damages, and crop damages for 1996 through 2016 for heat related events.

NCEI defines Excessive Heat as a combination of high temperatures (well above normal) and high humidity. An Excessive Heat event occurs and is reported in Storm Data whenever heat index values meet or exceed locally/regionally established Excessive Heat warning thresholds, on a widespread or localized basis. Fatalities (directly-related) or major impacts to human health occurring during Excessive Heat warning conditions are reported using this event category.

Fatalities or impacts to human health occurring when conditions meet locally/regionally defined heat advisory criteria are reported within the Heat event category. If deaths are determined to be a result of the heat, but locally/regionally defined heat warning or heat advisory criteria are not met, then the fatalities can only be mentioned in the narrative of another Storm Data event that occurred near the time of death.

Table 3.76. Annual Heat Events in Missouri, 1996-2016

Year	# of Events	Deaths	Injuries	Property Damages	Crop Damages
1996	8	2	44	-	-
1997	17	3	38	-	-
1998	63	5	306	-	-
1999	150	77	397	-	-
2000	322	18	266	$125,000	$105,000
2001	478	31	213	-	-
2002	131	17	334	-	-
2003	115	12	147	-	-
2004	38	1	74	-	-
2005	96	8	158	-	-
2006	228	16	856	-	-
2007	94	13	963	-	-
2008	31	0	68	-	-
2009	65	2	130	$30,000	-
2010	280	7	276	-	-
2011	291	14	726	$400,000	-
2012	353	34	672	-	-
2013	54	2	25	-	-
2014	74	0	10	-	-
2015	150	1	92	-	-
2016	127	4	116	-	-
Grand Total	**3165**	**267**	**5911**	**$ 555,000**	**$105,000**

Significant heat events include the following:

July/August 2001: The first real heat wave of the summer hit the area July 7 through July 10. Temperatures peaked in the middle to upper 90s with the Heat Index ranging from 105 to 110. Heat returned to the region in August as high temperatures hit the middle to upper 90s with the Heat Index ranging from 102 to 110. 30 deaths occurred in 2001 from heat.

July 2002: High temperatures climbed into the middle to upper 90's with Heat Indices from 105 to 110 degrees.

July 2006: Excessive Heat returned to the St. Louis area in late July and continued into early August. The temperature at Lambert International Airport hit 101 on both the 30th and 31st with the Heat Index around 110. July 2006 was no exception to heat wave conditions in Missouri. The NWS indicated that the July temperatures following the St. Louis storm were expected to be 91-95°F within a one-week period with the heat indices expected to reach 100°F in the metro area at that time. A federal disaster declaration was received on July 21, 2006, for the City of St. Louis and surrounding counties to the west and southwest of the City. Heat wave conditions continued throughout the month of July with heat indices reaching 105–115°F by the end of the month. The storm event caused many households and businesses to be without power for an extended period of time. The power outages caused the heat wave to have a profound effect on individuals residing within the impacted area. By July 31, 2006, 10 heat-related deaths had been reported in Jefferson County, St. Louis City, and St. Louis County. July 19, 2006, after reaching a high temperature of 100 degrees, a cluster of thunderstorms, also known as a mesoscale convective system, formed across Northern Illinois and propagated southwest across West Central Illinois and Eastern Missouri. Straight line winds created widespread wind damage from Central Illinois across the St. Louis Metropolitan Area and into the Eastern Ozarks. The damage sustained in the St. Louis Metropolitan Area was consistent with wind speeds between 70 and 90 mph. Two tornado tracks were also uncovered across Southwest Illinois near the towns of Bunker Hill and Edwardsville. Over 500,000 customers were left without power, and thus no air conditioning. A State of Emergency was declared for the St. Louis Area, and the National Guard was called in to help with heat evacuations. The temperature rose near 100 degrees once again on Thursday and heat index values were as high as 115 degrees in the affected region. (NWS MO) The power outages caused the heat wave to have a profound effect on individuals residing within the impacted area (CNN, 2006). By July 31, 2006, 10 heat-related deaths had been reported in Jefferson County, St. Louis City, and St. Louis County. This incident accounted for nearly half of the total 25 heat-related deaths that occurred in Missouri in 2006 (Missouri DHSS, 2011).

August 2007: The first and only Heat Wave of the summer started in August 4th and lasted through August 16th. Eight deaths were reported in the St. Louis Metro area. The city of St. Louis reported 422 heat related injuries. St. Louis County reported 519 heat related injuries. At least 450 people were injured at an outdoor concert held on August 6th, and another 50 were injured at another outdoor concert on the 14th. Many schools across the region went to an early dismissal schedule to combat the heat. St. Louis hit 100 degrees on the 7th and 8th, 102 on the 12th, 103 on the 14th, and 105 on the 15th. The highs on the 14th and 15th set new records. Columbia hit 100 or higher on six days and set a new record of 103 degrees on the 16th. August 2007 ended up being the 3rd warmest on record for St. Louis and the 4th warmest on record for Columbia. The Department of Health and Senior Services reported at least 1300 heat related injuries across the state.

July 2011: A major Heat Wave started on July 17th and continued into August. High temperatures ranged from the lower 90s to around 100. Columbia hit 100 on July 28 while St. Louis topped the century mark on six days, including four in a row from July 20 - 23. Low temperatures at night were generally around 80. The Heat Index ranged from around 105 to 110. There were five deaths reported in the City of St. Louis with three in St. Louis County. Over 100 people were treated at a U2 concert held at Busch Stadium the evening of the 17th.

June 2012: Some of the hottest temperatures in many years occurred the last 4 days of June and continued into July. St. Louis, MO recorded its highest ever June temperature hitting 108 degrees on June 28. Nearly all reporting stations were over 100 degrees the last 3 to 4 days of June with most sites around 105. The 28th was the hottest day. Some high temperatures across the Missouri counties on the 28th included 109 degrees at Spirit of St. Louis Airport in Chesterfield, 108 in Farmington and Fredericktown, 107 in Washington, Columbia, and Jefferson City, and 106 in Warrenton. The good thing was the air was very dry, thus the Heat Index was not much different than the air temperature. The City of St. Louis reported two heat related deaths on June 30. St. Louis County reported 20 heat related injuries on June 29, and 23 on June 30. The City of St. Louis reported 2 heat related deaths on June 30. An 80 year old man died in his home. There was a window air conditioner but it was not turned on. A 74 year old woman was found dead in her apartment. There was central air conditioning that was not turned on.

According to the USDA Risk Management Agency, insured crop losses throughout the State of Missouri as a result of Excessive Heat for the 19 year period of 1998 – 2016 totaled $149,701,372. Excessive Heat ranked 6th in the State for insured crop losses. Also, hot winds in Missouri totaled $8,499,208 in insured crop losses from the same timeframe. A detailed listing of insured crop losses by crop, county, and, year for insured crop losses is provided at the following link: https://www.rma.usda.gov/.

The NCEI Storm Events Database also provides information on previous extreme cold/wind chill and frost/freeze events in Missouri. **Table 3.77** lists the annual total of events, deaths, injuries, property damages, and crop damages for 1996 through 2016 for extreme cold events.

Table 3.77. Annual Extreme Cold & Frost/Freeze Events in Missouri

Year	# of Events	Deaths	Injuries	Property Damages	Crop Damages
1996					
1997	11	0	0	0	0
1998					
1999					
2000	166	1	0	$125,000	$105,000
2001	53	1	0	0	0
2002					
2003	5	0	0	0	0
2004					
2005	17	0	0	0	$2,645,000
2006	11	0	0	0	0
2007	184	0	0	0	$166,323,950
2008	46	0	0	0	$220,000
2009	40	0	0	0	0
2010	11	0	0	0	0
2011	22	0	0	0	0
2012	12	0	0	0	0
2013	33	0	0	0	0
2014	44	0	0	0	$100,000
2015	11	0	0	0	0
2016	11	0	0	0	0
Totals	**677**	**2**	**0**	**$125,000**	**$169,393,950**

Significant extreme cold events include the following:

December 2000: Abnormally cold air moved into the Ozarks by the middle of December as the main jet stream carved out a deep trough of low pressure over the eastern 2/3's of the nation. This pattern continued through the early part of January. The combination of deep snow cover and an abnormally strong arctic air mass kept temperatures 10 to 20 degrees below normal. The severe cold caused numerous water mains to brake, roof leakage, and hazardous roadways due to ice and snow. In Stafford, a water main broke under a new high school gymnasium causing considerable damage to the school ceiling tiles, light fixtures and the gymnasium floor. In addition, hay supplies rapidly decreased as persistent ice and snow covered fields. Snow cover and cold conditions also made it difficult for farmers and ranchers to feed their animals, which had an adverse effect on livestock and newly born calves. Several calves died due to the severe stress of the cold and low supply of hay, especially in southwest Missouri.

January 2001: The prolonged arctic freeze that began during the second week of December finally ended by January 4. During the first few days of the new year, temperatures averaged 15 to 25 degrees below normal. Overnight lows were in the single digits. As a result, ice continued to be a problem on the Mississippi River. The combination of ice and low river levels made navigation for barges very hazardous. About 10 miles north of Cape Girardeau, 15 barges loaded with coal went aground. Ice floes halted the ferry service between Dorena, MO and Hickman, KY until warmer weather arrived.

January 2009: In the wake of an arctic cold front, gusty northwest winds from 15 to 25 mph combined with a surge of arctic air to produce wind chills from minus 5 to minus 15 degrees.

February 2014: Cold air and north winds combined to bring wind chill values down to 30 degrees below zero.

May 2005: Record breaking cold settled over the Midwest during the early morning hours of 3 May 2005. The cold was of such intensity that all-time record minimums for the month of May were tied or shattered at most first order stations and many co-operative stations. Farmers that took advantage of the unseasonably mild weather during the first half of April had to replant after crops were killed off by the freeze. In some cases, crops had to be replanted even though the growing point was below the surface. This was due to the soil being a sandy loam which allowed freezing temperatures to penetrate into the ground.

April 2007: Unusually warm conditions during the month of March caused early season growth in vegetation across the Missouri Ozarks. Hay along with the wheat crop had begun to mature. During the nights of April 7th through the 9th, temperatures dropped into the upper teens to mid 20s, causing a hard freeze on matured vegetation. The wheat crop suffered approximately 90% damage. Hay crops along with fescue seed also sustained major damage. Total crop losses for 34 counties across the southwestern quadrant of Missouri were estimated at $147,905,541.

January 14–20, 1994: Northeast, central, and east-central Missouri experienced overnight low temperatures from below zero to –20°F. Hundreds of homes and businesses had frozen and busted water pipes. Wind chills, which ranged from -30 to -50°F, kept schools closed and accounted for 15 people being admitted to local hospitals for hypothermia and frostbite.

January 10–13, 1997: Northwest and west-central Missouri experienced overnight low temperatures below zero. No record low temperatures were recorded, but winds gusting up to 30 miles per hour produced afternoon wind chills as low as -30 to -50°F. According to the USDA Risk Management Agency, insured crop losses throughout the State of Missouri as a result of cold wet winter, cold winter, freeze, and frost conditions for the eleven year period of 1998 – 2008 totaled $20.9 million.

April 2007: Unusually warm conditions during the month of March caused early season growth in vegetation across the Missouri Ozarks. Hay along with the wheat crop had begun to mature. During the nights of April 7th through the 9th, temperatures dropped into the upper teens to mid-20s, causing a hard freeze on matured vegetation. The wheat crop suffered approximately 90% damage. Hay crops along with fescue seed also sustained major damage. Total crop losses for 34 counties across the southwestern quadrant of Missouri were estimated at $147,905,541.

Probability of Future Hazard Events

With a total of 3,165 extreme heat events from 1996 to December 2016 there are an average of 151 events per year. There are 677 recorded extreme cold events with an average of 32 events per year. Missourians have a very high probability that extreme temperature events will continue to occur each year.

Changing Future Conditions Considerations

Under a 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. For example, in southern Missouri, the annual maximum number of consecutive days with temperatures exceeding 95 degrees F is projected to increase by up to 20 days. Temperature increases will cause future heat waves to be more intense, a concern for this region which already experiences hot and humid conditions. Extreme heat is a concern for urban areas such as St. Louis and Kansas City, where the urban heat island effect raises summer temperatures. If the warming trend conditions, future heat waves are likely to be more intense, and cold wave intensity is projected to decrease.

The impacts of extreme heat events are experienced most acutely by the elderly and other vulnerable populations. High temperatures are exacerbated in urban environments, a phenomenon known as the urban heat island effect, which in turn tend to have higher concentrations of vulnerable populations. Higher demand for electricity as people try to keep cool amplifies stress on power systems and may lead to an increase in the number of power outages. Atmospheric concentrations of ozone occur at higher air temperatures, resulting in poorer air quality, while harmful algal blooms flourish in warmer water temperatures, resulting in poorer water quality.

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

State Vulnerability Overview

Extreme heat and extreme cold events are common occurrences in Missouri. The method used to determine vulnerability to extreme temperatures across Missouri was statistical analysis of data from several sources: National Centers for Environmental Information (NCEI) storm events data (1996 to December 31, 2016), total population and percentage of population over 65 data from the U.S. Census (2015 ACS), and the calculated Social Vulnerability Index for Missouri counties from the Hazards and Vulnerability Research Institute in the Department of Geography at the University of South Carolina.

From the statistical data collected, four factors were considered in determining overall vulnerability to extreme temperatures as follows: total population, percentage of population over 65, likelihood of occurrence, and social vulnerability. Based on natural breaks in the statistical data, a rating value of 1 through 5 was assigned to each factor. These rating values correspond to the following descriptive terms:

1) Low
2) Low-medium
3) Medium
4) Medium-high
5) High

Table 3.78 provides the factors considered and the ranges for the rating values assigned.

Table 3.78. Ranges for Extreme Temperature Vulnerability Factor Ratings

Factors Considered	Low (1)	Low-medium (2)	Medium (3)	Medium-High (4)	High (5)
Common Factors					
Total Population	2,057-28,879	28,880-66,520	66,521-174,974	174,975-385,590	385,591-1,003,362
Percent Population Over 65	7.2-13.9%	13.91-17.50%	17.51-20.60%	20.60-24.10%	24.11-31.50%
Social Vulnerability	1	2	3	4	5
Extreme Heat					
Likelihood of Occurrence (# of events/ yrs. of data)	.429-.619	.620-1.143	1.144-1.952	1.953-2.714	2.715-4.381
Extreme Cold					
Likelihood of Occurrence (# of events/ yrs. of data)	.030-.061	.062-.182	.183-.455	.456-.515	.516-.576

Once the individual ratings were determined for the above factors, a combined vulnerability rating was computed for extreme heat and extreme cold. **Table 3.79** provides the calculated ranges applied to determine overall vulnerability of Missouri counties to extreme temperatures. The figures that follow provide the mapped results of this analysis by county.

Table 3.79. Ranges for Extreme Temperatures Vulnerability Rating

	Low (1)	Low-medium (2)	Medium (3)	Medium-High (4)	High (5)
Extreme Heat Rating	5-7	8-9	10-11	12-13	14-17
Extreme Cold Rating	4-6	7-8	9-10	11-13	14-18

Table 3.80. Population, Percent of Population over 65, and SOVI Data by County

County	Total Population (2015 ACS)	Total Population Rating	Percentage of Population over 65	Percent of Population over 65 Rating	SOVI Ranking	SOVI Rating
Adair	13802	1	13.7	1	Low	1
Andrew	15963	1	17.1	2	Low	1
Atchison	25378	1	23.4	4	High	5
Audrain	89100	3	16.5	2	Low	1
Barry	8253	1	19.3	3	Low	1
Barton	12687	1	18.4	3	Medium Low	2
Bates	53221	2	18.7	3	Low	1
Benton	15593	1	27.5	5	Low	1
Bollinger	18268	1	17.4	2	Low	1
Boone	76720	3	10.1	1	Medium	3
Buchanan	13628	1	14.3	2	Medium Low	2
Butler	25690	1	17.1	2	Medium	3
Caldwell	9409	1	18.4	3	Medium	3
Callaway	315685	4	13.9	1	Medium	3
Camden	13373	1	24.1	4	Medium Low	2
Cape Girardeau	13405	1	15.1	2	Medium	3
Carroll	17482	1	19.9	3	Medium Low	2
Carter	24788	1	17.4	2	Medium	3
Cass	4858	1	14.9	2	Medium Low	2
Cedar	30895	2	23.1	4	Medium Low	2
Chariton	19183	1	22.4	4	Medium Low	2
Christian	102426	3	13.7	1	Medium	3
Clark	29862	2	19.1	3	Medium Low	2
Clay	10196	1	12.3	1	Low	1
Clinton	42255	2	16.7	2	Medium	3
Cole	44237	2	13.5	1	Medium	3
Cooper	8583	1	16.3	2	Medium	3
Crawford	6801	1	17.4	2	Medium Low	2
Dade	14858	1	21.8	4	Medium Low	2
Dallas	6692	1	18.6	3	Low	1
Daviess	22643	1	18.3	3	High	5
DeKalb	11703	1	15.3	2	Medium Low	2
Dent	288072	4	19.9	3	Medium Low	2
Douglas	10097	1	21.8	4	Medium High	4
Dunklin	17296	1	17.1	2	Low	1
Franklin	17642	1	15.1	2	Medium Low	2
Gasconade	83279	3	21	4	Medium Low	2
Gentry	9440	1	20	3	Medium Low	2
Greene	3694	1	15	2	Medium Low	2
Grundy	25113	1	21.2	4	Medium	3
Harrison	66520	2	21	4	Medium Low	2
Henry	44794	2	20	3	Medium	3
Hickory	8615	1	31.5	5	Medium	3
Holt	20171	1	22.3	4	Medium High	4
Howard	18208	1	16	2	Medium High	4
Howell	15335	1	18.2	3	Medium	3
Iron	44834	2	18.1	3	Medium Low	2
Jackson	22810	1	13.2	1	Medium	3
Jasper	28880	2	13.6	1	Medium	3
Jefferson	24526	1	12.8	1	Medium Low	2

County	Total Population (2015 ACS)	Total Population Rating	Percentage of Population over 65	Percent of Population over 65 Rating	SOVI Ranking	SOVI Rating
Johnson	18348	1	11.4	1	Medium Low	2
Knox	26096	1	20.3	3	Medium High	4
Laclede	21737	1	16.3	2	High	5
Lafayette	96096	3	17.5	2	High	5
Lawrence	12408	1	17	2	Medium High	4
Lewis	11880	1	17.5	2	Medium High	4
Lincoln	13934	1	11.9	1	Medium Low	2
Linn	23258	1	19.7	3	Medium High	4
Livingston	14036	1	19.3	3	Medium	3
Macon	4436	1	20.6	3	Medium Low	2
Madison	9014	1	18.8	3	Medium	3
Maries	9201	1	19.5	3	Medium High	4
Marion	18670	1	16.5	2	Medium	3
McDonald	4484	1	13.6	1	Medium	3
Mercer	4854	1	20.3	3	Medium	3
Miller	10139	1	17.3	2	Medium High	4
Mississippi	30943	2	16.1	2	Medium	3
Moniteau	78572	3	14.3	2	Medium	3
Monroe	12182	1	20.4	3	Medium High	4
Montgomery	235637	4	19.3	3	Medium	3
Morgan	40117	2	23.1	4	Medium	3
New Madrid	6353	1	17.1	2	Medium	3
Newton	10125	1	17	2	Medium High	4
Nodaway	1003362	5	13.8	1	Medium Low	2
Oregon	687623	5	21.9	4	Medium	3
Osage	8992	1	16.1	2	Medium	3
Ozark	118596	3	25.2	5	Medium High	4
Pemiscot	5306	1	15.3	2	Medium Low	2
Perry	37483	2	16.2	2	High	5
Pettis	31229	2	15	2	Medium	3
Phelps	224124	4	14.6	2	Medium High	4
Pike	174974	3	16.2	2	Medium High	4
Platte	25104	1	12.4	1	Medium	3
Polk	53951	2	16.9	2	Medium	3
Pulaski	3910	1	7.2	1	Medium High	4
Putnam	39008	2	22.8	4	Medium	3
Ralls	16446	1	18.8	3	Medium	3
Randolph	58615	2	15.1	2	Medium High	4
Ray	22810	1	16.3	2	Medium High	4
Reynolds	42951	2	22.5	4	Medium	3
Ripley	20826	1	19	3	Medium High	4
Saline	10953	1	16.4	2	Medium High	4
Schuyler	8258	1	19.4	3	Medium	3
Scotland	17919	1	18.5	3	Medium High	4
Scott	33513	2	16.4	2	Medium	3
Shannon	35473	2	18.6	3	Medium High	4
Shelby	35829	2	19.8	3	Medium High	4
St. Charles	7595	1	12.7	1	Medium High	4
St. Clair	32701	2	25.4	5	Medium	3
St. Francois	20609	1	14.8	2	Medium	3
St. Louis	6432	1	16	2	Medium High	4
St. Louis City	16393	1	11.2	1	Medium	3

County	Total Population (2015 ACS)	Total Population Rating	Percentage of Population over 65	Percent of Population over 65 Rating	SOVI Ranking	SOVI Rating
Ste. Genevieve	6263	1	16.7	2	Medium High	4
Stoddard	54592	2	18.8	3	Medium High	4
Stone	38180	2	26.4	5	Medium	3
Sullivan	6128	1	18.3	3	Medium High	4
Taney	10207	1	19.1	3	Medium High	4
Texas	54696	2	18.9	3	Medium High	4
Vernon	8963	1	17.3	2	Medium High	4
Warren	7589	1	16.1	2	Medium High	4
Washington	101603	3	14.7	2	Medium	3
Wayne	2057	1	21.7	4	Medium High	4
Webster	12308	1	14.3	2	Medium High	4
Worth	385590	4	24	4	Medium High	4
Wright	15028	1	18.2	3	High	5

Table 3.132 provides additional data obtained from the National Centers for Environmental Information to complete the overall vulnerability analysis and the total overall vulnerability rating for extreme temperatures.

Table 3.81. Likelihood of Occurrence and Overall Vulnerability Rating for Extreme Temperatures

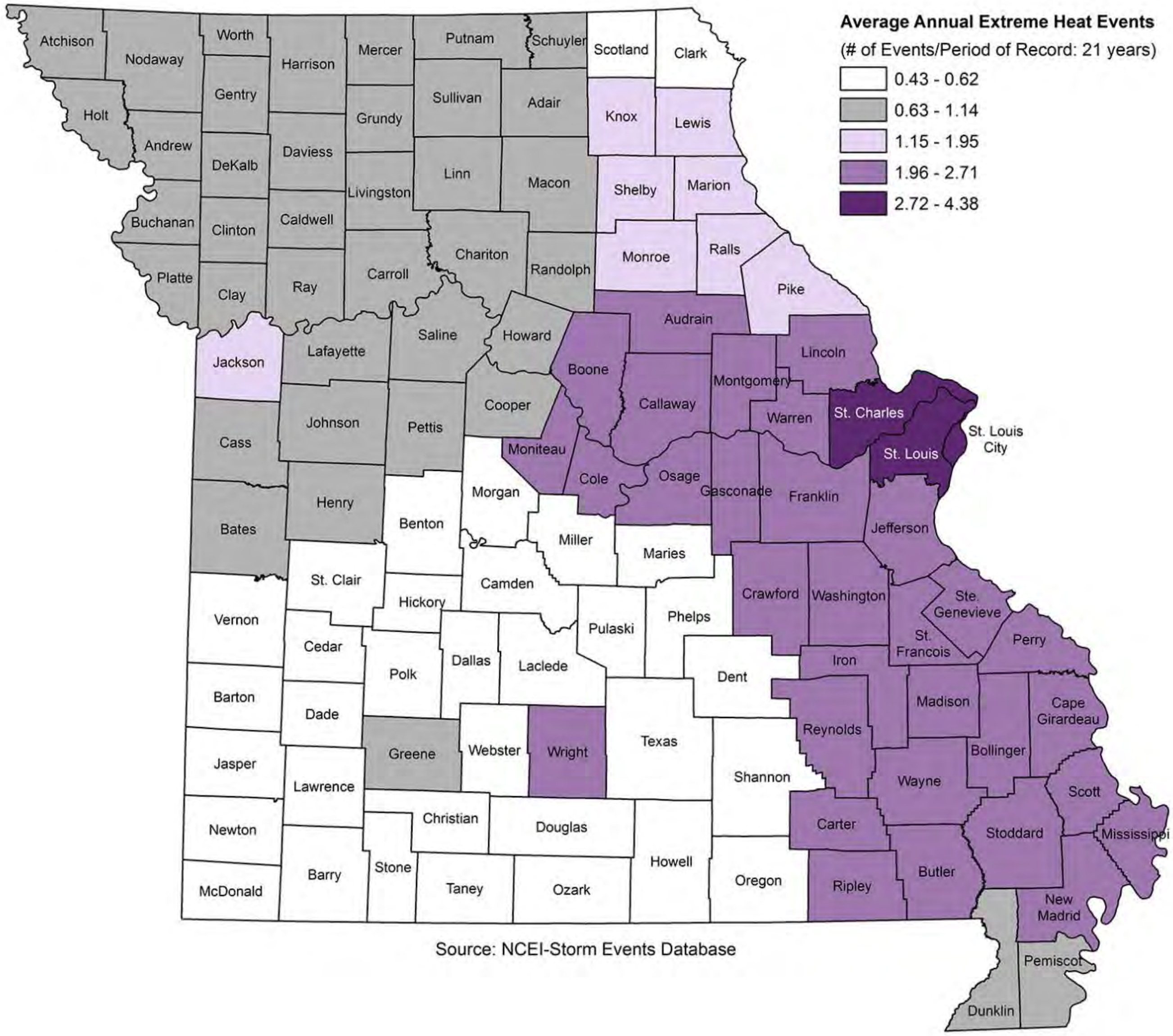
County	HEAT					COLD				
	Total Events	Likelihood of Occurrence	Likelihood Rating	Total Vulnerability	Total Vulnerability Description	Total Events	Likelihood of Occurrence	Likelihood Rating	Total Vulnerability	Total Vulnerability Description
Adair	16	0.76	2	5	Low	4	0.19	1	4	Low
Andrew	16	0.76	2	6	Low	3	0.14	1	5	Low
Atchison	16	0.76	2	12	Medium High	2	0.10	1	11	Medium High
Audrain	47	2.24	4	10	Medium	2	0.10	1	7	Low Medium
Barry	11	0.52	1	6	Low	3	0.14	1	6	Low
Barton	11	0.52	1	7	Low	3	0.14	1	7	Low Medium
Bates	18	0.86	2	8	Low Medium	3	0.14	1	7	Low Medium
Benton	11	0.52	1	8	Low Medium	3	0.14	1	8	Low Medium
Bollinger	51	2.43	4	8	Low Medium	38	1.81	5	9	Medium
Boone	54	2.57	4	11	Medium	2	0.10	1	8	Low Medium
Buchanan	17	0.81	2	7	Low	3	0.14	1	6	Low
Butler	57	2.71	4	10	Medium	30	1.43	3	9	Medium
Caldwell	17	0.81	2	9	Low Medium	3	0.14	1	8	Low Medium
Callaway	55	2.62	4	12	Medium High	4	0.19	1	9	Medium
Camden	11	0.52	1	8	Low Medium	3	0.14	1	8	Low Medium
Cape Girardeau	53	2.52	4	10	Medium	36	1.71	5	11	Medium High
Carroll	17	0.81	2	8	Low Medium	3	0.14	1	7	Low Medium
Carter	51	2.43	4	10	Medium	36	1.71	5	11	Medium High

County	HEAT					COLD				
	Total Events	Likelihood of Occurrence	Likelihood Rating	Total Vulnerability	Total Vulnerability Description	Total Events	Likelihood of Occurrence	Likelihood Rating	Total Vulnerability	Total Vulnerability Description
Cass	19	0.90	2	7	Low	3	0.14	1	6	Low
Cedar	11	0.52	1	9	Low Medium	3	0.14	1	9	Medium
Chariton	17	0.81	2	9	Low Medium	3	0.14	1	8	Low Medium
Christian	11	0.52	1	8	Low Medium	3	0.14	1	8	Low Medium
Clark	11	0.52	1	8	Low Medium	12	0.57	2	9	Medium
Clay	23	1.10	2	5	Low	3	0.14	1	4	Low
Clinton	17	0.81	2	9	Low Medium	3	0.14	1	8	Low Medium
Cole	50	2.38	4	10	Medium	2	0.10	1	7	Low Medium
Cooper	16	0.76	2	8	Low Medium	3	0.14	1	7	Low Medium
Crawford	53	2.52	4	9	Low Medium	2	0.10	1	6	Low
Dade	11	0.52	1	8	Low Medium	3	0.14	1	8	Low Medium
Dallas	11	0.52	1	6	Low	3	0.14	1	6	Low
Daviess	15	0.71	2	11	Medium	3	0.14	1	10	Medium
DeKalb	16	0.76	2	7	Low	3	0.14	1	6	Low
Dent	11	0.52	1	10	Medium	3	0.14	1	10	Medium
Douglas	11	0.52	1	10	Medium	3	0.14	1	10	Medium
Dunklin	20	0.95	2	6	Low	2	0.10	1	5	Low
Franklin	57	2.71	4	9	Low Medium	2	0.10	1	6	Low
Gasconade	52	2.48	4	13	Medium High	2	0.10	1	10	Medium
Gentry	17	0.81	2	8	Low Medium	4	0.19	1	7	Low Medium
Greene	15	0.71	2	7	Low	3	0.14	1	6	Low
Grundy	15	0.71	2	10	Medium	3	0.14	1	9	Medium
Harrison	17	0.81	2	10	Medium	4	0.19	1	9	Medium
Henry	17	0.81	2	10	Medium	3	0.14	1	9	Medium
Hickory	11	0.52	1	10	Medium	3	0.14	1	10	Medium
Holt	16	0.76	2	11	Medium	3	0.14	1	10	Medium
Howard	16	0.76	2	9	Low Medium	3	0.14	1	8	Low Medium
Howell	12	0.57	1	8	Low Medium	3	0.14	1	8	Low Medium
Iron	49	2.33	4	11	Medium	2	0.10	1	8	Low Medium
Jackson	33	1.57	3	8	Low Medium	3	0.14	1	6	Low
Jasper	13	0.62	1	7	Low	3	0.14	1	7	Low Medium
Jefferson	57	2.71	4	8	Low Medium	2	0.10	1	5	Low
Johnson	17	0.81	2	6	Low	3	0.14	1	5	Low
Knox	39	1.86	3	11	Medium	2	0.10	1	9	Medium
Laclede	11	0.52	1	9	Low Medium	3	0.14	1	9	Medium
Lafayette	17	0.81	2	12	Medium High	3	0.14	1	11	Medium High
Lawrence	12	0.57	1	8	Low Medium	3	0.14	1	8	Low Medium

County	HEAT					COLD				
	Total Events	Likelihood of Occurrence	Likelihood Rating	Total Vulnerability	Total Vulnerability Description	Total Events	Likelihood of Occurrence	Likelihood Rating	Total Vulnerability	Total Vulnerability Description
Lewis	40	1.90	3	10	Medium	2	0.10	1	8	Low Medium
Lincoln	51	2.43	4	8	Low Medium	2	0.10	1	5	Low
Linn	16	0.76	2	10	Medium	4	0.19	1	9	Medium
Livingston	15	0.71	2	9	Low Medium	3	0.14	1	8	Low Medium
Macon	16	0.76	2	8	Low Medium	4	0.19	1	7	Low Medium
Madison	48	2.29	4	11	Medium	2	0.10	1	8	Low Medium
Maries	11	0.52	1	9	Low Medium	3	0.14	1	9	Medium
Marion	41	1.95	3	9	Low Medium	2	0.10	1	7	Low Medium
McDonald	11	0.52	1	6	Low	3	0.14	1	6	Low
Mercer	16	0.76	2	9	Low Medium	4	0.19	1	8	Low Medium
Miller	11	0.52	1	8	Low Medium	3	0.14	1	8	Low Medium
Mississippi	52	2.48	4	11	Medium	28	1.33	3	10	Medium
Moniteau	50	2.38	4	12	Medium High	2	0.10	1	9	Medium
Monroe	41	1.95	3	11	Medium	2	0.10	1	9	Medium
Montgomery	53	2.52	4	14	High	2	0.10	1	11	Medium High
Morgan	11	0.52	1	10	Medium	3	0.14	1	10	Medium
New Madrid	56	2.67	4	10	Medium	28	1.33	3	9	Medium
Newton	11	0.52	1	8	Low Medium	3	0.14	1	8	Low Medium
Nodaway	17	0.81	2	10	Medium	4	0.19	1	9	Medium
Oregon	11	0.52	1	13	Medium High	3	0.14	1	13	Medium High
Osage	50	2.38	4	10	Medium	2	0.10	1	7	Low Medium
Ozark	11	0.52	1	13	Medium High	3	0.14	1	13	Medium High
Pemiscot	20	0.95	2	7	Low	2	0.10	1	6	Low
Perry	49	2.33	4	13	Medium High	37	1.76	5	14	High
Pettis	17	0.81	2	9	Low Medium	3	0.14	1	8	Low Medium
Phelps	11	0.52	1	11	Medium	3	0.14	1	11	Medium High
Pike	41	1.95	3	12	Medium High	2	0.10	1	10	Medium
Platte	24	1.14	2	7	Low	3	0.14	1	6	Low
Polk	11	0.52	1	8	Low Medium	3	0.14	1	8	Low Medium
Pulaski	11	0.52	1	7	Low	3	0.14	1	7	Low Medium
Putnam	16	0.76	2	11	Medium	4	0.19	1	10	Medium
Ralls	40	1.90	3	10	Medium	2	0.10	1	8	Low Medium
Randolph	16	0.76	2	10	Medium	3	0.14	1	9	Medium
Ray	16	0.76	2	9	Low Medium	3	0.14	1	8	Low Medium
Reynolds	47	2.24	4	13	Medium High	2	0.10	1	10	Medium
Ripley	55	2.62	4	12	Medium High	33	1.57	4	12	Medium High
Saline	16	0.76	2	9	Low Medium	3	0.14	1	8	Low Medium

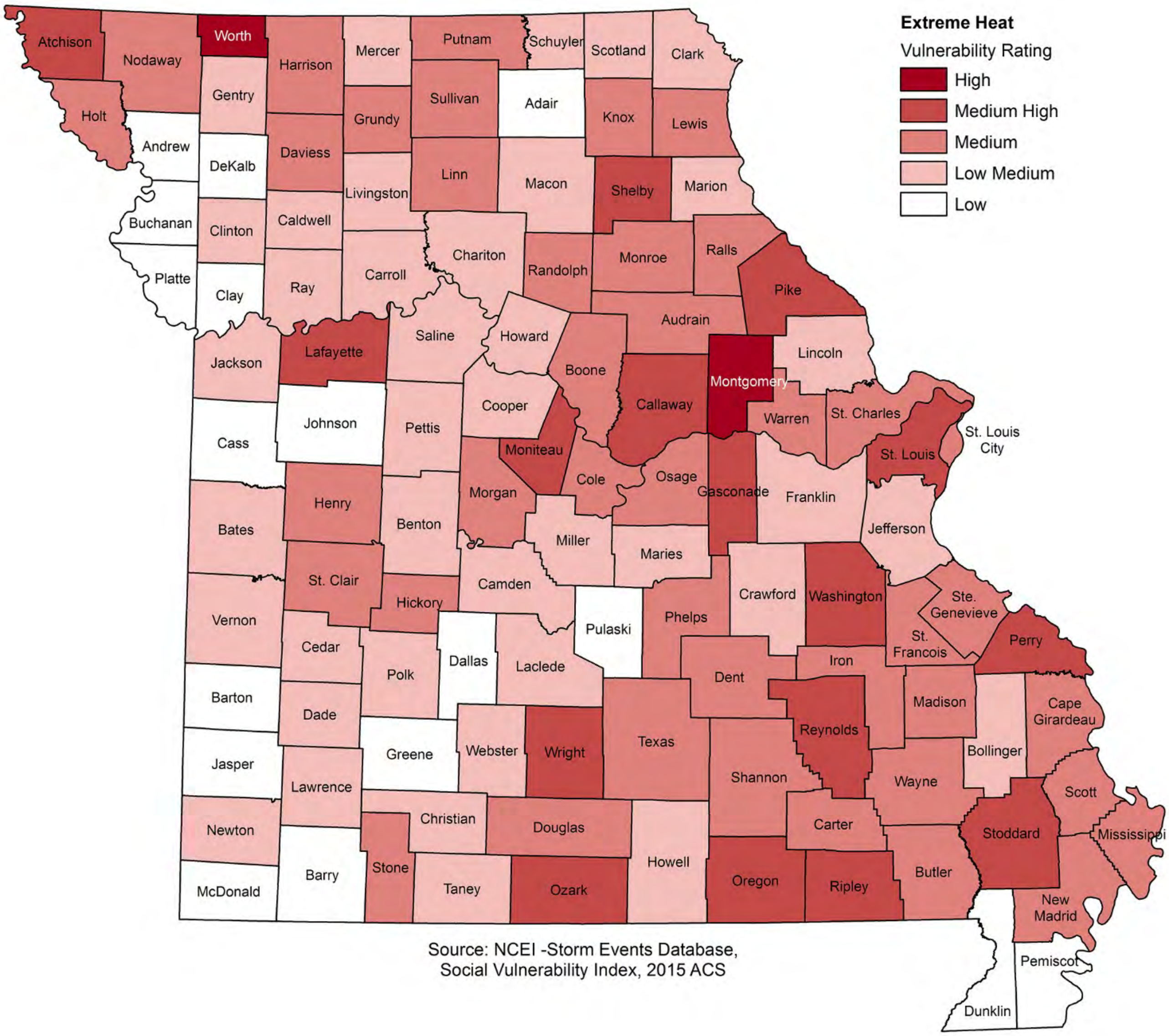
County	HEAT					COLD				
	Total Events	Likelihood of Occurrence	Likelihood Rating	Total Vulnerability	Total Vulnerability Description	Total Events	Likelihood of Occurrence	Likelihood Rating	Total Vulnerability	Total Vulnerability Description
Schuyler	16	0.76	2	9	Low Medium	4	0.19	1	8	Low Medium
Scotland	9	0.43	1	9	Low Medium	10	0.48	2	10	Medium
Scott	54	2.57	4	11	Medium	34	1.62	4	11	Medium High
Shannon	11	0.52	1	10	Medium	3	0.14	1	10	Medium
Shelby	39	1.86	3	12	Medium High	2	0.10	1	10	Medium
St. Charles	69	3.29	5	11	Medium	2	0.10	1	7	Low Medium
St. Clair	11	0.52	1	11	Medium	3	0.14	1	11	Medium High
St. Francois	53	2.52	4	10	Medium	2	0.10	1	7	Low Medium
St. Louis	81	3.86	5	12	Medium High	3	0.14	1	8	Low Medium
St. Louis City	92	4.38	5	10	Medium	2	0.10	1	6	Low
Ste. Genevieve	50	2.38	4	11	Medium	2	0.10	1	8	Low Medium
Stoddard	55	2.62	4	13	Medium High	30	1.43	3	12	Medium High
Stone	11	0.52	1	11	Medium	3	0.14	1	11	Medium High
Sullivan	16	0.76	2	10	Medium	4	0.19	1	9	Medium
Taney	11	0.52	1	9	Low Medium	3	0.14	1	9	Medium
Texas	11	0.52	1	10	Medium	3	0.14	1	10	Medium
Vernon	12	0.57	1	8	Low Medium	3	0.14	1	8	Low Medium
Warren	51	2.43	4	11	Medium	2	0.10	1	8	Low Medium
Washington	50	2.38	4	12	Medium High	2	0.10	1	9	Medium
Wayne	51	2.43	4	13	Medium High	37	1.76	5	14	High
Webster	11	0.52	1	8	Low Medium	3	0.14	1	8	Low Medium
Worth	16	0.76	2	14	High	4	0.19	1	13	Medium High
Wright	11	0.52	1	10	Medium	3	0.14	1	10	Medium

Figure 3.118. Average Annual Occurrence for Extreme Heat



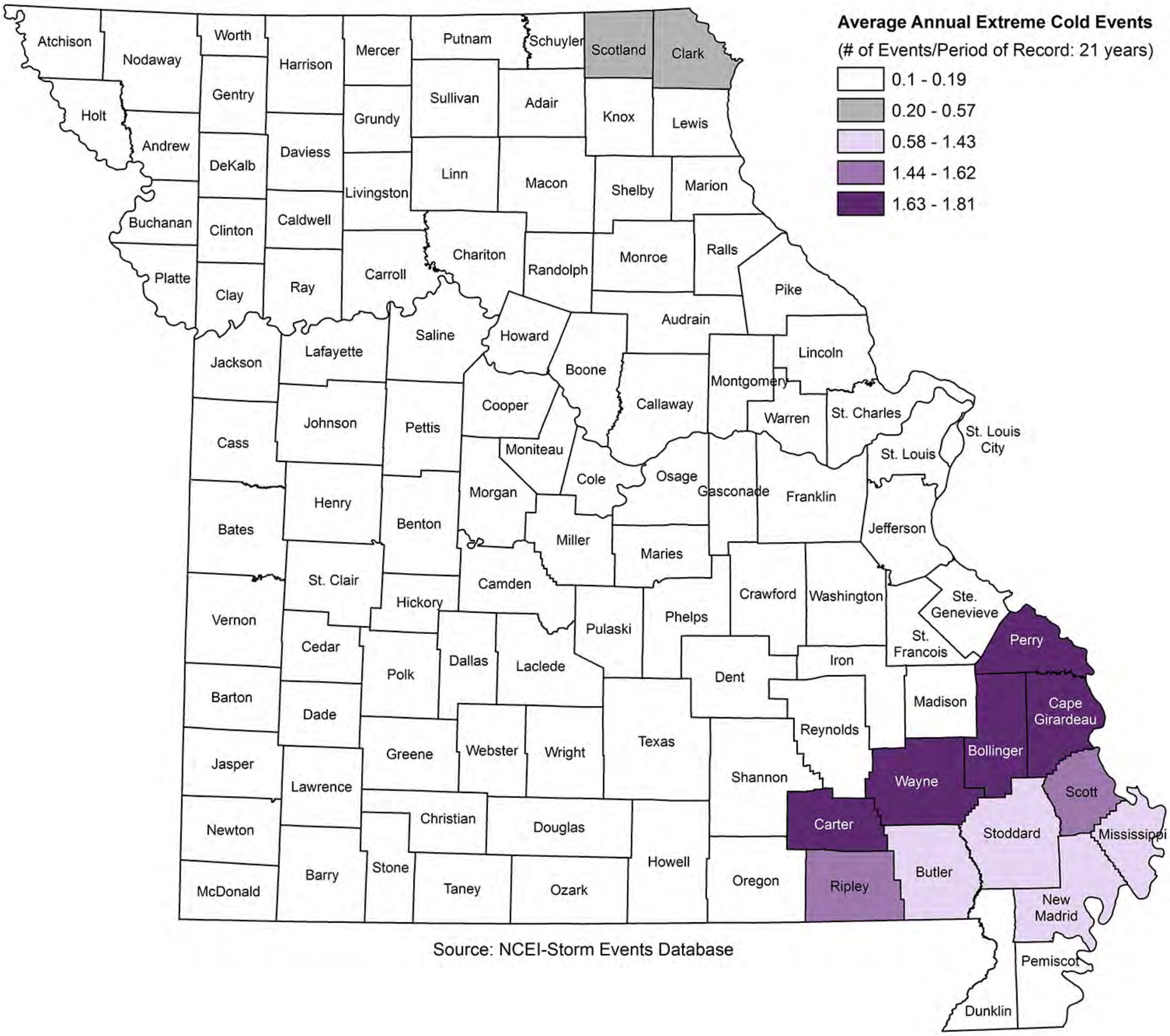
Source: NCEI-Storm Events Database

Figure 3.119. Vulnerability Summary for Extreme Heat



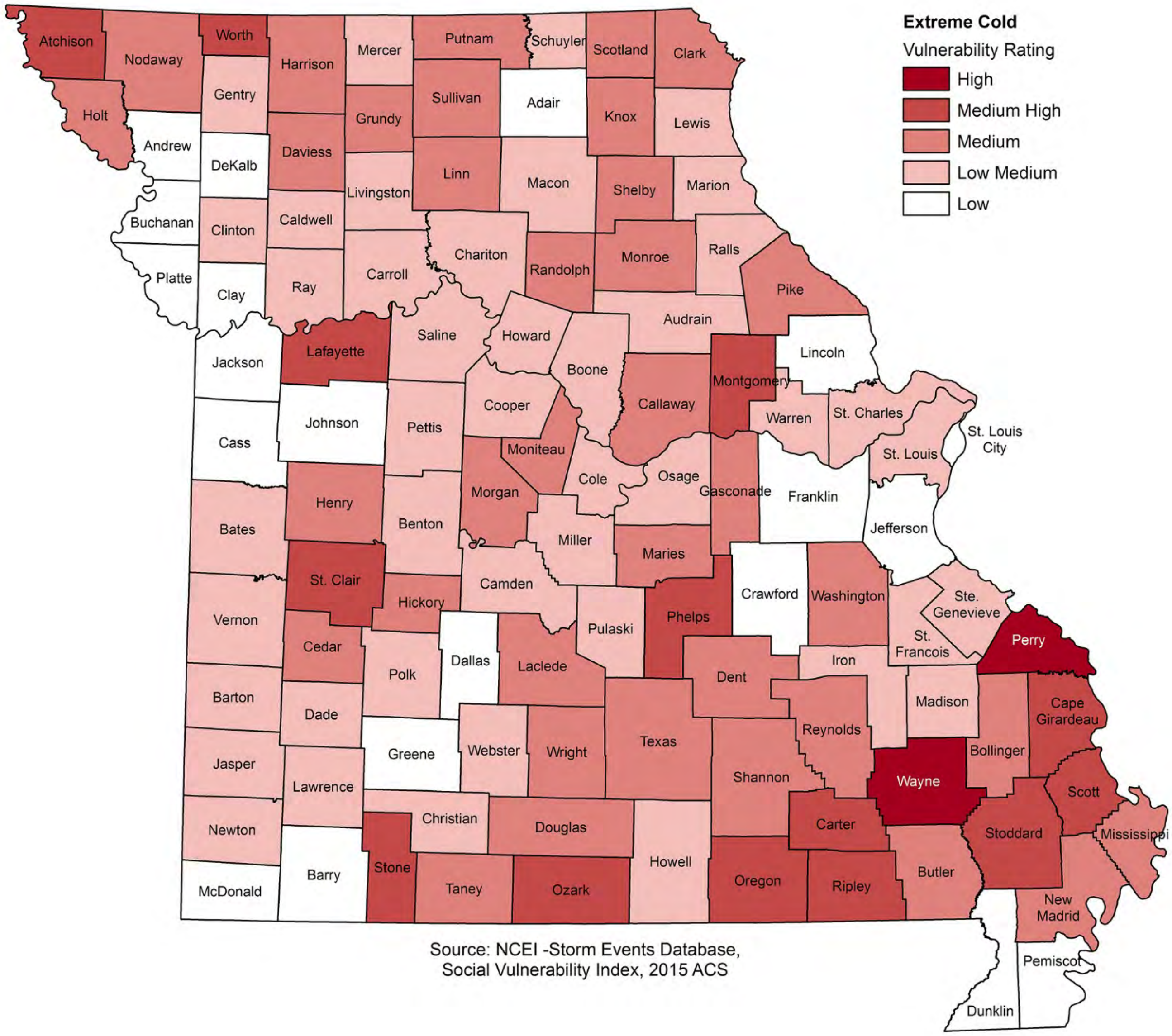
Source: NCEI -Storm Events Database,
Social Vulnerability Index, 2015 ACS

Figure 3.120. Average Annual Occurrence for Extreme Cold



Source: NCEI-Storm Events Database

Figure 3.121. Vulnerability Summary for Extreme Cold



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

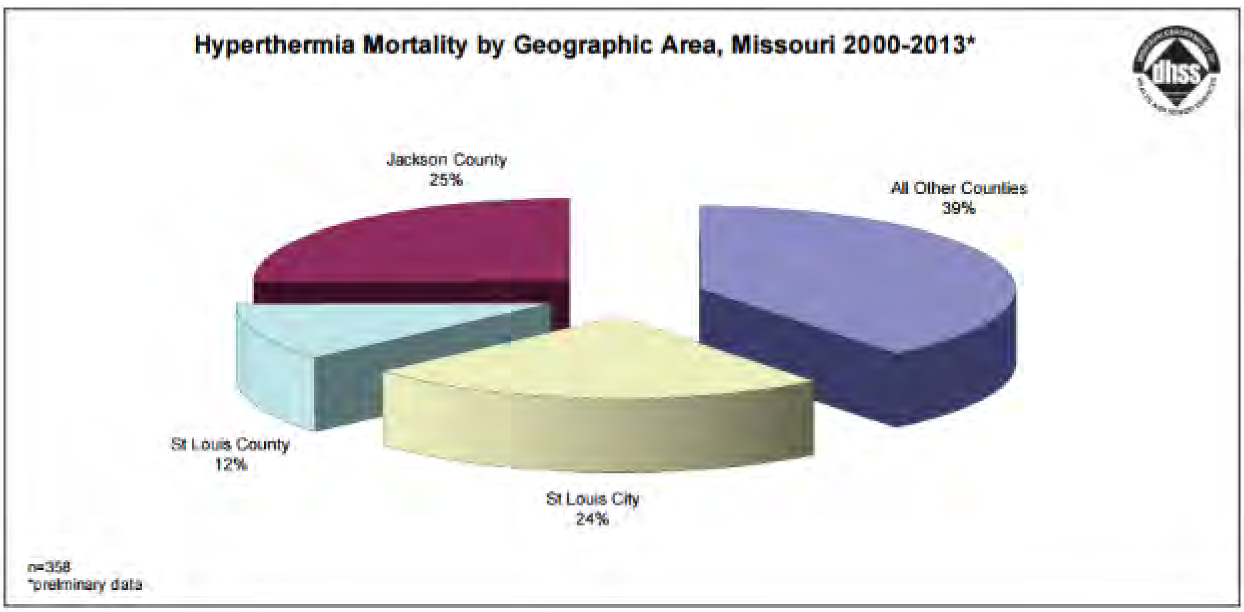
Extreme Heat/Heat Wave

The Missouri Department of Health and Senior Services reports: "In Missouri, the greatest numbers of heat-related deaths have occurred in the urban, more densely populated areas of St. Louis City, St Louis County and Jackson County (Kansas City). Of the 358 heat-related deaths reported from 2000 through 2013, there were 217 (61%) deaths in these metropolitan areas. Rural deaths accounted for 141 (39%) of the deaths. Non-Missouri residents who succumb to heat while visiting are considered cases, accounting for 11 deaths."

Half of the 358 deaths during 2000-2013 have been of people age 65 years and older. Victims in this population often live alone and have other complicating medical conditions. Also, lack of air conditioning or refusal to use it for fear of higher utility expenses contributes to the number of deaths in the senior population. There were 163 (46%) hyperthermia deaths occurring in the 5-year through 64 year-old age group. These deaths often have contributing causes such as physical activity (sports or work), complicating medical conditions, or substance abuse. Circumstances causing hyperthermia deaths in young children often involve a motor vehicle—a child left in or climbing into a parked vehicle during hot weather. From 2000-2013, there were 15 (4%) heat-related deaths of children less than five years of age.

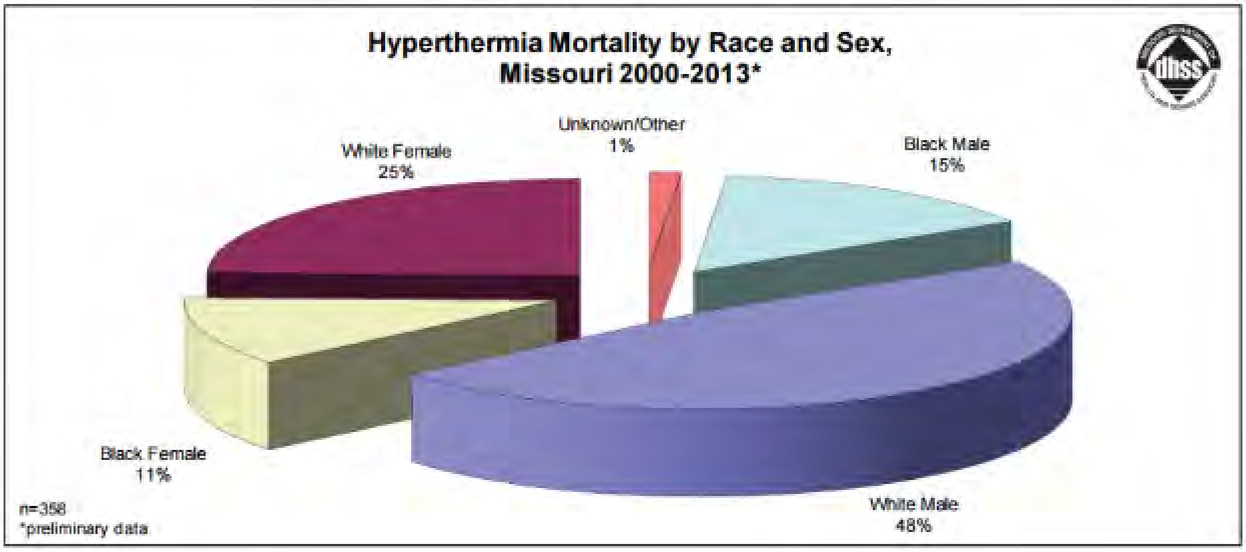
Figures 3.122 through 3.124, prepared by DHSS, present specific populations that are vulnerable to hyperthermia according to previous occurrences:

Figure 3.122. Hyperthermia Mortality by Geographic Area, Missouri 2000-2013



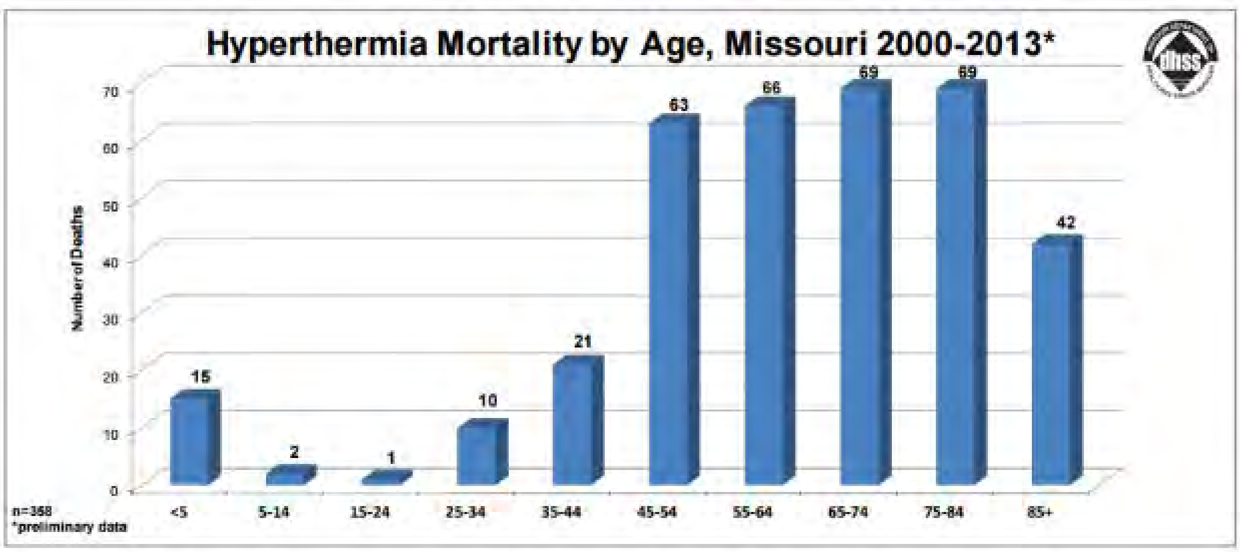
Source: Missouri DHSS, http://health.mo.gov/living/healthcondiseases/hyperthermia/pdf/hyper2.pdf

Figure 3.123. Hyperthermia Mortality by Race and Sex, Missouri 2000-2013



Source: Missouri DHSS, http://health.mo.gov/living/healthcondiseases/hyperthermia/pdf/hyper3.pdf

Figure 3.124. Hyperthermia Mortality by Age, Missouri 2000-2013

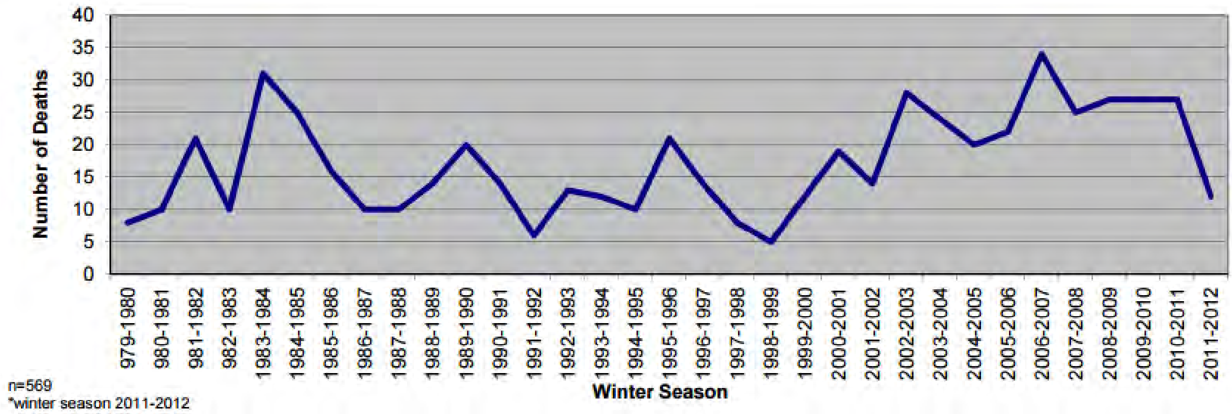


Source: Missouri DHSS, http://health.mo.gov/living/healthcondiseases/hyperthermia/pdf/hyper4.pdf

Extreme Cold

Data from the Missouri Department of Health and Senior Services shows that, in Missouri, 569 people have died from the cold during the winter months between 1979 and 2012 (see **Figure 3.125**). Data collection of hypothermia first began in Missouri in 1979.

Figure 3.125. Hypothermia Deaths, Missouri: Winter Seasons 1979–2012

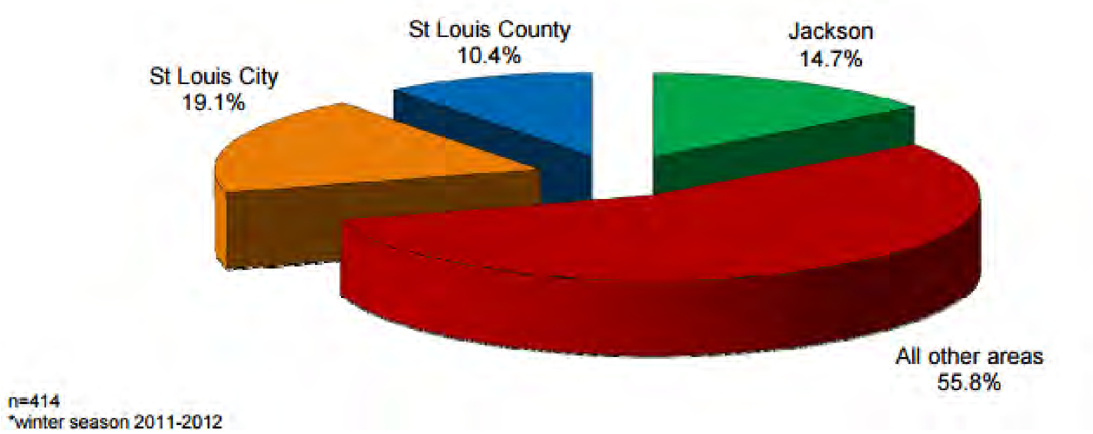


Source: Missouri DHSS, http://health.mo.gov/living/healthcondiseases/hypothermia/pdf/hypo1.pdf

The elderly are more likely to be victims of cold-related illness resulting in death. Too often, handicapped or elderly individuals fall outside their homes and are unable to reach shelter or help. During the cold weather seasons 1989–2012, a total of 414 hypothermia deaths have occurred, and 186 (44.9 percent) hypothermia deaths were of people aged 65 years and older. Substance abuse is often a contributing cause in hypothermia deaths of individuals between the ages of 25-64. From 1989 through 2012, substance abuse was a factor in 107 of the 208 (51.4%) deaths in this age group. Fortunately, deaths in people under 25-years are rare, accounting for only 19 (4.6 percent) of the total hypothermia deaths during this time frame. There have been two (0.5%) deaths in children less than five years of age. The largest number of Missouri hypothermia deaths was among males, comprising 299 (72.2%) of the 414 total cold related deaths. There were 115 (27.8%) female deaths.

In Missouri, slightly more deaths have occurred in the more rural areas of the State than in the metropolitan areas. Jackson County, St. Louis County and St. Louis City accounted for 44.2% (183) of deaths with 55.8% (231) occurring in other areas of Missouri. The geographic distribution of hypothermia deaths from 1989 to 2012 shows that there was one or more death from cold weather exposure in 83 of Missouri's 114 counties and St. Louis City, see **Figure 3.126**.

Figure 3.126. Hypothermia Deaths by Geographic Area, Missouri: 1989–2012



Source: Missouri DHSS, http://health.mo.gov/living/healthcondiseases/hypothermia/pdf/hypo9.pdf

Hazard Impact on Future Growth and Development

The four counties that rated "High" in overall vulnerability to extreme temperatures include Montgomery, Perry, Wayne, and Worth County. Perry and Wayne Counties are also experiencing population gains. With growing population and increased development, there is potential for increased losses because of the increase in exposure. Also, as the population above 65 years increases, counties will experience greater hyperthermia and hypothermia deaths in Missouri when extreme temperatures occur.

EMAP Consequence Analysis

Table 3.82. EMAP Impact Analysis: Severe Thunderstorms

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

Risk Summary

Many people do not realize how deadly a heat wave can be. In contrast to the visible, destructive, and violent nature of floods, hurricanes, and tornadoes, a heat wave is a "silent killer." Citizens of Missouri should be instructed to be aware of the warning signs of heat-related illness, such as light-headedness, mild nausea or confusion, sleepiness, or profuse sweating. Precautions include:

- Stay indoors as much as possible and limit exposure to the sun.
- Stay on the lowest floor out of the sunshine if air conditioning is not available.
- Consider spending the warmest part of the day in public buildings such as libraries, schools, movie theaters, shopping malls, and other community facilities. Circulating air can cool the body by increasing the evaporation rate of perspiration. Call 211 for the nearest location of a cooling center.
- Eat light, well-balanced meals at regular intervals. Avoid using salt tablets unless directed to do so by a physician.
- Drink plenty of water. Individuals with epilepsy or heart, kidney, or liver disease, who are on fluid-restricted diets, or who have problems with fluid retention should consult a doctor before increasing liquid intake.
- Limit intake of alcoholic beverages.
- Dress in loose-fitting, lightweight, and light-colored clothes that cover as much skin as possible.
- Protect your face and head by wearing a wide-brimmed hat. Wear sunscreen.

- Check on family, friends, and neighbors who do not have air conditioning and who spend much of their time alone.
- Never leave children or pets alone in closed vehicles.
- Avoid strenuous work during the warmest part of the day; use the buddy system when working in extreme heat; and take frequent breaks.

Although fans are less inexpensive to operate, they may not be effective, and may even be harmful when temperatures are very high. As the air temperature rises, airflow is increasingly ineffective in cooling the body until finally, at temperatures above 100°F (the exact number varies with the humidity); increasing air movement actually increases heat stress. More specifically, when the temperature of the air rises to about 100°F, the fan may be delivering overheated air to the skin at a rate that exceeds the capacity of the body to get rid of this heat, even with sweating, and the net effect is to add heat rather than to cool the body. An air conditioner, if one is available, is a much better alternative. More information on heat-related illness is available through the DHSS web page at http://health.mo.gov/living/healthcondiseases/hyperthermia/.

Extreme cold can also be life threatening. In order to avoid injury or death due to hypothermia, the following precautions may be taken:

- Call 911 for immediate medical assistance
- Gently move the victim to a warm place
- Monitor the victim's blood pressure and breathing
- If needed, give rescue breathing and CPR
- Remove wet clothing
- Dry off the victim
- Take the victim's temperature
- Warm the body core first, NOT the extremities. Warming the extremities first can cause shock.
- It can also drive cold blood toward the heart and lead to heart failure.
- Do not warm the victim too fast. Rapid warming may cause heart arrhythmias

Problem Statement:

Using Vulnerability for Extreme Heat as a key indicator, the counties with the most vulnerable populations are Worth and Montgomery. Mitigation resources allocated for extreme heat temperatures to these two counties would be the most beneficial. Using the Vulnerability for Extreme Cold as a key indicator, the counties with the most vulnerable populations are Wayne and Perry. Mitigation resources for extreme cold temperatures allocated to these two counties would be the most beneficial.

2018 risk assessment data and mapping is available through the Missouri Hazard Mitigation Viewer: http://bit.ly/MoHazardMitigationPlanViewer2018.

3.3.8. Severe Thunderstorms (includes damaging winds, hail, and lightning)

Probability	Severity
100% High Winds – 504 events per year average Hail – 604 events per year average Lightning – 11 events per year average	Moderate

Description/Location

A thunderstorm is defined as a storm that contains lightning and thunder which is caused by unstable atmospheric conditions. When the upper air which is cold sinks and the warm moist air rises, storm clouds or 'thunderheads' develop resulting in thunderstorms. This can occur singularly, in clusters or in lines. The National Weather Service defines a thunderstorm as severe if it contains hail that is one inch or the wind gusts are at 58 mph or higher (Note: the classification for hail size indicating a thunderstorm as severe was three-fourths of an inch during development of this plan. Therefore, that size range is utilized in the risk assessment.). 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. The entire State of Missouri is at risk to the damaging effects of Severe Thunderstorms. Other hazards associated with thunderstorms include: heavy rains causing flash flooding (discussed separately in Section 3.1), tornadoes (discussed separately in Section 3.4), damaging winds, hail, and lightning. This section of the risk assessment will focus on the damaging winds, hail, and lightning aspects of severe thunderstorms.

Damaging Winds

A severe thunderstorm can produce winds that can cause as much damage as a weak tornado and these winds can be life threatening. 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.

Hail

Severe thunderstorms can produce hail that can be three quarters of an inch or more in diameter and fall at speeds more than 100 mph. Hailstones of this size cause more than $1 billion in damages to properties and crops nationwide annually. Large hail can reach the size of grapefruit.

Lightning

Lightning—All thunderstorms produce lightning which often strikes outside of the area where it is raining and is known to fall more than 10 miles away from the rainfall area. Nationwide, lightning causes an average of 55 to 60 fatalities and 400 injuries each year.

Extent

Thunderstorms can occur anywhere across the state, the extent of damaging winds, hail, and lightning are measured by the following scales.

Damaging Winds

High wind is measured by the National Weather Service to define when an advisory is necessary. The High Wind definitions are listed below. For data collection and vulnerability analyses, the threshold of 40 mph was utilized.

- **High Wind** - Sustained wind speeds of 40 mph or greater lasting for 1 hour or longer, or winds of 58 mph or greater for any duration.
- **High Wind Advisory** - This product is issued by the National Weather Service when high wind speeds may pose a hazard. The criteria for this advisory varies from state to state. In Michigan, the criteria is sustained non-convective (not related to thunderstorms) winds greater than or equal to 30 mph lasting for one hour or longer, or winds greater than or equal to 45 mph for any duration.
- **High Wind Warning -** This product is issued by the National Weather Service when high wind speeds may pose a hazard or is life threatening. The criteria for this warning varies from state to state. In Michigan, the criteria is sustained non-convective (not related to thunderstorms) winds greater than or equal to 40 mph lasting for one hour or longer, or winds greater than or equal to 58 mph for any duration.
- **High Wind Watch** - This product is issued by the National Weather Service when there is the potential of high wind speeds developing that may pose a hazard or is life threatening. The criteria for this watch varies from state to state. In Michigan, the criteria is the potential for sustained non-convective (not related to thunderstorms) winds greater than or equal to 40 mph and/or gusts greater than or equal to 58 mph.

Hail

The National Weather Service classifies hail by diameter size, and corresponding everyday objects to help relay scope and severity to the population. The table below indicates the hailstone measurements utilized by the National Weather Service.

Table 3.83. Table 3-1 Hailstone Measurements

Average Diameter	Corresponding Household Object
0.25 inch	Pea
0.5 inch	Marble, Mothball
0.75 inch	Penny
0.88 inch	Nickel
1.00 inch	Quarter
1.25 inch	Half dollar
1.5 inch	Walnut, Ping-pong ball
1.75 inch	Golf-Ball
2.00 inch	Hen Egg
2.50 inch	Tennis Ball
2.75 inch	Baseball
3.00 inch	Teacup
4.00 inch	Softball
4.5 inch	Grapefruit

Source: National Weather Service, http://www.spc.noaa.gov/misc/tables/hailsize.htm

Lightning

Lightning is measured by the Lightning Activity Level (LAL) scale, created by the National Weather Service to define lightning activity into a specific categorical scale. The LAL is a common parameter that is part of fire weather forecasts nationwide. The LAL is reproduced below and the planning area is susceptible to all levels:

Table 3.84. Lightning Activity Level Scale

Level	Description
LAL 1	No thunderstorms
LAL 2	Isolated thunderstorms. Light rain will occasionally reach the ground. Lightning is very infrequent, 1 to 5 cloud to ground strikes in a five minute period
LAL 3	Widely scattered thunderstorms. Light to moderate rain will reach the ground. Lightning is infrequent, 6 to 10 cloud to ground strikes in a five minute period.
LAL 4	Scattered thunderstorms. Moderate rain is commonly produced. Lightning is frequent, 11 to 15 cloud to ground strikes in a five minute period.
LAL 5	Numerous thunderstorms. Rainfall is moderate to heavy. Lightning is frequent and intense, greater than 15 cloud to ground strikes in a five minute period.
LAL 6	Dry lightning (same as LAL 3 but without rain). This type of lightning has the potential for extreme fire activity and is normally highlighted in fire weather forecasts with a Red Flag warning.

Previous Occurrences

Damaging Winds

From January 1996 to December 2016, Missouri experienced 10,593 high wind events with damaging winds in excess of 40 mph. The table below provides annual statistics from 1996 to 2016 for events 40 miles per hour or greater.

Table 3.85. Annual High Wind Events in Missouri, 1996-2016

Year	# of Events	Deaths	Injuries	Property Damages	Crop Damages
1996	330	4	27	$17,521,510	$0
1997	256	0	11	$3,074,000	$5,000
1998	442	0	7	$ 2,587,000	$50,000
1999	337	0	11	$5,311,000	$0
2000	612	0	6	$7,304,000	$55,000
2001	560	0	37	$9,242,000	$0
2002	447	0	1	$3,877,500	$200,000
2003	529	1	10	$1,560,500	$4,850,000
2004	468	2	50	$2,924,500	$7,000
2005	652	0	5	$2,978,000	$15,500
2006	638	2	44	$4,080,600	$0
2007	357	0	3	$1,789,500	$765,000
2008	723	0	23	$60,278,850	$27,000,000

Year	# of Events	Deaths	Injuries	Property Damages	Crop Damages
2009	519	2	8	$144,452,100	$0
2010	584	0	7	$1,996,200	$0
2011	733	1	12	$6,514,250	$105,000
2012	481	2	108	$2,903,000	$0
2013	402	0	13	$2,879,750	$0
2014	469	0	12	$2,456,500	$0
2015	581	1	3	$1,644,000	$0
2016	473	0	2	$3,415,500	$0
Grand Total	**10,593**	**15**	**400**	**$288,790,260**	**$33,052,500**

Source: NCEI (http://www4.ncei.noaa.gov/cgi-win/wwcgi.dll?wwEvent~Storms); *Through 12/31/2016

Some of the more notable damaging wind events are described in additional detail below:

May 1996: A Memorial Day weekend storm identified by the NWS as a microburst caused more than $10 million in damage to homes in Lee's Summit, Missouri. The storm destroyed at least 13 homes and damaged more than 100 others in several Lee's Summit subdivisions. The city also incurred a substantial cost for debris removal and cleanup activities resulting from this devastating storm.

October 2000: High winds damaged a machine shed, Morton building; farm equipment, garage, modular home, and a frame home in Carroll County.

June 2001: A mobile home was destroyed causing two injuries in Putnam County.

May 2002: Wind gusts near 90 miles per hour caused considerable damage at a marina in St. Charles County on the Mississippi River. About 75 percent of the $2 million marina was destroyed.

June 2003: A line of strong storms moved across Clark County damaging 20,000 acres of crops (17,000 acres of corn and 3,000 acres of wheat).

August 2003: Two mobile homes were destroyed causing one injury and one fatality in Cass County. A camper trailer was overturned in Henry County causing three injuries.

July 2004: Severe winds caused damage at a campground near Truman Lake where 48 people were injured. One man that was driving his boat on the lake was killed. Other damages reported were to 35 homes and businesses.

July 2005: Intense straight line winds downed several trees in Laclede County and a few homes sustained structural damage. A roof was blown off of a large lumber yard and young boy was injured when a tree fell into his home.

March 2006: Four people were treated at a local hospital for minor injuries when their mobile home was destroyed near Portageville in New Madrid County.

April 2006: A man was killed when his mobile home was overturned in the Circle City area in Stoddard County. His son was also slightly injured. A NWS site survey indicated that straight line winds from 70 to 80 miles per hour were responsible for a path of widespread damage from Dexter east to Circle City.

July 19, 2006: Thunderstorm winds caused a partial collapse of a building that was due to be renovated in Lacledes Landing just north of the St. Louis Arch. Some of the bricks landed on the Eads Bridge causing the bridge to be temporarily closed to traffic. On the Arch grounds 120 trees were blown over and 90 others were severely damaged. At Busch Stadium, the infield tarp was torn and 30 people sustained injuries due to flying debris, including trash cans and vendor stands that were blown over within the stadium. Also, numerous trees, tree limbs, street signs and power lines were blown down throughout the City. By the time the storms moved south of the St. Louis area, an estimated 500,000 customers were without electric power.

January 2008: A powerful cold front moved rapidly southeast across southeast Missouri during the late afternoon hours. The temperature dropped 38 degrees between 4 and 8 P.M. in Cape Girardeau. An organized line of severe thunderstorms developed along the front as it crossed southeast Missouri. Widespread damaging winds accompanied the line of storms by the time they reached the Mississippi River. A couple of metal buildings were blown across fields. Approximately 20 telephone poles were snapped off.

May 2009: An intense squall line impacted extreme southeast Kansas and the Missouri Ozarks with mainly damaging winds. However, 19 tornadoes along with large hail was also observed. Due to the straight line nature of the winds, damage was widespread and intense. Sixty to 90 mph winds created widespread damage to trees, structures, and power poles across much of the county. Roof damage to homes and businesses was significant in and around the communities of Billings, Nixa, Highlandville, and Ozark. Two mobile homes were heavily damaged in Highlandville from large trees falling on them. Several power poles were knocked over in Nixa, causing damage to some of the mobile units of the school district.

August 2009: A downburst on August 7th caused extensive damage to several businesses in a strip mall on the west side of Jefferson City; damages were estimated at $1,000,000. On August 12, downburst winds did considerable damage to a 25 block area in the southwest section of Joplin. Power lines were downed with widespread power outages and nearly 60 windows were broken at the St. Johns Regional Medical Center. Damages from this event were estimated at $500,000.

August 2011: An isolated supercell drifted towards Maryville and produced winds in excess of 80 MPH. The storm resulted in $1 Million in property damages and $100 thousand in crop damages. This storm resulted in the evacuation of the Missouri State Fairgrounds, and knocked down the Missouri State Patrol's primary radio tower in St. Joseph. Luckily, there were no deaths or injuries associated with this storm.

April 2012: A supercell thunderstorm arrived between 3:40 and 3:50 PM causing localized damage near Busch Stadium. Winds up to 60 MPH collapsed a tent at a sports bar near the stadium, resulting in 100 injuries and one death.

January 2013: A line of thunderstorms intensified as it moved east across southeast Missouri. The storms increased as they moved into slightly more unstable air associated with a strengthening low level jet. The storms were aided by the approach of a strong upper level trough. Despite weak instability, winds of 90 knots in the lowest 3 kilometers coupled with extreme shear values resulted in damaging winds and isolated tornadoes with the strongest storms. Ahead of the thunderstorms, strong southerly gradient winds gusted up to 45 mph, mainly in the Cape Girardeau to Sikeston area.

April 2015: Damage at Spirit of St. Louis Airport was caused by a microburst, most likely near the end of runway 26R. The microburst began around 716 pm and likely ended shortly thereafter around 720 pm. There was heavy damage to a building about 440 yards from the end of runway 26R. The wind was estimated at up to 120 mph when it hit the building. A small garage door was blown off its track and the wind entered the building through this space. The wind peeled off the roof and compromised the structure of a second garage. The roof of this second garage mostly collapsed into the building. Roof materials were thrown as much as 150 yards from the building, including air conditioning units. The damage pattern was clearly divergent which lends to the microburst identification. Scattered minor tree, sign and roof damage was noted on the northern periphery of the microburst. Estimated wind speeds ranged from 65 to 90 mph.

Hail

From January 1996 to December 2016, Missouri experienced 12,694 hail events with hail larger than 0.75 inches in diameter. The table below provides annual statistics from 1996 to 2016.

Table 3.86. Annual Hail Events in Missouri

Year	# of Events	Deaths	Injuries	Property Damages	Crop Damages
1996	443	0	0	$266,350	$0
1997	270	0	0	$1,728,750	$510,000
1998	509	0	0	$376,780	$0
1999	254	0	0	$6,954,000	$0
2000	496	0	0	$2,076,930	$0
2001	632	0	0	$1,051,747,200	$0
2002	549	0	1	$296,650	$100,000
2003	1281	0	0	$18,550,710	$7,000
2004	680	0	0	$8,844,470	$1,026,000
2005	673	0	0	$85,130	$5,000
2006	1280	0	1	$10,088,000	$0
2007	449	0	0	$120,000	$0
2008	904	0	3	$1,957,000	$0
2009	479	0	1	$645,500	$0
2010	573	0	0	$1,271,500	$0
2011	996	0	0	$9,295,100	$0
2012	536	0	1	$300,000	$0
2013	312	0	0	$1,325,000	$0
2014	525	0	0	$335,000	$65,000
2015	467	0	0	$ 875,000	$0
2016	386	0	0	$4,175,000	$0
Grand Total	**12,694**	**0**	**7**	**$1,121,314,070**	**$1,713,000**

Source: NCEI (http://www4.ncei.noaa.gov/cgi-win/wwcgi.dll?wwEvent~Storms); *Through 12/31/2016

Some of the more notable damaging hail events are described in additional detail below:

April 2001: The Heavy Precipitation Supercell continued east from St. Charles County and moved into north St. Louis County. The storm will likely go down in history as one of the most damaging hail storms ever in the area. Hail ranged from 1 to nearly 3 inches in diameter. Thousands of homes and automobiles were damaged. Some automobile dealerships lost virtually their entire inventory. At the Ford Motor Company assembly plant in Hazelwood, all vehicles (hundreds) parked outside were damaged. In Florissant, a community of close to 70,000 people, it was estimated that almost every home suffered some type of hail damage. One insurance company reported that they were working on 20,000 vehicle and 18,000 property claims while another reported 14,600 vehicle and 14,400 property claims. As of April 18, at least 40,000 insurance claims for vehicles were taken in the St. Louis area alone. At Lambert St. Louis International Airport, 22 TWA jetliners suffered minor hail damage. The Missouri Air National Guard had at least 10 fighter aircraft severely damaged.

May 2002: A severe storm left behind a path of destruction over portions of Douglas County. An airport hangar near Ava was destroyed with debris scattered over a 200-yard area on the airport property. Several homes and cars in a subdivision north of Ava endured damage from hail along with numerous trees and power lines blown down. High winds and large hail caused nearly 60 apple trees at a local orchard to be blown down southeast of Lamar. Thousands of acres of wheat and fescue were damaged by hail in a swath six mile wide that extended from southwest of Lamar, through Barton County, and into Dade County.

May 2004: This appears to be the largest hailstone ever measured officially in the state of Missouri. It was 6 inches in diameter and 16 1/2 inches in circumference. Hail did extensive damage to roofs and crops across Linn County, and the property damage total is reflective of all the hail damage reported in the county. Property damage totaled $1.5M and crop damage totaled around $1M.

February 2006: Hail up to baseball size pounded the northwest part of St. Louis County. Several automobile dealerships suffered major damage to their vehicle inventory. Many homes from Maryland Heights, to Hazelwood, to Florissant, to Spanish Lake were going to need new roofs due to the hail damage. Many private vehicles were also damaged by the hail.

May 2008: Hail up to golf ball size fell on multiple counties. Most of the large hail fell on the south part of the town of Hannibal. About 200 cars in a manufacturing company parking lot were damaged.

April 2011: April 3, 2011, was an abnormally warm day, with high temperatures in the 80s and 90s. Record high temperatures were broken in several locations. A slow moving cold front, combined with a very strong spring storm system, produced widespread damaging thunderstorms, in the late afternoon and evening hours. Supercellular thunderstorms, developed along and ahead of the cold front, as it sank southward across the area. These thunderstorms produced extremely large hail, greater than golf balls in many areas, as well as damaging winds of 60 to 80 mph. The hardest hit areas, included the southern half of the Kansas City metropolitan area, especially in the Lee's Summit area. Numerous homes had various degrees of hail damage. Later in the evening, strong straight line winds in excess of 70 mph, produced significant damage in areas from Marshall, to Moberly, and Fayette. This hail event, left over a thousand homes in Lee's Summit with various degrees of hail damage. Damage included roofs, gutters, and siding. Automobiles at area dealerships and private automobiles also suffered numerous reports of damage. Property damage totaled around $7M.

April 2013: A long lived and long tracked high precipitation supercell produced very large and damaging hail across the area. There were reports of broken windows and damage to siding on homes. The estimated damage cost for the entire county including the city of Bolivar due to this storm will be in this event.

May 2014: Softball sized hail was reported near Crowder State Park. Power lines were also reported down in West Trenton at 5:15 PM.

April 2015: Large hail fell across Sullivan and Stanton. Most of the hail stones were between 1 and 3 inches. However, a few stones were up to 4 inches in diameter. A number of vehicles sustained major damage with broken windshields and large dents. Also, numerous homes sustained minor to moderate roof damage.

May 2016: Very large hail up to 4 inches in diameter fell across portions of St. Charles County. The hardest hit areas stretched from near Dardenne Prairie, O'Fallon and Weldon Spring east to Cottleville, St. Peters and St. Charles. Damage from this hail storm will be many millions of dollars as thousands of homes, vehicles and businesses were impacted and suffered damage. One hundred twenty cars at a car dealership near the intersection of I-64/Highway 94, sustained busted windows and lots of dents from large hail, some that were as big as baseballs. Reports of windows blown out, roofing and siding damage were common.

Lightning

From January 1996 to 2016, 226 damaging lightning events were reported in Missouri. There are likely thousands of lightning events that occur annually that go unreported either because damages did not occur or because the damages were not reported to be captured in NCEI statistics**. Table 3.87** provides annual statistics from 1996 to 2016 for reported lightning events in Missouri:

Table 3.87. Annual Reported Damaging Lightning Events in Missouri

Year	# of Events .75 in. or larger	Deaths	Injuries	Property Damages	Crop Damages
1996	9	1	1	$575,000	$0
1997	4	0	1	$11,000	$0
1998	6	0	2	$98,000	$0
1999	5	0	1	$73,000	$0
2000	10	0	4	$191,000	$0
2001	10	0	0	$320,000	$0
2002	14	5	1	$293,000	$0
2003	15	0	0	$17,000	$0
2004	11	0	0	$120,000	$0
2005	18	2	5	$810,000	$0
2006	12	0	2	$87,000	$2,000
2007	8	2	5	$227,000	$0
2008	18	0	17	$703,500	$0
2009	11	2	1	$164,000	$0
2010	18	1	7	$670,200	$0
2011	18	3	6	$509,000	$0
2012	3	0	4	$1,000	$14,000
2013	9	1	2	$557,000	$0
2014	8	1	1	$1,807,000	$0
2015	9	2	0	$1,151,000	$0
2016	10	1	0	$662,000	$0
Grand Total	**226**	**21**	**60**	**$9,046,700**	**$16,000**

Source: NCEI (http://www4.ncei.noaa.gov/cgi-win/wwcgi.dll?wwEvent~Storms); *Through 12/31/2016

Some of the more notable damaging lightning events are described in additional detail below:

August 2002: Lightning struck four individuals who got caught in an open field during a thunderstorm, and fled under a tree for shelter.

October 2005: Two men were killed and one injured by a lightning strike west of Hunnewell. The 3 men were doing road work near the bridge over the North Fork of the Salt River when the storm approached. They took shelter in a nearby shed, and when the storm appeared to let up, they headed for their vehicle. They were struck within a few feet of the vehicle. The men who died were killed instantly.

October 2008: Fourteen Buffalo High School students were injured from a large tree limb falling to the ground. This tree limb fell due to lightning striking the tree. All of the injuries from the students were minor.

May 2011: Emergency management officials relayed to the NWS that two law enforcement officers were struck by lightning while aiding in the recovery efforts from the EF-5 tornado in Joplin. Both officers were injured and taken to the hospital. One of the officers later died on June 2nd at the hospital from injuries he suffered from the lightning strike.

July 2011: A weak cool front that became stationary across the Ozarks and southeastern Kansas interacted with a very unstable airmass. Isolated strong to severe pulse storms occurred across the Ozarks which produced isolated wind damage. A small group was canoeing on the Gasconade River. As storms approached they left the river and took shelter under a tree. Lightning struck the three, killing one on site.

August 2012: A rather strong cold front and upper level shortwave moved across the Missouri Ozarks causing strong to severe storms to develop. These storms mainly produced damaging wind gusts and a several reports of large hail. Two people were injured from a lightning strike in Loring County. A mother and her daughter were struck by lightning in Hartville County. The bolt hit the house and traveled through a kitchen outlet. The two women were taken to a local hospital and were later released. No fire was caused by the bolt but some minor damage from the bolt was visible in the kitchen by charring around the outlet.

June 2014: Lightning struck a home on Woodmere Trail Court around 802 pm on June 21st. It smoldered for several hours. It became fully engulfed in flames by 2 am and that is when it was noticed by neighbors and they called 911. The family that lives there was out of town for the weekend. So no injuries reported. The house was destroyed and damage was estimated around $487,000.

May 2015: A lightning strike at the Table Rock Dam damaged two of the four hydro-power generating units. These two units remained offline for about 30 days until repaired. Each turbine unit would normally generate 50,000 Mwh of electricity. Power generated at the hydro-dam was decreased by half of normal capacity.

April 2016: A lightning struck a house in Highlandville which caused a fire. The house and property inside was a total loss.

Table 3.88 provides details on the Presidential Disaster Declarations in Missouri that included high winds or severe storms from 1975 to the present.

Table 3.88. Presidential Declarations in Missouri Including High Winds or Severe Storms, 1975 to Present

Date	Disaster No.	Incident Type	Counties Declared	Type of Assistance
May 3, 1975	DR-466	Tornadoes, High Winds, Hail	Caldwell, Newton, Macon, Shelby	PA & IA
July 21, 1976	DR-516	Severe Storms, Flooding	n/a	PA & IA
September 14, 1977	DR-538	Severe Storms, Flooding	n/a	PA & IA
May 15, 1980	DR-620	Severe Storms, Tornadoes	Pettis	IA Only
August 26, 1982	DR 667	Severe Storms, Flooding	n/a	PA & IA
December 10, 1982	DR 672	Severe Storms, Flooding	n/a	PA & IA
June 21, 1984	DR 713	Severe Storms, Flooding	n/a	PA & IA
October 14, 1986	DR 779	Severe Storms, Flooding	n/a	PA & IA

Date	Disaster No.	Incident Type	Counties Declared	Type of Assistance
May 24, 1990	DR 867	Flooding, Severe Storm	n/a	PA & IA
May 11, 1993	DR 989	Severe Storm, Flooding	Jefferson, Lincoln, Marion, Pike, Ralls, St. Charles, St. Louis, Ste. Genevieve	IA Only
July 9, 1993	DR 995	Flooding, Severe Storm	Adair, Andrew, Atchison, Audrain, Barry, Barton, Bates, Benton, Boone, Buchanan, Caldwell, Callaway, Camden, Cape Girardeau, Carroll, Cass, Chariton, Christian, Clark, Clay, Clinton, Cole, Cooper, Crawford, Dade, Dallas, Daviess, DeKalb, Douglas, Franklin, Gasconade, Gentry, Greene, Grundy, Harrison, Henry, Hickory, Holt, Howard, Howell, Jackson, Jasper, Jefferson, Johnson, Knox, Laclede, Lafayette, Lawrence, Lewis, Lincoln, Linn, Livingston, Macon, Maries, Marion, McDonald, Mercer, Miller, Mississippi, Moniteau, Monroe, Montgomery, Morgan, New Madrid, Newton, Nodaway, Osage, Ozark, Pemiscot, Perry, Pettis, Phelps, Pike, Platte, Polk, Pulaski, Putnam, Ralls, Randolph, Ray, Saline, Schuyler, Scotland, Scott, Shelby, St. Charles, St. Clair, St. Francois, St. Louis, Ste. Genevieve, Stoddard, Stone, Sullivan, Taney, Texas, Vernon, Warren, Washington, Wayne, Webster, Worth, Wright, St. Louis City*	IA
			Adair, Andrew, Atchison, Barry, Barton, Bates, Benton, Boone, Buchanan, Caldwell, Callaway, Camden, Cape Girardeau, Carroll, Cass, Chariton, Christian, Clark, Clay, Clinton, Cole, Cooper, Crawford, Dade, Dallas, Daviess, DeKalb, Douglas, Franklin, Gasconade, Gentry, Greene, Grundy, Harrison, Henry, Holt, Howard, Jackson, Jefferson, Johnson, Knox, Laclede, Lafayette, Lawrence, Lewis, Lincoln, Linn, Livingston, Macon, Maries, Marion, McDonald, Mercer, Miller, Mississippi, Moniteau, Monroe, Montgomery, Morgan, New Madrid, Newton, Nodaway, Osage, Ozark, Pemiscot, Perry, Pettis, Pike, Platte, Polk, Pulaski, Putnam, Ralls, Ray, Saline, Schuyler, Scotland, Shelby, St. Charles, St. Clair, St. Louis, Ste. Genevieve, Stone, Sullivan, Texas, Warren, Worth, Wright, St. Louis City	PA
December 1, 1993	DR 1006	Flooding, Severe Storm, Tornadoes	Bollinger, Butler, Cape Girardeau, Carter, Crawford, Dent, Franklin, Howell, Iron, Jefferson, Madison, Oregon, Perry, Pulaski, Reynolds, Ripley, Shannon, St. Francois, St. Louis, Ste. Genevieve, Stoddard, Texas, Washington, Wayne	IA
			Carter, Dent, Howell, Iron, Madison, Oregon, Perry, Reynolds, Shannon, St. Francois, Ste. Genevieve, Texas, Washington, Wayne	PA
April 21, 1994	DR 1023	Severe Storm, Flooding, Tornadoes	Barry, Callaway, Clay, Cole, Franklin, Jefferson, Lincoln, Morgan, Pemiscot, Phelps, Pulaski, Reynolds, Shannon, St. Charles, St. Louis, Vernon, Washington, St. Louis City*	IA Only
June 2, 1995	DR 1054	Severe Storm, Tornadoes, Hail, Flooding	Adair, Andrew, Atchison, Barry, Barton, Bates, Benton, Boone, Callaway, Camden, Cape Girardeau, Carroll, Cass, Chariton, Clark, Cole, Cooper, Dallas, Daviess, DeKalb, Franklin, Gasconade, Gentry, Henry, Howard, Jackson, Jasper, Jefferson, Johnson, Lafayette, Lewis, Lincoln, Linn, Macon, Maries, McDonald, Mercer, Miller, Mississippi, Moniteau, Montgomery, Morgan, New Madrid, Newton, Nodaway, Osage, Pemiscot, Perry, Ray, Saline, Scotland, Scott, St. Charles, St. Clair, St. Francois, St. Louis, Ste. Genevieve, Stone, Sullivan, Vernon, Warren, St. Louis City*	IA
			Andrew, Atchison, Barry, Bates, Benton, Boone, Callaway, Cape Girardeau, Carroll, Chariton, Clark, Cole, Cooper, Daviess, DeKalb, Franklin, Gasconade, Gentry, Henry, Howard, Jefferson, Johnson, Lafayette, Linn, Macon, McDonald, Mercer, Miller, Mississippi,	PA

Date	Disaster No.	Incident Type	Counties Declared	Type of Assistance
			Moniteau, Montgomery, Nodaway, Perry, Ray, Saline, St. Charles, St. Clair, St. Louis, Ste. Genevieve, Stone, Sullivan, Vernon, Warren	
October 14, 1998	DR 1253	Severe Storm and Flooding	Carroll, Clay, Jackson, Platte, Ray	IA
			Andrew, Barton, Caldwell, Carroll, Cedar, Chariton, Clay, Dade, DeKalb, Jackson, Linn, Livingston, Macon, Miller, Moniteau, Morgan, Platte, Polk, Ray	PA
October 19, 1998**	DR 1256	Severe Storm and Flooding	Jackson, St. Louis, St. Louis City*	IA Only
April 20, 1999	DR 1270	Severe Storms and Flooding	Andrew, Cole, Iron, Macon, Madison, Osage	IA Only
May 12, 2000	DR 1328	Severe Thunderstorms and Flash Flooding	Crawford, Franklin, Jefferson, Gasconade, St. Charles, St. Francois, St. Louis, Ste. Genevieve, Warren, Washington	IA
			Franklin, Gasconade, Jefferson	PA
May 6, 2002	DR 1412	Severe Storms and Tornadoes	Adair, Barry, Barton, Bollinger, Boone, Butler, Camden, Cape Girardeau, Carroll, Carter, Cedar, Chariton, Christian, Clark , Cooper, Crawford, Dade, Dallas, DeKalb, Dent, Douglas, Grundy, Howard, Howell, Iron, Johnson, Knox, Laclede, Lafayette, Lawrence, Lewis, Lincoln, Linn, Livingston, Macon, Madison, Maries, Marion, McDonald, Mercer, Miller, Mississippi, Oregon, Osage, Ozark, Pemiscot, Perry, Phelps, Pike, Polk, Pulaski, Ralls, Ray , Reynolds, Ripley, Ste Genevieve, Schuyler, Scotland, Scott, Shannon, Shelby, Stoddard, Stone, Sullivan, Taney, Texas, Vernon, Wayne, Webster, Wright	PA & IA
May 6, 2003	DR-1463	Tornadoes, Severe Storms, Flooding	Barry, Barton, Bates, Benton, Bollinger, Buchanan, Camden, Cape, Cass, Cedar, Christian, Clay, Clinton, Cooper, Crawford, Dade, Dallas, Dent, Douglas, Franklin, Knox, Gasconade, Girardeau, Greene, Henry, Hickory, Iron, Jackson, Jasper, Jefferson, Johnson, Laclede, Lafayette, Lawrence, McDonald, Miller, Monroe, Morgan, Newton, Osage, Perry Pettis, Phelps, Platte, Polk, Pulaski, Ray, St. Francois, St. Louis, Sainte Genevieve, Saline, Scott, St. Clair, Stoddard, Stone, Taney, Vernon, Washington, Webster	IA & PA
			Bollinger, Crawford, Franklin, Gasconade, Knox, Maries, Miller, Oregon, Osage, Pulaski, Washington	PA
June 11, 2004	D-1524	Tornadoes, Severe Storms, Flooding	Adair, Andrew, Bates, Benton, Caldwell, Carroll, Cass, Cedar, Chariton, Clay, Clinton, Daviess, DeKalb, Gentry, Grundy, Harrison, Henry, Hickory, Jackson, Johnson, Knox, Linn, Livingston, Macon, Mercer, Monroe, Nodaway, Platte, Polk, Randolph, Ray, Shelby, St. Clair, Sullivan, Vernon, and Worth	IA Only
March 16, 2006	DR-1631	Tornadoes, Severe Storms	Bates, Benton, Boone, Carroll, Cass, Cedar, Christian, Cooper, Crawford, Greene, Henry, Hickory, Howard, Iron, Jefferson, Johnson, Lawrence, Lincoln, Mississippi, Monroe, Montgomery, Morgan, New Madrid, Newton, Perry, Pettis, Phelps, Putnam, Randolph, St. Clair, Ste. Genevieve, Scott, Saline, Taney, Vernon, Webster, Wright	IA
			Bates, Bollinger, Benton, Boone, Carroll, Cedar, Christian, Davies, Greene, Henry, Hickory, Howard, Iron, Lawrence, Monroe, Montgomery, Morgan, Perry, Pettis, Putnam, Randolph, Ray, Saline, St. Clair, Vernon, Washington, Webster, Wright	PA
April 5, 2006	DR-1635	Tornadoes, Severe Storms	Andrew, Butler, Dunklin, Pemiscot, St. Francois, Stoddard	IA
			Jefferson, Andrew, Pettis, Pemiscot, St. Francis	PA

Date	Disaster No.	Incident Type	Counties Declared	Type of Assistance
November 2, 2006	DR-1667	Severe Storms	St. Louis City*	PA Only
July 21, 2006	EM-3267	Tornadoes, Severe Storms	St. Louis County, St. Louis City*, Dent, Iron, Jefferson, St. Charles, Washington	PA
June 11, 2007	DR-1708	Severe Storms/Flooding	Atchison, Nodaway, Holt, Worth, Gentry, Harrison, Mercer, Gundy, Sullivan, Linn, Livingston, Daviess, DeKalb, Andrew, Buchanan, Clinton, Caldwell, Carroll, Chariton, Howard, Saline, Ray, Lafayette, Platte, Clay, Jackson, Cass, Bates, Morgan, Osage	IA & PA
September 21, 2007	DR-1728	Severe Storms/Flooding	Dade, Lawrence, Polk, Greene, Dallas, Webster, Laclede	PA
February 5, 2008	DR-1742	Severe Storms Tornadoes, and Flooding	Newton, McDonald, Barry, stone, Webster, Dallas, Laclede, Phelps, Maries	PA
March 19, 2008	DR-1749	Severe Storms and Flooding	Bollinger, Carter, Christian, Franklin, Greene, Iron, Jasper, Jefferson, Maries, Newton, Oregon, Phelps, Pulaski, Reynolds, St. Francois, Stone, Texas, Washington, and Wayne Counties	IA
			Audrain, Barry, Barton, Boone, Bollinger, Butler, Callaway, Camden, Cape Girardeau, Carter, Cedar, Christian, Cole, Cooper, Crawford, Dade, Dallas, Dent, Douglas, Dunklin, Franklin, Gasconade, Greene, Hickory, Howard, Howell, Iron, Jasper, Jefferson, Laclede, Lawrence, Lincoln, Madison, Maries, McDonald, Miller, Mississippi, Montgomery, Moniteau, Morgan, New Madrid, Newton, Oregon, Osage, Ozark, Pemiscot, Perry, Phelps, Pike, Polk, Pulaski, Reynolds, Ripley, St. Charles, St. Clair, St. Francois, St. Louis, Ste. Genevieve, Shannon, Scott, Stoddard, Stone, Taney, Texas, Vernon, Warren, Washington, Wayne, Webster, and Wright	PA
May 23, 2008	DR-1760	Severe Storms and Tornadoes	Jasper, Newton and Barry	IA
June 25, 2008	DR-1773	Severe Storms and Flooding	Adair, Andrew, Callaway, Cass, Chariton, Clark, Gentry, Greene, Harrison, Holt, Johnson, Lewis, Lincoln, Linn, Livingston, Macon, Marion, Monroe, Nodaway, Pike, Putnam, Ralls, St. Charles, Stone, Taney, Vernon, and Webster	IA
			Adair, Andrew, Atchison, Audrain, Bates, Callaway, Cape Girardeau, Carroll, Chariton, Clark, Christian, Daviess, Gentry, Grundy, Harrison, Howard, Holt, Knox, Lewis, Lincoln, Linn, Macon, Marion, Miller, Mississippi, Monroe, Morgan, Nodaway, Perry, Pettis, Pike, Putnam, Ralls, Ray, Shelby, St. Charles, Stone, Sullivan, Taney, and Vernon Counties for Public Assistance. Andrew, Atchison, Buchanan, Cape Girardeau, Clark, Holt, Jefferson, Lewis, Lincoln, Livingston, Marion, Mercer, Mississippi, New Madrid, Nodaway, Pemiscot, Perry, Pike, Platte, Polk, Ralls, Randolph, Saline, Schuyler, Scotland, St. Charles, St. Louis, Ste. Genevieve, Scott, the Independent City of St. Louis, Webster, and Worth	
November 13, 2008	DR-1809	Severe Storms, Flooding and Tornadoes	Boone, Callaway, Chariton, Howell, Jefferson, Lewis, Lincoln, Linn, Marion, Montgomery, Osage, Schuyler, St. Charles, St. Louis, Stone, Taney, Texas, and Webster Counties and the Independent City of St. Louis	IA
			Adair, Audrain, Barry, Bollinger, Butler, Callaway, Cape Girardeau, Carter, Chariton, Christian, Clark, Crawford, Dent, Douglas, Dunklin, Howard, Howell, Knox, Lewis, Lincoln, Linn, Madison, Maries, Marion, Miller, Mississippi, New Madrid, Oregon, Ozark, Perry, Ralls, Randolph, Ray, Reynolds, Ripley, Schuyler, Scotland, Scott, Shannon,	PA

Date	Disaster No.	Incident Type	Counties Declared	Type of Assistance
			Shelby, St. Genevieve, Stoddard, Stone, Sullivan, Taney, Texas, Wayne, Webster, and Wright	
June 19, 2009	DR-1847	Severe Storms, Tornadoes, and Flooding	Adair, Barry, Barton, Bollinger, Cape Girardeau, Christian, Dade, Dallas, Dent, Douglas, Greene, Howell, Iron, Jasper, Jefferson, Laclede, Lawrence, Madison, Newton, Ozark, Polk, Reynolds, Ripley, Saint Francois, Shannon, Texas, Washington and Webster.	IA
			Adair, Barton, Bollinger, Camden, Cape Girardeau, Cedar, Crawford, Dade, Dallas, Dent, Douglas, Greene, Grundy, Hickory, Howell, Iron, Jasper, Knox, Laclede, Lewis, Livingston, Madison, Maries, Marion, Miller, Newton, Oregon, Ozark, Perry, Phelps, Polk, Pulaski, Ray, Reynolds, Ripley, Saint Francois, Sainte Genevieve, Saline, Shannon, Shelby, Stone, Sullivan, Texas, Vernon, Washington, Wayne, Webster and Wright.	PA
June 19, 2009	DR-1847	Severe Storms, Tornadoes, and Flooding	Adair, Barry, Barton, Bollinger, Cape Girardeau, Christian, Dade, Dallas, Dent, Douglas, Greene, Howell, Iron, Jasper, Jefferson, Laclede, Lawrence, Madison, Newton, Ozark, Polk, Reynolds, Ripley, St. Francois, Shannon, Texas, Washington, Webster	IA
			Adair, Barton, Bollinger, Camden, Cape Girardeau, Cedar, Crawford, Dade, Dallas, Dent, Douglas, Greene, Hickory, Howell, Iron, Jasper, Knox, Laclede, Lewis, Madison, Maries, Marion, Miller, Newton, Oregon, Ozark, Perry, Phelps, Polk, Pulaski, Ray, Reynolds, Ripley, St. Francois, Ste. Genevieve, Saline, Shannon, Shelby, Stone, Sullivan, Texas, Vernon, Washington, Wayne, Webster, Wright	PA
August 17, 2010	DR-1934	Severe Storms, Flooding, and Tornadoes	Adair, Andrew, Atchison, Buchanan, Caldwell, Carroll, Cass, Chariton, Clark, Clinton, Daviess, DeKalb, Gentry, Grundy, Harrison, Holt, Howard, Jackson, Knox, Lafayette, Lewis, Linn, Livingston, Marion, Mercer, Monroe, Nodaway, Perry, Pike, Putnam, Ralls, Ray, Schuyler, Scotland, Shelby, Sullivan and Worth.	PA
May 9, 2011	DR-1980	Severe Storms, Flooding,and Tornadoes	Bollinger, Butler, Cape Girardeau, Carter, Dunklin, Howell, Jasper, Lawrence, McDonald, Mississippi, New Madrid, Newton, Pemiscot, Pettis, Phelps County, Pulaski, Reynolds, Ripley, Saint Francois, Saint Louis, Scott, Stoddard, Stone, Taney and Wayne.	IA
			Barry, Bollinger, Butler Conty, Cape Girardeau, Carter, Christian, Douglas, Dunklin, Howell, Iron, Jasper, Madison, McDonald, Miller, Mississippi, New Madrid, Newton, Oregon, Ozark, Pemiscot, Perry, Pettis, Polk, Reynolds, Ripley, Saint Francois, Saint Louis, Sainte Genevieve, Scott, Shannon, Stoddard, Stone, Taney, Texas, Washington, Wayne, Webster and Wright.	PA
July 18, 2013	DR-4130	Severe Storms, Straight-line Winds, Tornadoes, and Flooding	Barton, Callaway, Cape Girardeau, Chariton, Clark, Howard, Iron, Knox, Lewis, Lincoln, Maries, Marion, Miller, Montgomery, Osage, Perry, Pike, Putnam, Ralls, Saint Charles, Saint Louis, Sainte Genevieve, Scotland, Shelby, Stoddard, Sullivan, Texas and Webster.	PA
September 6, 2013	DR-4144	Severe Storms, Straight-line Winds, and Flooding	Barry, Camden, Cedar, Dade, Dallas, Laclede, Maries, McDonald, Miller, Osage, Ozark, Phelps, Pulaski, Shannon, Taney, Texas, Webster and Wright.	PA
October 31, 2014	DR-4200	Severe Storms, Tornadoes, Straight-line Winds, and Flooding	Adair, Andrew, Atchison, Daviess, Gentry, Grundy, Harrison, Holt, Knox, Lewis, Linn, Livingston, Macon, Mercer, Nodaway, Putnam, Ralls, Shelby, Sullivan and Worth.	PA

Date	Disaster No.	Incident Type	Counties Declared	Type of Assistance
August 7, 2015	DR-4238	Severe Storms, Tornadoes, Straight-line Winds, and Flooding	Adair, Andrew, Atchison, Audrain, Barry, Bates, Benton, Buchanan, Caldwell, Camden, Chariton, Christian, Clark, Clay, Clinton, Cole, Crawford, Dade, Dallas, Daviess, DeKalb, Douglas, Gentry, Harrison, Henry, Hickory, Holt, Jackson, Jefferson, Johnson, Knox, Laclede, Lafayette, Lewis, Lincoln, Linn, Livingston, Macon, Maries, Marion, McDonald, Miller, Moniteau, Monroe, Montgomery, Morgan, New Madrid, Nodaway, Oregon, Osage, Ozark, Pemiscot, Perry, Pettis, Phelps, Pike, Platte, Polk, Putnam, Ralls, Ray, Saline, Schuyler, Scotland, Shannon, Shelby, St. Clair, Ste. Genevieve, Stone, Sullivan, Taney, Texas, Washington, Webster, Worth and Wright.	PA
January 21, 2016	DR-4250	Severe Storms, Tornadoes, Straight-line Winds, and Flooding	Barry, Barton, Camden, Cape Girardeau, Cole, Crawford, Franklin, Gasconade, Greene, Hickory, Jasper, Jefferson, Laclede, Lawrence, Lincoln, Maries, McDonald, Morgan, Newton, Osage, Phelps, Polk, Pulaski, Saint Louis, Scott, St. Charles, St. Francois, Ste. Genevieve, Stone, Taney, Texas, Webster and Wright.	IA
			Barry, Bollinger, Camden, Cape Girardeau, Cedar, Crawford, Dade, Dallas, Douglas, Dunklin, Franklin, Gasconade, Greene, Howell, Iron, Jasper, Jefferson, Lawrence, Lincoln, McDonald, Mississippi, New Madrid, Newton, Ozark, Pemiscot, Perry, Phelps, Pulaski, Reynolds, Saint Louis City, Saint Louis, Scott, Shannon, St. Charles, St. Clair, Ste. Genevieve, Stoddard, Stone, Taney, Texas, Washington and Webster.	PA

Source: Federal Emergency Management Agency, State Emergency Management Agency
Note: *IA denotes Individual Assistance; PA denotes Public Assistance

According to the USDA Risk Management Agency, insured crop losses throughout the State of Missouri as a result of hail conditions for the 21-year period of 1998 – 2016 totaled $32,067,155. During this same period, insured crop losses for wind/excess wind were $13,699,954.

Probability of Future Hazard Events

Severe thunderstorm events are a common occurrence throughout Missouri. The probability has been determined to be 100% based on the NCEI data for the 21-year period from 1996-2016, resulting in the following annual average events:

- High wind - average 504 events per year
- Hail – average 604 hail events per year
- Lightning - average of 11 events per year

Severe thunderstorms and the associated wind, hail and lightning also cause deaths and injuries annually in the United States. During the 21-year period from 1996-2016, there were a combined 57 deaths and 527 injuries reported to NCEI resulting from high winds, hail, and lightning in Missouri. This translates to an annualized occurrence of 2.7 deaths and 25 injuries. With so many variables involved in death and injury occurrences, it is difficult to estimate future occurrences. However, it is noted that death and injury do occur annually in Missouri as a result of the severe thunderstorm hazard.

Changing Future Conditions Considerations

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

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

State Vulnerability Overview

The method used to determine vulnerability to severe thunderstorms across Missouri was statistical analysis of data from several sources: National Centers for Environmental Information (NCEI) storm events data (1996 to December 31, 2016), HAZUS Building Exposure Value data, housing density and mobile home data from the U.S. Census (2015 ACS), and the calculated Social Vulnerability Index for Missouri Counties from the Hazards and Vulnerability Research Institute in the Department of Geography at the University of South Carolina.

From the statistical data collected, six factors were considered in determining overall vulnerability to lightning as follows: housing density, building exposure, percentage of mobile homes, social vulnerability, likelihood of occurrence, and average annual property loss. Based on natural breaks in the statistical data, a rating value of 1 through 5 was assigned to each factor. These rating values correspond to the following descriptive terms:

1) Low
2) Low-medium
3) Medium
4) Medium-high
5) High

Table 3.89 provides the factors considered and the ranges for the rating values assigned.

Table 3.89. Ranges for Severe Thunderstorm Vulnerability Factor Ratings

Factors Considered	Low (1)	Low Medium (2)	Medium (3)	Medium High (4)	High (5)
Common Factors					
Housing Density (# per sq. mile)	4.11-44.23	44.24-134.91	134.92-259.98	259.99-862.69	862.70-2836.23
Building Exposure ($)	$269,532-$3,224,641	$3,224,642-$8,792,829	$8,792,830-$22,249,768	$22,249,769-$46,880,213	$46,880,214-$138,887,850
Percent Mobile Homes	0.2-4.5%	4.6-8.8%	8.9-14%	14.1-21.2%	21.3-33.2%
Social Vulnerability	1	2	3	4	5
					Wind
Likelihood of Occurrence (# of events/ yrs. of data)	0.90 - 2.90	2.91 - 4.57	4.58 - 7.00	7.01 - 12.05	12.06 - 20.86
Average Annual Property Loss (annual property loss/ yrs of data)	$0.00 – $81,047.62	$81,047.63 – $200,428.57	$200,428.58 – $363,500.00	$363,500.01 – $837,242.86	$837,242.87 – $2,481,809.52
					Hail
Likelihood of Occurrence (# of events/ yrs. of data)	1.19 - 2.76	2.77 - 4.86	4.87 - 7.81	7.82 - 12.38	12.39 - 18.10
Average Annual Property Loss (annual property loss/ yrs. of data)	$0.00 - $41,547.62	$41,547.63 – $171,980.95	$171,980.96 – $467,857.14	$467,857.15 – $9,714,523.81	$9,714,523.82 – $40,594,285.71
					Lightning
Likelihood of Occurrence (# of events/ yrs. of data)	0-.05	.06-0.14	0.15-0.29	0.30-0.43	0.44-0.67
Average Annual Property Loss (annual property loss/ yrs. Of data)	$0-$476.19	$476.20-$1,904.76	$1,904.77-$7,476.19	$7,476.20-$13,142.86	$13,142.87-$57,000

Once the ranges were determined and applied to all factors considered in the analysis for wind, hail, and lightning, they were rated individually and factored together to determine an overall vulnerability rating for thunderstorms. **Table 3.90** provides the calculated ranges applied to determine overall vulnerability of Missouri counties to severe thunderstorms.

Table 3.90. Ranges for Severe Thunderstorm Combined Vulnerability Rating

	Low (1)	Low Medium (2)	Medium (3)	Medium High(4)	High (5)
Severe Thunderstorm Combined Vulnerability	12-16	17-19	20-23	24-29	30-36

Table 3.91. Housing Density, Building Exposure, SOVI, and Mobile Home Data by County

County	Total Building Exposure (Hazus)	Building Exposure Rating	Housing Density	Housing Density Rating	SOVI Ranking	SOVI Ranking Rating	Percent Mobile Homes	Percent Mobile Homes Rating
Adair	$2,599,614,000	1	19.93	1	Medium	3	8.1	2
Andrew	$1,724,819,000	1	16.88	1	Medium Low	2	7.6	2
Atchison	$806,754,000	1	5.42	1	Medium High	4	3.5	1
Audrain	$2,689,090,000	1	15.62	1	Medium High	4	7.6	2
Barry	$3,736,121,000	2	22.40	1	Medium	3	16.1	4
Barton	$1,414,960,000	1	9.42	1	Medium	3	10.3	3
Bates	$1,650,150,000	1	9.36	1	Medium	3	12.4	3
Benton	$2,478,458,000	1	19.93	1	Medium High	4	22.6	5
Bollinger	$1,035,129,000	1	9.45	1	Medium Low	2	18.9	4
Boone	$18,473,209,000	3	105.32	2	Low	1	3.9	1
Buchanan	$10,579,076,000	3	94.32	2	Medium	3	4.5	1
Butler	$4,144,110,000	2	28.30	1	Medium High	4	13.8	3
Caldwell	$984,103,000	1	10.80	1	Medium	3	16	4
Callaway	$4,410,445,000	2	22.21	1	Medium Low	2	15	4
Camden	$8,325,943,000	2	62.86	2	Medium High	4	7.6	2
Cape Girardeau	$8,792,829,000	2	56.87	2	Medium	3	7.1	2
Carroll	$1,199,939,000	1	6.63	1	Medium	3	9.4	3
Carter	$519,266,000	1	6.38	1	Medium High	4	22.3	5
Cass	$10,922,958,000	3	58.01	2	Low	1	5.3	2
Cedar	$1,307,607,000	1	15.13	1	Medium High	4	14.6	4
Chariton	$938,756,000	1	5.53	1	Medium High	4	11.2	3
Christian	$7,747,900,000	2	57.48	2	Medium Low	2	5.7	2
Clark	$709,999,000	1	6.84	1	Medium Low	2	16.2	4
Clay	$27,589,080,000	4	237.97	3	Medium Low	2	2.1	1
Clinton	$2,282,850,000	1	21.20	1	Medium	3	5.5	2
Cole	$10,724,282,000	3	82.94	2	Medium Low	2	3.2	1
Cooper	$1,797,081,000	1	13.21	1	Medium Low	2	6.6	2
Crawford	$2,389,455,000	1	16.06	1	Medium	3	14.8	4
Dade	$738,641,000	1	8.05	1	Medium	3	13.1	3
Dallas	$1,358,763,000	1	14.04	1	Medium	3	19.2	4
Daviess	$958,602,000	1	7.42	1	Medium	3	11.4	3
DeKalb	$1,090,102,000	1	10.21	1	Low	1	14.6	4
Dent	$1,451,544,000	1	9.65	1	Medium High	4	20.1	4
Douglas	$1,047,849,000	1	7.95	1	Medium	3	16.9	4
Dunklin	$2,976,060,000	1	26.53	1	High	5	10.1	3
Franklin	$11,417,093,000	3	47.40	2	Medium Low	2	9.6	3

County	Total Building Exposure (Hazus)	Building Exposure Rating	Housing Density	Housing Density Rating	SOVI Ranking	SOVI Ranking Rating	Percent Mobile Homes	Percent Mobile Homes Rating
Gasconade	$1,888,630,000	1	15.77	1	Medium	3	10.6	3
Gentry	$689,499,000	1	6.52	1	Medium High	4	9.5	3
Greene	$32,106,732,000	4	189.79	3	Medium	3	3.3	1
Grundy	$1,175,303,000	1	11.49	1	Medium High	4	6.6	2
Harrison	$1,024,720,000	1	6.07	1	Medium High	4	9.4	3
Henry	$2,536,896,000	1	15.64	1	Medium	3	11.6	3
Hickory	$865,580,000	1	16.92	1	High	5	32.9	5
Holt	$622,760,000	1	6.01	1	Medium	3	7.8	2
Howard	$1,086,442,000	1	9.79	1	Medium Low	2	17	4
Howell	$3,550,892,000	2	19.47	1	Medium	3	16	4
Iron	$978,688,000	1	9.62	1	Medium High	4	18.7	4
Jackson	$89,309,906,000	5	519.48	4	Medium	3	0.9	1
Jasper	$12,070,483,000	3	80.05	2	Medium	3	5.6	2
Jefferson	$22,249,768,000	3	134.91	2	Low	1	11.2	3
Johnson	$6,044,509,000	2	26.18	1	Low	1	10.3	3
Knox	$438,423,000	1	4.51	1	Medium High	4	12.4	3
Laclede	$3,218,581,000	1	20.62	1	Medium	3	18.5	4
Lafayette	$3,841,393,000	2	23.42	1	Medium Low	2	10.2	3
Lawrence	$3,495,760,000	2	27.09	1	Medium	3	11.7	3
Lewis	$995,873,000	1	8.94	1	Medium	3	19.3	4
Lincoln	$4,719,921,000	2	33.63	1	Low	1	18.3	4
Linn	$1,551,785,000	1	10.36	1	Medium High	4	9.9	3
Livingston	$1,711,120,000	1	12.66	1	Medium High	4	7.3	2
Macon	$1,634,837,000	1	9.52	1	Medium High	4	12.1	3
Madison	$1,135,602,000	1	12.03	1	Medium High	4	13.2	3
Maries	$955,863,000	1	8.71	1	Medium	3	16.9	4
Marion	$3,224,641,000	1	29.49	1	Medium High	4	5.3	2
McDonald	$1,683,620,000	1	18.26	1	Medium	3	24.2	5
Mercer	$401,520,000	1	4.67	1	Medium High	4	11.2	3
Miller	$2,404,472,000	1	21.50	1	Medium High	4	13.5	3
Mississippi	$1,114,534,000	1	13.86	1	Medium High	4	7.6	2
Moniteau	$1,508,058,000	1	14.80	1	Medium Low	2	8.8	2
Monroe	$979,485,000	1	7.43	1	Medium	3	16.5	4
Montgomery	$1,397,445,000	1	11.45	1	Medium High	4	10.6	3
Morgan	$2,872,295,000	1	25.80	1	Medium High	4	18.8	4
New Madrid	$1,765,289,000	1	12.64	1	High	5	11.4	3
Newton	$5,509,504,000	2	38.96	1	Medium Low	2	14.6	4

County	Total Building Exposure (Hazus)	Building Exposure Rating	Housing Density	Housing Density Rating	SOVI Ranking	SOVI Ranking Rating	Percent Mobile Homes	Percent Mobile Homes Rating
Nodaway	$2,447,800,000	1	10.96	1	Medium	3	6.7	2
Oregon	$891,037,000	1	6.89	1	Medium High	4	18.7	4
Osage	$1,611,790,000	1	10.85	1	Low	1	8.8	2
Ozark	$926,358,000	1	7.55	1	Medium	3	20.2	4
Pemiscot	$1,642,290,000	1	16.48	1	High	5	9.7	3
Perry	$2,233,009,000	1	18.14	1	Medium Low	2	8	2
Pettis	$4,468,128,000	2	26.68	1	Medium	3	5.8	2
Phelps	$4,743,488,000	2	29.35	1	Medium Low	2	10.2	3
Pike	$1,861,578,000	1	11.68	1	Medium Low	2	11	3
Platte	$11,360,168,000	3	94.90	2	Low	1	0.7	1
Polk	$2,708,704,000	1	20.98	1	Medium	3	11.6	3
Pulaski	$5,334,660,000	2	33.60	1	Low	1	9.7	3
Putnam	$532,020,000	1	5.73	1	Medium	3	7.4	2
Ralls	$1,155,646,000	1	10.93	1	Medium Low	2	14.3	4
Randolph	$2,425,165,000	1	22.11	1	Medium Low	2	13.7	3
Ray	$2,537,055,000	1	17.52	1	Medium Low	2	5.4	2
Reynolds	$669,647,000	1	4.97	1	Medium High	4	20.2	4
Ripley	$1,131,335,000	1	10.40	1	Medium High	4	25.1	5
Saline	$2,437,646,000	1	13.35	1	Medium	3	6.3	2
Schuyler	$401,800,000	1	6.79	1	Medium	3	9.4	3
Scotland	$541,487,000	1	5.38	1	Medium High	4	7	2
Scott	$4,036,288,000	2	40.47	1	Medium	3	12.8	3
Shannon	$678,728,000	1	4.11	1	Medium	3	16.5	4
Shelby	$786,622,000	1	6.37	1	Medium	3	10.2	3
St. Charles	$41,845,005,000	4	259.98	3	Low	1	2.9	1
St. Clair	$936,097,000	1	8.36	1	Medium High	4	23.9	5
St. Francois	$6,180,166,000	2	64.59	2	Medium Low	2	17	4
St. Louis	$138,887,850,000	5	862.69	4	Medium Low	2	0.2	1
St. Louis City	$46,880,213,000	4	2836.23	5	High	5	0.4	1
Ste. Genevieve	$2,163,144,000	1	17.27	1	Medium Low	2	12.1	3
Stoddard	$2,989,130,000	1	16.52	1	Medium	3	11.5	3
Stone	$3,936,498,000	2	44.23	1	Medium High	4	15.8	4
Sullivan	$624,603,000	1	5.16	1	Medium High	4	10	3
Taney	$6,120,612,000	2	47.41	2	High	5	13.4	3
Texas	$2,293,426,000	1	9.86	1	Medium	3	21.2	4
Vernon	$2,251,400,000	1	11.47	1	Medium High	4	11	3
Warren	$3,478,576,000	2	34.75	1	Medium Low	2	13	3

County	Total Building Exposure (Hazus)	Building Exposure Rating	Housing Density	Housing Density Rating	SOVI Ranking	SOVI Ranking Rating	Percent Mobile Homes	Percent Mobile Homes Rating
Washington	$1,730,986,000	1	14.34	1	Medium	3	33.2	5
Wayne	$1,256,590,000	1	10.54	1	Medium High	4	30.6	5
Webster	$2,782,115,000	1	24.42	1	Medium Low	2	14	3
Worth	$269,532,000	1	4.78	1	Medium High	4	8.3	2
Wright	$1,602,331,000	1	12.66	1	Medium	3	14.7	4

Table 3.92 provides the additional data obtained from the National Centers for Environmental Information to complete the overall vulnerability analysis.

Table 3.92. Number of High Wind, Hail, and Lightning Events, Likelihood of Occurrence, and Associated Ratings

County	HIGH WIND			HAIL			LIGHTNING		
	Total Number of Events	Likelihood of Occurrence	Likelihood of Occurrence Rating	Total Number of Events	Likelihood of Occurrence	Likelihood of Occurrence Rating	Total Number of Events	Likelihood of Occurrence	Likelihood of Occurrence Rating
Adair	64	3.048	2	70	3.333	2	1	0.048	1
Andrew	53	2.524	1	80	3.810	2	0	0.000	1
Atchison	79	3.762	2	114	5.429	3	0	0.000	1
Audrain	79	3.762	2	58	2.762	1	3	0.143	2
Barry	160	7.619	4	193	9.190	4	1	0.048	1
Barton	110	5.238	3	142	6.762	3	1	0.048	1
Bates	55	2.619	1	127	6.048	3	1	0.048	1
Benton	105	5.000	3	108	5.143	3	2	0.095	2
Bollinger	70	3.333	2	71	3.381	2	1	0.048	1
Boone	137	6.524	3	243	11.571	4	14	0.667	5
Buchanan	87	4.143	2	112	5.333	3	0	0.000	1
Butler	98	4.667	3	84	4.000	2	1	0.048	1
Caldwell	53	2.524	1	71	3.381	2	7	0.333	4
Callaway	96	4.571	2	134	6.381	3	0	0.000	1
Camden	121	5.762	3	151	7.190	3	0	0.000	1
Cape Girardeau	119	5.667	3	82	3.905	2	9	0.429	4
Carroll	45	2.143	1	79	3.762	2	0	0.000	1
Carter	48	2.286	1	45	2.143	1	1	0.048	1
Cass	134	6.381	3	244	11.619	4	1	0.048	1
Cedar	86	4.095	2	102	4.857	2	1	0.048	1
Chariton	47	2.238	1	67	3.190	2	0	0.000	1

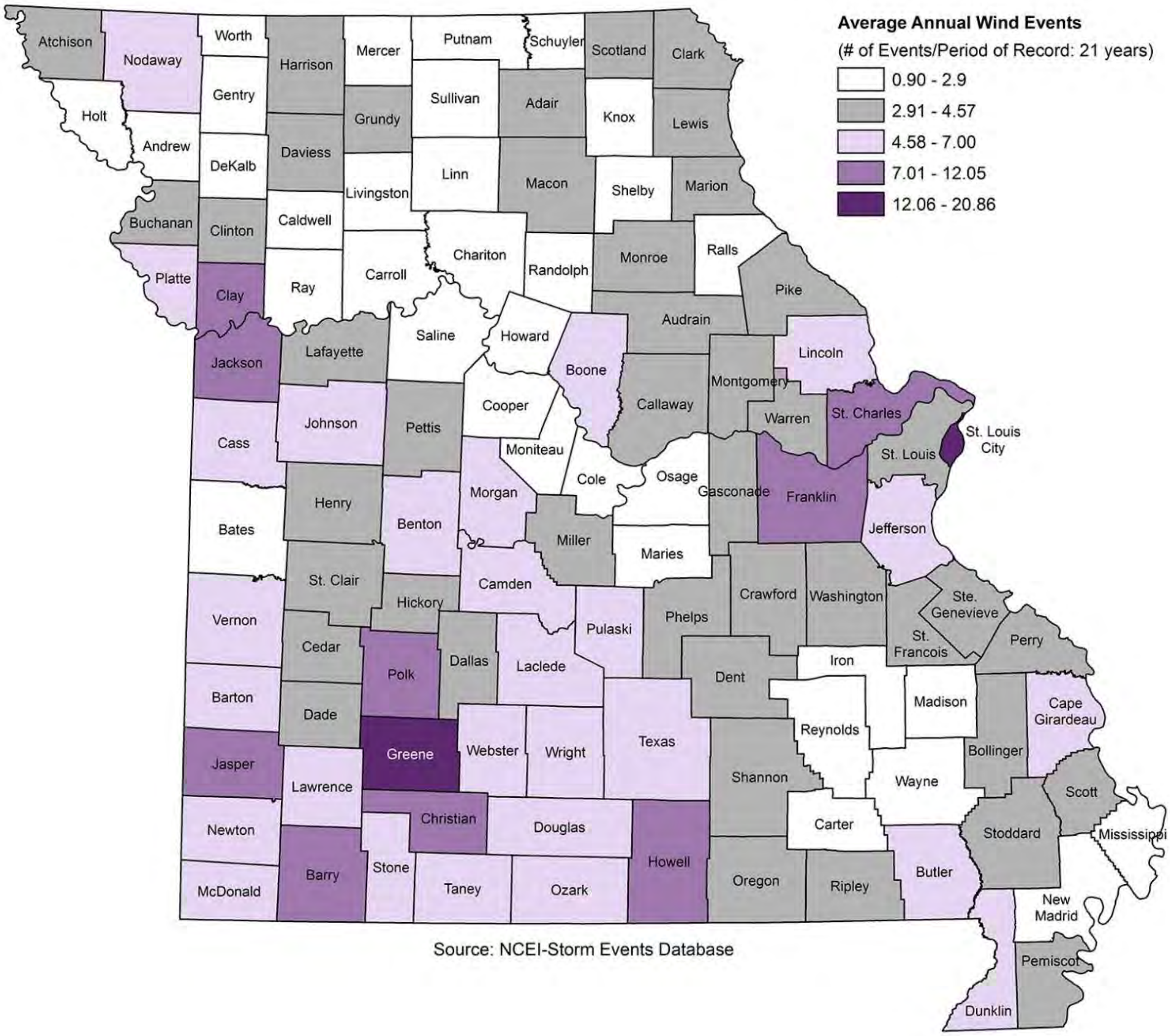
County	HIGH WIND			HAIL			LIGHTNING		
	Total Number of Events	Likelihood of Occurrence	Likelihood of Occurrence Rating	Total Number of Events	Likelihood of Occurrence	Likelihood of Occurrence Rating	Total Number of Events	Likelihood of Occurrence	Likelihood of Occurrence Rating
Christian	192	9.143	4	173	8.238	4	6	0.286	3
Clark	80	3.810	2	65	3.095	2	2	0.095	2
Clay	175	8.333	4	260	12.381	4	0	0.000	1
Clinton	71	3.381	2	109	5.190	3	0	0.000	1
Cole	60	2.857	1	95	4.524	2	7	0.333	4
Cooper	43	2.048	1	97	4.619	2	1	0.048	1
Crawford	70	3.333	2	94	4.476	2	0	0.000	1
Dade	84	4.000	2	100	4.762	2	1	0.048	1
Dallas	95	4.524	2	117	5.571	3	3	0.143	2
Daviess	86	4.095	2	120	5.714	3	1	0.048	1
DeKalb	53	2.524	1	97	4.619	2	0	0.000	1
Dent	63	3.000	2	78	3.714	2	0	0.000	1
Douglas	131	6.238	3	128	6.095	3	3	0.143	2
Dunklin	104	4.952	3	86	4.095	2	1	0.048	1
Franklin	185	8.810	4	195	9.286	4	2	0.095	2
Gasconade	81	3.857	2	98	4.667	2	1	0.048	1
Gentry	39	1.857	1	68	3.238	2	0	0.000	1
Greene	438	20.857	5	371	17.667	5	12	0.571	5
Grundy	80	3.810	2	122	5.810	3	0	0.000	1
Harrison	62	2.952	2	102	4.857	2	0	0.000	1
Henry	65	3.095	2	84	4.000	2	0	0.000	1
Hickory	72	3.429	2	79	3.762	2	0	0.000	1
Holt	32	1.524	1	84	4.000	2	0	0.000	1
Howard	27	1.286	1	72	3.429	2	0	0.000	1
Howell	163	7.762	4	172	8.190	4	3	0.143	2
Iron	59	2.810	1	43	2.048	1	1	0.048	1
Jackson	253	12.048	4	380	18.095	5	6	0.286	3
Jasper	209	9.952	4	186	8.857	4	12	0.571	5
Jefferson	123	5.857	3	192	9.143	4	8	0.381	4
Johnson	124	5.905	3	191	9.095	4	1	0.048	1
Knox	45	2.143	1	38	1.810	1	0	0.000	1
Laclede	143	6.810	3	163	7.762	3	5	0.238	3
Lafayette	80	3.810	2	101	4.810	2	0	0.000	1
Lawrence	105	5.000	3	164	7.810	3	0	0.000	1
Lewis	75	3.571	2	75	3.571	2	3	0.143	2
Lincoln	105	5.000	3	89	4.238	2	1	0.048	1
Linn	58	2.762	1	75	3.571	2	0	0.000	1

County	HIGH WIND			HAIL			LIGHTNING		
	Total Number of Events	Likelihood of Occurrence	Likelihood of Occurrence Rating	Total Number of Events	Likelihood of Occurrence	Likelihood of Occurrence Rating	Total Number of Events	Likelihood of Occurrence	Likelihood of Occurrence Rating
Livingston	54	2.571	1	78	3.714	2	0	0.000	1
Macon	67	3.190	2	93	4.429	2	0	0.000	1
Madison	44	2.095	1	28	1.333	1	0	0.000	1
Maries	51	2.429	1	66	3.143	2	0	0.000	1
Marion	64	3.048	2	77	3.667	2	4	0.190	3
McDonald	102	4.857	3	115	5.476	3	1	0.048	1
Mercer	37	1.762	1	67	3.190	2	0	0.000	1
Miller	82	3.905	2	123	5.857	3	0	0.000	1
Mississippi	61	2.905	1	31	1.476	1	2	0.095	2
Moniteau	60	2.857	1	56	2.667	1	1	0.048	1
Monroe	63	3.000	2	44	2.095	1	0	0.000	1
Montgomery	68	3.238	2	87	4.143	2	0	0.000	1
Morgan	102	4.857	3	132	6.286	3	1	0.048	1
New Madrid	58	2.762	1	42	2.000	1	0	0.000	1
Newton	123	5.857	3	207	9.857	4	2	0.095	2
Nodaway	99	4.714	3	158	7.524	3	0	0.000	1
Oregon	76	3.619	2	79	3.762	2	0	0.000	1
Osage	44	2.095	1	72	3.429	2	0	0.000	1
Ozark	117	5.571	3	140	6.667	3	2	0.095	2
Pemiscot	75	3.571	2	53	2.524	1	1	0.048	1
Perry	64	3.048	2	36	1.714	1	2	0.095	2
Pettis	96	4.571	2	116	5.524	3	3	0.143	2
Phelps	90	4.286	2	123	5.857	3	5	0.238	3
Pike	79	3.762	2	75	3.571	2	1	0.048	1
Platte	120	5.714	3	200	9.524	4	1	0.048	1
Polk	166	7.905	4	189	9.000	4	0	0.000	1
Pulaski	101	4.810	3	140	6.667	3	2	0.095	2
Putnam	31	1.476	1	49	2.333	1	0	0.000	1
Ralls	59	2.810	1	50	2.381	1	3	0.143	2
Randolph	61	2.905	1	56	2.667	1	0	0.000	1
Ray	51	2.429	1	73	3.476	2	2	0.095	2
Reynolds	44	2.095	1	41	1.952	1	2	0.095	2
Ripley	62	2.952	2	68	3.238	2	0	0.000	1
Saline	45	2.143	1	78	3.714	2	0	0.000	1
Schuyler	19	0.905	1	25	1.190	1	0	0.000	1
Scotland	74	3.524	2	69	3.286	2	4	0.190	3
Scott	84	4.000	2	71	3.381	2	3	0.143	2

County	HIGH WIND			HAIL			LIGHTNING		
	Total Number of Events	Likelihood of Occurrence	Likelihood of Occurrence Rating	Total Number of Events	Likelihood of Occurrence	Likelihood of Occurrence Rating	Total Number of Events	Likelihood of Occurrence	Likelihood of Occurrence Rating
Shannon	94	4.476	2	86	4.095	2	0	0.000	1
Shelby	44	2.095	1	38	1.810	1	5	0.238	3
St. Charles	238	11.333	4	210	10.000	4	6	0.286	3
St. Clair	78	3.714	2	110	5.238	3	2	0.095	2
St. Francois	88	4.190	2	71	3.381	2	3	0.143	2
St. Louis	73	3.476	2	359	17.095	5	13	0.619	5
St. Louis City	343	16.333	5	50	2.381	1	4	0.190	3
Ste. Genevieve	63	3.000	2	43	2.048	1	5	0.238	3
Stoddard	89	4.238	2	84	4.000	2	3	0.143	2
Stone	112	5.333	3	170	8.095	4	5	0.238	3
Sullivan	45	2.143	1	62	2.952	2	0	0.000	1
Taney	129	6.143	3	126	6.000	3	3	0.143	2
Texas	100	4.762	3	153	7.286	3	2	0.095	2
Vernon	137	6.524	3	146	6.952	3	1	0.048	1
Warren	75	3.571	2	70	3.333	2	3	0.143	2
Washington	70	3.333	2	126	6.000	3	0	0.000	1
Wayne	56	2.667	1	71	3.381	2	2	0.095	2
Webster	147	7.000	3	160	7.619	3	0	0.000	1
Worth	19	0.905	1	65	3.095	2	0	0.000	1
Wright	124	5.905	3	142	6.762	3	3	0.143	2

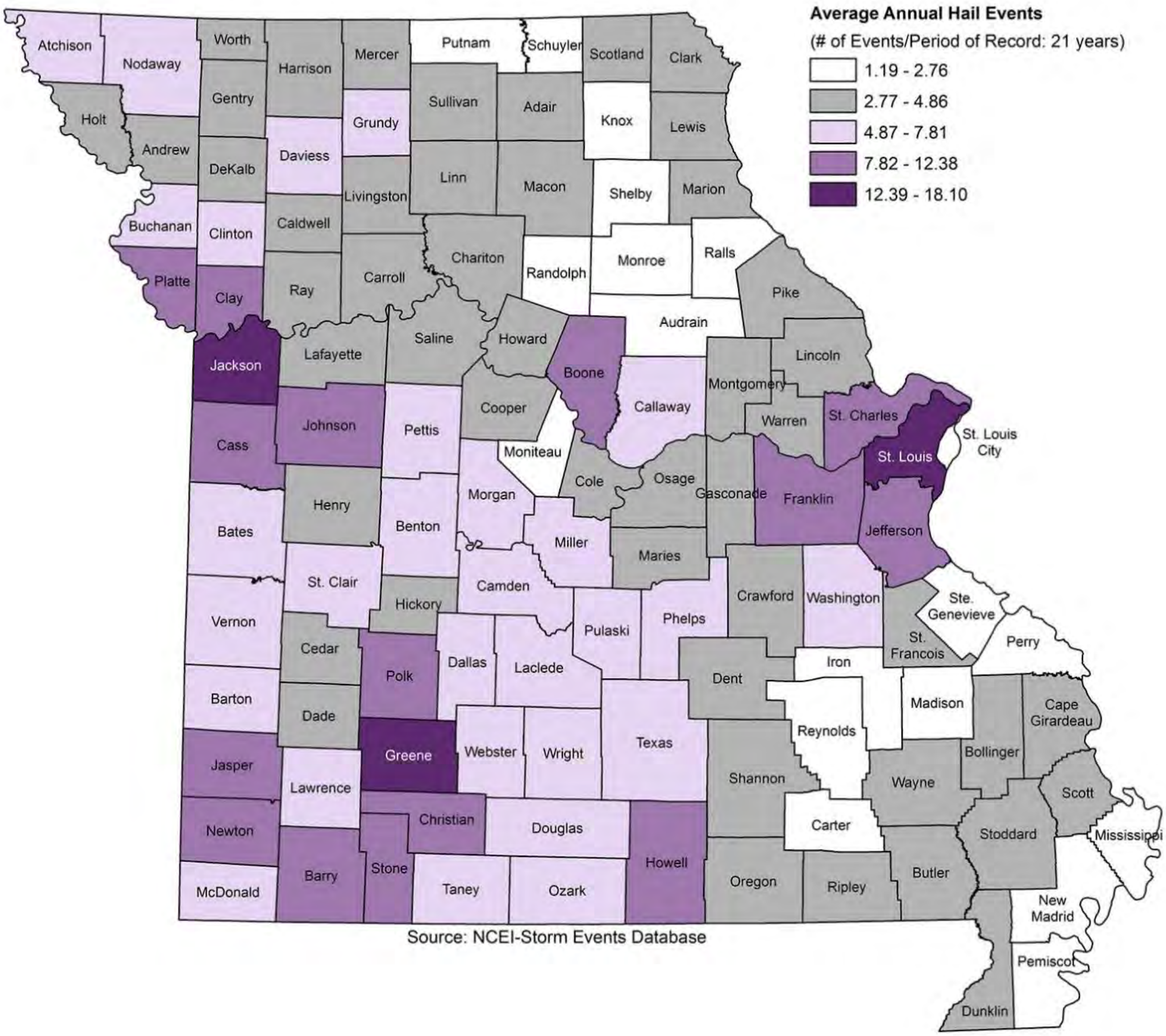
Figures 3.127-3.129 present the Average Annual occurrence for wind, hail, and lightning events in Missouri counties based on the historical events reported in the NCEI database for the period from 1996 to December 2016.

Figure 3.127. Figure 3-1 Average Annual High Wind Events (40 MPH and higher)



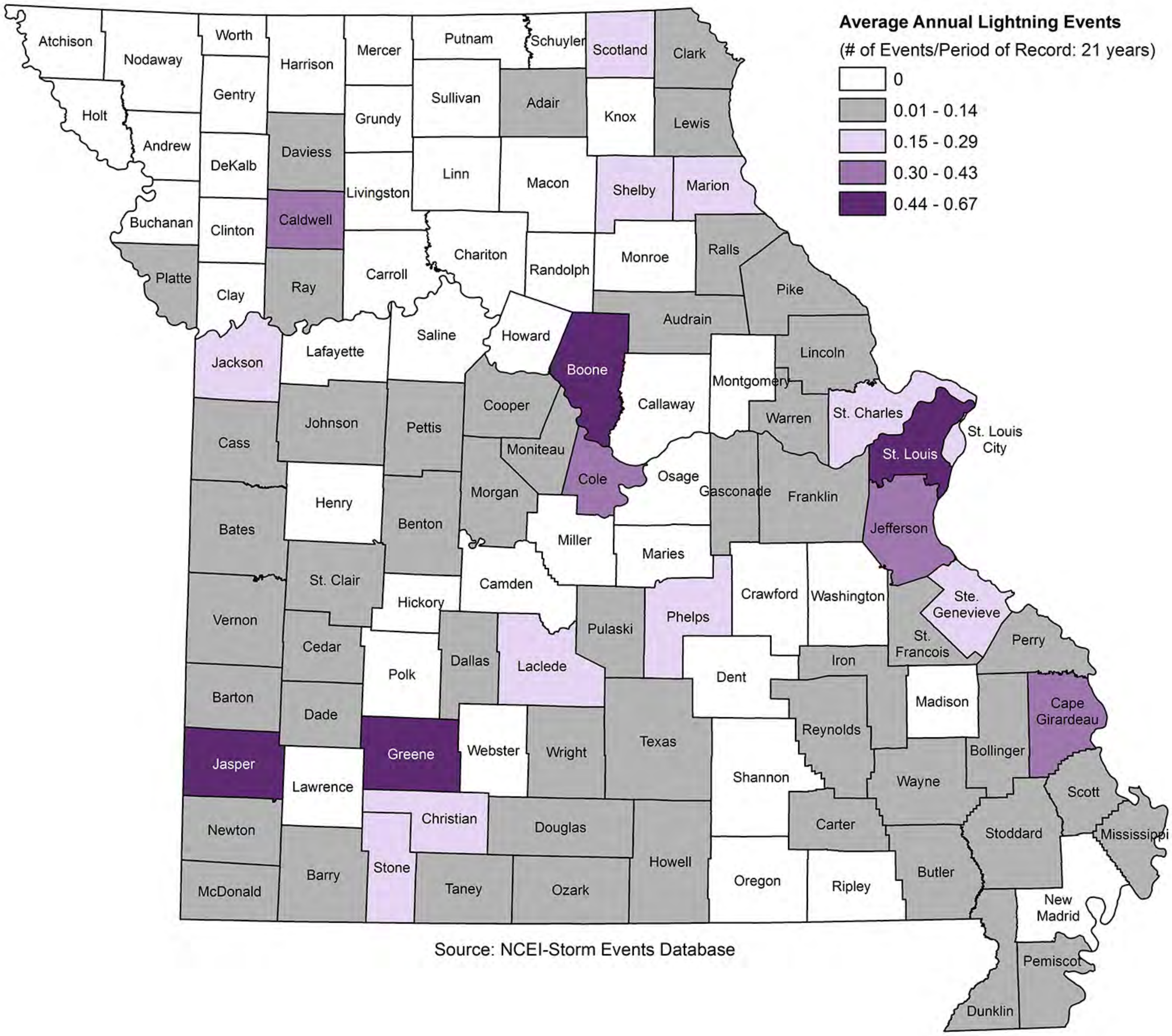
Source: NCEI-Storm Events Database

Figure 3.128. Average Annual Occurrence of Hail Events



Source: NCEI-Storm Events Database

Figure 3.129. Average Annual Occurrence of Lightning Events



Source: NCEI-Storm Events Database

Table 3.93 provides additional data obtained from the National Centers for Environmental Information for property loss to complete the overall vulnerability analysis.

Table 3.93. Annualized Property Loss and Associated Ratings

COUNTY	HIGH WIND		HAIL		LIGHTNING	
	Total Annualized Property Loss	Total Annualized Property Loss Rating	Total Annualized Property Loss	Total Annualized Property Loss Rating	Total Annualized Property Loss	Total Annualized Property Loss Rating
Adair	$8,500	1	$952	1	$9,524	4
Andrew	$5,095	1	$0	1	$0	1
Atchison	$8,905	1	$0	1	$0	1
Audrain	$476	1	$0	1	$0	1
Barry	$271,548	3	$40,952	1	$238	1
Barton	$503,024	4	$762	1	$476	1
Bates	$3,014	1	$328,190	3	$95	1
Benton	$31,048	1	$7,190	1	$714	2
Bollinger	$480,143	4	$71,429	2	$476	1
Boone	$5,000	1	$0	1	$27,857	5
Buchanan	$60,429	1	$476	1	$0	1
Butler	$520,286	4	$64,571	2	$476	1
Caldwell	$8,143	1	$1,190	1	$3,333	3
Callaway	$25,476	1	$7,429	1	$0	1
Camden	$53,048	1	$16,286	1	$0	1
Cape Girardeau	$350,333	3	$17,476	1	$2,952	3
Carroll	$14,429	1	$0	1	$0	1
Carter	$117,000	2	$4,000	1	$0	1
Cass	$22,119	1	$1,429	1	$1,190	2
Cedar	$345,952	3	$14,524	1	$2,619	3
Chariton	$2,714	1	$143	1	$0	1
Christian	$510,929	4	$440	1	$31,905	5
Clark	$32,333	1	$106,500	2	$11,905	4
Clay	$77,095	1	$84,310	2	$0	1
Clinton	$3,798	1	$0	1	$0	1
Cole	$49,524	1	$0	1	$1,667	2
Cooper	$4,857	1	$476	1	$238	1
Crawford	$7,000	1	$0	1	$0	1
Dade	$63,833	1	$476	1	$2,619	3
Dallas	$164,238	2	$5,500	1	$190	1
Daviess	$5,536	1	$26,905	1	$238	1
DeKalb	$717	1	$476	1	$0	1
Dent	$58,167	1	$1,071	1	$0	1

COUNTY	HIGH WIND		HAIL		LIGHTNING	
	Total Annualized Property Loss	Total Annualized Property Loss Rating	Total Annualized Property Loss	Total Annualized Property Loss Rating	Total Annualized Property Loss	Total Annualized Property Loss Rating
Douglas	$280,238	3	$18,167	1	$2,857	3
Dunklin	$37,977	1	$4,401	1	$48	1
Franklin	$7,619	1	$26,190	1	$0	1
Gasconade	$1,667	1	$47,619	2	$5,952	3
Gentry	$6,164	1	$266,667	3	$0	1
Greene	$837,243	4	$24,310	1	$36,762	5
Grundy	$2,695	1	$14,286	1	$0	1
Harrison	$5,857	1	$5,000	1	$0	1
Henry	$6,505	1	$48	1	$0	1
Hickory	$56,000	1	$5,333	1	$0	1
Holt	$29,857	1	$4,857	1	$0	1
Howard	$14,429	1	$2,381	1	$0	1
Howell	$184,571	2	$14,810	1	$429	1
Iron	$48	1	$5	1	$0	1
Jackson	$618,798	4	$467,857	3	$13,143	4
Jasper	$280,095	3	$4,048	1	$57,000	5
Jefferson	$5,714	1	$2,571	1	$2,476	3
Johnson	$15,417	1	$3,143	1	$762	2
Knox	$0	1	$0	1	$0	1
Laclede	$81,048	1	$15,262	1	$25,929	5
Lafayette	$9,619	1	$15,476	1	$0	1
Lawrence	$250,810	3	$295,714	3	$0	1
Lewis	$0	1	$1,429	1	$0	1
Lincoln	$857	1	$0	1	$0	1
Linn	$6,381	1	$71,429	2	$0	1
Livingston	$30,645	1	$14,286	1	$0	1
Macon	$8,012	1	$48	1	$0	1
Madison	$11,905	1	$0	1	$0	1
Maries	$11,048	1	$238	1	$0	1
Marion	$5,238	1	$47,619	2	$1,200	2
McDonald	$38,810	1	$31,429	1	$476	1
Mercer	$2,190	1	$1,190	1	$0	1
Miller	$10,929	1	$3,476	1	$0	1
Mississippi	$317,619	3	$9,524	1	$1,429	2
Moniteau	$238	1	$0	1	$9,524	4
Monroe	$2,381	1	$476	1	$0	1
Montgomery	$1,929	1	$0	1	$0	1

COUNTY	HIGH WIND		HAIL		LIGHTNING	
	Total Annualized Property Loss	Total Annualized Property Loss Rating	Total Annualized Property Loss	Total Annualized Property Loss Rating	Total Annualized Property Loss	Total Annualized Property Loss Rating
Morgan	$17,952	1	$3,333	1	$714	2
New Madrid	$335,619	3	$95	1	$0	1
Newton	$200,429	2	$4,048	1	$2,524	3
Nodaway	$92,724	2	$238	1	$0	1
Oregon	$59,095	1	$952	1	$0	1
Osage	$857	1	$0	1	$0	1
Ozark	$167,286	2	$3,143	1	$12,857	4
Pemiscot	$34,667	1	$2,760	1	$0	1
Perry	$2,481,810	5	$286,190	3	$48	1
Pettis	$23,250	1	$95,238	2	$1,905	2
Phelps	$28,381	1	$0	1	$11,048	4
Pike	$1,048	1	$0	1	$476	1
Platte	$23,714	1	$63,810	2	$4,762	3
Polk	$363,500	3	$30,976	1	$0	1
Pulaski	$22,786	1	$1,429	1	$1,190	2
Putnam	$13,667	1	$0	1	$0	1
Ralls	$952	1	$0	1	$0	1
Randolph	$16,938	1	$0	1	$0	1
Ray	$23,143	1	$0	1	$476	1
Reynolds	$286	1	$0	1	$2,619	3
Ripley	$327,286	3	$714	1	$0	1
Saline	$2,190	1	$4,286	1	$0	1
Schuyler	$3,571	1	$0	1	$0	1
Scotland	$22,029	1	$171,981	2	$13,095	4
Scott	$508,048	4	$34,048	1	$4,286	3
Shannon	$153,238	2	$0	1	$0	1
Shelby	$476	1	$0	1	$7,476	3
St. Charles	$119,095	2	$9,714,524	4	$23,905	5
St. Clair	$19,762	1	$476	1	$857	2
St. Francois	$17,381	1	$0	1	$0	1
St. Louis	$53,286	1	$40,594,286	5	$12,619	4
St. Louis City	$40,952	1	$35,714	1	$238	1
Ste. Genevieve	$714	1	$0	1	$333	1
Stoddard	$540,286	4	$5,524	1	$1,048	2
Stone	$178,571	2	$3,238	1	$42,381	5
Sullivan	$4,881	1	$143	1	$0	1
Taney	$75,048	1	$26,429	1	$25,238	5

COUNTY	HIGH WIND		HAIL		LIGHTNING	
	Total Annualized Property Loss	Total Annualized Property Loss Rating	Total Annualized Property Loss	Total Annualized Property Loss Rating	Total Annualized Property Loss	Total Annualized Property Loss Rating
Texas	$59,833	1	$13,524	1	$238	1
Vernon	$38,524	1	$23,857	1	$857	2
Warren	$0	1	$0	1	$0	1
Washington	$0	1	$0	1	$0	1
Wayne	$197,000	2	$8,095	1	$0	1
Webster	$292,767	3	$2,869	1	$0	1
Worth	$500	1	$0	1	$0	1
Wright	$193,119	2	$41,548	1	$2,905	3

Table 3.94 provides the combined vulnerability rating for thunderstorms. The figure that follows presents the mapped results of this analysis by county.

Table 3.94. Thunderstorm Vulnerability Ratings

County	Total Sum of All Factor Ratings	Overall Vulnerability Rating for Thunderstorms	Overall Vulnerability Rating for Thunderstorms Description
Adair	18	2	Low Medium
Andrew	13	1	Low
Atchison	16	1	Low
Audrain	16	1	Low
Barry	24	4	Medium High
Barton	21	3	Medium
Bates	18	2	Low Medium
Benton	23	3	Medium
Bollinger	20	3	Medium
Boone	26	4	Medium High
Buchanan	18	2	Low Medium
Butler	23	3	Medium
Caldwell	21	3	Medium
Callaway	18	2	Low Medium
Camden	20	3	Medium
Cape Girardeau	25	4	Medium High

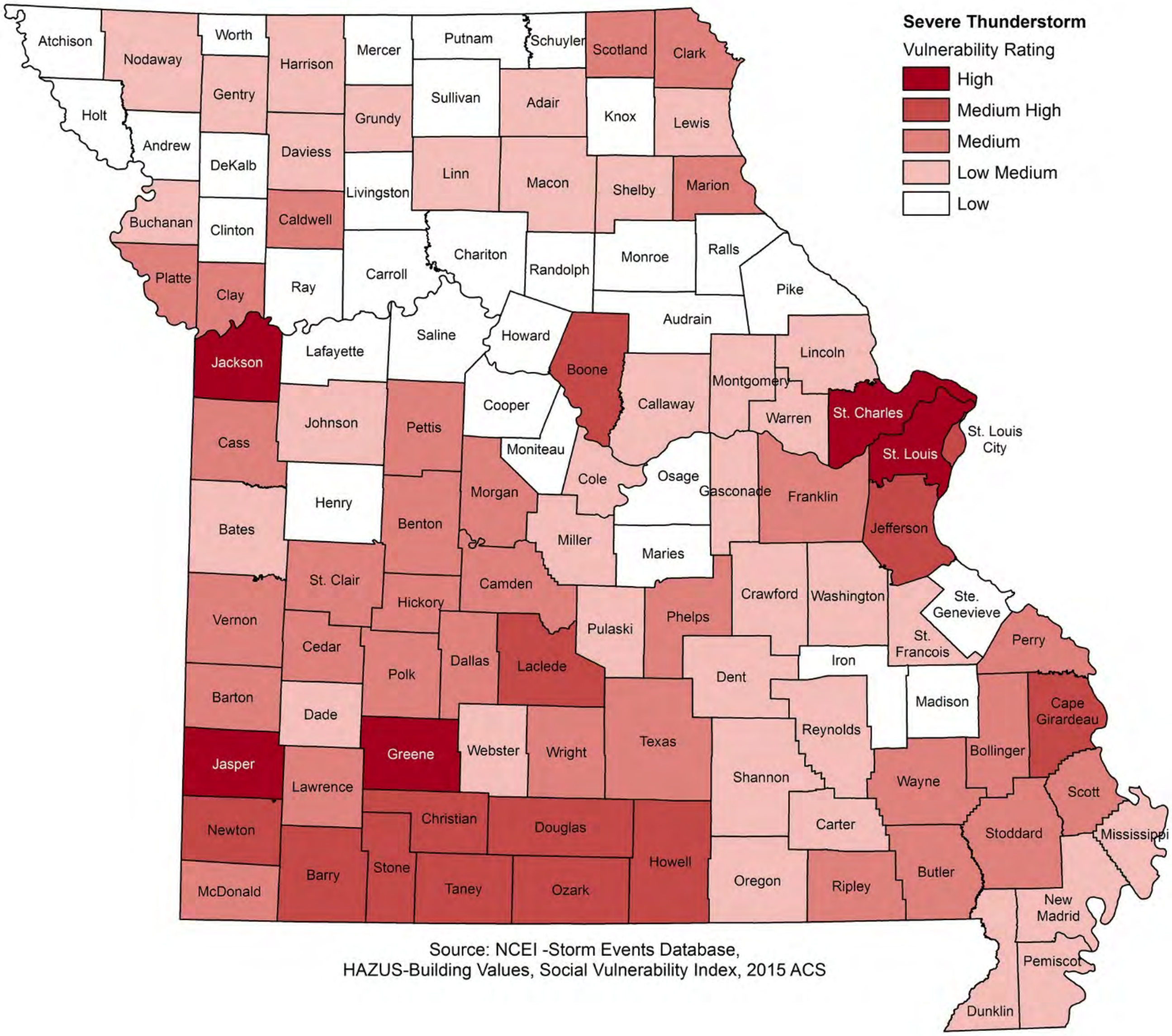
County	Total Sum of All Factor Ratings	Overall Vulnerability Rating for Thunderstorms	Overall Vulnerability Rating for Thunderstorms Description
Linn	17	2	Low Medium
Livingston	15	1	Low
Macon	17	2	Low Medium
Madison	15	1	Low
Maries	16	1	Low
Marion	20	3	Medium
McDonald	20	3	Medium
Mercer	16	1	Low
Miller	18	2	Low Medium
Mississippi	18	2	Low Medium
Moniteau	15	1	Low
Monroe	16	1	Low
Montgomery	17	2	Low Medium
Morgan	21	3	Medium
New Madrid	18	2	Low Medium
Newton	24	4	Medium High

County	Total Sum of All Factor Ratings	Overall Vulnerability Rating for Thunderstorms	Overall Vulnerability Rating for Thunderstorms Description
Carroll	15	1	Low
Carter	18	2	Low Medium
Cass	20	3	Medium
Cedar	22	3	Medium
Chariton	16	1	Low
Christian	29	4	Medium High
Clark	21	3	Medium
Clay	23	3	Medium
Clinton	16	1	Low
Cole	19	2	Low Medium
Cooper	13	1	Low
Crawford	17	2	Low Medium
Dade	18	2	Low Medium
Dallas	20	3	Medium
Daviess	17	2	Low Medium
DeKalb	14	1	Low
Dent	18	2	Low Medium
Douglas	24	4	Medium High
Dunklin	19	2	Low Medium
Franklin	23	3	Medium
Gasconade	19	2	Low Medium
Gentry	18	2	Low Medium
Greene	36	5	High
Grundy	17	2	Low Medium
Harrison	17	2	Low Medium
Henry	16	1	Low
Hickory	20	3	Medium
Holt	14	1	Low
Howard	15	1	Low
Howell	24	4	Medium High
Iron	16	1	Low
Jackson	36	5	High
Jasper	32	5	High
Jefferson	25	4	Medium High
Johnson	19	2	Low Medium
Nodaway	18	2	Low Medium
Oregon	18	2	Low Medium
Osage	12	1	Low
Ozark	24	4	Medium High
Pemiscot	17	2	Low Medium
Perry	20	3	Medium
Pettis	20	3	Medium
Phelps	22	3	Medium
Pike	15	1	Low
Platte	21	3	Medium
Polk	22	3	Medium
Pulaski	19	2	Low Medium
Putnam	13	1	Low
Ralls	15	1	Low
Randolph	13	1	Low
Ray	14	1	Low
Reynolds	19	2	Low Medium
Ripley	21	3	Medium
Saline	14	1	Low
Schuyler	14	1	Low
Scotland	22	3	Medium
Scott	23	3	Medium
Shannon	18	2	Low Medium
Shelby	18	2	Low Medium
St. Charles	31	5	High
St. Clair	22	3	Medium
St. Francois	19	2	Low Medium
St. Louis	34	5	High
St. Louis City	27	4	Medium High
Ste. Genevieve	16	1	Low
Stoddard	21	3	Medium
Stone	29	4	Medium High
Sullivan	16	1	Low
Taney	27	4	Medium High
Texas	20	3	Medium

County	Total Sum of All Factor Ratings	Overall Vulnerability Rating for Thunderstorms	Overall Vulnerability Rating for Thunderstorms Description
Knox	15	1	Low
Laclede	25	4	Medium High
Lafayette	16	1	Low
Lawrence	23	3	Medium
Lewis	18	2	Low Medium
Lincoln	17	2	Low Medium

County	Total Sum of All Factor Ratings	Overall Vulnerability Rating for Thunderstorms	Overall Vulnerability Rating for Thunderstorms Description
Vernon	20	3	Medium
Warren	17	2	Low Medium
Washington	19	2	Low Medium
Wayne	20	3	Medium
Webster	19	2	Low Medium
Worth	15	1	Low
Wright	23	3	Medium

Figure 3.130. Vulnerability Summary for Severe Thunderstorm



State Estimates of Potential Losses

To determine potential financial loss estimates to severe thunderstorms in Missouri, the available historical loss data was annualized. In the case of frequently occurring weather-related hazards such as severe thunderstorms, annualized historical loss data is considered to be the best resource for determining future potential losses. As discussed above in the vulnerability overview for this hazard, the planning team obtained historical loss data from the National Centers for Environmental Information for wind, hail, and lightning for the period from 1996 to December 2016.

Table 3.95. Annualized Severe Thunderstorm Damages in Missouri

County	HIGH WIND		HAIL		LIGHTNING	
	Annualized Property Loss	Annualized Property Loss Ratio	Annualized Property Loss	Annualized Property Loss Ratio	Annualized Property Loss	Annualized Property Loss Ratio
Adair	$8,500	0.00000327	$952	0.00000037	$9,524	0.00000366
Andrew	$5,095	0.00000295	$0	0.00000000	$0	0.00000000
Atchison	$8,905	0.00001104	$0	0.00000000	$0	0.00000000
Audrain	$476	0.00000018	$0	0.00000000	$0	0.00000000
Barry	$271,548	0.00007268	$40,952	0.00001096	$238	0.00000006
Barton	$503,024	0.00035550	$762	0.00000054	$476	0.00000034
Bates	$3,014	0.00000183	$328,190	0.00019889	$95	0.00000006
Benton	$31,048	0.00001253	$7,190	0.00000290	$714	0.00000029
Bollinger	$480,143	0.00046385	$71,429	0.00006900	$476	0.00000046
Boone	$5,000	0.00000027	$0	0.00000000	$27,857	0.00000151
Buchanan	$60,429	0.00000571	$476	0.00000005	$0	0.00000000
Butler	$520,286	0.00012555	$64,571	0.00001558	$476	0.00000011
Caldwell	$8,143	0.00000827	$1,190	0.00000121	$3,333	0.00000339
Callaway	$25,476	0.00000578	$7,429	0.00000168	$0	0.00000000
Camden	$53,048	0.00000637	$16,286	0.00000196	$0	0.00000000
Cape Girardeau	$350,333	0.00003984	$17,476	0.00000199	$2,952	0.00000034
Carroll	$14,429	0.00001202	$0	0.00000000	$0	0.00000000
Carter	$117,000	0.00022532	$4,000	0.00000770	$0	0.00000000
Cass	$22,119	0.00000203	$1,429	0.00000013	$1,190	0.00000011
Cedar	$345,952	0.00026457	$14,524	0.00001111	$2,619	0.00000200
Chariton	$2,714	0.00000289	$143	0.00000015	$0	0.00000000
Christian	$510,929	0.00006594	$440	0.00000006	$31,905	0.00000412
Clark	$32,333	0.00004554	$106,500	0.00015000	$11,905	0.00001677
Clay	$77,095	0.00000279	$84,310	0.00000306	$0	0.00000000
Clinton	$3,798	0.00000166	$0	0.00000000	$0	0.00000000
Cole	$49,524	0.00000462	$0	0.00000000	$1,667	0.00000016
Cooper	$4,857	0.00000270	$476	0.00000026	$238	0.00000013

County	HIGH WIND		HAIL		LIGHTNING	
	Annualized Property Loss	Annualized Property Loss Ratio	Annualized Property Loss	Annualized Property Loss Ratio	Annualized Property Loss	Annualized Property Loss Ratio
Crawford	$7,000	0.00000293	$0	0.00000000	$0	0.00000000
Dade	$63,833	0.00008642	$476	0.00000064	$2,619	0.00000355
Dallas	$164,238	0.00012087	$5,500	0.00000405	$190	0.00000014
Daviess	$5,536	0.00000577	$26,905	0.00002807	$238	0.00000025
DeKalb	$717	0.00000066	$476	0.00000044	$0	0.00000000
Dent	$58,167	0.00004007	$1,071	0.00000074	$0	0.00000000
Douglas	$280,238	0.00026744	$18,167	0.00001734	$2,857	0.00000273
Dunklin	$37,977	0.00001276	$4,401	0.00000148	$48	0.00000002
Franklin	$7,619	0.00000067	$26,190	0.00000229	$0	0.00000000
Gasconade	$1,667	0.00000088	$47,619	0.00002521	$5,952	0.00000315
Gentry	$6,164	0.00000894	$266,667	0.00038675	$0	0.00000000
Greene	$837,243	0.00002608	$24,310	0.00000076	$36,762	0.00000114
Grundy	$2,695	0.00000229	$14,286	0.00001215	$0	0.00000000
Harrison	$5,857	0.00000572	$5,000	0.00000488	$0	0.00000000
Henry	$6,505	0.00000256	$48	0.00000002	$0	0.00000000
Hickory	$56,000	0.00006470	$5,333	0.00000616	$0	0.00000000
Holt	$29,857	0.00004794	$4,857	0.00000780	$0	0.00000000
Howard	$14,429	0.00001328	$2,381	0.00000219	$0	0.00000000
Howell	$184,571	0.00005198	$14,810	0.00000417	$429	0.00000012
Iron	$48	0.00000005	$5	0.00000000	$0	0.00000000
Jackson	$618,798	0.00000693	$467,857	0.00000524	$13,143	0.00000015
Jasper	$280,095	0.00002320	$4,048	0.00000034	$57,000	0.00000472
Jefferson	$5,714	0.00000026	$2,571	0.00000012	$2,476	0.00000011
Johnson	$15,417	0.00000255	$3,143	0.00000052	$762	0.00000013
Knox	$0	0.00000000	$0	0.00000000	$0	0.00000000
Laclede	$81,048	0.00002518	$15,262	0.00000474	$25,929	0.00000806
Lafayette	$9,619	0.00000250	$15,476	0.00000403	$0	0.00000000
Lawrence	$250,810	0.00007175	$295,714	0.00008459	$0	0.00000000
Lewis	$0	0.00000000	$1,429	0.00000143	$0	0.00000000
Lincoln	$857	0.00000018	$0	0.00000000	$0	0.00000000
Linn	$6,381	0.00000411	$71,429	0.00004603	$0	0.00000000
Livingston	$30,645	0.00001791	$14,286	0.00000835	$0	0.00000000
Macon	$8,012	0.00000490	$48	0.00000003	$0	0.00000000
Madison	$11,905	0.00001048	$0	0.00000000	$0	0.00000000
Maries	$11,048	0.00001156	$238	0.00000025	$0	0.00000000

County	HIGH WIND		HAIL		LIGHTNING	
	Annualized Property Loss	Annualized Property Loss Ratio	Annualized Property Loss	Annualized Property Loss Ratio	Annualized Property Loss	Annualized Property Loss Ratio
Marion	$5,238	0.00000162	$47,619	0.00001477	$1,200	0.00000037
McDonald	$38,810	0.00002305	$31,429	0.00001867	$476	0.00000028
Mercer	$2,190	0.00000546	$1,190	0.00000296	$0	0.00000000
Miller	$10,929	0.00000455	$3,476	0.00000145	$0	0.00000000
Mississippi	$317,619	0.00028498	$9,524	0.00000855	$1,429	0.00000128
Moniteau	$238	0.00000016	$0	0.00000000	$9,524	0.00000632
Monroe	$2,381	0.00000243	$476	0.00000049	$0	0.00000000
Montgomery	$1,929	0.00000138	$0	0.00000000	$0	0.00000000
Morgan	$17,952	0.00000625	$3,333	0.00000116	$714	0.00000025
New Madrid	$335,619	0.00019012	$95	0.00000005	$0	0.00000000
Newton	$200,429	0.00003638	$4,048	0.00000073	$2,524	0.00000046
Nodaway	$92,724	0.00003788	$238	0.00000010	$0	0.00000000
Oregon	$59,095	0.00006632	$952	0.00000107	$0	0.00000000
Osage	$857	0.00000053	$0	0.00000000	$0	0.00000000
Ozark	$167,286	0.00018058	$3,143	0.00000339	$12,857	0.00001388
Pemiscot	$34,667	0.00002111	$2,760	0.00000168	$0	0.00000000
Perry	$2,481,810	0.00111142	$286,190	0.00012816	$48	0.00000002
Pettis	$23,250	0.00000520	$95,238	0.00002131	$1,905	0.00000043
Phelps	$28,381	0.00000598	$0	0.00000000	$11,048	0.00000233
Pike	$1,048	0.00000056	$0	0.00000000	$476	0.00000026
Platte	$23,714	0.00000209	$63,810	0.00000562	$4,762	0.00000042
Polk	$363,500	0.00013420	$30,976	0.00001144	$0	0.00000000
Pulaski	$22,786	0.00000427	$1,429	0.00000027	$1,190	0.00000022
Putnam	$13,667	0.00002569	$0	0.00000000	$0	0.00000000
Ralls	$952	0.00000082	$0	0.00000000	$0	0.00000000
Randolph	$16,938	0.00000698	$0	0.00000000	$0	0.00000000
Ray	$23,143	0.00000912	$0	0.00000000	$476	0.00000019
Reynolds	$286	0.00000043	$0	0.00000000	$2,619	0.00000391
Ripley	$327,286	0.00028929	$714	0.00000063	$0	0.00000000
Saline	$2,190	0.00000090	$4,286	0.00000176	$0	0.00000000
Schuyler	$3,571	0.00000889	$0	0.00000000	$0	0.00000000
Scotland	$22,029	0.00004068	$171,981	0.00031761	$13,095	0.00002418
Scott	$508,048	0.00012587	$34,048	0.00000844	$4,286	0.00000106
Shannon	$153,238	0.00022577	$0	0.00000000	$0	0.00000000
Shelby	$476	0.00000061	$0	0.00000000	$7,476	0.00000950

County	HIGH WIND		HAIL		LIGHTNING	
	Annualized Property Loss	Annualized Property Loss Ratio	Annualized Property Loss	Annualized Property Loss Ratio	Annualized Property Loss	Annualized Property Loss Ratio
St. Charles	$119,095	0.00000285	$9,714,524	0.00023215	$23,905	0.00000057
St. Clair	$19,762	0.00002111	$476	0.00000051	$857	0.00000092
St. Francois	$17,381	0.00000281	$0	0.00000000	$0	0.00000000
St. Louis	$53,286	0.00000038	$40,594,286	0.00029228	$12,619	0.00000009
St. Louis City	$40,952	0.00000087	$35,714	0.00000076	$238	0.00000001
Ste. Genevieve	$714	0.00000033	$0	0.00000000	$333	0.00000015
Stoddard	$540,286	0.00018075	$5,524	0.00000185	$1,048	0.00000035
Stone	$178,571	0.00004536	$3,238	0.00000082	$42,381	0.00001077
Sullivan	$4,881	0.00000781	$143	0.00000023	$0	0.00000000
Taney	$75,048	0.00001226	$26,429	0.00000432	$25,238	0.00000412
Texas	$59,833	0.00002609	$13,524	0.00000590	$238	0.00000010
Vernon	$38,524	0.00001711	$23,857	0.00001060	$857	0.00000038
Warren	$0	0.00000000	$0	0.00000000	$0	0.00000000
Washington	$0	0.00000000	$0	0.00000000	$0	0.00000000
Wayne	$197,000	0.00015677	$8,095	0.00000644	$0	0.00000000
Webster	$292,767	0.00010523	$2,869	0.00000103	$0	0.00000000
Worth	$500	0.00000186	$0	0.00000000	$0	0.00000000
Wright	$193,119	0.00012052	$41,548	0.00002593	$2,905	0.00000181

Based on this data, the following figures provide the potential annualized loss estimates for high wind, hail, and lightning based on historical damages. The figures at the conclusion of this section provide the combined total annualized losses to provide a total potential loss estimate for the severe thunderstorm hazard. There are no distinct patterns of loss that can be inferred from the maps other than higher losses in areas with greater exposure. Thus, this analysis demonstrates the random distribution of this hazard and its impacts around the State of Missouri.

Figure 3.131. Annualized High Wind Damages (40 MPH or Greater)

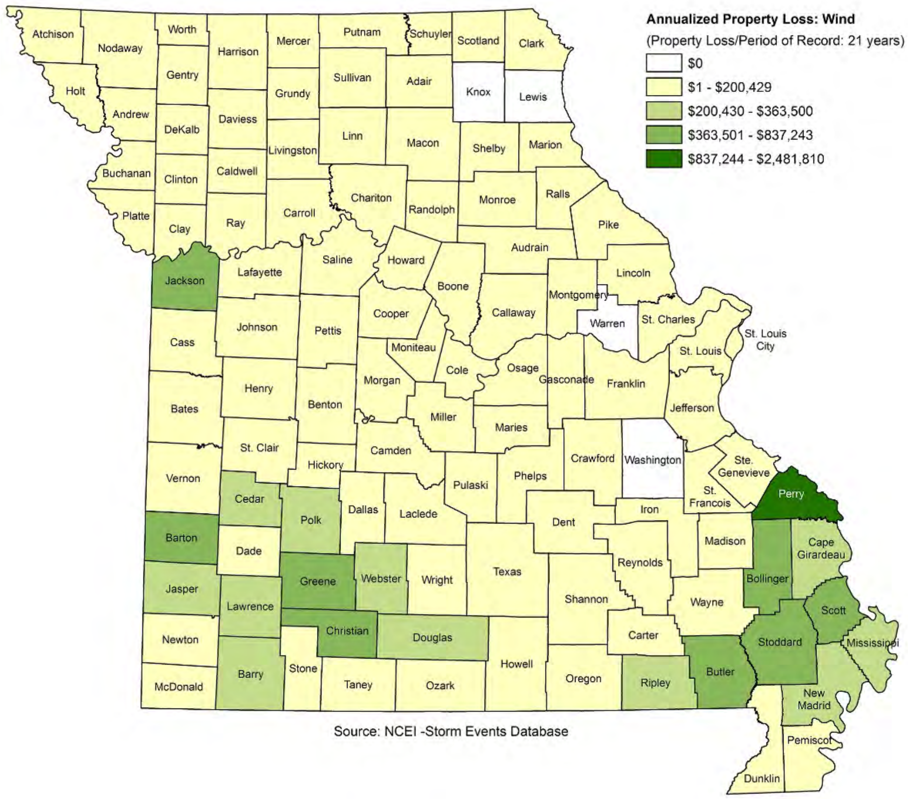


Figure 3.132. Annualized Hail Damages

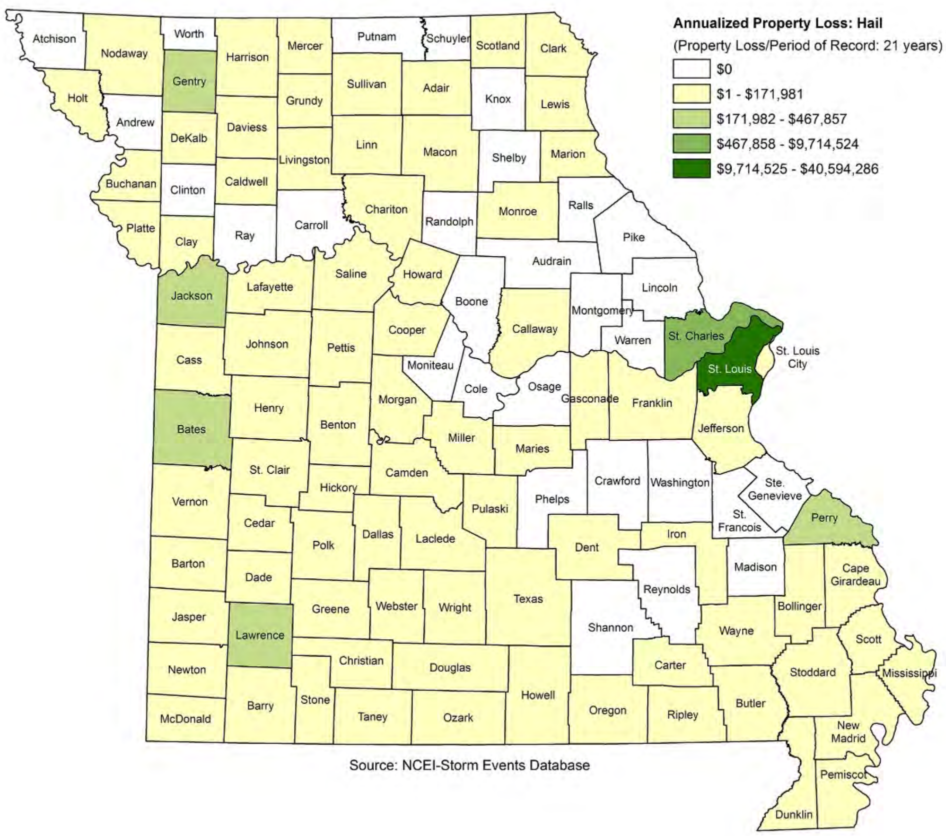


Figure 3.133. Annualized Lightning Damages

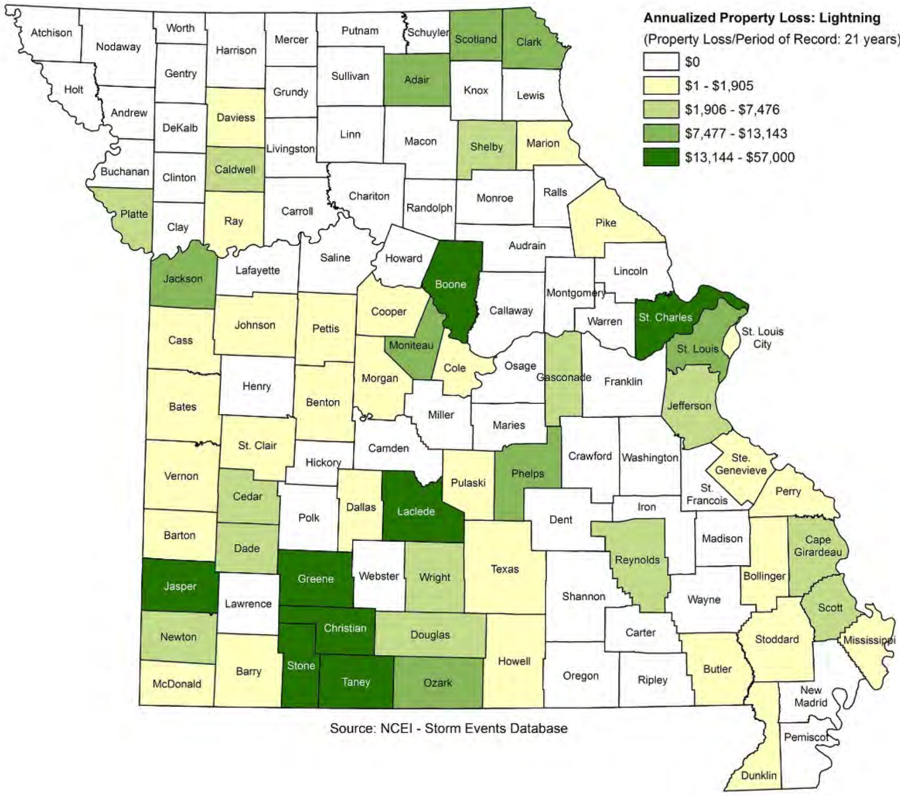


Figure 3.134. Annualized Wind Property Loss Ratio

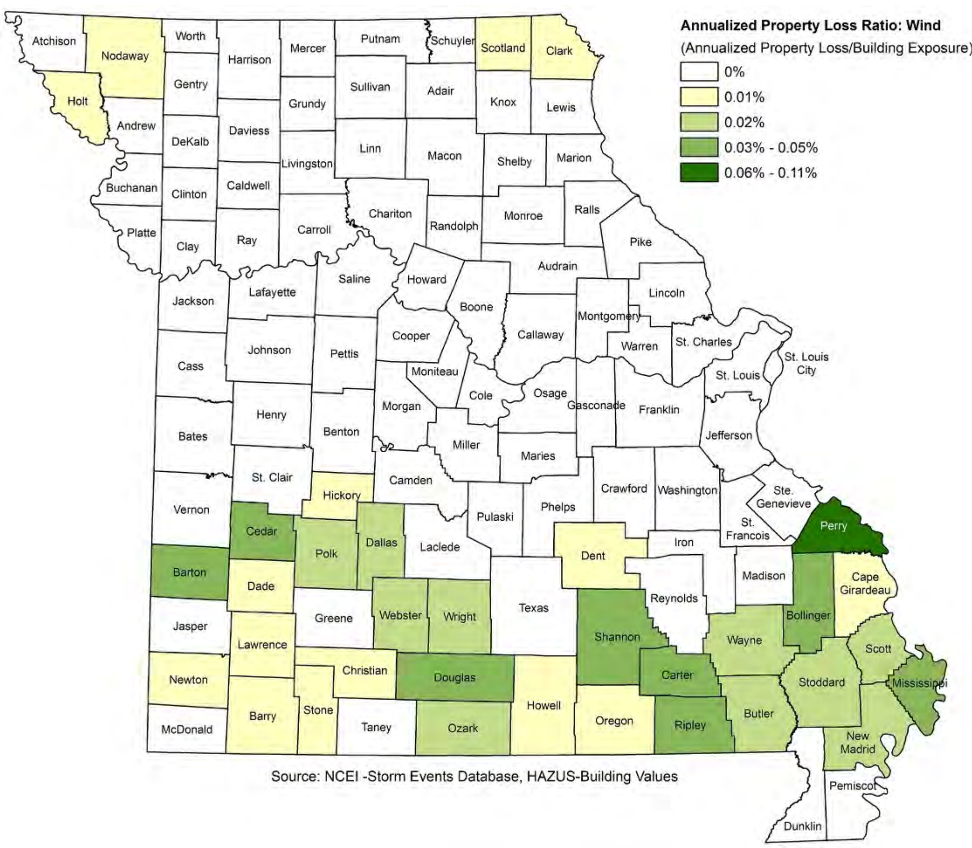


Figure 3.135. Annualized Hail Property Loss Ratio

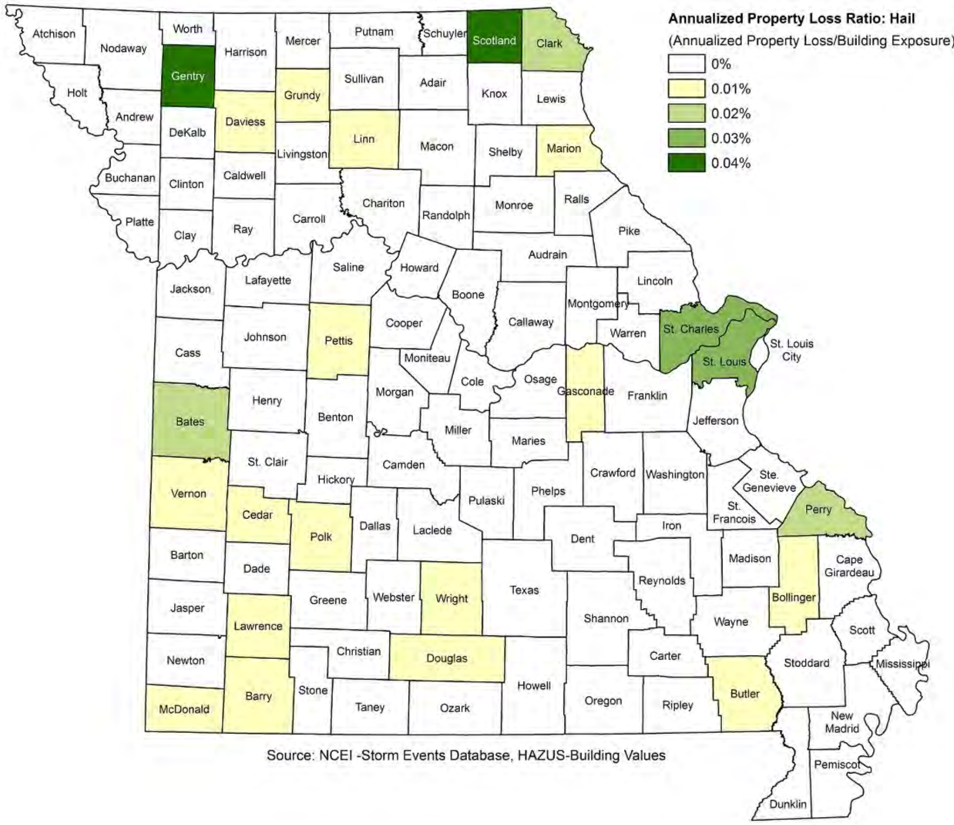
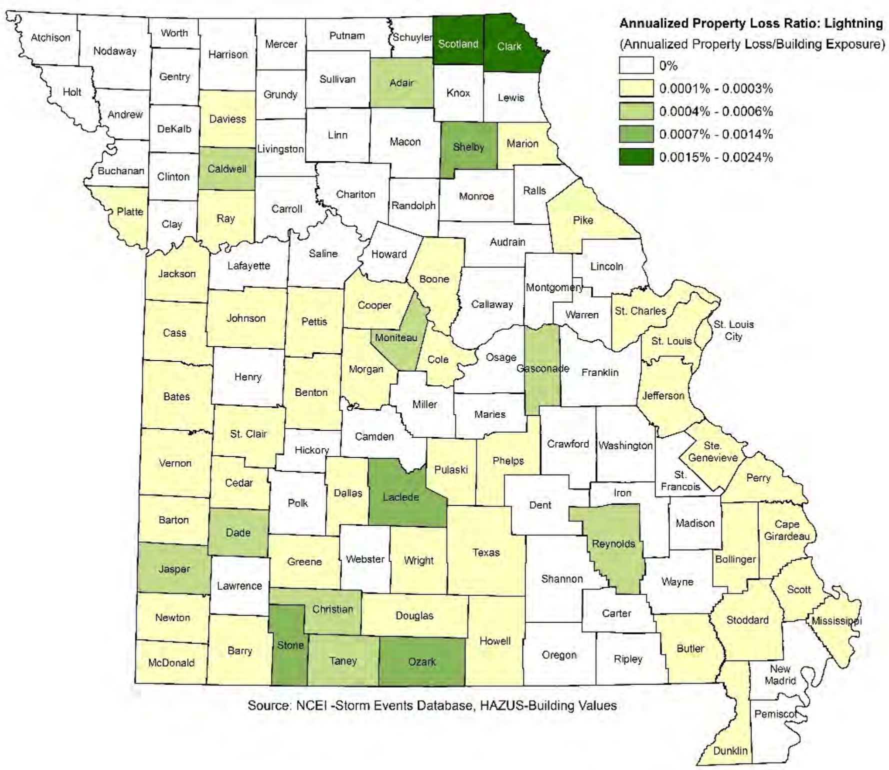


Figure 3.136. Annualized Lightning Property Loss Ratio



Hazard Impact on Future Growth and Development

The five counties that rated "High" in overall vulnerability to Severe Thunderstorms include Greene, Jackson, Jasper, St. Charles, and St. Louis Counties. All are experiencing housing gains. With growing population and increased development, there is potential for increased losses as a result of the increase in exposure. But, this will be dependent on where the severe thunderstorms occur which is a variable that cannot be predicted due to the random nature of this hazard.

EMAP Consequence Analysis

Table 3.96. EMAP Impact Analysis: Severe Thunderstorms

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

Risk Summary

Severe thunderstorms losses are usually attributed to associated hazards of hail, downburst winds, lightning and heavy rains. Losses to hail and high wind are typically insured losses that are localized and do not result in presidential disaster declarations. However, in some cases, impacts are severe and widespread and assistance outside the State capabilities is necessary. Hail and wind also can have devastating impacts on crops. Severe thunderstorms/heavy rains that lead to flooding are accounted for in the riverine flooding profile.

Problem Statement:

Using Vulnerability to Severe Thunderstorm as a key indicator, the most vulnerable areas are Jackson, Jasper, Greene, St. Charles and St. Louis Counties. Mitigation resources allocated to Severe Thunderstorms to these counties would be the most beneficial.

2018 risk assessment data and mapping is available through the Missouri Hazard Mitigation Viewer: http://bit.ly/MoHazardMitigationPlanViewer2018.

3.3.9. Severe Winter Weather

Probability	Severity
100% 233 events per year average	Moderate

Description/Location

Severe winter weather, including snowstorms, ice storms, and extreme cold, can affect any area of Missouri. The greatest threat is likely to occur in the area north of the Missouri River, as with the devastating Kansas City area ice storm on January 31, 2002, which stretched into central Missouri and led to a presidential disaster declaration (DR 1403).

Severe winter weather, such as snow, ice storms, and extreme cold can cause injuries, deaths, and property damage in a variety of ways. Winter storms are considered deceptive killers. This is because most deaths are indirectly related to the storm. Causes of death range from traffic accidents due to adverse driving conditions such as icy roads, to heart attacks caused by overexertion while shoveling snow and from other related activities. Hypothermia or frostbite may be considered the most direct cause of death and injury that can be attributed to winter storms or severe cold.

Economic costs are also difficult to measure. Heavy accumulations of ice can bring down trees, electric power lines and poles, telephone lines, and communications towers (see **Figure 3.137**) Power outages create an increased risk of fire, as home occupants use alternative fuel sources (wood, kerosene, etc. for heat and fuel-burning lanterns or candles for emergency lighting). These storms can also affect utility and city operations due to debris removal and landfill hauling. In the 2002 ice storm, one home burned when ice-laden tree limbs fell and tore the electrical junction box from the outside of the home. Electrical sparks ignited a blaze that destroyed the home.

Figure 3.137. Damaged poles in Poplar Bluff, MO, January 2009

Photo courtesy of SEMA

Crops and trees can be damaged, and livestock can be killed or injured due to deep snow, ice, or severe cold. Buildings and automobiles may be damaged from falling tree limbs, power lines, and poles. Local

3 Risk Assessment

governments, home and business owners, and power companies are often faced with spending millions of dollars to restore services, remove debris, and haul debris. Federal Public Assistance for local governments and Individual Assistance for citizens and businesses can help to cover much of the expense.

Extent

Weather data indicates that the Missouri counties north of the Missouri River receive an average annual snowfall of 18 to 22 inches. Counties south of the Missouri River receive an annual average of 8 to 12 inches. The events that involve borderline conditions of freezing rain and ice are highly unpredictable. The durations of the more serious events combined with other factors, such as high winds, are also highly unpredictable.

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

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

Additional information on Wind Chill is provided in Section 3.3.7 Extreme Temperatures.

Previous Occurrences

Historical information on severe winter weather events was obtained from the NCEI Storm Database. **Tables 3.97 through 3.102** present annual events for ice storms, heavy snow, blizzards, winter storms, and winter weather, respectively. Significant events are further highlighted following each table.

Table 3.97. Annual Ice Storm Events in Missouri, 1996-2016

Year	# of Events	Deaths	Injuries	Property Damages	Crop Damages
1996	46	0	0	4,235,000	0
1997	32	0	0	0	0
1998	40	0	0	0	0
1999	32	0	0	150,000	0
2000	37	0	0	10,000	0
2001	44	0	0	25,000	0

Year	# of Events	Deaths	Injuries	Property Damages	Crop Damages
2002	32	0	0	$32,437,000	0
2003	0	0	0	0	0
2004	24	0	0	0	0
2005	21	0	0	$20,000	0
2006	30	0	0	$10,000	0
2007	152	0	0	$373,213,000	0
2008	94	0	0	0	0
2009	12	0	0	$50,190,000	0
2010	1	0	0	0	0
2013	15	0	0	$750,000	0
2014	0	0	0	0	0
2015	0	0	0	0	0
2016	0	0	0	0	0
Grand Total	**612**	**0**	**0**	**$461,040,000**	**0**

Significant ice storm events include the following:

January 2002: A long-lived major ice and snow storm blasted much of northwest, northern and central Missouri from late Tuesday, January 29th, until Thursday, January 31st. Ice accumulations of over an inch were observed from the Kansas City metropolitan area, east and north through Moberly Missouri. At one point 409,504 total customers were without electrical power with some residents without power up to two weeks. For the Kansas City area, the ice storm was ranked as the worst ever. Further north across northern Missouri, heavy snow fell generally along and north of a line, from St. Joseph to Trenton to Kirksville. Snow accumulations ranged from 8 to 14 inches.

January 2007: One of the greatest disasters to ever impact southwest Missouri, including the Springfield metro area, occurred in the form of an ice storm. Several counties, mainly along and north of the interstate 44 corridor, experienced ice accumulations up to two and a half inches. 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.

Table 3.98. Annual Heavy Snow Events in Missouri

Year	# of Events	Deaths	Injuries	Property Damages	Crop Damages
1996	6	0	0	$1,500,000	0
1997	65	0	2	$10,470,000	0
1998	0	0	0	0	0
1999	24	0	0	0	0
2000	107	0	0	$450,000	0
2001	31	0	0	0	0
2002	48	0	0	0	0

Year	# of Events	Deaths	Injuries	Property Damages	Crop Damages
2003	45	0	0	$6,020	0
2004	19	0	0	0	0
2005	11	0	0	0	0
2006	36	0	0	$6,000	0
2007	41	0	0	0	0
2008	43	0	0	0	0
2009	14	0	0	0	0
2010	23	0	0	0	0
2011	20	0	0	0	0
2013	54	0	0	0	0
2014	38	0	0	0	0
2015	63	0	0	0	0
Grand Total	688	0	2	$12,432,020	0

Significant heavy snow events include the following:

December 2000: A major winter storm dropped as much as 14 inches of snow across the Missouri Ozarks. The hardest hit areas were along I-44 from Joplin to Lebanon. In these areas, over a foot of snow was reported. Lesser amounts were found near the Arkansas border where some sleet and freezing rain mixed in with the snow. Due to the weight of the heavy snowfall, some roofs and carports were damaged along with some minor power outages. In addition, a turkey farm was damaged in Ozark County, an appliance store outdoor canopy collapsed in Nevada, and a sports complex dome collapsed in Joplin due to the heavy snowfall. Although numerous accidents and road closures were reported, no serious injuries occurred.

Table 3.99. Annual Blizzard Events in Missouri

Year	# of Events	Deaths	Injuries	Property Damages	Crop Damages
1998	0	0	0	0	0
1999	0	0	0	0	0
2000	0	0	0	0	0
2001	0	0	0	0	0
2002	0	0	0	0	0
2003	0	0	0	0	0
2004	0	0	0	0	0
2005	0	0	0	0	0
2006	0	0	0	0	0
2007	0	0	0	0	0
2008	0	0	0	0	0
2009	32	0	0	0	0
2010	0	0	0	0	0
2011	76	1	0	$140,000	0

Year	# of Events	Deaths	Injuries	Property Damages	Crop Damages
2012	10	0	0	0	0
2013	0	0	0	0	0
2014	0	0	0	0	0
2015	0	0	0	0	0
2016	0	0	0	0	0
Totals	**118**	**1**	**0**	**$140,000**	**0**

Significant blizzard events include the following:

December 2009: A powerful storm system brought heavy snow, ice and even blizzard conditions, to a large portion of the central plains, on December 7-9, 2009. The greatest impact occurred across north central and northeast Kansas, southeast Nebraska, northwest and north central Missouri, and both southern and eastern Iowa, where strong winds gusting up to 45 mph produced blizzard conditions. The heaviest snowfall also occurred in these areas, where accumulations of 8 to 12 inches were common. The greatest snow total was 14 inches, observed in Rockport, Missouri.

February 2011: A major winter storm brought heavy wintry precipitation to the Missouri Ozarks and southeast Kansas on February 1, 2011. This impressive winter storm brought heavy snow and blizzard conditions from Oklahoma through eastern Kansas and the northwest half of Missouri and into the western Great Lakes region. Snowfall amounts ranged from around 20 to 24 inches in parts of west central into central Missouri to trace amounts over south central Missouri. In addition to the heavy snowfall, winds of 15 to 30 mph with some gusts near 40 mph occurred during the day and nighttime hours of February 1st creating significant blowing and drifting of snow along with bitterly cold wind chills. This created blizzard conditions with near zero visibility at times and snow drifts up to several feet. Significant accumulations of sleet and freezing rain occurred across portions of southern Missouri. Sleet accumulations of one-half to 2 inches fell along and just south of the Interstate 44 corridor. Freezing rain accumulations ranged from one tenth to three quarters of an inch along and south of Interstate 44 with accumulations up to three quarters of an inch in south central Missouri into the eastern Missouri Ozarks.

Table 3.100. Annual Winter Storm Events in Missouri

Year	# of Events	Deaths	Injuries	Property Damages	Crop Damages
1996	64	0	0	$10,000	0
1997	167	0	0	$20	0
1998	132	0	0	0	0
1999	108	0	0	$3,030,000	0
2000	123	0	0	0	0
2001	99	0	0	$260,000	0
2002	191	0	0	$600,000	0
2003	251	0	0	0	0
2004	146	0	0	$2,000	0
2005	51	2	0	0	0
2006	100	0	67	$321,845,700	0
2007	70	0	0	$8,000	0

Year	# of Events	Deaths	Injuries	Property Damages	Crop Damages
2008	83	0	0	$9,152,000	0
2009	94	0	0	$120,450,000	0
2010	104	0	0	0	0
2011	134	0	0	0	0
2012	20	0	0	0	0
2013	252	0	0	0	0
2014	162	0	0	$1,010,000	0
2015	117	0	0	$204,000	0
2016	2	0	0	30000	0
Grand Total	2470	2	67	456601720	0

Significant winter storm events include the following:

January 1999: At one point late on the 1st and early on the 2nd, the Barton County Electrical Cooperative lost power to 4,500 members out of a 5,800 member system. Numerous wires, power lines, and trees were downed due to a heavy ice accumulation. In south central Missouri, the Howell-Oregon Electric Cooperative lost power to 16,000 of its 21,000 members due to downed power lines and trees from a heavy ice accumulation. Some customers were without power for 6 days. Ice accumulated to 2 inches in some locations in south central Missouri. In central Missouri on January 2nd, the Empire Electric Cooperative said that power had been interrupted to 35,000 of its customers due to downed power lines from a heavy ice accumulation. On January 1st, one person was killed and one was injured when their car struck a bridge railing and overturned into a creek in Pulaski County. A band of snow and sleet (in addition to the ice) fell from southwest to central Missouri. Three to six inch amounts occurred in southwest Missouri in the Springfield, Galena, Ozark, and Buffalo areas. Heavier amounts of 5 to 10 inches occurred in central Missouri near the Lake of the Ozarks. The heaviest 8 to 10 inches of snow occurred in Morgan and northern Miller Counties. In some rural areas, schools remained closed for nearly two weeks after the Christmas/New Year holiday period.

November 2006: A major winter storm hit central, northeast, east central and parts of southeast Missouri from November 30 through December 1. Over a foot of snow fell across parts of central Missouri while a major ice storm hit parts of east central and southeast Missouri, including the St. Louis area. Ice accumulations of 1 inch or more downed trees and power lines resulting in at least 300,000 electric customers losing service for up to a week. Downed limbs and trees damaged homes and automobiles across the area as well. Many rural schools were closed for several days due to slick roads and power outages. The National Guard was called out to several counties to assist with debris removal and other emergency services. Damages across the region were expected to be in excess of $100 million.

January 2009: This prolonged, major winter storm was termed the worst in decades for southeast Missouri. The storm dumped 6 to 10 inches of sleet and snow along and north of a line from Van Buren through Greenville to Cape Girardeau. This resulted in very difficult driving conditions along with at least two dozen roof collapses. South of that line, at least one inch of ice accumulated. This resulted in catastrophic damage to trees, power lines, and utility poles in places such as Dexter, Sikeston, Charleston, and New Madrid. A utility company serving much of the region reported this was the most damaging event in the history of the company. More than 145 miles of high-voltage transmission lines were down in that company's area alone. A utility manager stated that ice accumulation made high voltage lines five inches in diameter. This was sufficient to bring down the two-pole structures with cross arms that carry transmission lines. At least 6,000 power poles in southeast Missouri were replaced after being snapped or downed. One utility company briefed the governor that restoration of its facilities would cost 80 million dollars. Nearly 100 percent of residents lost power. Power was restored to most residents of cities and larger towns in 5 to 9 days, but the last rural residents went three weeks without power. Both cell and landline phone services were out for a few days in many places. Downed trees and limbs blocked numerous roads.

Thirteen state roads were closed one week after the storm. Tree limbs landed on vehicles and punctured some house roofs. In the hardest hit areas from Charleston to Sikeston to Dexter, very few trees were not damaged. A few fatalities were indirectly caused by the storm. In New Madrid County, a woman and her teenage daughter died of apparent carbon monoxide poisoning from a gas-powered generator in the garage. In Advance, a 78-year-old man perished in a house fire likely started by an alternative heat or light source. No accurate count of storm-related injuries was maintained. However, Scott County alone recorded 20 cases of serious carbon monoxide poisoning. Scott County reported one person very seriously injured while clearing debris. A number of people throughout the region were injured in slips and falls. The National Guard assisted local and state agencies with recovery efforts, including door-to-door welfare checks in rural areas. Emergency shelters were opened for those without heat. Water supplies were interrupted in some towns where water towers could not be replenished by pumps. Gas was difficult to find for a few days due to a combination of power outages and high demand. A dusk-to-dawn curfew was imposed for a few days in some cities, including Dexter and Sikeston. Some structure fires were sparked by alternative heating, lighting, and cooking devices. Numerous traffic accidents occurred during the first several hours of the storm, sending several people to medical clinics. An aluminum plant in New Madrid suffered severe damage when the aluminum being processed cooled due to the power outage. Production was reduced by 75 percent, and full production was not expected to resume for up to a year.

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

Table 3.101. Annual Winter Weather Events in Missouri

Year	# of Events	Deaths	Injuries	Property Damages	Crop Damages
1996	11	0	0	0	0
1997	0	0	0	0	0
1998	24	0	0	0	0
1999	0	0	0	0	0
2000	21	0	0	0	0
2001	4	0	0	0	0
2002	0	0	0	0	0
2003	14	0	0	0	0
2004	0	0	0	0	0
2005	14	0	0	0	0
2006	51	0	0	$5,000	0
2007	86	0	0	0	0
2008	76	0	0	0	0

Year	# of Events	Deaths	Injuries	Property Damages	Crop Damages
2009	15	0	0	0	0
2010	78	0	0	0	0
2011	127	0	0	$4,000	0
2012	95	0	0	0	0
2013	60	0	0	0	0
2014	41	0	0	0	0
2015	47	0	0	$10,000	0
2016	42	0	0	$1,000,000	0
Totals	**806**	**0**	**0**	**$1,019,000**	**0**

Significant winter weather events include the following:

January 2016: Widespread freezing drizzle caused significant travel problems around the Springfield metro area during the afternoon and evening commute. While accidents also occurred elsewhere in southwest Missouri, there was a much greater concentration of accidents in and around Springfield/Greene County. A thin glaze of ice from freezing drizzle caused very high impacts and over 50 motor vehicle accidents and slideoffs across Greene County and the Springfield metro area during the afternoon and evening commute. Over a dozen accidents involving school buses were reported as well. Some of the accidents resulted in some damage to guard rails, traffic lights, traffic signs, and fences along the roads. Roadways were extremely hazardous and impassable in some places. There were some minor injuries reported but no serious injuries or fatalities.

December 2016: Freezing drizzle caused major travel impacts and numerous accidents around the Missouri Ozarks. There were a few fatalities associated with car accidents which were indirectly caused by the icy road conditions. Two Sunrise Beach firefighters were injured when their fire truck was involved in an accident due to slick road conditions. The fire truck was totaled. The Osage Beach fire department assist in more than a dozen vehicle crashes due to slick road conditions. An Osage Beach fire truck was damaged in an accident.

February 15–16, 1993: Central and southern Missouri was covered with up to 21 inches of snow. The airport at Cape Girardeau received 6 inches of snow in one hour and 20 minutes.

January 14–20, 1994: Northeast, central, and east-central Missouri experienced overnight low temperatures from below zero to –20°F. Hundreds of homes and businesses had frozen and busted water pipes. Wind chills, which ranged from -30 to -50°F, kept schools closed and accounted for 15 people being admitted to local hospitals for hypothermia and frostbite.

January 16–17, 1994: A layer of ice up to 2 inches thick formed over sections of southeast Missouri, followed by 6 to 10 inches of snow. Some areas were without power for more than 24 hours. Roofs collapsed due to the heavy weight of snow and ice.

December 6, 1994: Ice accumulations of 0.5 to 1 inch were reported across northwest, north-central, and northeast Missouri. Over 75 percent of the residents in this region were without power. Phone and cable television were also out. A few rural areas were without power for at least seven days. The City of St. Joseph was declared a disaster area by Governor Mel Carnahan because of damage totaling nearly $4 million.

January 18–19, 1995: Central Missouri received heavy snows, dumping 19.7 inches over Columbia alone and setting a new 24-hour snowfall record. Parts of I-70, I-44, and other major highways were closed due to drifting snow. Snow fell at such a fast rate that snowplows and graders became stuck. Almost 5,000 birds were killed when several large chicken and turkey barns collapsed. Thousands of people were without power and telephone service. The Jefferson City and Columbia airports were closed for a time. The University of Missouri at Columbia canceled classes for the first time in nearly 17 years. State offices in Jefferson City were also closed.

October 22–23, 1996: An early snowfall hit the Kansas City area, dumping as much as 8.5 inches of heavy wet snow. Approximately 130,000 residences were without power, and an estimated $1.5 million in property damage was reported.

January 10–13, 1997: Northwest and west-central Missouri experienced overnight low temperatures below zero. No record low temperatures were recorded, but winds gusting up to 30 miles per hour produced afternoon wind chills as low as -30 to -50°F.

April 10–11, 1997: A spring snowstorm dumped up to 24 inches in extreme north Missouri. Schuyler County alone reported $2 million in damage, mostly due to the heavy snow causing roofs on farm buildings to collapse.

Table 3.102 presents the severe winter weather events that have received presidential declarations. The summaries that follow it describe some of the more significant declaration events occurring in Missouri in recent years. (Much of this information was taken from the National Weather Service's *Storm Data and Unusual Weather Phenomena* publication.)

Table 3.102. Presidential Declarations for Missouri Severe Winter Weather Since 1975

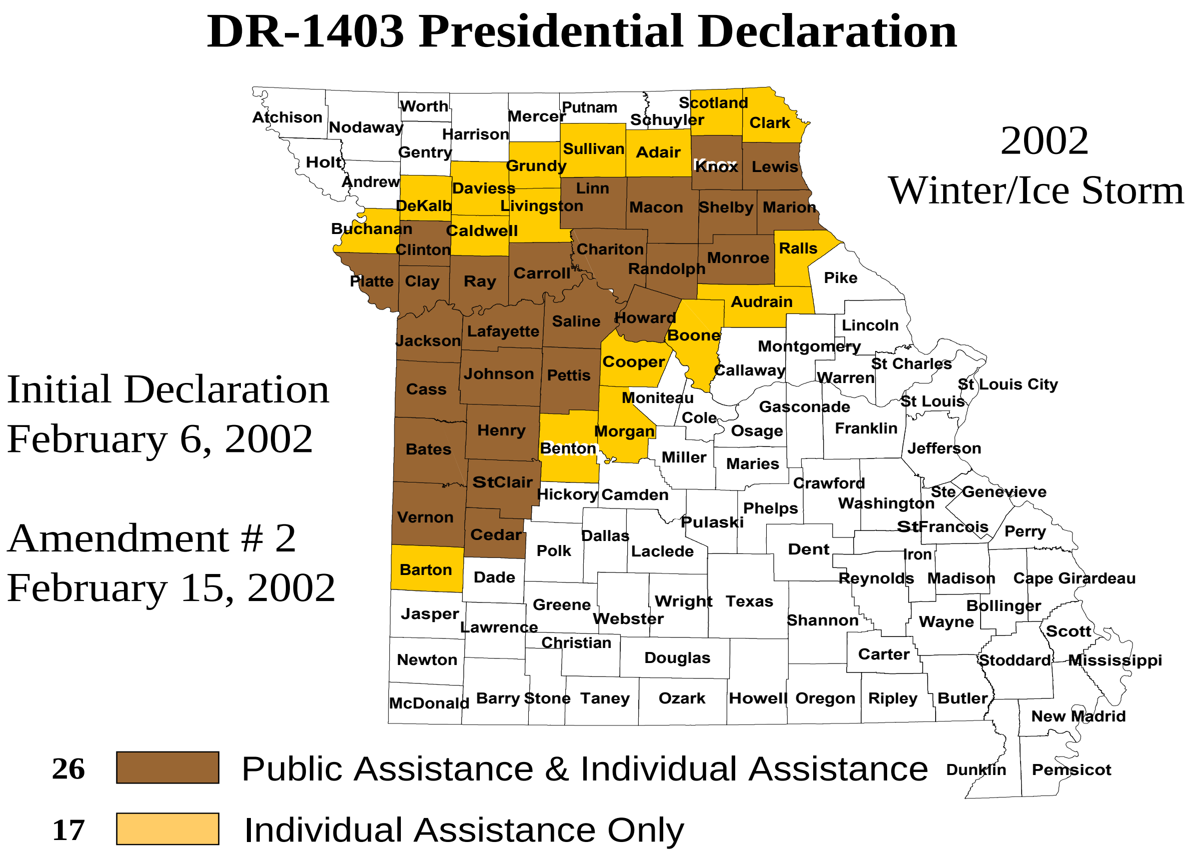
Declaration Date	Disaster No.	Incident Type	Counties Declared	Type of Assistance*
March 12, 1979	EM 3071	Ice Jam, Flooding	n/a	PA
February 6, 2002	DR 1403	Ice Storm	Adair, Audrain, Barton, Bates, Benton, Boone, Buchanan, Caldwell, Carroll, Cass, Cedar, Chariton, Clark, Clay, Clinton, Cooper, Daviess, DeKalb, Grundy, Henry, Howard, Jackson, Johnson, Knox, Lafayette, Lewis, Linn, Livingston, Macon, Marion, Monroe, Morgan, Pettis, Platte, Ralls, Randolph, Ray, Saline, Scotland, Shelby, St. Clair, Sullivan, Vernon	IA
			Bates, Carroll, Cass, Cedar, Chariton, Clay, Clinton, Henry, Howard, Jackson, Johnson, Knox, Lafayette, Lewis, Linn, Macon, Marion, Monroe, Pettis, Platte, Randolph, Ray, Saline, Shelby, St. Clair, Vernon	PA
December 29, 2006	DR 1673	Severe Winter Storms	Boone, Callaway, Camden, Cole, Greene, Iron, Marion, Miller, Reynolds, St. Francois, St. Louis, Ste. Genevieve, Washington, St. Louis City	PA

Declaration Date	Disaster No.	Incident Type	Counties Declared	Type of Assistance*
January 15, 2007	DR 1676	Severe Winter Storms and Flooding	Barry, Barton, Benton, Boone, Callaway, Camden, Cedar, Christian, Cole, Crawford, Dade, Dallas, Dent, Franklin, Gasconade, Greene, Hickory, Jasper, Laclede, Lawrence, Lincoln, Maries, McDonald, Miller, Montgomery, Newton, Osage, Phelps, Polk, Pulaski, St. Charles, St. Clair, St. Louis, Stone, Texas, Warren, Webster, Wright Counties, St. Louis City	PA
December 12, 2007	DR-3281	Severe Winter Storms	Emergency Declaration for all counties in Missouri	PA
December 27, 2007	DR-1736	Severe Winter Storms	Adair, Andrew, Atchison, Audrain, Barton, Benton, Boone, Buchanan, Caldwell, Callaway, Camden, Cedar, Clinton, Cole, Dade, Daviess, DeKalb, Gentry, Grundy, Harrison, Hickory, Holt, Jasper, Lincoln, Linn, McDonald, Mercer, Miller, Moniteau, Montgomery, Morgan, Newton, Nodaway, Osage, Pike, Putnam, St. Clair, Schuyler, Scotland, Sullivan, Warren, and Worth Counties.	PA
March 12, 2008	DR-1748	Severe Winter Storms and Flooding	Bollinger, Butler, Cape Girardeau, Carter, Christian, Douglas, Greene, Madison, Mississippi, Ozark, Reynolds, Scott, Shannon, Stoddard, Texas, Wayne, Webster, and Wright Counties	PA
January 30, 2009	DR-3303	Severe Winter Storms	Emergency Declaration for all counties in Missouri	PA
February 17, 2009	DR-1822	Severe Winter Storms	Bollinger, Butler, Cape Girardeau, Carter, Dunklin, Howell, Madison, Mississippi, New Madrid, Oregon, Ozark, Pemiscot, Reynolds, Ripley, Scott, Shannon, Stoddard, Stone, Taney and Wayne Counties	PA
March 23, 2011	DR-1961	Severe Winter Storms	Adair, Andrew, Audrain, Barton, Bates, Benton, Boone, Buchanan, Caldwell, Callaway, Camden, Carroll, Cass, Cedar, Chariton, Clark, Clinton, Cole, Cooper, Dade, Dallas, DeKalb, Grundy, Henry, Hickory, Howard, Johnson, Knox, Laclede, Lafayette, Lewis, Linn, Livingston, Macon, Madison, Maries, Marion, McDonald, Miller, Moniteau, Monroe, Montgomery, Morgan, Newton, Osage, Pettis, Pike, Platte, Polk, Pulaski, Putnam, Ralls, Randolph, Ray, Saint Clair, Saline, Schuyler, Scotland, Shelby, Sullivan, Vernon and Worth.	PA

5Source: Federal Emergency Management Agency, State Emergency Management Agency
Note :*IA denotes Individual Assistance; PA denotes Public Assistance

January 31, 2002 (DR 1403): A massive severe winter storm system dumped snow and ice from Oklahoma to Kansas and into central and northern Missouri. In Missouri alone, more than 600,000 residents were without power, as ice-encased power lines snapped in fierce winds or were pulled down by falling trees and limbs. Loss of electricity included more than 460,000 people in the Kansas City metro area alone (Jackson, Cass, Clay, and Platte counties). Additionally, residents in a line from Kansas City to the Iowa-Illinois border were without power as rural electric cooperative lines broke as well. Outages ranged from several days to nearly two weeks. Damage to property, power restoration, and the cost of debris removal for local governments was so high that Missouri received a presidential disaster declaration (DR 1403) on February 6, 2002, which ultimately included 43 counties; 26 were designated for both Individual and Public Assistance, and 17 were eligible for Individual Assistance only (see **Figure 3.138)**. The total eligible Public Assistance costs for this disaster ($61.9 million dollars as of August 2002) ranks the 2002 ice storm as Missouri's second most costly disaster to date.

Figure 3.138. January 2002 Ice Storm



November 30–December 1, 2006 (DR 1673): A severe winter storm dropped freezing rain, sleet, ice, and snow over Missouri (see **Figure 3.139)** for a map of the counties that received disaster declarations). According to Pat Guinan, University of Missouri climatologist, the storm was unprecedented for the time of year it hit. Some areas of the State experienced up to 14 inches of snow. The freezing rain and sleet caused major power outages, blocked roads, and caused structural damage to buildings across the State. Eleven deaths were attributed to the event.

January 12–14, 2007 (DR 1676): A series of severe winter storms swept across Missouri causing heavy damage throughout the State. An area from Joplin to St. Louis along the I-44 corridor was the heaviest hit (see **Figure 3.140)** for a map of the counties that received disaster declarations). The storm system caused power outages for over 330,000 households/businesses statewide, caused 15 weather-related deaths, and sent over 4,300 citizens to more than 119 shelters. Preliminary eligible costs for Public Assistance were estimated at $109.3 million. Of this amount, approximately $51 million in damages was estimated by the 15 Missouri Electric Cooperatives that sustained damage to their electrical lines, substations and equipment.

Figure 3.139. November–December 2006 Winter Storm

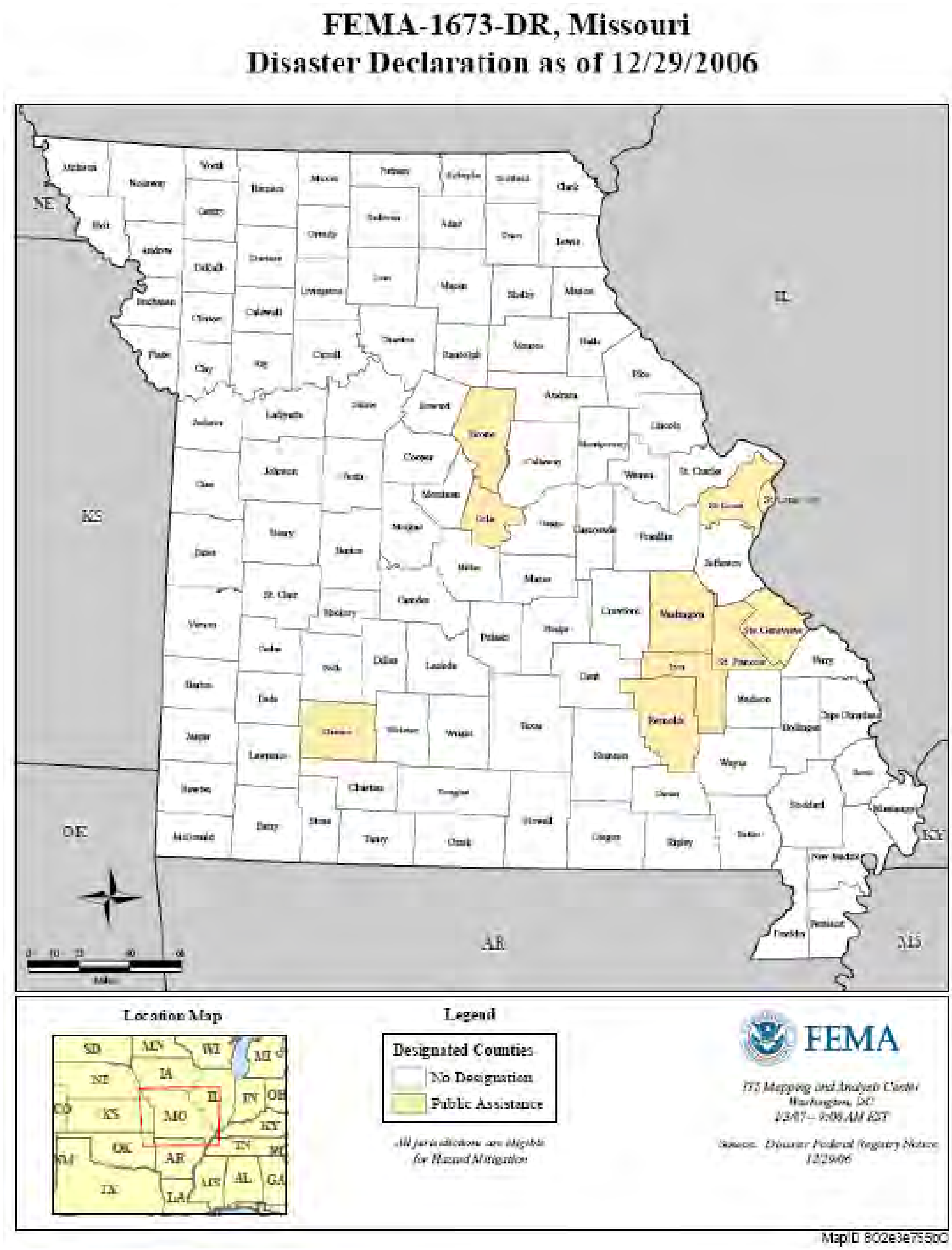
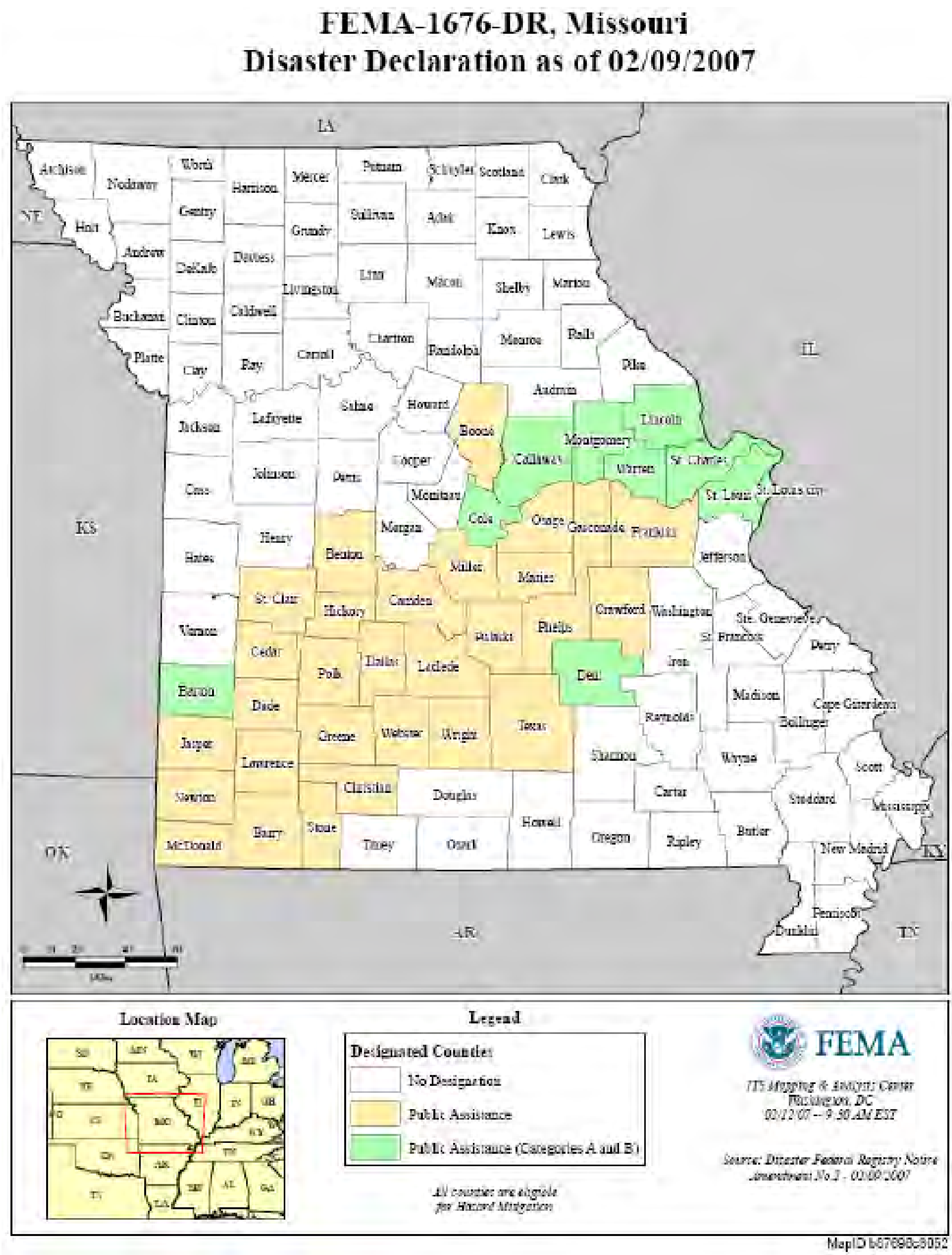


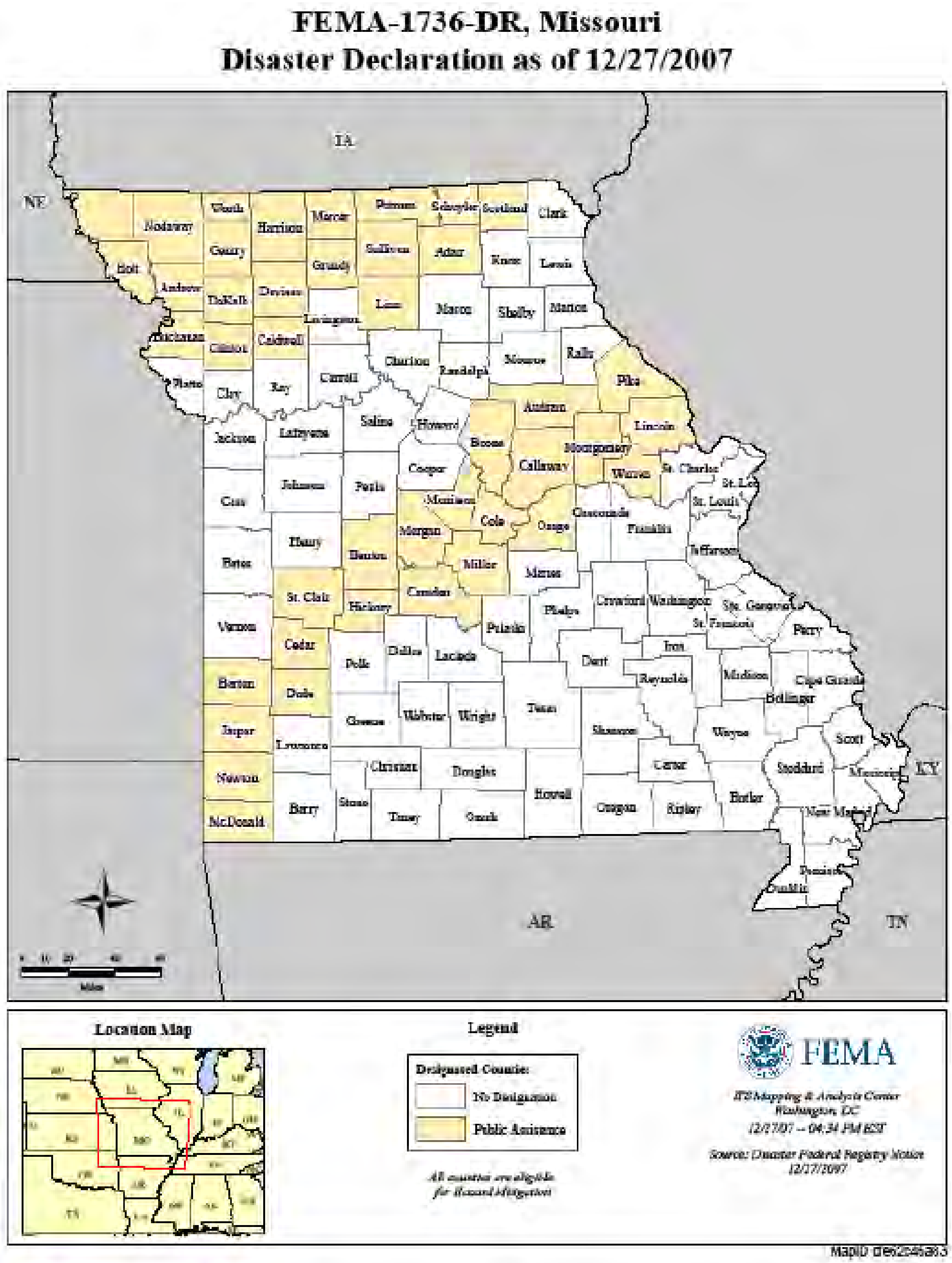
Figure 3.140. January 2007 Winter Storms



December 6, 2007 (DR-1736): A major ice storm hit parts of central, northeast, and east central Missouri (see **Figure 3.141** for a map of the counties that received disaster declarations). Up to a half inch of ice accumulated along with up to one inch of sleet. Trees and power lines were down throughout the area. Many businesses had to close due to loss of electricity. Schools across the area were closed for several days. Over 32,000 power outages were reported in Boone, Callaway, Cole, Lincoln, Moniteau, and Pike Counties. Shelters were opened in Cole, Pike and Warren Counties. From 50 to 60 people stayed at the shelters in Cole County at various times with over 100 coming in daily for hot meals. There were two fatalities reported in automobile accidents across mid-Missouri.

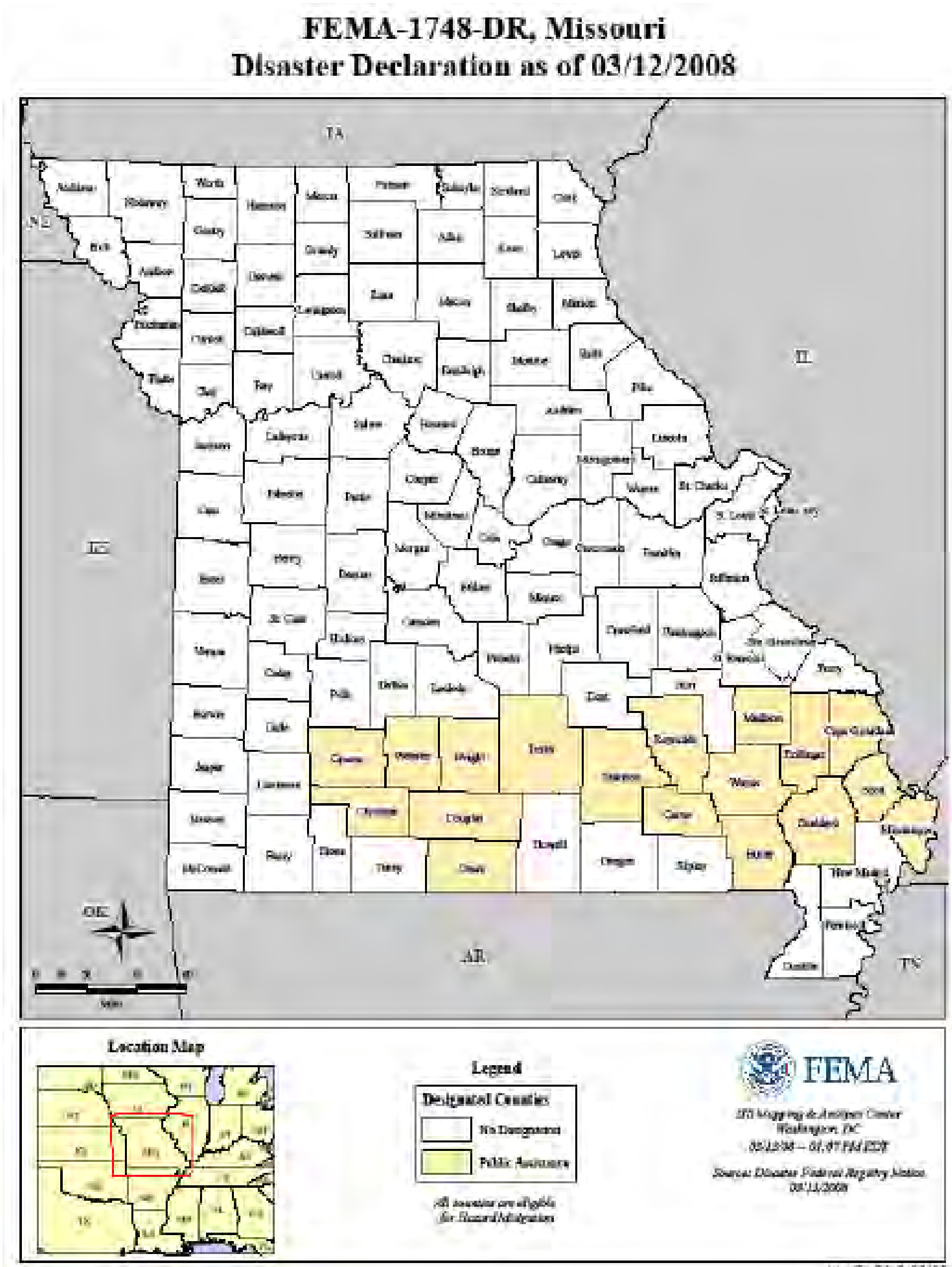
Another round of freezing rain was observed from December 9th through December 11, 2007. A slow moving storm system brought a long duration of freezing rain to a large portion of the nations mid-section. Canadian high pressure kept cold air at the surface with readings in the upper 20s to lower 30s. Very warm and moist air aloft was transported north ahead of the storm system. The result of these two ingredients led to several rounds of freezing rain. Ice rapidly accumulated on many surfaces, especially trees and power lines. Ice accumulation was particularly devastating along and north of the Missouri River. Ice accumulations of 3/4 of an inch were common, with isolated accumulations around an inch, along and north of a Bean Lake to Trenton, to Unionville line. Along and south of the Interstate 70 corridor, accumulations were less than a half inch. Numerous tree branches and power lines were downed, especially along and north of a St. Joseph to Unionville. Around 165,000 residents went without power, some for almost two weeks. Twenty Missouri electric cooperatives in the Association of Missouri Electric Cooperatives sustained damage to their electrical lines, substations and equipment from the ice storm at an estimated cost of $10.8 million. There were also numerous traffic accidents due to the icy roads.

Figure 3.141. December 2007 Winter Storm



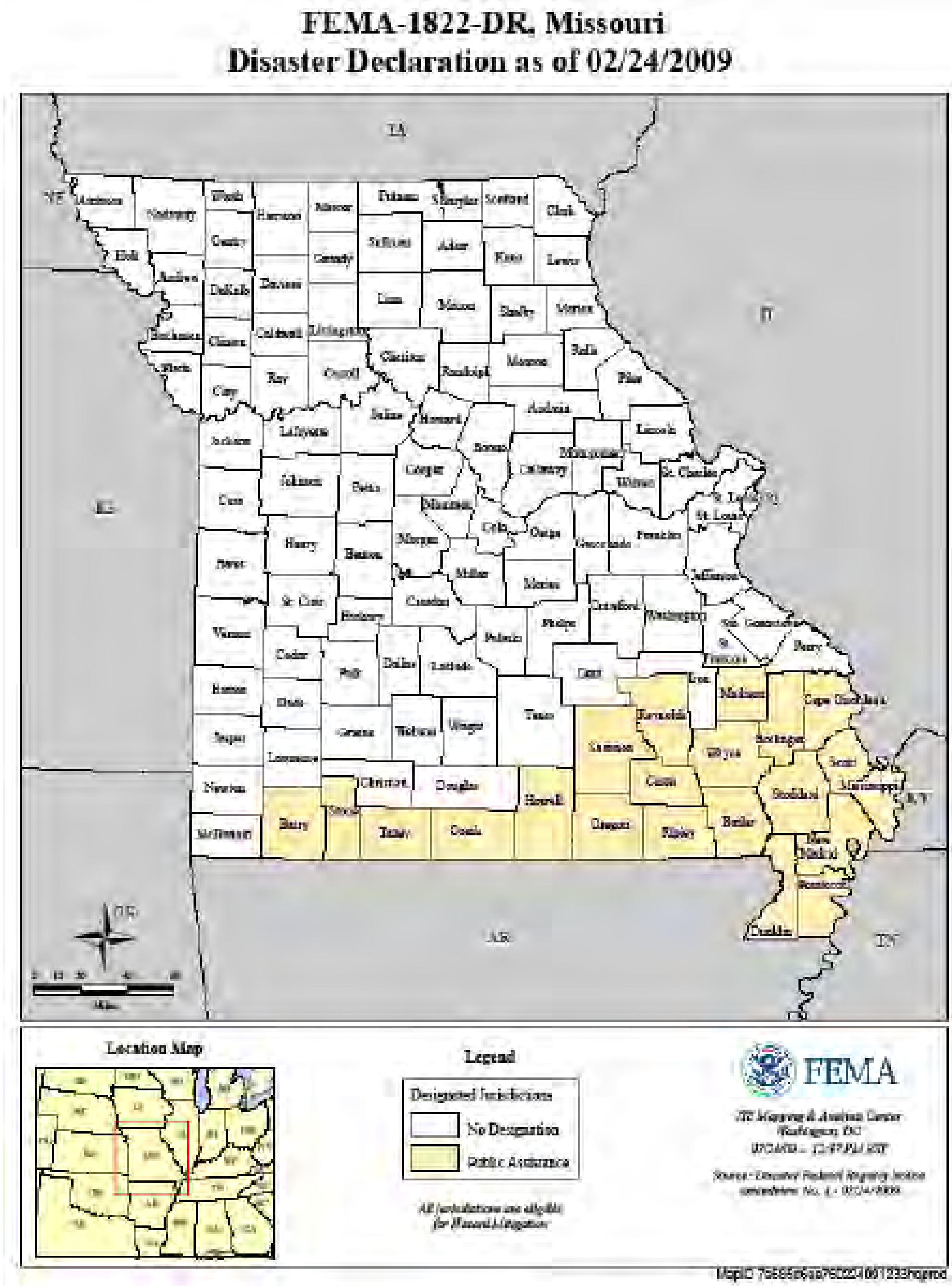
February10-14, 2008 (DR-1748): A wintry mix of precipitation affected a large area of the southern half of Missouri (see **Figure 3.142)** for a map of the counties that received disaster declarations). A significant ice even occurred. Over 15,000 power outages were reported and some continued for almost two weeks. Fourteen Missouri Electric Cooperatives that belong to the Association of Missouri Electric Cooperatives sustained damage to their electrical lines, substations and equipment from the ice storm at an estimated cost of $5.1 million. Shelters and feeding stations were set up in numerous counties. There were two storm-related traffic fatalities and 54 storm-related traffic injuries.

Figure 3.142. February 2008 Winter Storm



January 26-29, 2009 (DR-3303 and DR-1822): A cold front mixed with Gulf moisture created ice and freezing rain. High winds on February 11th caused additional damage in southern Missouri (see **Figure 3.143)** for a map of the counties that received disaster declarations). There were eight fatalities associated with this storm (six in traffic accidents and two with carbon monoxide poisoning). Up to 8000 customers were without power and some were out over three weeks. Seven Missouri Electric Cooperatives that are part of the Association of Missouri Electric Cooperatives sustained damage to their electrical lines, substations and equipment from the ice storm at an estimated cost of $175 million.

Figure 3.143. January 2009 Winter Storm



January 31, 2011 to February 5, 2011 (DR-1961): The first true blizzard in many years hit from Central to Northeast Missouri. Up to 20 inches of snow fell along with winds gusting over 40 mph. For many counties it was a record snowfall event. The National Guard was called out to help clear County roads and assist with emergency transportation. The region was brought to a standstill for several days. A Federal disaster declaration was obtained for many counties in order to assist with the cost of snow removal. Light freezing rain and sleet started to fall on Monday 1/31 with an inch of sleet accumulating by the early morning hours of Tuesday (2/1). By midday Tuesday (2/1) the precipitation had changed to snow and the wind started to increase. I-70 was shut down from Warren County to just east of Kansas City about 8 pm that evening. The snow tapered off to flurries by Wednesday (2/2) morning. The strong wind continued through the day producing very cold wind chill values.

In addition, the Missouri Department of Transportation (MODOT) incurs statewide annual costs for snow and ice removal. In an average winter, MoDOT plows approximately 6 million miles of snow and ice. According to the MoDOT 2016 Report to the Joint Committee on Transportation Oversight, the fiscal year 2016 cost for winter operations was $25 million, which was a mild winter season. This amount can vary drastically from year to year due to weather conditions. Over the last five years, the annual cost of winter operations ranged from $18 million to $75 million.

According to the USDA Risk Management Agency, insured crop losses throughout the State of Missouri as a result of cold wet winter, cold winter, freeze, and frost conditions for the ten-year period of 2007 through 2016 totaled $58.2 million.

Probability of Future Hazard Events

Severe Winter Weather is a common occurrence in Missouri. The total number of winter weather events recorded through the NCEI, including Blizzard, Heavy Storm, Ice Storm, Winter Storm and Winter Weather, was 4,694 over a 21-year period from 1996 through 2016. This results in approximately 223 events per year or a 100% probability.

Changing Future Conditions Considerations

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

State Vulnerability Overview

For areas north of the Missouri River, the probability of a snowstorm, ice storm, or extreme cold should be considered high due to historically higher average snowfall and lower average temperatures. However, the SRMT has the rated the severity as moderate due local knowledge of the overall level of preparedness in this area. For example, homes and businesses may be better insulated due to the higher probability of severe cold relative to other areas. Also, people living in this area may be more likely to use snow tires or purchase four-wheel-drive vehicles. People living in this area may be more likely to maintain adequate supplies of home heating fuels and consider other preparedness measures. Local and state governments may have access to more snow clearing equipment and maintain adequate supplies of materials needed for snow or ice removal. School districts and businesses may be more likely to develop and use snow routes or establish closing procedures.

Areas south of the Missouri River have a lower probability of a snowstorm, ice storm, or extreme cold due to their lower average snowfalls and temperatures. Events in these areas also have a moderate potential severity. This may be due to a lower level of preparedness. People living in this area may have homes with inadequate insulation or fail to maintain an adequate supply of home heating fuels. People may be less likely to equip their vehicles with snow tires or purchase four-wheel-drive vehicles. Local and state governments may not maintain sufficient amounts of equipment and materials. Schools and businesses may not have formal snow routes or closing procedures.

People are adversely affected by winter storms, ice storms, and extreme cold, some more than others. Observations by the National Oceanic and Atmospheric Administration (NOAA) indicate that of winter deaths related to exposure to cold, 50 percent were over 60 years old, over 75 percent were male, and about 20 percent occurred in the home. Of winter deaths related to ice and snow, about 70 percent occur in automobiles, and 25 percent are people caught in storms. As noted earlier, ice storms can result in significant economic costs to homeowners, business owners, and utility companies. The ice storm in December 1994 demonstrated the environmental damage that can occur. Thousands of trees and plants were cut down or damaged as a result of the ice storm. The problem of debris clearance caused environmental impacts due to the permitted burning of debris and reduced landfill space.

The method used to determine vulnerability to severe winter weather across Missouri was statistical analysis of data from several sources: National Centers for Environmental Information (NCEI) storm events data (1996 to December 31, 2016), HAZUS Building Exposure Value data, housing density data from the U.S. Census (2015 ACS), and the calculated Social Vulnerability Index for Missouri Counties from the Hazards and Vulnerability Research Institute in the Department of Geography at the University of South Carolina.

From the statistical data collected, five factors were considered in determining overall vulnerability to severe winter weather as follows: housing density, building exposure, social vulnerability, likelihood of occurrence, and average annual property loss. Based on natural breaks in the statistical data, a rating value of 1 through 5 was assigned to each factor. These rating values correspond to the following descriptive terms:

1) Low
2) Low-medium
3) Medium
4) Medium-high
5) High

Table 3.103 provides the factors considered and the ranges for the rating values assigned.

Table 3.103. Ranges for Severe Winter Weather Vulnerability Factor Ratings

Factors Considered	Low (1)	Low Medium (2)	Medium (3)	Medium High (4)	High (5)
Common Factors					
Housing Density (# per sq. mile)	4.11-44.23	44.24-134.91	134.92-259.98	259.99-862.69	862.70-2836.23
Building Exposure ($)	$269,532-$3,224,641	$3,224,642-$8,792,829	$8,792,830-$22,249,768	$22,249,769-$46,880,213	$46,880,214-$138,887,850
Social Vulnerability	1	2	3	4	5
Likelihood of Occurrence (# of events/ yrs. of data)	1.05-1.43	1.44-1.76	1.77-2.10	2.11-2.67	2.68-4.57
Average Annual Property Loss (annual property loss/ yrs. Of data)	$0-$143,095.24	$143,095.25-$406,666.67	$406,666.68-$1,191,000.95	$1,191,000.96-$3,184,761.90	$3,184,761.91-$5,861,666.67

Once the individual ratings were determined for the above factors, a combined vulnerability rating was computed for severe winter weather events. **Table 3.104** provides the calculated ranges applied to determine overall vulnerability of Missouri counties to severe winter weather. The figures that follow provide the mapped results of this analysis by county.

Table 3.104. Ranges for Severe Winter Weather Combined Vulnerability Rating

	Low (1)	Low-medium (2)	Medium (3)	Medium-high-4	High (5)
Severe Winter Weather Combined Vulnerability	7-8	8-10	10-12	12-15	15-22

Table 3.105. Housing Density, Building Exposure, and SOVI Data by County

County	Total Building Exposure (Hazus)	Building Exposure Rating	Housing Density	Housing Density Rating	SOVI Ranking	SOVI Rating
Adair	$2,599,614,000	1	19.93	1	Medium	3
Andrew	$1,724,819,000	1	16.88	1	Medium Low	2
Atchison	$806,754,000	1	5.42	1	Medium High	4
Audrain	$2,689,090,000	1	15.62	1	Medium High	4
Barry	$3,736,121,000	2	22.40	1	Medium	3
Barton	$1,414,960,000	1	9.42	1	Medium	3
Bates	$1,650,150,000	1	9.36	1	Medium	3
Benton	$2,478,458,000	1	19.93	1	Medium High	4
Bollinger	$1,035,129,000	1	9.45	1	Medium Low	2
Boone	$18,473,209,000	3	105.32	2	Low	1
Buchanan	$10,579,076,000	3	94.32	2	Medium	3
Butler	$4,144,110,000	2	28.30	1	Medium High	4
Caldwell	$984,103,000	1	10.80	1	Medium	3
Callaway	$4,410,445,000	2	22.21	1	Medium Low	2

County	Total Building Exposure (Hazus)	Building Exposure Rating	Housing Density	Housing Density Rating	SOVI Ranking	SOVI Rating
Camden	$8,325,943,000	2	62.86	2	Medium High	4
Cape Girardeau	$8,792,829,000	2	56.87	2	Medium	3
Carroll	$1,199,939,000	1	6.63	1	Medium	3
Carter	$519,266,000	1	6.38	1	Medium High	4
Cass	$10,922,958,000	3	58.01	2	Low	1
Cedar	$1,307,607,000	1	15.13	1	Medium High	4
Chariton	$938,756,000	1	5.53	1	Medium High	4
Christian	$7,747,900,000	2	57.48	2	Medium Low	2
Clark	$709,999,000	1	6.84	1	Medium Low	2
Clay	$27,589,080,000	4	237.97	3	Medium Low	2
Clinton	$2,282,850,000	1	21.20	1	Medium	3
Cole	$10,724,282,000	3	82.94	2	Medium Low	2
Cooper	$1,797,081,000	1	13.21	1	Medium Low	2
Crawford	$2,389,455,000	1	16.06	1	Medium	3
Dade	$738,641,000	1	8.05	1	Medium	3
Dallas	$1,358,763,000	1	14.04	1	Medium	3
Daviess	$958,602,000	1	7.42	1	Medium	3
DeKalb	$1,090,102,000	1	10.21	1	Low	1
Dent	$1,451,544,000	1	9.65	1	Medium High	4
Douglas	$1,047,849,000	1	7.95	1	Medium	3
Dunklin	$2,976,060,000	1	26.53	1	High	5
Franklin	$11,417,093,000	3	47.40	2	Medium Low	2
Gasconade	$1,888,630,000	1	15.77	1	Medium	3
Gentry	$689,499,000	1	6.52	1	Medium High	4
Greene	$32,106,732,000	4	189.79	3	Medium	3
Grundy	$1,175,303,000	1	11.49	1	Medium High	4
Harrison	$1,024,720,000	1	6.07	1	Medium High	4
Henry	$2,536,896,000	1	15.64	1	Medium	3
Hickory	$865,580,000	1	16.92	1	High	5
Holt	$622,760,000	1	6.01	1	Medium	3
Howard	$1,086,442,000	1	9.79	1	Medium Low	2
Howell	$3,550,892,000	2	19.47	1	Medium	3
Iron	$978,688,000	1	9.62	1	Medium High	4
Jackson	$89,309,906,000	5	519.48	4	Medium	3
Jasper	$12,070,483,000	3	80.05	2	Medium	3
Jefferson	$22,249,768,000	3	134.91	2	Low	1
Johnson	$6,044,509,000	2	26.18	1	Low	1
Knox	$438,423,000	1	4.51	1	Medium High	4
Laclede	$3,218,581,000	1	20.62	1	Medium	3

County	Total Building Exposure (Hazus)	Building Exposure Rating	Housing Density	Housing Density Rating	SOVI Ranking	SOVI Rating
Lafayette	$3,841,393,000	2	23.42	1	Medium Low	2
Lawrence	$3,495,760,000	2	27.09	1	Medium	3
Lewis	$995,873,000	1	8.94	1	Medium	3
Lincoln	$4,719,921,000	2	33.63	1	Low	1
Linn	$1,551,785,000	1	10.36	1	Medium High	4
Livingston	$1,711,120,000	1	12.66	1	Medium High	4
Macon	$1,634,837,000	1	9.52	1	Medium High	4
Madison	$1,135,602,000	1	12.03	1	Medium High	4
Maries	$955,863,000	1	8.71	1	Medium	3
Marion	$3,224,641,000	1	29.49	1	Medium High	4
McDonald	$1,683,620,000	1	18.26	1	Medium	3
Mercer	$401,520,000	1	4.67	1	Medium High	4
Miller	$2,404,472,000	1	21.50	1	Medium High	4
Mississippi	$1,114,534,000	1	13.86	1	Medium High	4
Moniteau	$1,508,058,000	1	14.80	1	Medium Low	2
Monroe	$979,485,000	1	7.43	1	Medium	3
Montgomery	$1,397,445,000	1	11.45	1	Medium High	4
Morgan	$2,872,295,000	1	25.80	1	Medium High	4
New Madrid	$1,765,289,000	1	12.64	1	High	5
Newton	$5,509,504,000	2	38.96	1	Medium Low	2
Nodaway	$2,447,800,000	1	10.96	1	Medium	3
Oregon	$891,037,000	1	6.89	1	Medium High	4
Osage	$1,611,790,000	1	10.85	1	Low	1
Ozark	$926,358,000	1	7.55	1	Medium	3
Pemiscot	$1,642,290,000	1	16.48	1	High	5
Perry	$2,233,009,000	1	18.14	1	Medium Low	2
Pettis	$4,468,128,000	2	26.68	1	Medium	3
Phelps	$4,743,488,000	2	29.35	1	Medium Low	2
Pike	$1,861,578,000	1	11.68	1	Medium Low	2
Platte	$11,360,168,000	3	94.90	2	Low	1
Polk	$2,708,704,000	1	20.98	1	Medium	3
Pulaski	$5,334,660,000	2	33.60	1	Low	1
Putnam	$532,020,000	1	5.73	1	Medium	3
Ralls	$1,155,646,000	1	10.93	1	Medium Low	2
Randolph	$2,425,165,000	1	22.11	1	Medium Low	2
Ray	$2,537,055,000	1	17.52	1	Medium Low	2
Reynolds	$669,647,000	1	4.97	1	Medium High	4
Ripley	$1,131,335,000	1	10.40	1	Medium High	4
Saline	$2,437,646,000	1	13.35	1	Medium	3

County	Total Building Exposure (Hazus)	Building Exposure Rating	Housing Density	Housing Density Rating	SOVI Ranking	SOVI Rating
Schuyler	$401,800,000	1	6.79	1	Medium	3
Scotland	$541,487,000	1	5.38	1	Medium High	4
Scott	$4,036,288,000	2	40.47	1	Medium	3
Shannon	$678,728,000	1	4.11	1	Medium	3
Shelby	$786,622,000	1	6.37	1	Medium	3
St. Charles	$41,845,005,000	4	259.98	3	Low	1
St. Clair	$936,097,000	1	8.36	1	Medium High	4
St. Francois	$6,180,166,000	2	64.59	2	Medium Low	2
St. Louis	$138,887,850,000	5	862.69	4	Medium Low	2
St. Louis City	$46,880,213,000	4	2836.23	5	High	5
Ste. Genevieve	$2,163,144,000	1	17.27	1	Medium Low	2
Stoddard	$2,989,130,000	1	16.52	1	Medium	3
Stone	$3,936,498,000	2	44.23	1	Medium High	4
Sullivan	$624,603,000	1	5.16	1	Medium High	4
Taney	$6,120,612,000	2	47.41	2	High	5
Texas	$2,293,426,000	1	9.86	1	Medium	3
Vernon	$2,251,400,000	1	11.47	1	Medium High	4
Warren	$3,478,576,000	2	34.75	1	Medium Low	2
Washington	$1,730,986,000	1	14.34	1	Medium	3
Wayne	$1,256,590,000	1	10.54	1	Medium High	4
Webster	$2,782,115,000	1	24.42	1	Medium Low	2
Worth	$269,532,000	1	4.78	1	Medium High	4
Wright	$1,602,331,000	1	12.66	1	Medium	3

Table 3.106 provides the additional data obtained from the National Centers for Environmental Information to complete the overall vulnerability analysis and the total overall vulnerability rating for severe winter weather. The total number of winter weather events includes blizzard, heavy snow, ice storm, winter storm, and winter weather events.

Table 3.106. Additional Statistical Data Compiled for Vulnerability Analysis

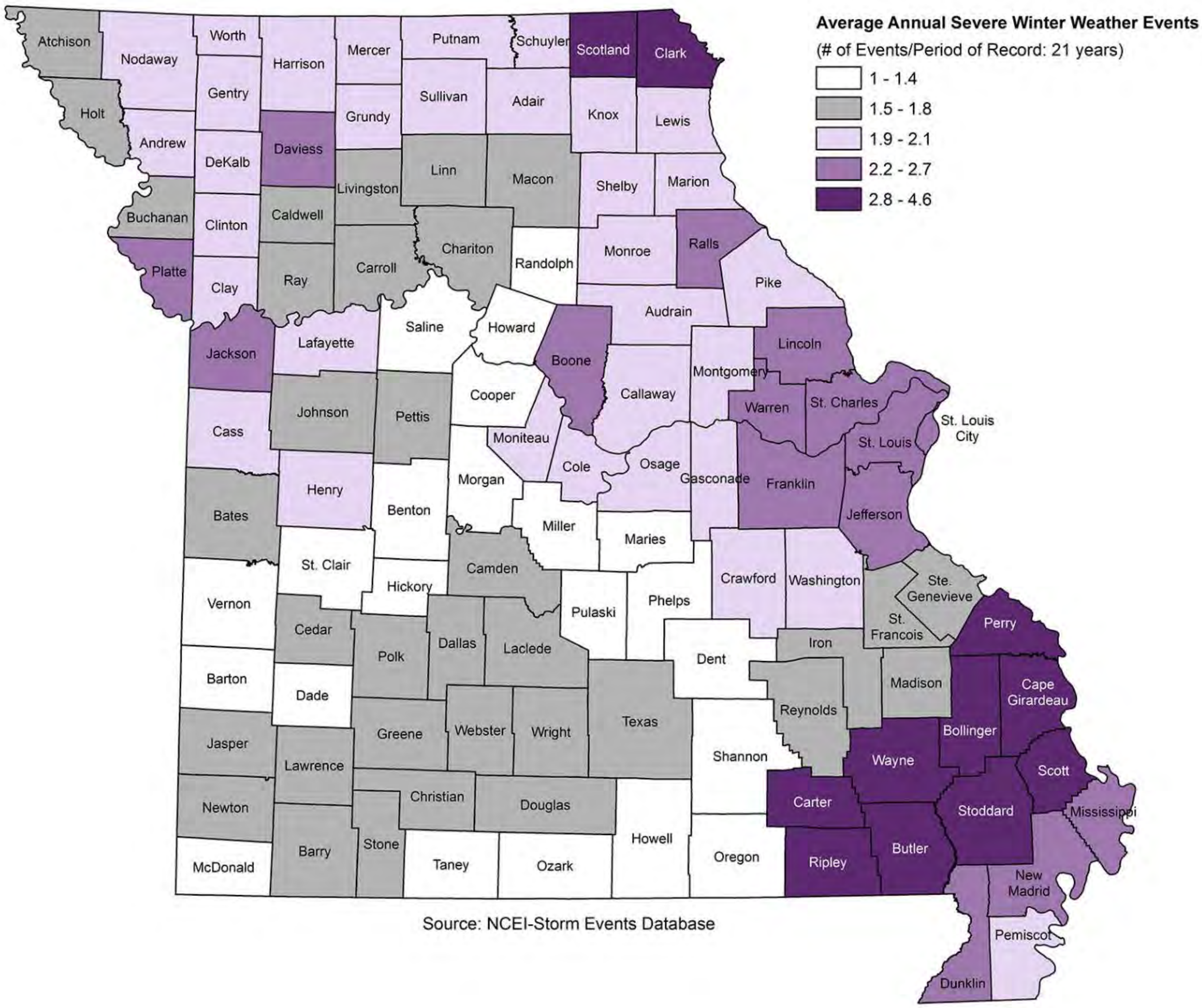
County	Total Number of Winter Weather Events	Likelihood of Occurrence	Likelihood of Occurrence Rating	Total Annualized Property Loss	Total Annualized Property Loss Rating	Overall Vulnerability Rating	Overall Vulnerability Rating Description
Adair	40	1.9048	3	$ 9,762	1	9	Low Medium
Andrew	39	1.8571	3	$ 28,571	2	9	Low Medium
Atchison	37	1.7619	2	$ 9,619	1	9	Low Medium
Audrain	43	2.0476	3	$ -	1	10	Low Medium

County	Total Number of Winter Weather Events	Likelihood of Occurrence	Likelihood of Occurrence Rating	Total Annualized Property Loss	Total Annualized Property Loss Rating	Overall Vulnerability Rating	Overall Vulnerability Rating Description
Barry	32	1.5238	2	$ 207,619	2	10	Low Medium
Barton	30	1.4286	1	$ 380,952	2	8	Low
Bates	33	1.5714	2	$ 27,762	2	9	Low Medium
Benton	28	1.3333	1	$ 16,667	2	9	Low Medium
Bollinger	80	3.8095	5	$ 107,143	2	11	Medium
Boone	47	2.2381	4	$ 61,524	2	12	Medium
Buchanan	37	1.7619	2	$ 1,190	1	11	Medium
Butler	70	3.3333	5	$ 990,476	3	15	Medium High
Caldwell	36	1.7143	2	$ 10,000	1	8	Low
Callaway	41	1.9524	3	$ 55,667	2	10	Low Medium
Camden	31	1.4762	2	$ 5,736,667	5	15	Medium High
Cape Girardeau	83	3.9524	5	$ 171,429	2	14	Medium High
Carroll	33	1.5714	2	$ 11,905	1	8	Low
Carter	72	3.4286	5	$ 66,667	2	13	Medium
Cass	43	2.0476	3	$ 319,048	2	11	Medium
Cedar	31	1.4762	2	$ 86,429	2	10	Low Medium
Chariton	32	1.5238	2	$ 9,524	1	9	Low Medium
Christian	33	1.5714	2	$ 33,810	2	10	Low Medium
Clark	96	4.5714	5	$ 833	1	10	Low Medium
Clay	41	1.9524	3	$ 12,952	1	13	Medium High
Clinton	39	1.8571	3	$ 9,762	1	9	Low Medium
Cole	42	2.0000	3	$ 18,000	2	12	Medium
Cooper	28	1.3333	1	$ 47,857	2	7	Low
Crawford	40	1.9048	3	$ 35,905	2	10	Low Medium
Dade	30	1.4286	1	$ 37,619	2	8	Low
Dallas	33	1.5714	2	$ 5,011,429	5	12	Medium
Daviess	47	2.2381	4	$ 16,667	2	11	Medium
DeKalb	40	1.9048	3	$ 16,667	2	8	Low
Dent	30	1.4286	1	$ 7,381	1	8	Low
Douglas	33	1.5714	2	$ 13,333	1	8	Low
Dunklin	45	2.1429	4	$ 1,191,001	3	14	Medium High
Franklin	45	2.1429	4	$ 25,429	2	13	Medium High
Gasconade	42	2.0000	3	$ 6,524	1	9	Low Medium
Gentry	38	1.8095	3	$ 72,619	2	11	Medium
Greene	37	1.7619	2	$ 5,861,667	5	17	High
Grundy	44	2.0952	3	$ 143,095	2	11	Medium
Harrison	42	2.0000	3	$ 13,095	1	10	Low Medium

County	Total Number of Winter Weather Events	Likelihood of Occurrence	Likelihood of Occurrence Rating	Total Annualized Property Loss	Total Annualized Property Loss Rating	Overall Vulnerability Rating	Overall Vulnerability Rating Description
Henry	41	1.9524	3	$ 9,857	1	9	Low Medium
Hickory	28	1.3333	1	$ 756,429	3	11	Medium
Holt	31	1.4762	2	$ 40,476	2	9	Low Medium
Howard	22	1.0476	1	$ 47,857	2	7	Low
Howell	29	1.3810	1	$ 16,905	2	9	Low Medium
Iron	35	1.6667	2	$ 4,667	1	9	Low Medium
Jackson	56	2.6667	4	$ 762,381	3	19	High
Jasper	31	1.4762	2	$ 270,714	2	12	Medium
Jefferson	46	2.1905	4	$ 0	1	11	Medium
Johnson	36	1.7143	2	$ 9,524	1	7	Low
Knox	41	1.9524	3	$ 0	1	10	Low Medium
Laclede	34	1.6190	2	$ 2,401,667	4	11	Medium
Lafayette	39	1.8571	3	$ 14,286	1	9	Low Medium
Lawrence	34	1.6190	2	$ 263,095	2	10	Low Medium
Lewis	41	1.9524	3	$ 0	1	9	Low Medium
Lincoln	48	2.2857	4	$ 0	1	9	Low Medium
Linn	35	1.6667	2	$ 5,000	1	9	Low Medium
Livingston	36	1.7143	2	$ 5,238	1	9	Low Medium
Macon	33	1.5714	2	$ 9,762	1	9	Low Medium
Madison	33	1.5714	2	$ 0	1	9	Low Medium
Maries	24	1.1429	1	$ 185,952	2	8	Low
Marion	44	2.0952	3	$ 0	1	10	Low Medium
McDonald	28	1.3333	1	$ 15,952	2	8	Low
Mercer	39	1.8571	3	$ 24,286	2	11	Medium
Miller	25	1.1905	1	$ 3,184,762	4	11	Medium
Mississippi	55	2.6190	4	$ 985,714	3	13	Medium High
Moniteau	41	1.9524	3	$ 9,524	1	8	Low
Monroe	42	2.0000	3	$ 0	1	9	Low Medium
Montgomery	43	2.0476	3	$ 286	1	10	Low Medium
Morgan	27	1.2857	1	$ 9,557	1	8	Low
New Madrid	56	2.6667	4	$ 1,033,810	3	14	Medium High
Newton	32	1.5238	2	$ 1,931,667	4	11	Medium
Nodaway	39	1.8571	3	$ 9,524	1	9	Low Medium
Oregon	27	1.2857	1	$ 7,143	1	8	Low
Osage	40	1.9048	3	$ 4,857	1	7	Low
Ozark	29	1.3810	1	$ 10,714	1	7	Low
Pemiscot	43	2.0476	3	$ 1,191,001	3	13	Medium High

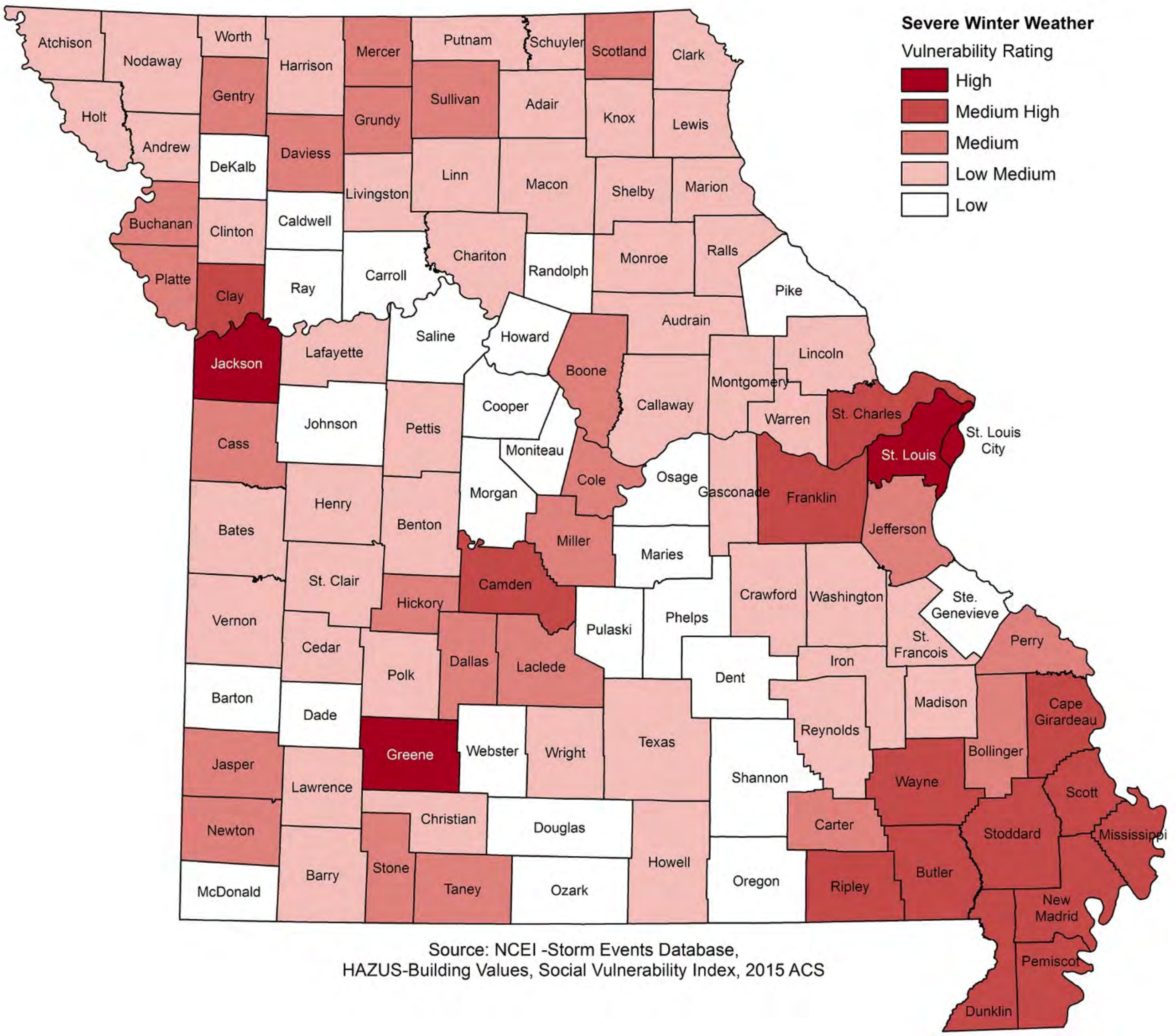
County	Total Number of Winter Weather Events	Likelihood of Occurrence	Likelihood of Occurrence Rating	Total Annualized Property Loss	Total Annualized Property Loss Rating	Overall Vulnerability Rating	Overall Vulnerability Rating Description
Perry	80	3.8095	5	$ 27,810	2	11	Medium
Pettis	36	1.7143	2	$ 5,381	1	9	Low Medium
Phelps	27	1.2857	1	$ 259,286	2	8	Low
Pike	41	1.9524	3	$ 0	1	8	Low
Platte	46	2.1905	4	$ 250,095	2	12	Medium
Polk	32	1.5238	2	$ 67,857	2	9	Low Medium
Pulaski	27	1.2857	1	$ 406,667	2	7	Low
Putnam	43	2.0476	3	$ 24,048	2	10	Low Medium
Ralls	46	2.1905	4	$ 0	1	9	Low Medium
Randolph	26	1.2381	1	$ 23,810	2	7	Low
Ray	33	1.5714	2	$ 14,286	1	7	Low
Reynolds	32	1.5238	2	$ 5,714	1	9	Low Medium
Ripley	69	3.2857	5	$ 728,571	3	14	Medium High
Saline	30	1.4286	1	$ 19,143	2	8	Low
Schuyler	42	2.0000	3	$ 107,381	2	10	Low Medium
Scotland	96	4.5714	5	$ 1,167	1	12	Medium
Scott	69	3.2857	5	$ 1,035,905	3	14	Medium High
Shannon	30	1.4286	1	$ 7,857	1	7	Low
Shelby	41	1.9524	3	$ 0	1	9	Low Medium
St. Charles	48	2.2857	4	$ 960,429	3	15	Medium High
St. Clair	27	1.2857	1	$ 71,905	2	9	Low Medium
St. Francois	34	1.6190	2	$ 56,905	2	10	Low Medium
St. Louis	49	2.3333	4	$ 2,085,714	4	19	High
St. Louis City	46	2.1905	4	$ 2,490,476	4	22	High
Ste. Genevieve	34	1.6190	2	$ 25,190	2	8	Low
Stoddard	69	3.2857	5	$ 976,190	3	13	Medium High
Stone	33	1.5714	2	$ 21,190	2	11	Medium
Sullivan	40	1.9048	3	$ 36,190	2	11	Medium
Taney	30	1.4286	1	$ 20,000	2	12	Medium
Texas	32	1.5238	2	$ 15,714	2	9	Low Medium
Vernon	29	1.3810	1	$ 51,905	2	9	Low Medium
Warren	46	2.1905	4	$ 4,571	1	10	Low Medium
Washington	39	1.8571	3	$ 15,000	2	10	Low Medium
Wayne	77	3.6667	5	$ 102,381	2	13	Medium High
Webster	36	1.7143	2	$ 285,238	2	8	Low
Worth	38	1.8095	3	$ 13,095	1	10	Low Medium
Wright	35	1.6667	2	$ 20,476	2	9	Low Medium

Figure 3.144. Average Annual Occurrence of Severe Winter Weather Events



Source: NCEI-Storm Events Database

Figure 3.145. Vulnerability Summary for Severe Winter Weather



State Estimates of Potential Losses

To determine potential financial loss estimates to severe winter weather in Missouri, the available historical property loss data was annualized. In the case of frequently occurring weather-related hazards such as severe winter weather, annualized historical loss data is considered to be the best resource for determining future potential losses. As discussed above in the vulnerability overview for this hazard, the planning team obtained historical loss data from the NCEI Storm Event Database for Blizzard, Heavy Storm Ice Storm, Winter Storm and Winter Weather for the period from 1996 to December 2016. The total property damage was $931,232,740 which results in approximately $44,344,416 in property loss per year.

Table 3.107. Annualized Severe Winter Weather Damages in Missouri

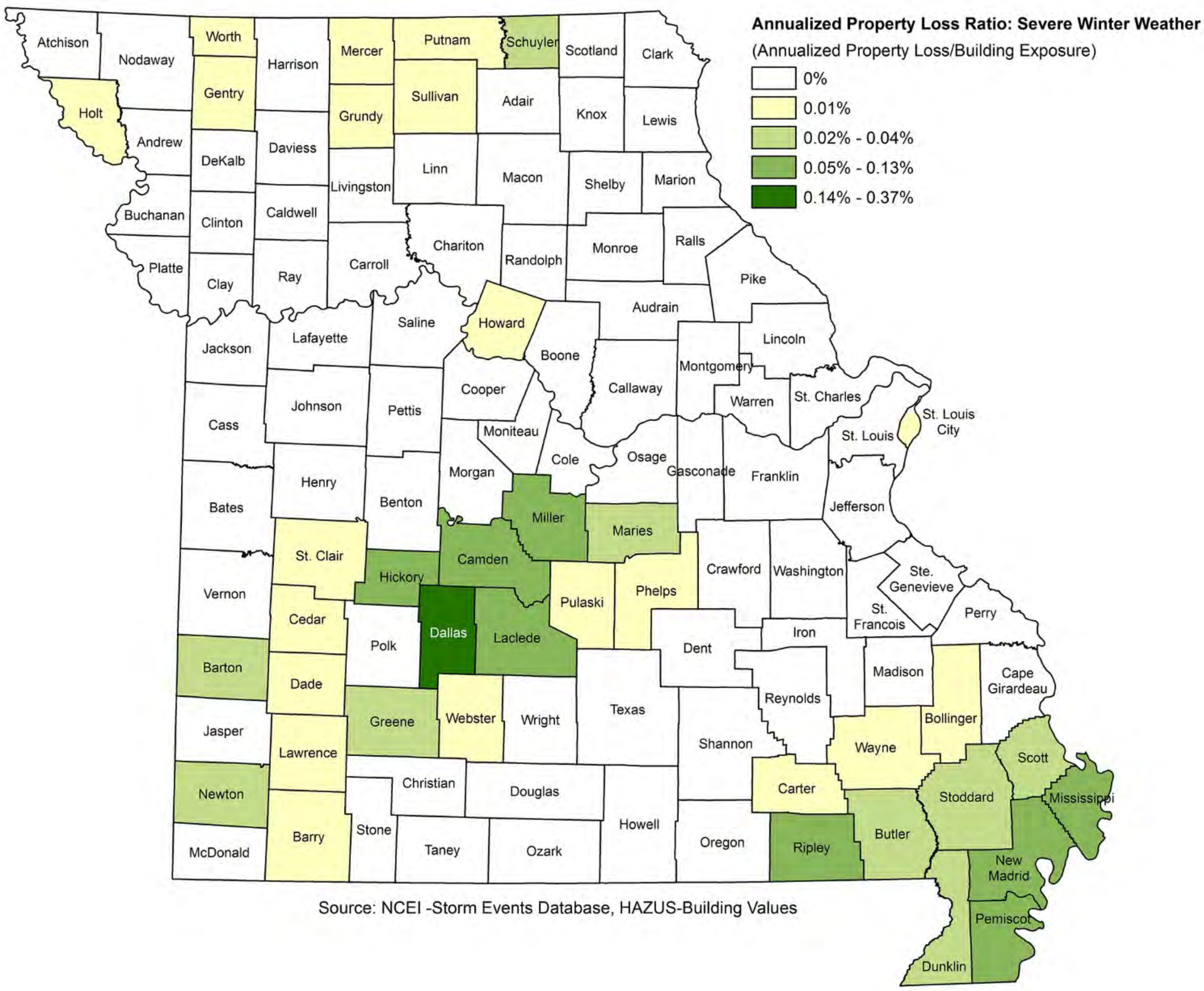
County	Annualized Blizzard Property Loss ($)	Annualized Heavy Snow Property Loss ($)	Annualized Ice Storm Property Loss ($)	Annualized Winter Storm Property Loss ($)	Annualized Winter Weather Property Loss ($)	Total Annualized Winter Weather Property Loss ($)
Adair	$0	$9,524	$238	$0	$0	$9,762
Andrew	$0	$4,762	$23,810	$0	$0	$28,571
Atchison	$0	$4,762	$4,762	$95	$0	$9,619
Audrain	$0	$0	$0	$0	$0	$0
Barry	$0	$714	$197,619	$9,286	$0	$207,619
Barton	$0	$3,810	$333,810	$43,333	$0	$380,952
Bates	$0	$48	$27,714	$0	$0	$27,762
Benton	$0	$238	$16,429	$0	$0	$16,667
Bollinger	$0	$0	$7,143	$100,000	$0	$107,143
Boone	$0	$0	$31,095	$30,429	$0	$61,524
Buchanan	$0	$0	$1,190	$0	$0	$1,190
Butler	$0	$0	$4,762	$985,714	$0	$990,476
Caldwell	$0	$0	$476	$9,524	$0	$10,000
Callaway	$0	$0	$0	$55,667	$0	$55,667
Camden	$0	$952	$11,905	$5,716,667	$7,143	$5,736,667
Cape Girardeau	$0	$0	$2,381	$169,048	$0	$171,429
Carroll	$0	$0	$11,905	$0	$0	$11,905
Carter	$0	$0	$4,762	$61,905	$0	$66,667
Cass	$0	$0	$319,048	$0	$0	$319,048
Cedar	$0	$714	$83,333	$2,381	$0	$86,429
Chariton	$0	$0	$9,524	$0	$0	$9,524
Christian	$0	$1,667	$23,810	$8,333	$0	$33,810
Clark	$0	$0	$714	$0	$119	$833
Clay	$0	$11,905	$1,048	$0	$0	$12,952
Clinton	$0	$0	$238	$9,524	$0	$9,762
Cole	$0	$0	$1,619	$16,381	$0	$18,000
Cooper	$0	$0	$47,857	$0	$0	$47,857
Crawford	$0	$0	$35,905	$0	$0	$35,905
Dade	$0	$714	$35,714	$1,190	$0	$37,619
Dallas	$0	$714	$5,007,143	$3,571	$0	$5,011,429
Daviess	$0	$4,762	$11,905	$0	$0	$16,667
DeKalb	$0	$4,762	$11,905	$0	$0	$16,667
Dent	$0	$238	$0	$7,143	$0	$7,381
Douglas	$0	$476	$6,905	$5,952	$0	$13,333
Dunklin	$0	$143	$1,190,714	$143	$0	$1,191,001
Franklin	$0	$0	$15,905	$9,524	$0	$25,429
Gasconade	$0	$0	$6,524	$0	$0	$6,524
Gentry	$0	$71,429	$1,190	$0	$0	$72,619

County	Annualized Blizzard Property Loss ($)	Annualized Heavy Snow Property Loss ($)	Annualized Ice Storm Property Loss ($)	Annualized Winter Storm Property Loss ($)	Annualized Winter Weather Property Loss ($)	Total Annualized Winter Weather Property Loss ($)
Greene	$1,905	$13,095	$5,809,524	$8,571	$28,571	$5,861,667
Grundy	$0	$142,857	$238	$0	$0	$143,095
Harrison	$0	$11,905	$1,190	$0	$0	$13,095
Henry	$0	$238	$9,619	$0	$0	$9,857
Hickory	$0	$476	$36,905	$719,048	$0	$756,429
Holt	$0	$4,762	$35,714	$0	$0	$40,476
Howard	$0	$0	$47,857	$0	$0	$47,857
Howell	$0	$0	$5,000	$11,905	$0	$16,905
Iron	$0	$0	$0	$4,667	$0	$4,667
Jackson	$0	$47,619	$714,286	$0	$476	$762,381
Jasper	$0	$2,857	$252,381	$10,714	$4,762	$270,714
Jefferson	$0	$0	$0	$0	$0	$0
Johnson	$0	$0	$9,524	$0	$0	$9,524
Knox	$0	$0	$0	$0	$0	$0
Laclede	$0	$2,381	$2,393,333	$1,190	$4,762	$2,401,667
Lafayette	$0	$0	$14,286	$0	$0	$14,286
Lawrence	$714	$2,381	$254,762	$5,238	$0	$263,095
Lewis	$0	$0	$0	$0	$0	$0
Lincoln	$0	$0	$0	$0	$0	$0
Linn	$0	$0	$238	$4,762	$0	$5,000
Livingston	$0	$0	$476	$4,762	$0	$5,238
Macon	$0	$0	$9,762	$0	$0	$9,762
Madison	$0	$0	$0	$0	$0	$0
Maries	$0	$238	$161,905	$23,810	$0	$185,952
Marion	$0	$0	$0	$0	$0	$0
McDonald	$2,857	$1,429	$9,286	$2,381	$0	$15,952
Mercer	$0	$23,810	$476	$0	$0	$24,286
Miller	$0	$476	$146,190	$3,038,095	$0	$3,184,762
Mississippi	$0	$0	$0	$985,714	$0	$985,714
Moniteau	$0	$0	$0	$9,524	$0	$9,524
Monroe	$0	$0	$0	$0	$0	$0
Montgomery	$0	$0	$286	$0	$0	$286
Morgan	$0	$238	$4,190	$5,129	$0	$9,557
New Madrid	$0	$0	$0	$1,033,810	$0	$1,033,810
Newton	$1,190	$714	$1,919,048	$8,333	$2,381	$1,931,667
Nodaway	$0	$4,762	$4,762	$0	$0	$9,524
Oregon	$0	$0	$0	$7,143	$0	$7,143
Osage	$0	$0	$4,857	$0	$0	$4,857
Ozark	$0	$4,762	$0	$5,952	$0	$10,714

County	Annualized Blizzard Property Loss ($)	Annualized Heavy Snow Property Loss ($)	Annualized Ice Storm Property Loss ($)	Annualized Winter Storm Property Loss ($)	Annualized Winter Weather Property Loss ($)	Total Annualized Winter Weather Property Loss ($)
Pemiscot	$0	$143	$1,190,714	$143	$0	$1,191,001
Perry	$0	$0	$4,762	$22,857	$190	$27,810
Pettis	$0	$0	$5,000	$381	$0	$5,381
Phelps	$0	$1,667	$240,952	$16,667	$0	$259,286
Pike	$0	$0	$0	$0	$0	$0
Platte	$0	$11,905	$238,190	$0	$0	$250,095
Polk	$0	$2,381	$59,524	$5,952	$0	$67,857
Pulaski	$0	$952	$400,476	$5,238	$0	$406,667
Putnam	$0	$23,810	$238	$0	$0	$24,048
Ralls	$0	$0	$0	$0	$0	$0
Randolph	$0	$0	$23,810	$0	$0	$23,810
Ray	$0	$0	$14,286	$0	$0	$14,286
Reynolds	$0	$0	$0	$5,714	$0	$5,714
Ripley	$0	$0	$4,762	$723,810	$0	$728,571
Saline	$0	$0	$19,143	$0	$0	$19,143
Schuyler	$0	$107,143	$238	$0	$0	$107,381
Scotland	$0	$0	$1,048	$0	$119	$1,167
Scott	$0	$0	$2,381	$1,033,524	$0	$1,035,905
Shannon	$0	$0	$238	$7,619	$0	$7,857
Shelby	$0	$0	$0	$0	$0	$0
St. Charles	$0	$0	$8,048	$952,381	$0	$960,429
St. Clair	$0	$476	$14,286	$57,143	$0	$71,905
St. Francois	$0	$0	$0	$56,905	$0	$56,905
St. Louis	$0	$0	$4,762	$2,080,952	$0	$2,085,714
St. Louis City	$0	$0	$0	$2,490,476	$0	$2,490,476
Ste. Genevieve	$0	$0	$0	$25,190	$0	$25,190
Stoddard	$0	$0	$4,762	$971,429	$0	$976,190
Stone	$0	$714	$19,048	$1,429	$0	$21,190
Sullivan	$0	$35,714	$476	$0	$0	$36,190
Taney	$0	$952	$19,048	$0	$0	$20,000
Texas	$0	$714	$7,381	$7,619	$0	$15,714
Vernon	$0	$1,190	$45,238	$5,476	$0	$51,905
Warren	$0	$0	$4,571	$0	$0	$4,571
Washington	$0	$0	$0	$15,000	$0	$15,000
Wayne	$0	$0	$7,143	$95,238	$0	$102,381
Webster	$0	$4,524	$262,381	$18,333	$0	$285,238
Worth	$0	$11,905	$1,190	$0	$0	$13,095
Wright	$0	$476	$13,095	$6,905	$0	$20,476

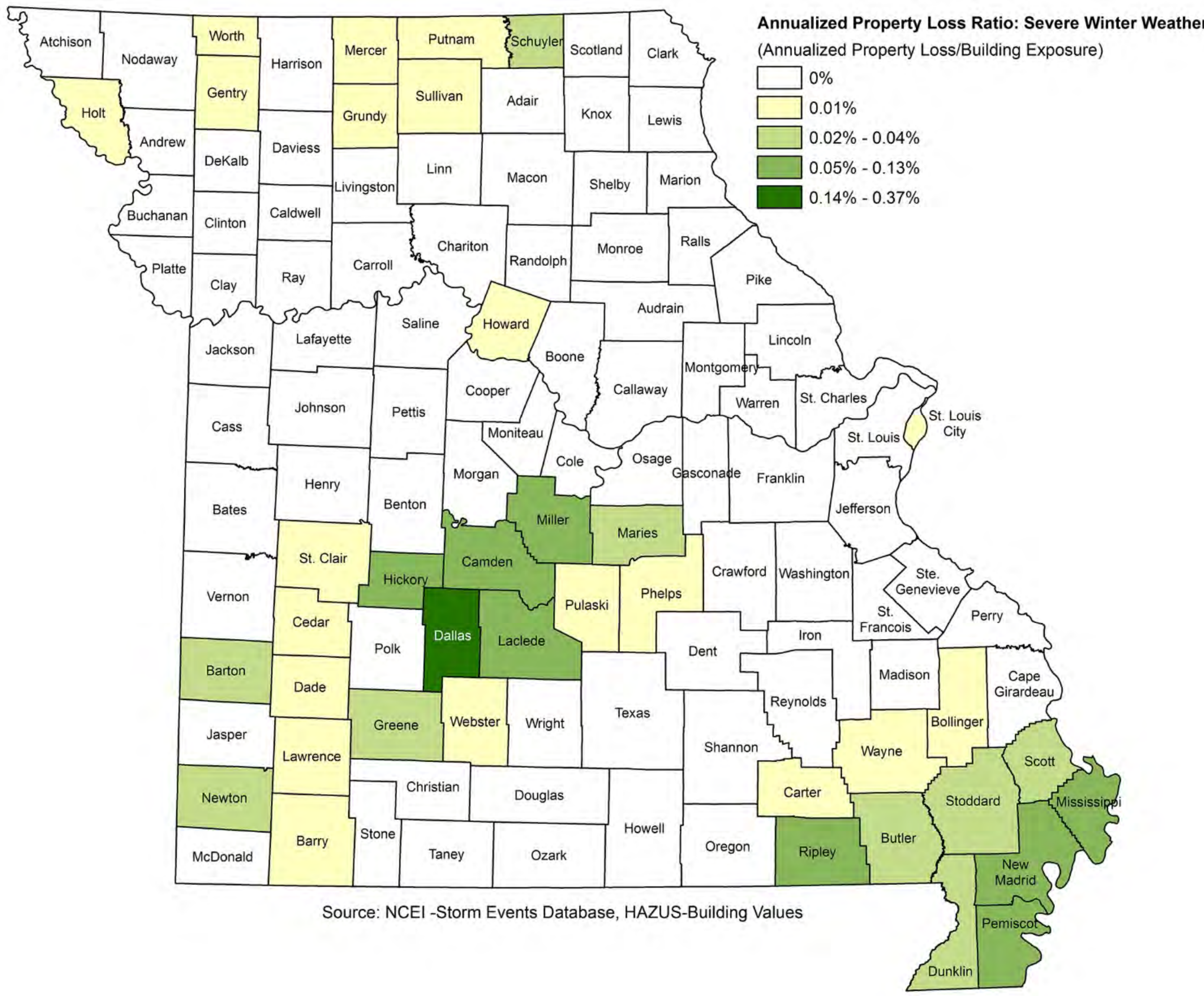
Based on this data, the figures below provide the potential annualized loss estimates for total winter weather historical damages. There are no distinct patterns of loss that can be inferred from the maps other than higher losses in areas with greater exposure. Thus, this analysis demonstrates the random distribution of this hazard and its impacts around the State of Missouri.

Figure 3.146. Annualized Winter Weather Damages



Source: NCEI -Storm Events Database, HAZUS-Building Values

Figure 3.147. Annualized Winter Weather Property Loss Ratio



Source: NCEI -Storm Events Database, HAZUS-Building Values

Hazard Impact on Future Growth and Development

In recent years, the weather pattern has caused more changes than development trend changes in Missouri. Future development could potentially increase vulnerability to this hazard by increasing demand on the utilities and increasing the exposure of infrastructure networks.

According to the overall vulnerability summary for winter storms, the following counties have high vulnerability ratings: Greene, Jackson, St. Louis, and St. Louis City. All of the following counties have growing population rates.

EMAP Consequence Analysis

The information in the table below is from the Impact Analysis of Potential for Detrimental Impacts of Hazards done for the Emergency Management Accreditation Program.

Table 3.108. EMAP Impact Analysis: Severe Winter Weather

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

Risk Summary

As previously noted, snowstorms, ice storms, and extreme cold can interact to cause many hazards. Only a few degrees may be the difference between rain, ice, or snow. Duration and intensity of any of these events will determine the overall impact of a particular event. Wind speed may be the difference between a minor snow and a blizzard. These events cannot be prevented. Preparedness for these events may be the greatest single factor to reduce loss of life, injury, and property damage. NOAA weather broadcasts via radio and television provide important information for people to prepare and thus reduce risks to their lives and property.

Problem Statement:

Using Vulnerability for Severe Winter Weather as a key indicator, the counties with the most vulnerable populations are St. Louis City and Jackson, Greene and St. Louis Counties. Using Annualized Winter Weather Damages and Loss Ratios as key indicators, the most vulnerable counties are Dallas, Camden and Greene. Mitigation efforts and dollars focused on these areas would likely prove most effective.

2018 risk assessment data and mapping is available through the Missouri Hazard Mitigation Viewer: http://bit.ly/MoHazardMitigationPlanViewer2018.

3.3.10. Tornadoes

Probability	Severity
100% 39.6 events per year average	High

Description/Location

Tornadoes are cyclical windstorms often associated with the Midwestern areas of the United States. Weather conditions conducive to tornadoes often produce a wide range of other dangerous storm activities, including severe thunderstorms, downbursts, straight-line winds, lightning, hail, and heavy rains. For the purpose of this analysis, tornadoes are considered in one category. Other severe weather activities associated with tornadoes are profiled separately in this document in Section 3.1.8 Severe Thunderstorms. **Figure 3.148** illustrates damage from a tornado that struck Joplin, MO on May 22, 2011.

Figure 3.148. May 22, 2011 Joplin, Missouri EF5 Tornado Damage

Source: Mark Schiefelbein/Associated Press

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

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

Canada across Lake Superior to Maine. During its move northward in the spring and its recession south during the fall, the jet stream crosses Missouri, causing the large thunderstorms that breed tornadoes.

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

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

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

Extent

Tornadoes are classified according to the EF- Scale (the original F – Scale was developed by Dr. Theodore Fujita, a renowned severe storm researcher). The Enhanced F- Scale (see 0) attempts to rank tornadoes according to wind speed based on the damage caused. This update to the original F scale was implemented in the U.S. on February 1, 2007.

Table 3.109. Enhanced F Scale for Tornado Damage

FUJITA SCALE			DERIVED EF SCALE		OPERATIONAL EF SCALE	
F Number	Fastest 1/4-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 Enhanced F-scale still is a set of wind estimates (not measurements) based on damage. It uses three-second gusts estimated at the point of damage based on a judgment of 8 levels of damage to the 28 indicators listed in **Table 3.110**. These estimates vary with height and exposure. **Important**: The 3 second gust is not the same wind as in standard surface observations. Standard measurements are taken by weather stations in open exposures, using a directly measured, "one minute mile" speed.

Table 3.110. Enhanced F Scale Damage Indicators

NUMBER	DAMAGE INDICATOR	ABBREVIATION
1	Small barns, farm outbuildings	SBO
2	One- or two-family residences	FR12
3	Single-wide mobile home (MHSW)	MHSW
4	Double-wide mobile home	MHDW
5	Apt, condo, townhouse (3 stories or less)	ACT
6	Motel	M
7	Masonry apt. or motel	MAM
8	Small retail bldg. (fast food)	SRB
9	Small professional (doctor office, branch bank)	SPB
10	Strip mall	SM
11	Large shopping mall	LSM
12	Large, isolated ("big box") retail bldg.	LIRB
13	Automobile showroom	ASR
14	Automotive service building	ASB
15	School - 1-story elementary (interior or exterior halls)	ES
16	School - jr. or sr. high school	JHSH
17	Low-rise (1-4 story) bldg.	LRB
18	Mid-rise (5-20 story) bldg.	MRB
19	High-rise (over 20 stories)	HRB
20	Institutional bldg. (hospital, govt. or university)	IB
21	Metal building system	MBS
22	Service station canopy	SSC
23	Warehouse (tilt-up walls or heavy timber)	WHB
24	Transmission line tower	TLT
25	Free-standing tower	FST
26	Free standing pole (light, flag, luminary)	FSP
27	Tree - hardwood	TH
28	Tree - softwood	TS

Source: National Weather Service, www.spc.noaa.gov/faq/tornado/ef-scale.html

Figure 3.149 illustrates the total number tornadoes per U.S. County between 1955 and 2014. Counties within Missouri have recorded between 1 and 60 tornadoes during this nearly 59-year period. None of the counties within Missouri reported zero tornado events.

Figure 3.149. Tornado Activity in the United States

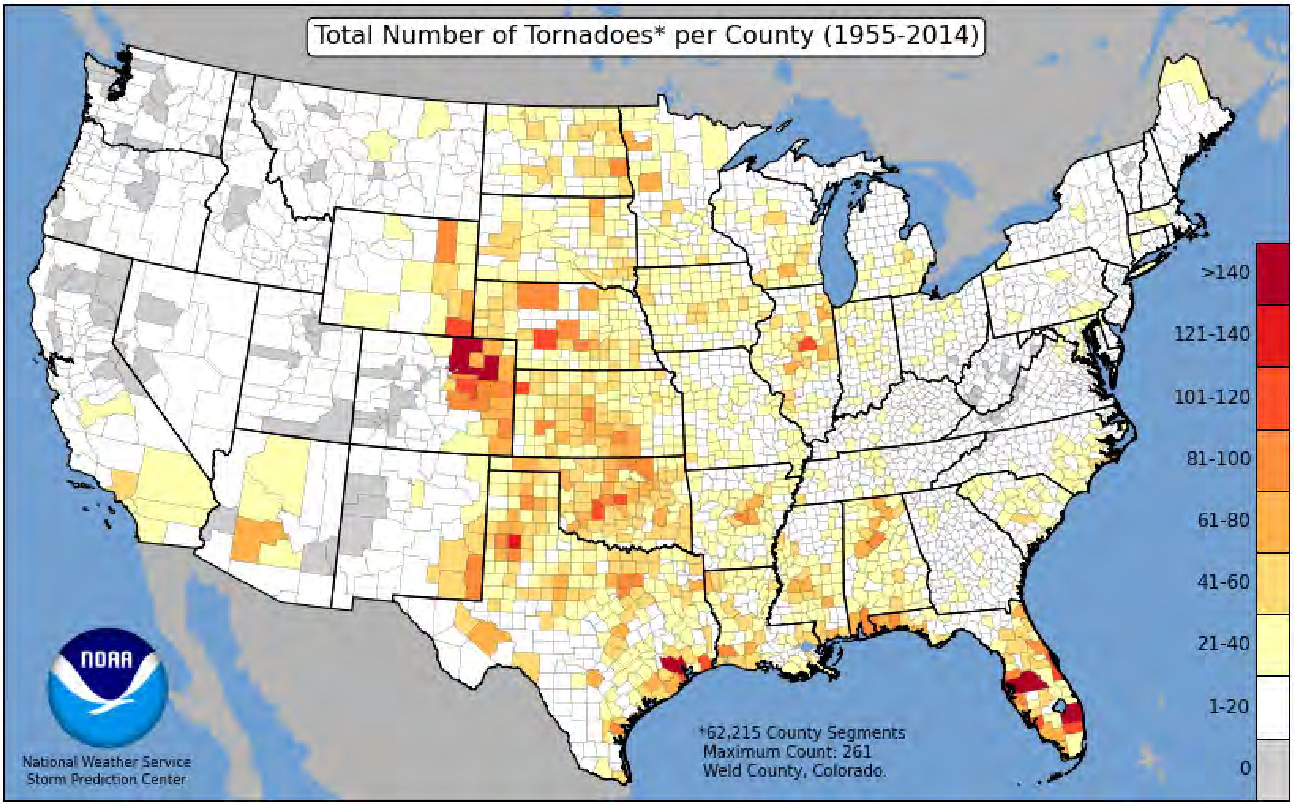


Table 3.111 reports the percentage of Missouri Tornadoes by F-Scale, 1950–2016.

Table 3.111. Missouri Tornadoes by F-Scale, 1950–2016

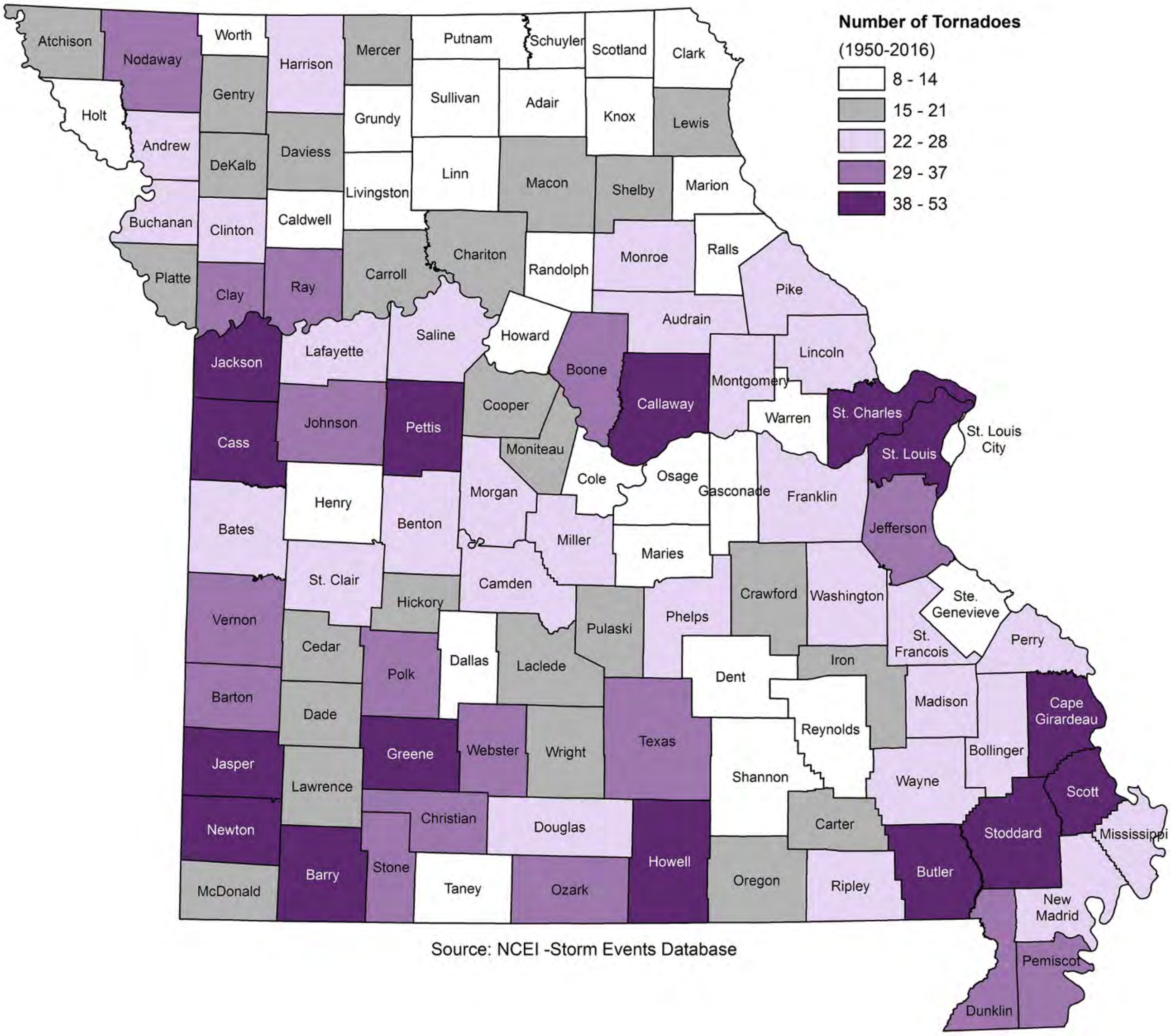
Scale	Percentage
F0	36.4%
F1	38.5%
F2	16.7%
F3	6.1%
F4	2.2%
F5	0.1%

Source: NCEI Storm Events Database, https://www.ncei.noaa.gov/stormevents/

Previous Occurrences

Historically, Missouri has experienced numerous tornadoes of varied intensities. The National Centers for Environmental Information reports that 2,370 tornadoes occurred in Missouri from 1950 to December 31, 2016, with 389 deaths and over $5.3 billion in damage. See **Figure 3.150** for the historical number of tornadoes in Missouri by county. Descriptions of significant tornado events are provided in the following paragraphs.

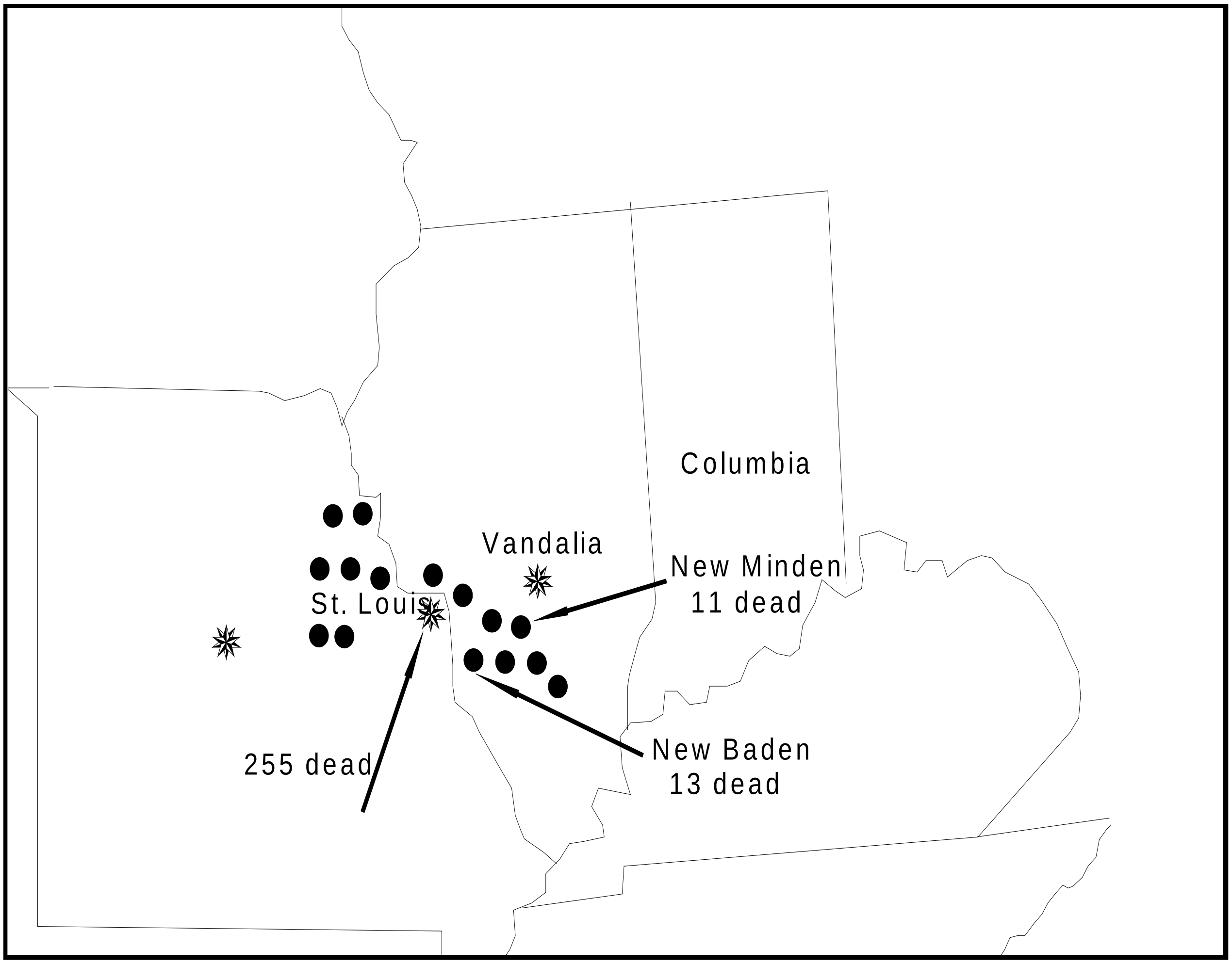
Figure 3.150. Historical Number of Tornadoes in Missouri



Source: NCEI -Storm Events Database

On **May 27, 1896**, between the hours of 2 and 8 p.m., a series of 18 tornadoes known as the "St. Louis, Missouri, Outbreak" struck Missouri and Illinois. These tornadoes resulted in 306 deaths and $15 million in damage (see **Figure 3.151**).

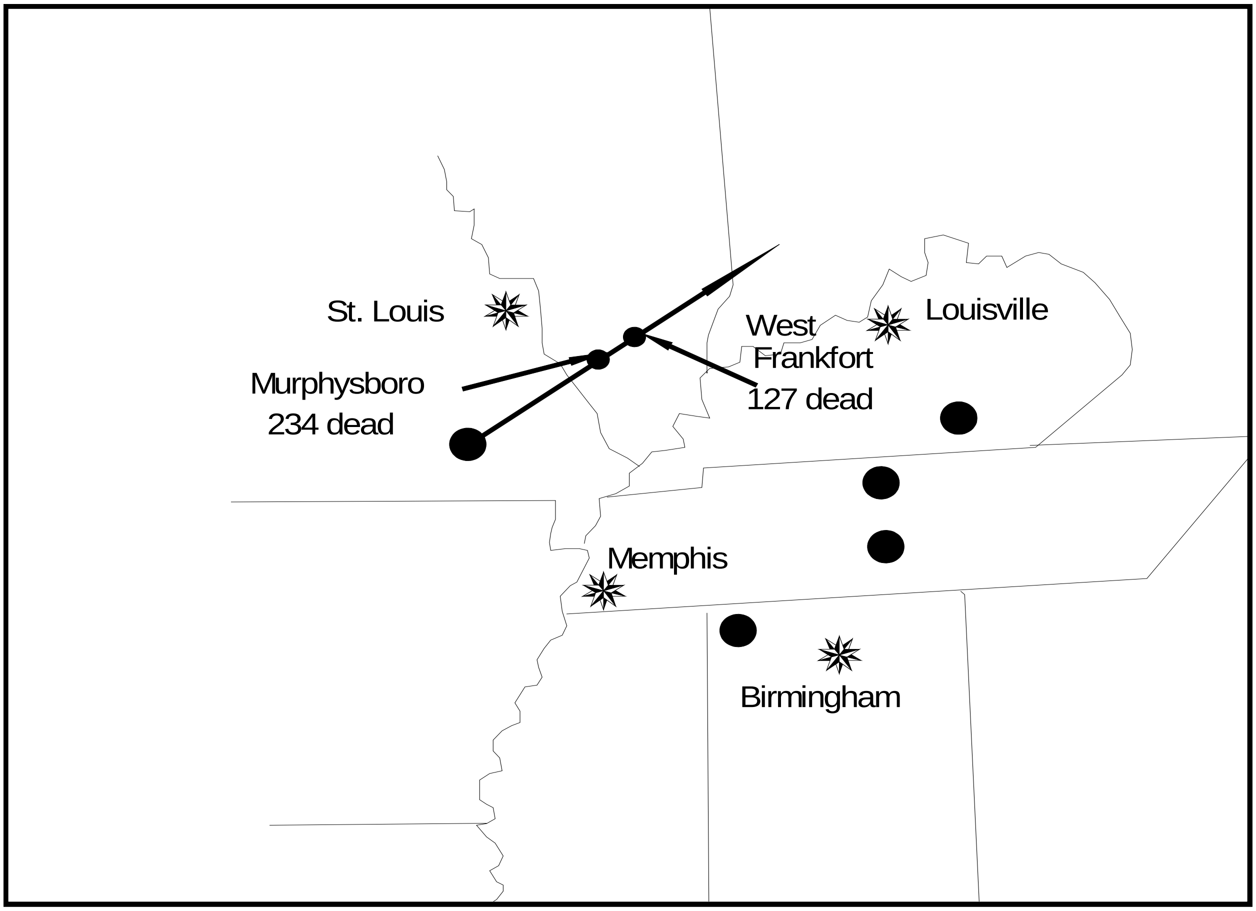
Figure 3.151. St. Louis, Missouri, Tornado Outbreak of 1896



Source: State Hazard Analysis, October 2009

The worst tornado in U.S. history, in terms of deaths and destruction, occurred in Missouri on **March 18, 1925**, between 1 and 6 p.m. (see Figure 3.152). The great "tri-state" tornado originated in Reynolds County and it proceeded east-northeast through the southern quarter of Illinois and into Indiana, covering 219 miles. It caused over $18 million in damage, affected six states, and killed 689 people.

Figure 3.152. The Great Tri-State Tornado of 1925



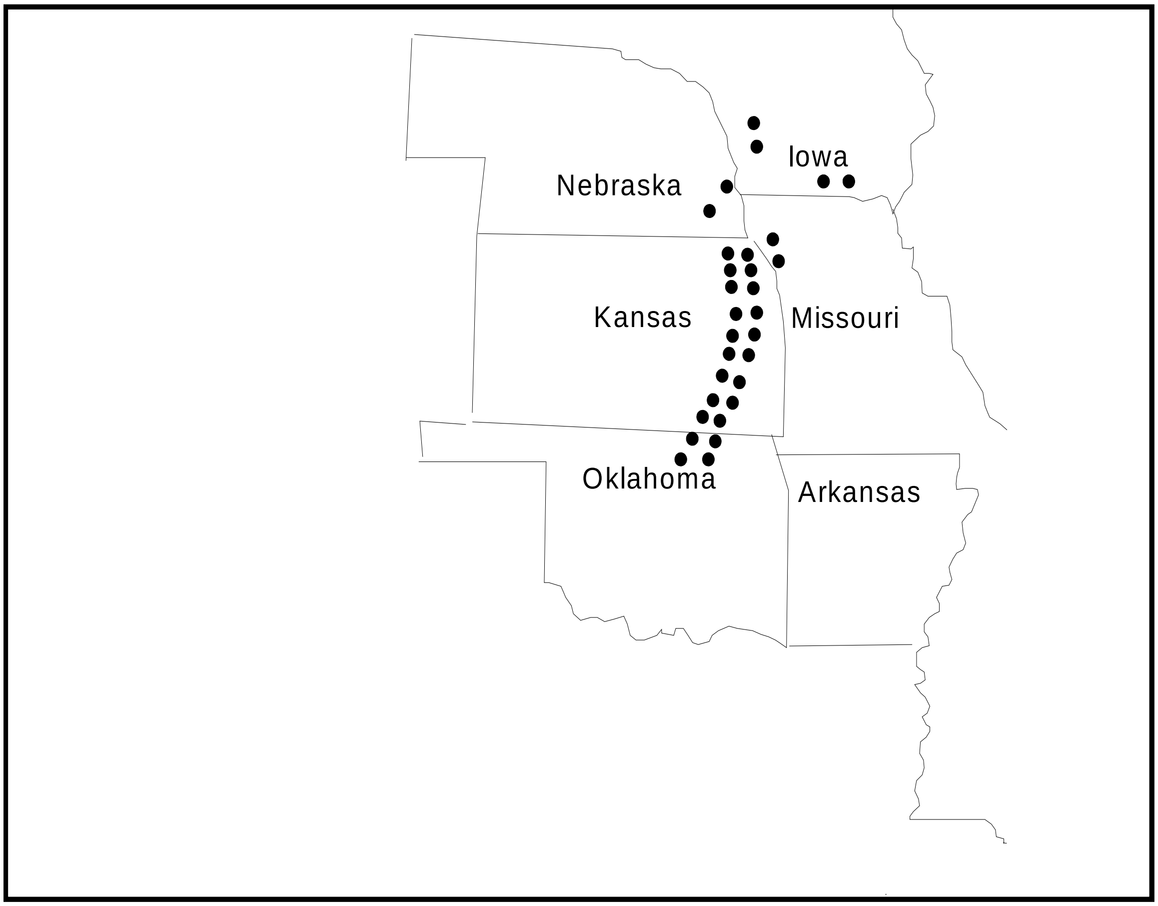
Source: State Hazard Analysis, October 2009

The City of Poplar Bluff, Missouri, was almost wiped out by a tornado on **May 9, 1927**. This tornado took 92 lives and caused an estimated $2 million in damage. The same day, two severe tornadoes struck St. Louis, Missouri. The first tornado moved across the entire city from the western city limits to the Mississippi River through the Lafayette Park area, killing 306 people in Missouri and Illinois and causing almost $13 million in damage. The second tornado started in the southwestern part of the City and proceeded through the Tower Grove and Vanderventer areas, then on to Granite City, Illinois. Seventy-nine people were killed, and about $23 million in damage resulted from this storm.

On **May 20, 1957**, an F-5 tornado hit Jackson County causing major damage in the Ruskin Heights area. According to NCEI, the tornado caused 37 deaths, 176 injuries and $2.5 million in damages as it carved a path ranging from one-tenth to nearly one-half mile wide and sped northeast at approximately 42 miles per hour.

During the afternoon and evening of April 3, and the early morning of **April 4, 1974**, a “super outbreak” of 148 tornadoes across 13 states killed more than 300 people, injured more than 6,000 and caused $600 million in damage (see **Figure 3.153**).

Figure 3.153. The Tornado Super Outbreaks in 1974



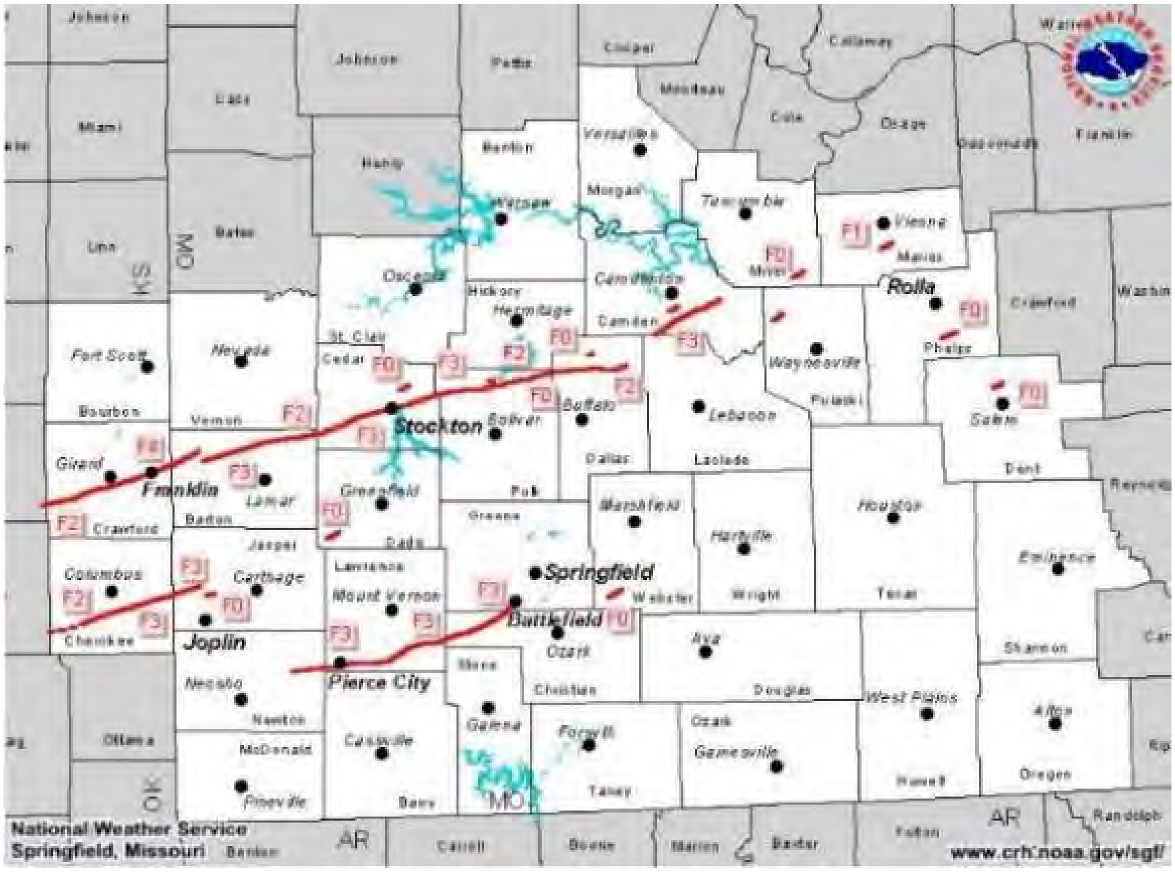
Source: State Hazard Analysis, October 2009

On the afternoon of April 26, and the early morning of **April 27, 1991**, an outbreak of 54 tornadoes covering six states, including Missouri, resulted in 21 deaths, 308 injuries, and damage exceeding $277 million. There were two deaths in vehicles and 15 deaths in and near mobile homes.

On **July 4, 1995**, at approximately 5:40 p.m., a tornado struck the Randolph County community of Moberly. The initial touchdown of the storm was south of town. The storm then moved through the eastern half of the community. The tornado uplifted approximately 7 miles northeast of Moberly. At least 15 people were injured, 25 businesses damaged, along with the courthouse, and some 300 families affected. This resulted in a Small Business Administration disaster declaration for low interest loans. The tornado was characterized by the National Weather Service as an F3 tornado.

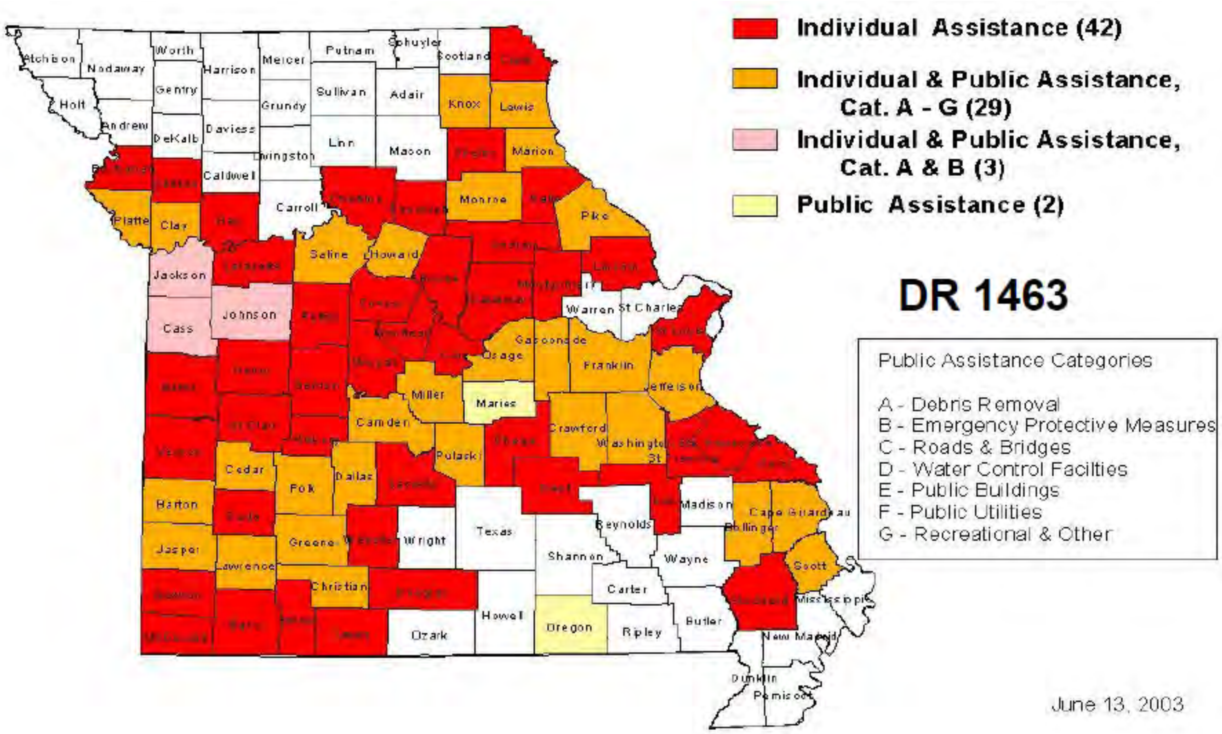
A record 84 tornadoes were recorded in Missouri in 2003. During the week of **May 4, 2003**, 79 of those tornadoes occurred, mostly in the southwest portion of Missouri. There were several F4 tornadoes on May 4 in Platte, Clay, and Barton Counties. There were nineteen people killed by the tornadoes in southwest Missouri. That is the highest total since 1959 when 21 were killed. It is only the fourth year in which double-digit deaths from tornadoes occurred in Missouri since 1950. The killer tornadoes all occurred on May 4, 2003 (see **Figure 3.154 and Figure 3.155**). The tornadoes that hit Newton, Lawrence, Christian, and Greene Counties killed seven people. Five people were killed by a tornado that hit Cedar and Dallas Counties. A tornado that hit Camden County killed four people, two people died from a tornado in Jasper County, and one person died in Barton County. The tornadoes injured 171 people. That is the highest total since 1957 when 310 people were injured. This information was provided by the National Weather Service.

Figure 3.154. Map of the May 4, 2003, Tornadoes



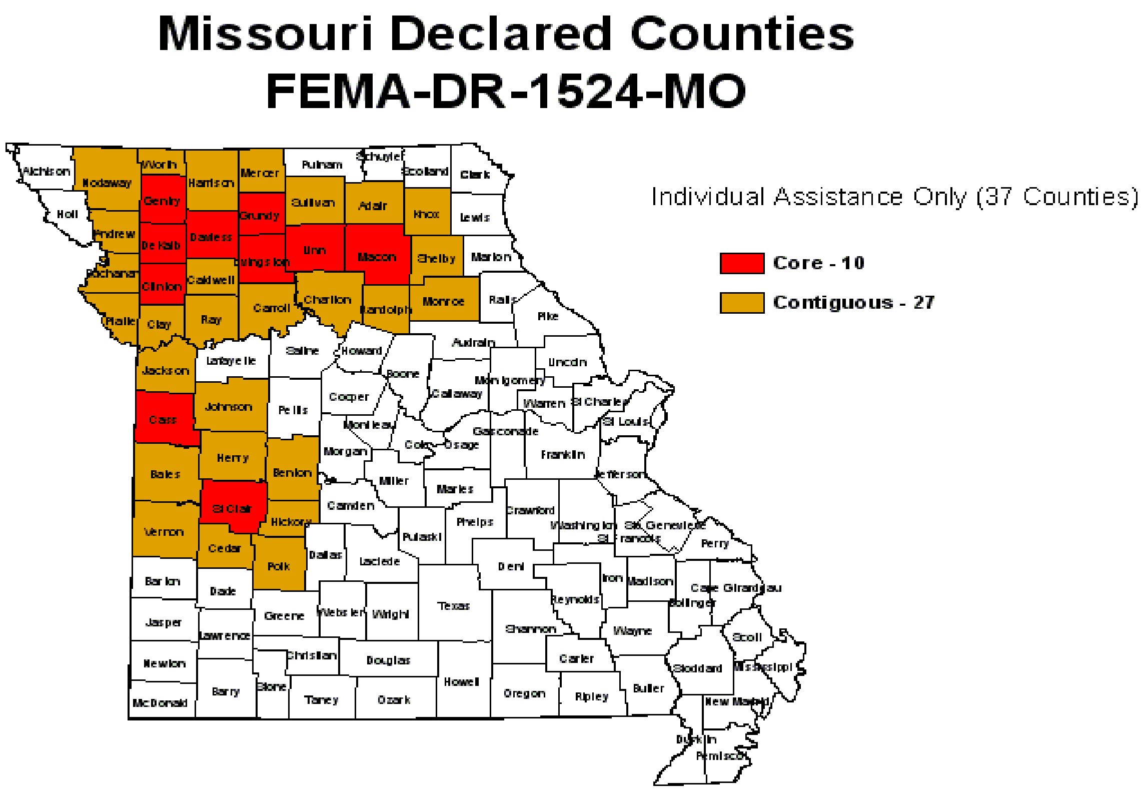
Source: National Weather Service, www.crh.noaa.gov/sgf

Figure 3.155. Disaster Assistance by County, May 2003



On **May 29, 2004**, nine tornadoes touched down in northern and western Missouri (See **Figure 3.156**). The strongest, an F4, struck just east of Weatherby in DeKalb County, destroying homes and killing three people.

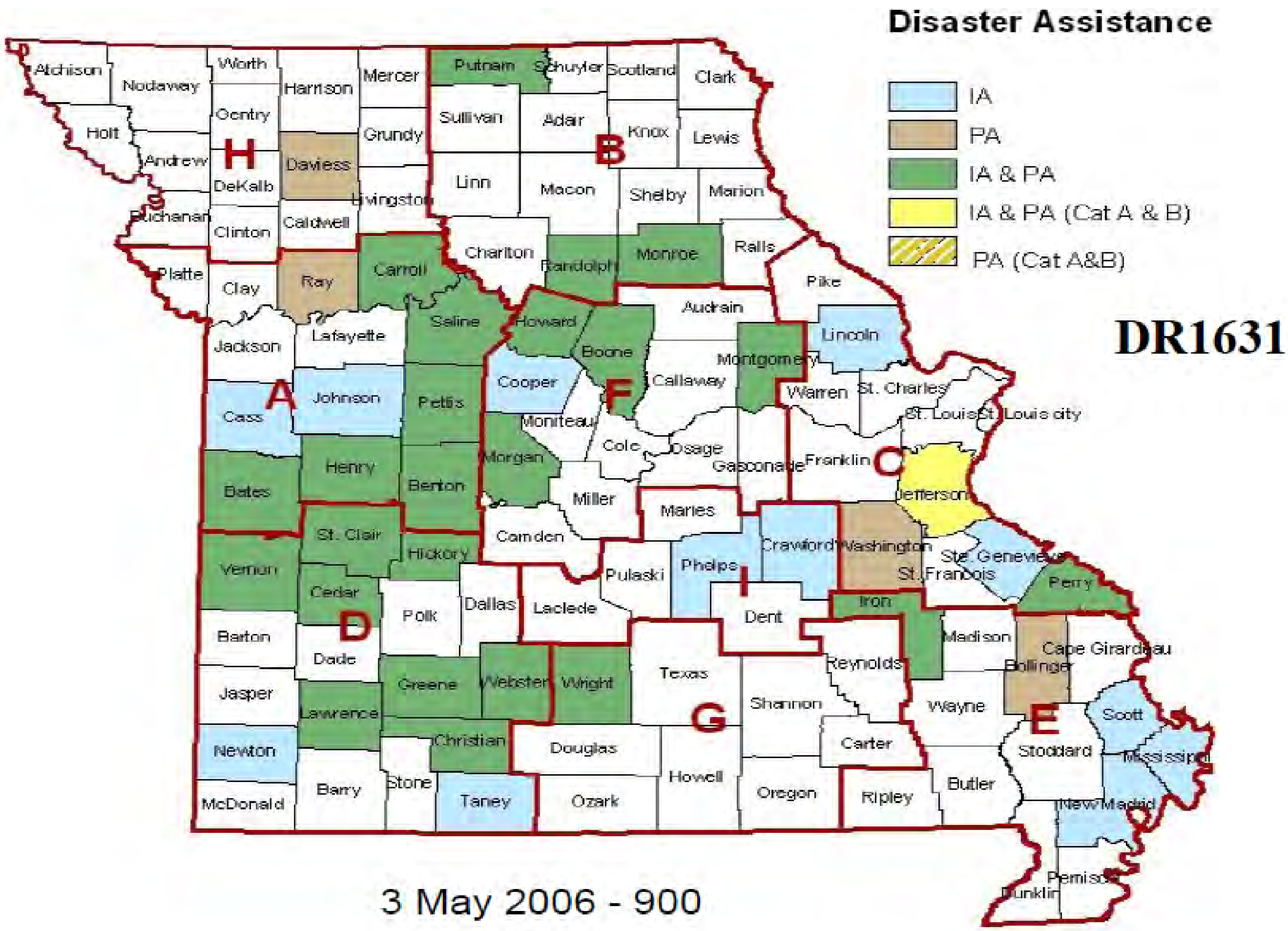
Figure 3.156. Disaster Assistance by County, May 29, 2004



The year 2006 was a record year for tornadoes and severe weather outbreaks for Missouri. There were 102 tornadoes recorded which surpassed the previous record year of 2003 when 84 tornadoes were recorded. Four sets of major storms went through the State: March 8–13 (DR 1631), March 30–April 2 (DR 1635), July 19–21 (EM 3267 and DR 1667), and September 22–23 tornado damages

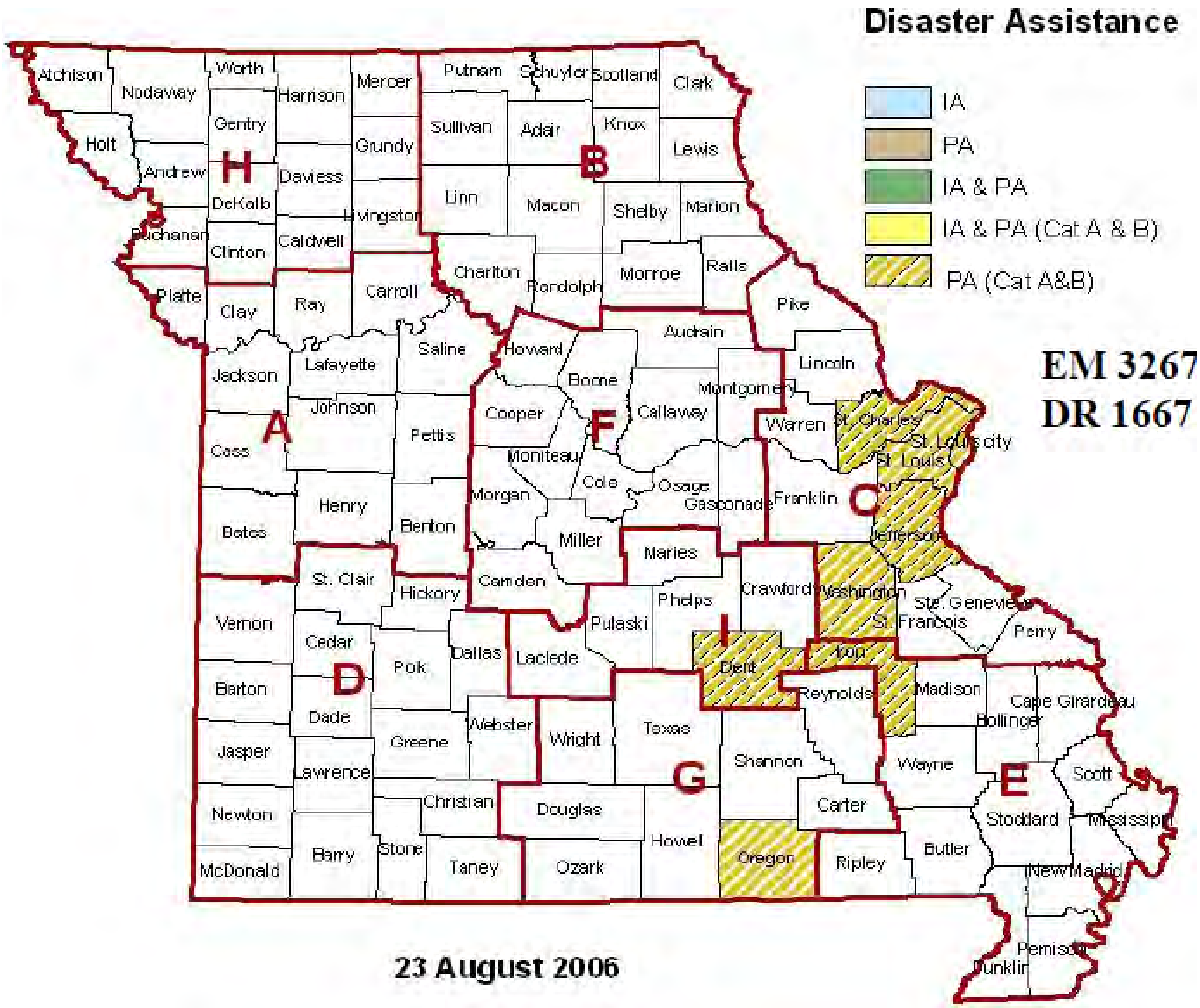
Between the two March/April storms, which both received declarations for severe storms, tornadoes, and flooding, 44 tornadoes touched down in Missouri. Fourteen people were killed (making it the fifth year in which double-digit deaths from tornadoes occurred in Missouri since 1950), 147 were injured, 646 homes were destroyed, 3,678 homes were damaged, and 1,134 homes were affected. As of June 14, 2006, Missouri citizens had received more than $32 million in federal recovery assistance. As a result of the first round of storms, 41 counties received major disaster declarations (see **Figure 3.157**). Also, there was an estimated $5.6 million in damages from these tornadoes reported by four Missouri Electrical Cooperatives. The second round of storms resulted in major disaster declarations for seven counties (see **Figure 3.158**). In Pemiscot County, 100 percent of Braggadocio, 80 percent of Deering, and over 60 percent of Caruthersville were destroyed. Major problems included drinking water, utilities, debris removal, and shelter and housing.

Figure 3.157. Disaster Assistance by County—March 2006



3 Risk Assessment

Figure 3.158. Disaster Assistance by County—July 2006



On **September 22, 2006**, another series of severe storms and tornadoes swept across the State and destroyed over 600 residences and 75 businesses in 12 counties. The National Weather Service confirmed an F4 tornado in Perry County. Also, there was an estimated $986,000 in damages reported by nine Missouri Electrical Cooperatives from the tornadoes.

In 2007, there were 45 tornadoes recorded by the NCEI database causing $2.133 million in property damages, three fatalities, and five injuries. There were no federal declarations for tornado damages, but several notable tornadoes. An overnight series of tornadoes started February 28th & continue through the night into March 1st and crossed the State. A total of nine tornadoes did approximately $880,000 damage in Bates, Henry, Cass, Johnson, Monroe, Shelby, Ozark, and Howell Counties.

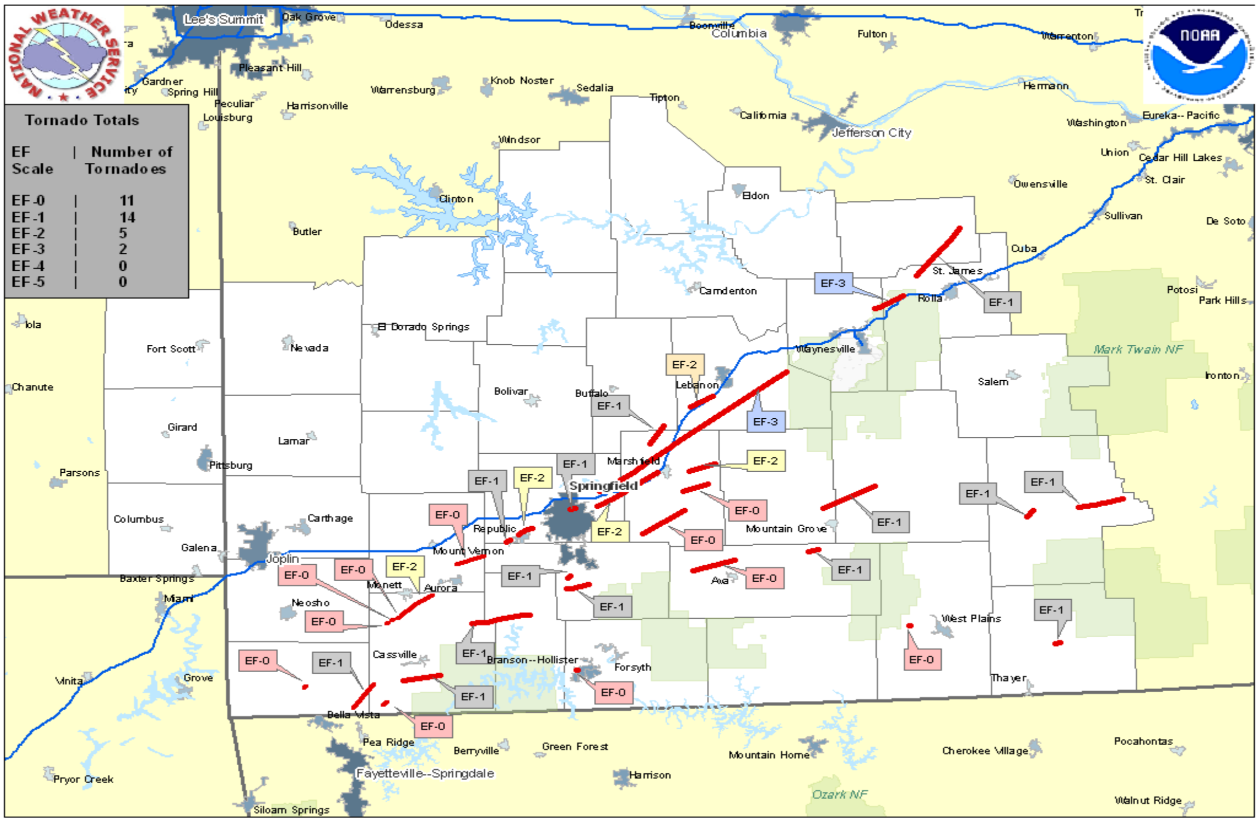
On **October 17, 2007**, a cold front initiated severe thunderstorms producing isolated tornadoes during the early evening hours through early morning of October 18th. Most of the damage occurred in rural eastern Lawrence County to five houses, a dairy barn, and a saw mill. More damage to homes, trees, corn crop, and a machine shed were recorded in Greene, Johnson, Laclede, Callaway, and Monroe Counties.

In 2008, there were 103 tornadoes recorded by the NCEI database with 242 injuries, 19 fatalities, $97.9 million in property damages and producing three federal disasters in Missouri.

A tornado outbreak on **January 7-8, 2008 (DR-1742 –** see **Figure 3.160**) was an unusually early severe weather outbreak hit the Missouri Ozarks Monday afternoon, January 7th, into the early morning hours Tuesday, January 8th, 2008. Numerous supercell thunderstorms spawned at least 29 tornadoes that resulted in significant damage to homes, trees and power lines. The supercell thunderstorms were followed by a violent squall line that produced damaging straight line winds in excess of 70 mph. In addition, the storms produced torrential rainfall and flash flooding. The storms developed as an intense storm system tracked out of the Rockies and interacted with an unseasonably warm, moist and unstable airmass across the Ozarks. **Figure 3.159** below shows the paths of the tornadic events on January 7-8, 2008.

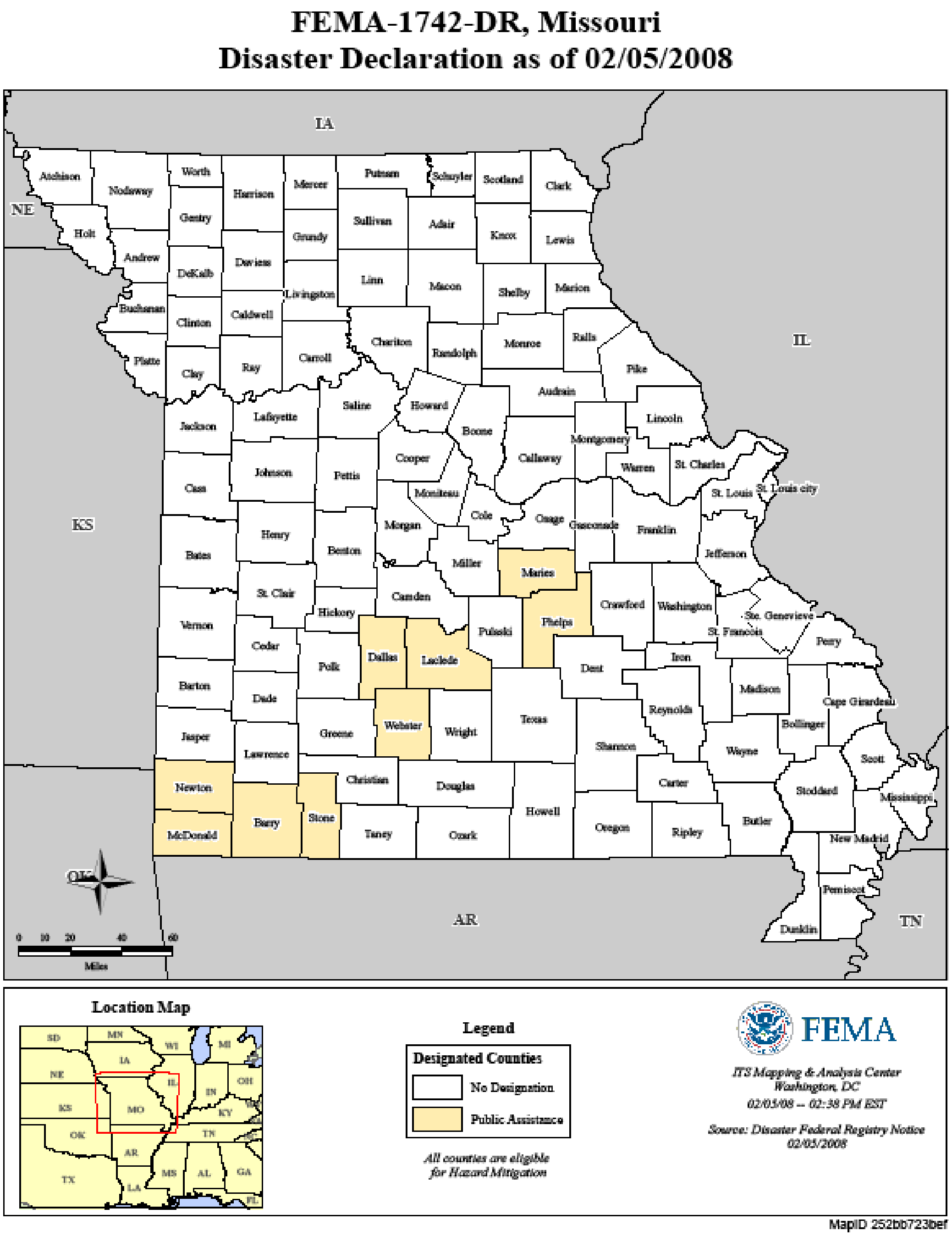
The National Weather Service in Springfield, Missouri issued 33 severe thunderstorm warnings and 62 tornado warnings in approximately a 12-hour period. A total of 161 severe weather reports were received from mid-afternoon on January 7th through the early morning hours on January 8th.

Figure 3.159. Tornado Path on January 7-8, 2008



Source: National Weather Service, www.crh.noaa.gov/sgf

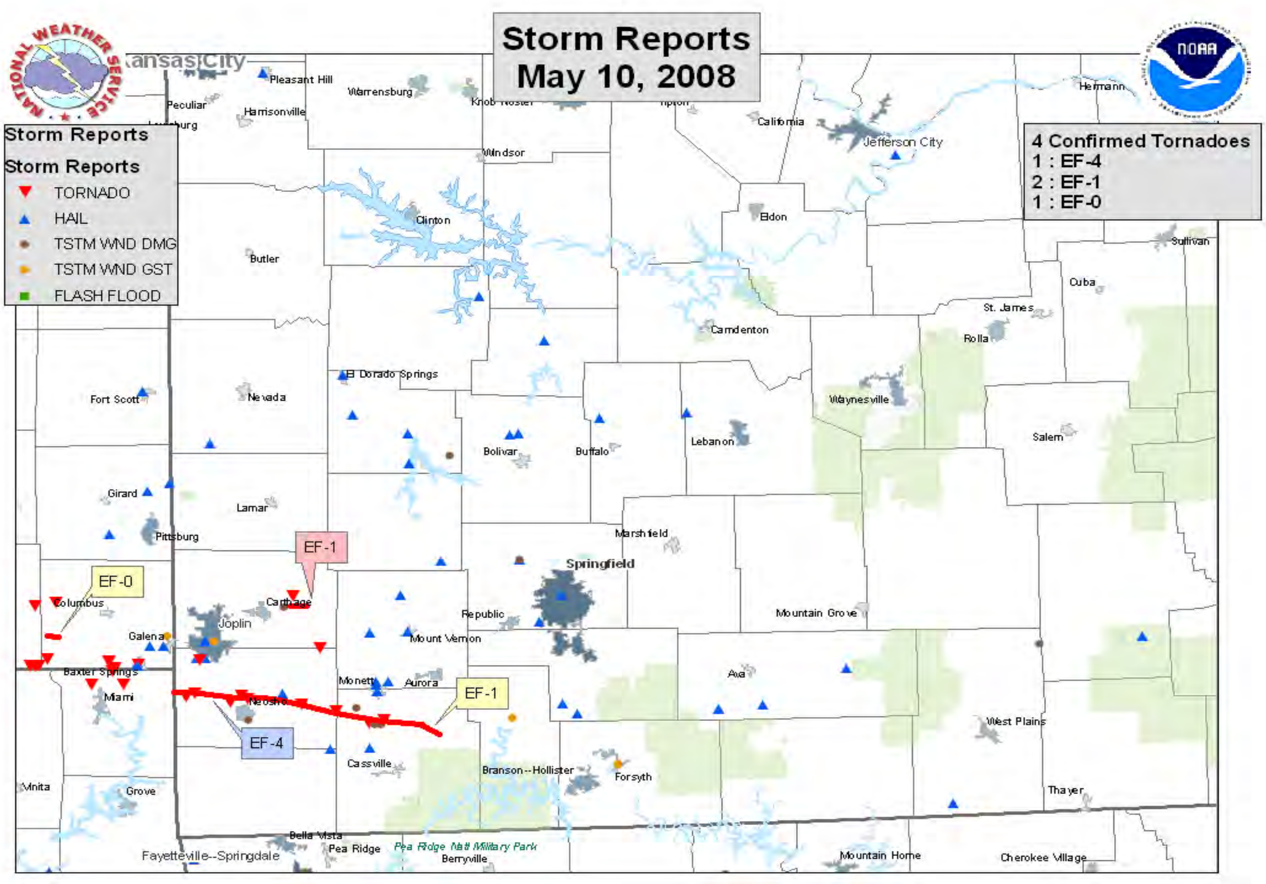
Figure 3.160. Disaster Assistance by Counties –February 2008



May 10, 2008 (DR-1760 – see **Figure 3.162**)--A strong area of low pressure lifted northeast out of southwest Missouri and into central Missouri during the evening. Instability increased over southeast Kansas and the southwest corner of Missouri during the late afternoon as temperatures rose into the mid to upper 70s. The instability along with the strong cold front caused severe thunderstorms to develop. With strong wind shear in the area, the storms in this area quickly became tornadic along with producing large hail to the size of softballs. The tornadic storms were mainly concentrated in an area from Cherokee County, Kansas to Newton and Barry Counties in Missouri. **Figure 3.161** below shows the paths of the tornadic events on January 7-8, 2008.

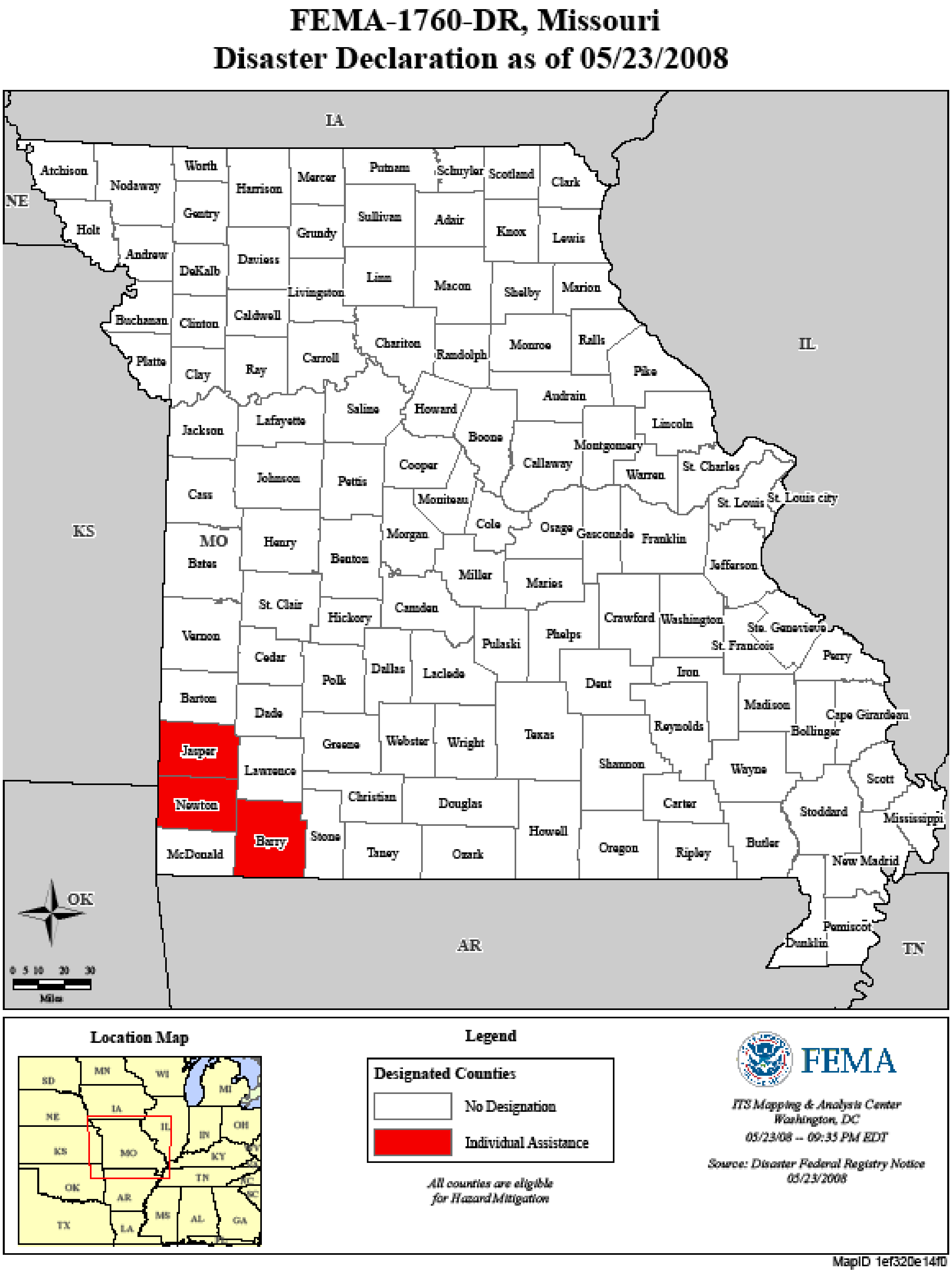
These storms moved into southwest Missouri causing devastating damage to homes, businesses, and trees in Newton, Barry, and Jasper Counties. One tornado, with an intensity that ranged from EF-4 to EF-1, killed 15 people as it tracked through Newton and Barry Counties, while another tornado killed one person in Jasper County. Also, there was $229,100 in estimated damages reported by two Missouri Electrical Cooperatives from the tornadoes.

Figure 3.161. Tornado Path on May 10, 2008



Source: National Weather Service, www.crh.noaa.gov/sgf

Figure 3.162. Disaster Assistance by Counties-May 2008



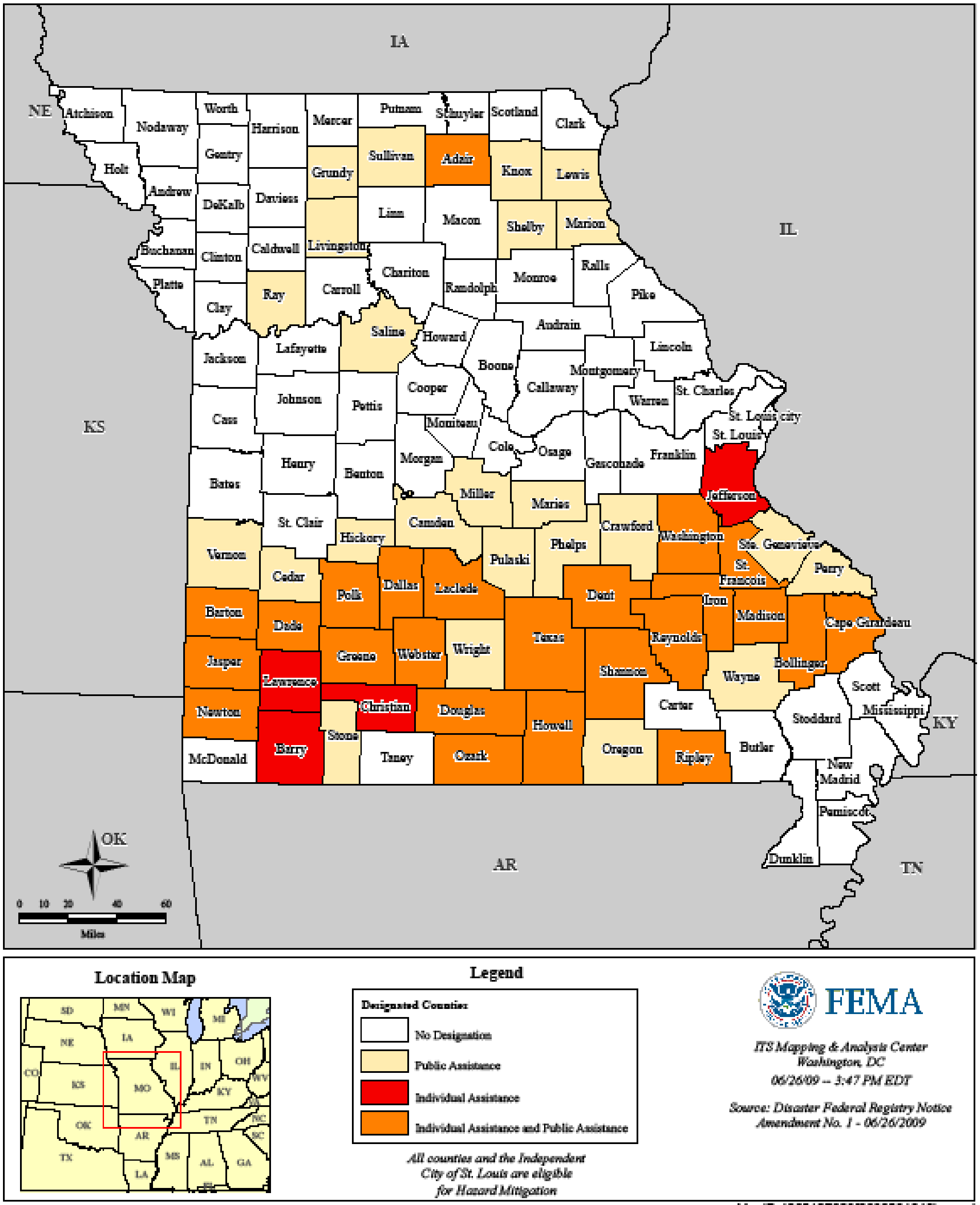
There was one additional tornado that produced damages to be included with FEMA-DR-1809. It occurred on November 6, 2008 along the western side of Table Rock Lake near the community of Mano in Barry County. This EF-1 tornado damaged boat docks on Table Rock Lake.

May 13, 2009 (DR-1847 – See **Figure 3.163**)--During the evening of May 13, 2009, a series of powerful supercell storms developed ahead of a cold front, pushing southward out of Iowa and Nebraska. These supercell storms produced a wide array of severe weather, with large hail up to the size of golf balls and winds up to 60 mph reported. These storms marched across eastern Kansas and northern Missouri during the evening hours, with a strong supercell storm producing tornadic activity in parts of northeast Missouri. Damage surveys conducted by the National Weather Service, in conjunction with emergency management, have found evidence of three tornadoes in Sullivan and Adair Counties. All tornadoes appeared to have been produced by the same supercell thunderstorm. There were three fatalities. Moderate to severe damage was reported, in the Kirksville area. Also, there was $180,000 in estimated damages reported by three Missouri Electrical Cooperatives from the tornadoes.

May 22, 2011 (DR-1980) – From May 21st through May 26th a massive storm system stretching from Lake Superior southwest to central Texas spawned numerous tornadoes as it swept east across the country. In the late afternoon hours of May 22nd, a large, multiple-vortex tornado touched down just outside Joplin, Missouri. The Joplin tornado had recorded wind speeds of greater than 200 mph and had a maximum width of nearly a mile. The twister touched down just east of the Kansas border just north of I-44. It then proceeded to move East and South through the city of Joplin before finally weakening and dissipating near Diamond, Missouri. All told, 158 people were killed and over 1,100 injured making this tornado the deadliest to hit the U.S. since 1947. Some 25% of Joplin had been completely demolished and estimates on insurance claims have been as high as $3 billion making it the single most costly tornado in U.S. history. In addition to the 158 dead in Missouri due to the Joplin tornado, the late may tornado outbreak killed 20 others throughout the states of Arkansas, Kansas, Minnesota, and Oklahoma. The storm system spawned a total of 242 tornados including a second EF-5 that touched down near Calumet, Oklahoma and caused significant damage throughout the Midwestern United States.

Figure 3.163. Disaster Assistance by Counties-May 8-16, 2009

FEMA-1847-DR, Missouri
Disaster Declaration as of 06/26/2009



May 29 to June 10, 2013 (DR-4130) - Storms developed along an outflow boundary that was laid out along the I-70 corridor. The storms produced wind damage, large hail as well as 9 tornadoes. Two of the tornadoes were rated EF3 as they moved through the St. Louis metro area. Also, heavy rain fell causing flash flooding in some locations, which persisted into the early morning hours of June 1st. On July 3, 2013, Governor Jeremiah W. Nixon requested a major disaster declaration due to severe storms, straight-line winds, tornadoes, and flooding during the period of May 29 to June 10, 2013. The Governor requested a declaration for Individual Assistance for seven counties, Public Assistance for 30 counties, and Hazard Mitigation statewide. On July 18, 2013, President Obama declared that a major disaster exists in the State of Missouri.

September 9-10, 2014 (DR 4200) - During the afternoon and evening of September 9, 2014 a line of thunderstorms moved though eastern Nebraska into Iowa and northern Missouri. Along the southwestern edge of the line a strong supercell formed, producing widespread wind and hail across far northwestern Missouri. This supercell went on to produce 5 brief and weak tornadoes across northwestern Missouri before finally dissipating. The main line of convection then caused wind damage across northern Missouri through the remainder of the overnight hours. Another tornado then formed early in the morning on September 10 near Kirksville, Missouri. On October 22, 2014, Governor Jeremiah W. Nixon requested a major disaster declaration due to severe storms, tornadoes, straight-line winds, and flooding during the period of September 9-10, 2014. The Governor requested a declaration for Public Assistance for 20 counties and Hazard Mitigation statewide. On October 31, 2014, President Obama declared that a major disaster exists in the State of Missouri.

May 15 to July 27, 2015 (DR 4238) - A strong upper level system moved through the Midwest region and produced a squall line of thunderstorms across the Missouri Ozarks. This squall line of storms produced numerous reports of wind damage and a few weak tornadoes. On July 21, 2015, Governor Jeremiah W. Nixon requested a major disaster declaration due to severe storms, tornadoes, straight-line winds, and flooding during the period of May 15 to July 27, 2015. The Governor requested a declaration for Individual Assistance for 15 counties, Public Assistance for 68 counties, and Hazard Mitigation statewide. On August 7, 2015, President Obama declared that a major disaster exists in the State of Missouri.

December 23, 2015 to January 9, 2016 (DR 4250) - Two fast-moving lines of strong to severe storms moved east across southeast Missouri, accompanied by strong winds and isolated tornadoes. The tornado began near the Current River along Highway Z and then moved northeast. Hundreds of trees were snapped or uprooted within a well-defined path in the Ozark National Scenic Riverways. On January 21, 2016, President Barack Obama granted Governor Jay Nixon's request for a major disaster declaration for Missouri.

Table 3.112 lists Missouri tornado events that resulted in federal disaster declarations since 1975. Table 3.113The table summarizes Missouri tornado statistics from 1950 through 2016.

Table 3.112. Disaster Declarations for Missouri Tornado Events Since 1975

Declaration Date	Disaster No.	Incident Type	Counties Declared	Type of Assistance*
May 3, 1975	DR 466	Tornadoes, High Winds, Hail	Caldwell, Newton, Macon, Shelby	PA & IA
May 7, 1977	DR 535	Tornadoes, Flooding	Carroll, Clay, Lafayette, Ray, Cass, Jackson, Pettis	PA & IA
April 21, 1979	DR 579	Tornadoes, Torrential Rain, Flooding	n/a	

Declaration Date	Disaster No.	Incident Type	Counties Declared	Type of Assistance*
May 15, 1980	DR 620	Severe Storms, Tornadoes	Pettis	IA Only
May 1986	n/a	Tornadoes	Scott, Mississippi, Cape Girardeau, Perry	SBA Loans
November 1988	n/a	Tornadoes	St. Charles, Barry	SBA Loans
December 1, 1993	DR 1006	Flooding, Severe Storm, Tornadoes	Bollinger, Butler, Cape Girardeau, Carter, Crawford, Dent, Franklin, Howell, Iron, Jefferson, Madison, Oregon, Perry, Pulaski, Reynolds, Ripley, Shannon, St. Francois, St. Louis, Ste. Genevieve, Stoddard, Texas, Washington, Wayne	IA
			Carter, Dent, Howell, Iron, Madison, Oregon, Perry, Reynolds, Shannon, St. Francois, Ste. Genevieve, Texas, Washington, Wayne	PA
April 21, 1994	DR 1023	Severe Storm, Flooding, Tornadoes	Barry, Callaway, Clay, Cole, Franklin, Jefferson, Lincoln, Morgan, Pemiscot, Phelps, Pulaski, Reynolds, Shannon, St. Charles, St. Louis, Vernon, Washington, St. Louis City	IA
June 2, 1995	DR 1054	Severe Storm, Tornadoes, Hail, Flooding	Adair, Andrew, Atchison, Barry, Barton, Bates, Benton, Boone, Callaway, Camden, Cape Girardeau, Carroll, Cass, Chariton, Clark, Cole, Cooper, Dallas, Daviess, DeKalb, Franklin, Gasconade, Gentry, Henry, Howard, Jackson, Jasper, Jefferson, Johnson, Lafayette, Lewis, Lincoln, Linn, Macon, Maries, McDonald, Mercer, Miller, Mississippi, Moniteau, Montgomery, Morgan, New Madrid, Newton, Nodaway, Osage, Pemiscot, Perry, Ray, Saline, Scotland, Scott, St. Charles, St. Clair, St. Francois, St. Louis, Ste. Genevieve, Stone, Sullivan, Vernon, Warren, St. Louis City	IA
			Andrew, Atchison, Barry, Bates, Benton, Boone, Callaway, Cape Girardeau, Carroll, Chariton, Clark, Cole, Cooper, Daviess, DeKalb, Franklin, Gasconade, Gentry, Henry, Howard, Jefferson, Johnson, Lafayette, Linn, Macon, McDonald, Mercer, Miller, Mississippi, Moniteau, Montgomery, Nodaway, Perry, Ray, Saline, St. Charles, St. Clair, St. Louis, Ste. Genevieve, Stone, Sullivan, Vernon, Warren	PA
July 1995	n/a	Tornadoes	Randolph, (City of Moberly)	SBA Loans
May 6, 2002	DR 1412	Severe Storms and Tornadoes	Barry, Barton, Bollinger, Butler, Camden, Cape Girardeau, Carter, Cedar, Christian, Crawford, Dade, Dallas, Dent, Douglas, Dunklin, Greene, Hickory, Howell, Iron, Jasper, Jefferson, Laclede, Lawrence, Madison, McDonald, Mississippi, New Madrid, Newton, Oregon, Ozark, Pemiscot, Perry, Polk, Reynolds, Ripley, Scott, Shannon, St. Francois, St. Genevieve, Stoddard, Stone, Taney, Texas, Vernon, Washington, Wayne, Webster, Wright	IA

Declaration Date	Disaster No.	Incident Type	Counties Declared	Type of Assistance*
			Adair, Barry, Barton, Bollinger, Boone, Butler, Camden, Cape Girardeau, Carroll, Carter, Cedar, Chariton, Christian, Clark, Cooper, Crawford, Dade, Dallas, DeKalb, Dent, Douglas, Grundy, Howard, Howell, Iron, Johnson, Knox, Laclede, Lafayette, Lawrence, Lewis, Lincoln, Linn, Livingston, Macon, Madison, Maries, Marion, McDonald, Mercer, Miller, Mississippi, Oregon, Osage, Ozark, Pemiscot, Perry, Phelps, Pike, Polk, Pulaski, Ralls, Ray, Reynolds, Ripley, Schuyler, Scotland, Scott, Shannon, Shelby, Ste. Genevieve, Stoddard, Stone, Sullivan, Taney, Texas, Vernon, Wayne, Webster, Wright	PA
May 6, 2003	DR 1463	Severe Storms, Tornadoes, and Flooding	Barry, Barton, Bates, Benton, Bollinger, Buchanan, Camden, Cape, Cass, Cedar, Christian, Clay, Clinton, Cooper, Crawford, Dade, Dallas, Dent, Douglas, Franklin, Knox, Gasconade, Girardeau, Greene, Henry, Hickory, Iron, Jackson, Jasper, Jefferson, Johnson, Laclede, Lafayette, Lawrence, McDonald, Miller, Monroe, Morgan, Newton, Osage, Perry Pettis, Phelps, Platte, Polk, Pulaski, Ray, St. Francois, St. Louis, Ste. Genevieve, Saline, Scott, St. Clair, Stoddard, Stone, Taney, Vernon, Washington, Webster	IA
			Bollinger, Crawford, Franklin, Gasconade, Knox, Maries, Miller, Oregon, Osage, Pulaski, Washington	PA
June 11, 2004	DR 1524	Severe Storms, Tornadoes, and Flooding	Adair, Andrew, Bates, Benton, Caldwell, Carroll, Cass, Cedar, Chariton, Clay, Clinton, Daviess, DeKalb, Gentry, Grundy, Harrison, Henry, Hickory, Jackson, Johnson, Knox, Linn, Livingston, Macon, Mercer, Monroe, Nodaway, Platte, Polk, Randolph, Ray, Shelby, St. Clair, Sullivan, Vernon, Worth	IA
March 16, 2006	DR 1631	Severe Storms, Tornadoes, and Flooding	Bates, Benton, Boone, Carroll, Cass, Cedar, Christian, Cooper, Crawford, Greene, Henry, Hickory, Howard, Iron, Jefferson, Johnson, Lawrence, Lincoln, Mississippi, Monroe, Montgomery, Morgan, New Madrid, Newton, Perry, Pettis, Phelps, Putnam, Randolph, St. Clair, Ste. Genevieve, Scott, Saline, Taney, Vernon, Webster, Wright	IA
			Bates, Bollinger, Benton, Boone, Carroll, Cedar, Christian, Daviess, Greene, Henry, Hickory, Howard, Iron, Lawrence, Monroe, Montgomery, Morgan, Perry, Pettis, Putnam, Randolph, Ray, Saline, St. Clair, Vernon, Washington, Webster, Wright	PA
April 5, 2006	DR 1635	Severe Storms, Tornadoes, and Flooding	Andrew, Butler, Dunklin, Pemiscot, St. Francois, Stoddard	IA
			Andrew, Jefferson, Pemiscot, Pettis, St. Francois	PA
February 5, 2008	DR 1742	Severe Storms, Tornadoes, and Flooding	Barry, Dallas, Laclede, Maries, McDonald, Newton, Phelps, Stone, Webster	PA
May 23, 2008	DR 1760	Severe Storms, & Tornadoes	Barry, Jasper, Newton	IA

Declaration Date	Disaster No.	Incident Type	Counties Declared	Type of Assistance*
November 13, 2008	DR 1809	Severe Storms, Flooding & a Tornado	Adair, Audrain, Barry, Bollinger, Boone, Butler, Callaway, Cape Girardeau, Carter, Chariton, Christian, Clark, Crawford, Dent, Douglas, Dunklin, Howard, Howell, Jefferson, Knox, Lewis, Lincoln, Linn, Madison, Maries, Marion, Miller, Mississippi, Montgomery, New Madrid, Oregon, Osage, Ozark, Perry, Ralls, Randolph, Ray, Reynolds, Ripley, Schuyler, Scotland, Scott, Shannon, Shelby, St. Charles, St, Louis, Ste. Genevieve, Stoddard, Stone, Sullivan, Taney, Texas, Wayne, Webster, Wright and Independent City of St Louis.	IA & PA (not all counties list have IA & PA assistance)
June 19, 2009	DR 1847	Severe Storms, Tornadoes & Flooding	Adair, Barry, Barton, Bollinger, Camden, Cape Girardeau, Christian, Cedar, Crawford, Dade, Dallas, Dent, Douglas, Greene, Hickory, Howell, Iron, Jackson, Jasper, Knox, Laclede, Lawrence, Lewis, Madison, Maries, Marion, Miller, Newton, Oregon, Ozark, Perry, Phelps, Polk, Pulaski, Ray, Reynolds, Ripley, St. Francois, Ste. Genevieve, Saline, Shannon, Shelby, Stone, Sullivan, Texas, Vernon, Washington, Wayne, Webster, Wright	IA & PA (not all counties list have IA & PA assistance)
August 17, 2010	DR 1934	Severe Storms, Flooding, and Tornadoes	Adair, Andrew, Atchison, Buchanan, Caldwell, Carroll, Cass, Chariton, Clark, Clinton, Daviess, DeKalb, Gentry, Grundy, Harrison, Holt, Howard, Jackson, Lafayette, Lewis, Livingston, Mercer, Nodaway, Putnam, Ray, Schuyler, Scotland, Sullivan, Worth	PA
May 9, 2011	DR 1980	Severe Storms, Tornadoes and Flooding	Barry, Bollinger, Butler, Cape Girardeau, Carter, Christian, Douglas, Dunklin, Howell, Iron, Jasper, Lawrence, Madison, McDonald, Miller, Mississippi, New Madrid, Newton, Oregon, Ozark, Pemiscot, Perry, Pettis, Phelps, Polk, Pulaski, Reynolds, Ripley, Scott, Shannon, St. Francois, St. Louis, Ste. Genevieve, Stoddard, Stone, Taney, Texas, Washington, Wayne, Webster, Wright	IA & PA (not all counties list have IA & PA assistance)
July 18, 2013	DR 4130	Severe Storms, Straight-line Winds, Tornadoes and Flooding	Barton, Callaway, Cape Girardeau, Chariton, Clark, Howard, Iron, Knox, Lewis, Lincoln, Maries, Marion, Miller, Montgomery, Osage, Perry, Pike, Putnam, Ralls, Scotland, Shelby, St. Charles, St. Louis, Ste. Genevieve, Stoddard, Sullivan, Texas, Webster	PA
October 31, 2014	DR 4200	Severe Storms, Tornadoes, Straight-line Winds, and Flooding	Adair, Andrew, Atchison, Daviess, Gentry, Grundy, Harrison, Holt, Knox, Lewis, Linn, Livingston, Macon, Mercer, Nodaway, Putnam, Ralls, Shelby, Sullivan, Worth	PA
August 7, 2015	DR 4238	Severe Storms, Tornadoes, Straight-line Winds, and Flooding	Adair, Andrew, Atchison, Audrain, Barry, Bates, Benton, Buchanan, Caldwell, Camden, Chariton, Christian, Clark, Clay, Clinton, Cole, Crawford, Dade, Dallas, Daviess, DeKalb, Douglas, Gentry, Harrison, Henry, Hickory, Holt, Jackson, Jefferson, Johnson, Knox, Laclede, Lafayette, Lewis, Lincoln, Linn, Livingston, Macon, Maries, Marion, McDonald, Miller, Moniteau, Monroe, Montgomery, Morgan, New Madrid, Nodaway, Oregon, Osage, Ozark, Pemiscot, Perry, Pettis, Phelps, Pike, Platte, Polk, Putnam, Ralls, Ray, Saline, Schuyler, Scotland, Shannon, Shelby, St. Clair, Ste. Genevieve, Stone, Sullivan, Taney, Texas, Washington, Webster, Worth, Wright	PA

Declaration Date	Disaster No.	Incident Type	Counties Declared	Type of Assistance*
January 21, 2016	DR 4250	Severe Storms, Tornadoes, Straight-line Winds, and Flooding	Barry, Barton, Bollinger, Camden, Cape, Girardeau, Cedar, Cole, Crawford, Dade, Dallas, Douglas, Dunklin, Franklin, Gasconade, Greene, Hickory, Howell, Iron, Jasper, Jefferson, Laclede, Lawrence, Lincoln, Maries, McDonald, Mississippi, Morgan, New Madrid, Newton, Osage, Ozark, Pemiscot, Perry, Phelps, Polk, Pulaski, Reynolds, Scott, Shannon, St. Charles, St. Clair, St. Francois, St. Louis city, St. Louis, Ste. Genevieve, Stoddard, Stone, Taney, Texas, Washington, Webster, Wright	IA & PA (not all counties list have IA & PA assistance)

Source: Federal Emergency Management Agency, State Emergency Management Agency
Note: IA denotes Individual Assistance; PA denotes Public Assistance, SBA denotes Small Business Administration

Table 3.113. Missouri Tornado Statistics, 1950–2016

Total Number of Tornadoes	2,650
Total Number of Deaths	394
Total Number of Injuries	4,430
Yearly Average of Tornadoes	39.6
Yearly Average of Deaths	5.9
Yearly Average of Injuries	66.1

Source: NCEI Storm Events Database, https://www.ncei.noaa.gov/stormevents/

According to the USDA Risk Management Agency, insured crop losses throughout the State of Missouri as a result of tornado damages for the ten-year period of 2007 – 2016 totaled $139,097.

Probability of Future Hazard Events

The United States has 10 times more tornadoes than any other nation in the world. Missouri averages 39.6 tornadoes per year and has recorded 2,650 tornadoes between 1950 and December 31, 2016. Missourians have a 100% probability that tornadoes will continue to affect their lives.

Changing Future Conditions Considerations

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

State Vulnerability Overview

Every tornado is a potential killer, and many are capable of great destruction. Tornadoes can topple buildings, roll mobile homes, uproot trees, hurl people and animals through the air for hundreds of yards, and fill the air with lethal, windblown debris. Sticks, glass, roofing material, and lawn furniture all become deadly missiles when driven by tornado winds. In 1975, a Mississippi tornado carried a home freezer for more than a mile. Once, a tornado in Broken Bow, Oklahoma, carried a motel sign 30 miles and dropped it in Arkansas. Tornadoes do their destructive work through the combined action of their strong rotary winds and the impact of windblown debris. In the simplest case, the force of the tornado's winds pushes the windward wall of a building inward. The roof is lifted up, and the other walls fall outward. Until recently, this damage pattern led to the incorrect belief that the structure had exploded as a result of the atmospheric pressure drop associated with the tornado.

The method used to determine vulnerability to tornadoes across Missouri was statistical analysis of data from several sources: HAZUS building exposure value data, population density and mobile home data from the U.S. Census (2015 ACS), the calculated Social Vulnerability Index for Missouri Counties from the Hazards and Vulnerability Research Institute in the Department of Geography at the University of South Carolina, and storm events data (1950 to December 31, 2016) from the National Centers for Environmental Information (NCEI). It is important to realize that one limitation to the NCEI data is that many tornadoes that might have occurred in uninhabited areas, as well as some in inhabited areas, may not have been reported. The incompleteness of the data suggests that it is not appropriate for use in parametric modeling. In addition, NOAA data cannot show a realistic frequency distribution of different Fujita scale tornado events, except for recent years. Thus a parametric model based on a combination of many physical aspects of the tornado to predict future expected losses was not used. The statistical model used for this analysis was probabilistic based purely on tornado frequency and historic losses. It is based on past experience and forecasts the expected results for the immediate or extended future.

From the statistical data collected, six factors were considered in determining overall vulnerability to tornadoes as follows: building exposure, population density, social vulnerability, percentage of mobile homes, likelihood of occurrence, and annual property loss. Based on natural breaks in the statistical data, a rating value of 1 through 5 was assigned to each factor. These rating values correspond to the following descriptive terms:

1) Low
2) Low-medium
3) Medium
4) Medium-high
5) High

Table 3.114 provides the factors considered and the ranges for the rating values assigned.

Table 3.114. Ranges for Tornado Vulnerability Factor Ratings

Factors Considered	Low (1)	Low-medium (2)	Medium (3)	Medium-High (4)	High (5)
Common Factors					
Building Exposure ($)	$269,532-$3,224,641	$3,224,642-$8,792,829	$8,792,830-$22,249,768	$22,249,769-$46,880,213	$46,880,214-$138,887,850
Population Density (#per sq. mile)	4.11-44.23	44.24-134.91	134.92-259.98	259.99-862.69	862.70-2,836.23
Social Vulnerability	1	2	3	4	5
Percent Mobile Homes	0.2-4.5%	4.51-8.8%	8.81-14%	14.01-21.2%	21.21-33.2%
Likelihood of Occurrence (# of events/ yrs. of data)	0.119 - 0.208	0.209 - 0.313	0.314 - 0.417	0.418 - 0.552	0.553 - 0.791
Total Annualized Property Loss ($ / yrs. of data)	$974 - $281,874	$281,875 - $991,825	$991,826 - $2,099,000	$2,099,001 - $5,047,474	$5,047,475 - $42,467,109

Once the ranges were determined and applied to all factors considered in the analysis, the ratings were combed to determine an overall vulnerability rating for tornadoes. **Table 3.130** provides the calculated ranges applied to determine overall vulnerability of Missouri counties to tornadoes. The figures that follow provide the mapped results of this analysis by county.

Table 3.115. Ranges for Tornado Combined Vulnerability Rating

	Low (1)	Low-medium (2)	Medium (3)	Medium-High (4)	High (5)
Tornado Combined Vulnerability	7-10	11-12	13-14	15-16	17-21

Table 3.116 provides the building exposure, population density, SOVI index ranking and percentage of mobile homes by county and associated vulnerability rating.

Table 3.116. Building Exposure, Population Density, SOVI, and Mobile Home Data by County

County	Total Building Exposure (Hazus)	Exposure Rating	Population Density	Population Rating	SOVI Index Ranking	SOVI Rating	Percent Mobile Homes	Mobile Home Rating
Adair	$2,599,614,000	1	44.73	1	Medium	3	8.1	2
Andrew	$1,724,819,000	1	39.97	1	Medium Low	2	7.6	2
Atchison	$806,754,000	1	9.69	1	Medium High	4	3.5	1
Audrain	$2,689,090,000	1	37.70	1	Medium High	4	7.6	2
Barry	$3,736,121,000	2	46.04	1	Medium	3	16.1	4
Barton	$1,414,960,000	1	20.07	1	Medium	3	10.3	3
Bates	$1,650,150,000	1	19.66	1	Medium	3	12.4	3
Benton	$2,478,458,000	1	26.52	1	Medium High	4	22.6	5
Bollinger	$1,035,129,000	1	19.71	1	Medium Low	2	18.9	4
Boone	$18,473,209,000	3	255.28	2	Low	1	3.9	1
Buchanan	$10,579,076,000	3	218.37	2	Medium	3	4.5	1
Butler	$4,144,110,000	2	61.83	1	Medium High	4	13.8	3
Caldwell	$984,103,000	1	21.14	1	Medium	3	16	4
Callaway	$4,410,445,000	2	53.72	1	Medium Low	2	15	4
Camden	$8,325,943,000	2	67.44	1	Medium High	4	7.6	2
Cape Girardeau	$8,792,829,000	2	135.81	2	Medium	3	7.1	2
Carroll	$1,199,939,000	1	12.95	1	Medium	3	9.4	3
Carter	$519,266,000	1	12.34	1	Medium High	4	22.3	5
Cass	$10,922,958,000	3	145.81	2	Low	1	5.3	2
Cedar	$1,307,607,000	1	29.37	1	Medium High	4	14.6	4
Chariton	$938,756,000	1	10.10	1	Medium High	4	11.2	3
Christian	$7,747,900,000	2	148.01	2	Medium Low	2	5.7	2
Clark	$709,999,000	1	13.48	1	Medium Low	2	16.2	4
Clay	$27,589,080,000	4	593.10	3	Medium Low	2	2.1	1
Clinton	$2,282,850,000	1	49.19	1	Medium	3	5.5	2
Cole	$10,724,282,000	3	194.84	2	Medium Low	2	3.2	1
Cooper	$1,797,081,000	1	31.24	1	Medium Low	2	6.6	2
Crawford	$2,389,455,000	1	33.03	1	Medium	3	14.8	4
Dade	$738,641,000	1	15.50	1	Medium	3	13.1	3
Dallas	$1,358,763,000	1	30.31	1	Medium	3	19.2	4
Daviess	$958,602,000	1	14.65	1	Medium	3	11.4	3
DeKalb	$1,090,102,000	1	30.11	1	Low	1	14.6	4
Dent	$1,451,544,000	1	20.71	1	Medium High	4	20.1	4

County	Total Building Exposure (Hazus)	Exposure Rating	Population Density	Population Rating	SOVI Index Ranking	SOVI Rating	Percent Mobile Homes	Mobile Home Rating
Douglas	$1,047,849,000	1	16.44	1	Medium	3	16.9	4
Dunklin	$2,976,060,000	1	57.10	1	High	5	10.1	3
Franklin	$11,417,093,000	3	111.01	1	Medium Low	2	9.6	3
Gasconade	$1,888,630,000	1	28.69	1	Medium	3	10.6	3
Gentry	$689,499,000	1	13.62	1	Medium High	4	9.5	3
Greene	$32,106,732,000	4	426.58	2	Medium	3	3.3	1
Grundy	$1,175,303,000	1	23.20	1	Medium High	4	6.6	2
Harrison	$1,024,720,000	1	11.92	1	Medium High	4	9.4	3
Henry	$2,536,896,000	1	31.19	1	Medium	3	11.6	3
Hickory	$865,580,000	1	23.05	1	High	5	32.9	5
Holt	$622,760,000	1	9.69	1	Medium	3	7.8	2
Howard	$1,086,442,000	1	21.86	1	Medium Low	2	17	4
Howell	$3,550,892,000	2	43.26	1	Medium	3	16	4
Iron	$978,688,000	1	18.40	1	Medium High	4	18.7	4
Jackson	$89,309,906,000	5	1137.58	3	Medium	3	0.9	1
Jasper	$12,070,483,000	3	185.74	2	Medium	3	5.6	2
Jefferson	$22,249,768,000	3	341.32	2	Low	1	11.2	3
Johnson	$6,044,509,000	2	65.06	1	Low	1	10.3	3
Knox	$438,423,000	1	7.76	1	Medium High	4	12.4	3
Laclede	$3,218,581,000	1	46.39	1	Medium	3	18.5	4
Lafayette	$3,841,393,000	2	52.04	1	Medium Low	2	10.2	3
Lawrence	$3,495,760,000	2	62.41	1	Medium	3	11.7	3
Lewis	$995,873,000	1	20.21	1	Medium	3	19.3	4
Lincoln	$4,719,921,000	2	87.30	1	Low	1	18.3	4
Linn	$1,551,785,000	1	19.99	1	Medium High	4	9.9	3
Livingston	$1,711,120,000	1	28.23	1	Medium High	4	7.3	2
Macon	$1,634,837,000	1	19.14	1	Medium High	4	12.1	3
Madison	$1,135,602,000	1	25.10	1	Medium High	4	13.2	3
Maries	$955,863,000	1	17.01	1	Medium	3	16.9	4
Marion	$3,224,641,000	1	66.10	1	Medium High	4	5.3	2
McDonald	$1,683,620,000	1	41.97	1	Medium	3	24.2	5
Mercer	$401,520,000	1	8.14	1	Medium High	4	11.2	3
Miller	$2,404,472,000	1	42.38	1	Medium High	4	13.5	3
Mississippi	$1,114,534,000	1	34.10	1	Medium High	4	7.6	2
Moniteau	$1,508,058,000	1	38.46	1	Medium Low	2	8.8	2
Monroe	$979,485,000	1	13.25	1	Medium	3	16.5	4
Montgomery	$1,397,445,000	1	21.82	1	Medium High	4	10.6	3
Morgan	$2,872,295,000	1	33.75	1	Medium High	4	18.8	4
New Madrid	$1,765,289,000	1	26.98	1	High	5	11.4	3
Newton	$5,509,504,000	2	93.82	1	Medium Low	2	14.6	4
Nodaway	$2,447,800,000	1	26.01	1	Medium	3	6.7	2
Oregon	$891,037,000	1	13.87	1	Medium High	4	18.7	4
Osage	$1,611,790,000	1	22.55	1	Low	1	8.8	2
Ozark	$926,358,000	1	12.63	1	Medium	3	20.2	4
Pemiscot	$1,642,290,000	1	35.49	1	High	5	9.7	3
Perry	$2,233,009,000	1	40.44	1	Medium Low	2	8	2
Pettis	$4,468,128,000	2	61.94	1	Medium	3	5.8	2
Phelps	$4,743,488,000	2	66.68	1	Medium Low	2	10.2	3
Pike	$1,861,578,000	1	27.37	1	Medium Low	2	11	3
Platte	$11,360,168,000	3	228.70	2	Low	1	0.7	1
Polk	$2,708,704,000	1	49.14	1	Medium	3	11.6	3
Pulaski	$5,334,660,000	2	97.28	1	Low	1	9.7	3

County	Total Building Exposure (Hazus)	Exposure Rating	Population Density	Population Rating	SOVI Index Ranking	SOVI Rating	Percent Mobile Homes	Mobile Home Rating
Putnam	$532,020,000	1	9.39	1	Medium	3	7.4	2
Ralls	$1,155,646,000	1	21.70	1	Medium Low	2	14.3	4
Randolph	$2,425,165,000	1	52.01	1	Medium Low	2	13.7	3
Ray	$2,537,055,000	1	40.10	1	Medium Low	2	5.4	2
Reynolds	$669,647,000	1	7.96	1	Medium High	4	20.2	4
Ripley	$1,131,335,000	1	21.92	1	Medium High	4	25.1	5
Saline	$2,437,646,000	1	30.78	1	Medium	3	6.3	2
Schuyler	$401,800,000	1	14.44	1	Medium	3	9.4	3
Scotland	$541,487,000	1	11.12	1	Medium High	4	7	2
Scott	$4,036,288,000	2	92.88	1	Medium	3	12.8	3
Shannon	$678,728,000	1	8.23	1	Medium	3	16.5	4
Shelby	$786,622,000	1	12.23	1	Medium	3	10.2	3
St. Charles	$41,845,005,000	4	688.01	3	Low	1	2.9	1
St. Clair	$936,097,000	1	14.09	1	Medium High	4	23.9	5
St. Francois	$6,180,166,000	2	147.20	2	Medium Low	2	17	4
St. Louis	$138,887,850,000	5	1975.90	4	Medium Low	2	0.2	1
St. Louis City	$46,880,213,000	4	5099.10	5	High	5	0.4	1
Ste. Genevieve	$2,163,144,000	1	35.90	1	Medium Low	2	12.1	3
Stoddard	$2,989,130,000	1	36.27	1	Medium	3	11.5	3
Stone	$3,936,498,000	2	66.68	1	Medium High	4	15.8	4
Sullivan	$624,603,000	1	9.80	1	Medium High	4	10	3
Taney	$6,120,612,000	2	86.32	1	High	5	13.4	3
Texas	$2,293,426,000	1	21.82	1	Medium	3	21.2	4
Vernon	$2,251,400,000	1	25.20	1	Medium High	4	11	3
Warren	$3,478,576,000	2	78.19	1	Medium Low	2	13	3
Washington	$1,730,986,000	1	32.62	1	Medium	3	33.2	5
Wayne	$1,256,590,000	1	17.66	1	Medium High	4	30.6	5
Webster	$2,782,115,000	1	63.26	1	Medium Low	2	14	3
Worth	$269,532,000	1	7.72	1	Medium High	4	8.3	2
Wright	$1,602,331,000	1	26.79	1	Medium	3	14.7	4

Table 3.132 provides additional data obtained from the National Centers for Environmental Information to complete the overall vulnerability analysis and the total overall vulnerability rating for tornadoes.

Table 3.117. Likelihood of Occurrence, Annual Property Loss, and Overall Vulnerability Rating for Tornadoes

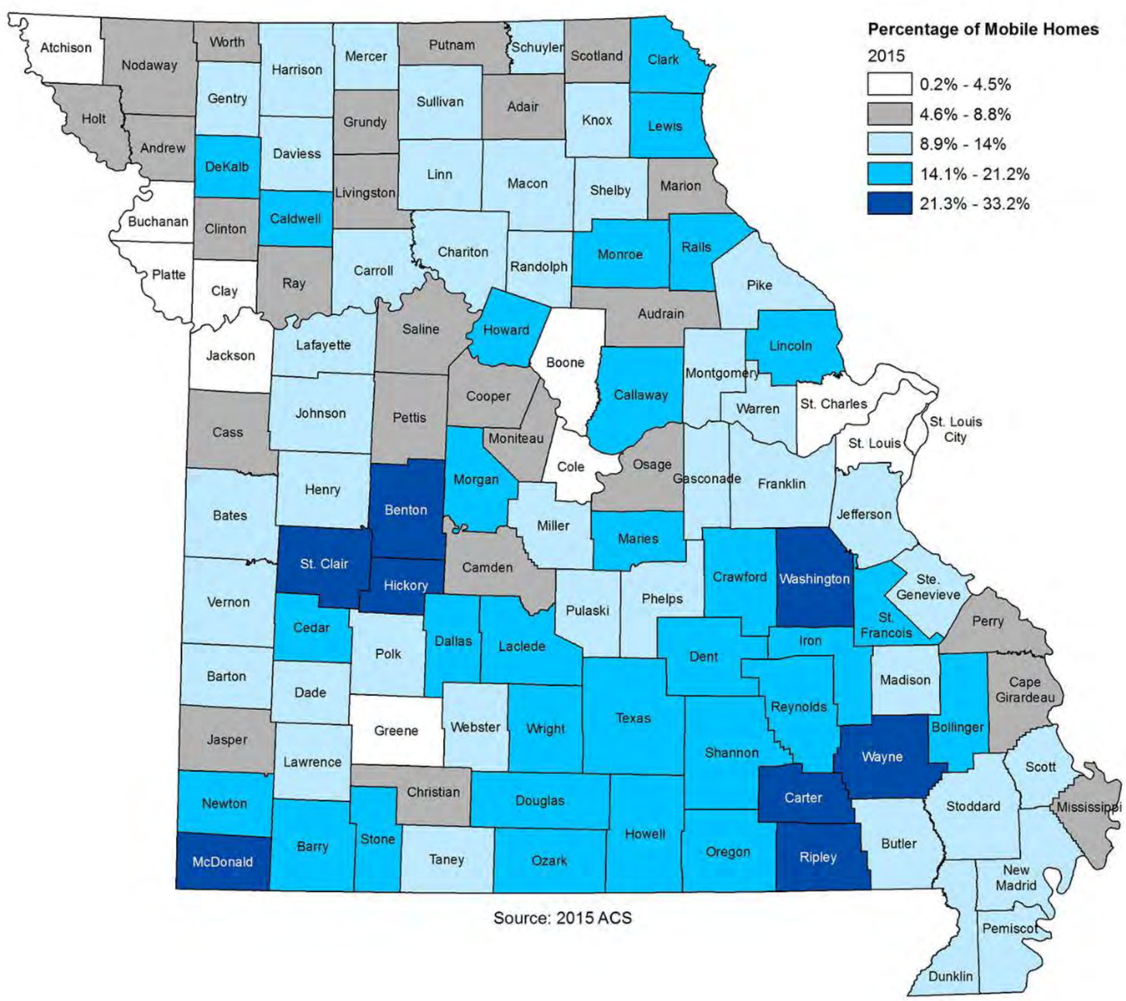
County	Total Number of Tornadoes	Likelihood of Occurrence	Likelihood of Occurrence Rating	Total Annualized Property Loss	Total Annualized Property Loss Rating	Overall Vulnerability Rating	Overall Vulnerability Rating Description
Adair	11	0.164	1	$77,616	1	9	Low
Andrew	24	0.358	3	$96,572	1	10	Low
Atchison	19	0.284	2	$9,851	1	10	Low
Audrain	24	0.358	3	$46,008	1	12	Low Medium
Barry	39	0.582	5	$312,239	2	17	High
Barton	34	0.507	4	$666,170	2	14	Medium
Bates	25	0.373	3	$20,307	1	12	Low Medium
Benton	26	0.388	3	$85,823	1	15	Medium High
Bollinger	26	0.388	3	$87,701	1	12	Low Medium

County	Total Number of Tornadoes	Likelihood of Occurrence	Likelihood of Occurrence Rating	Total Annualized Property Loss	Total Annualized Property Loss Rating	Overall Vulnerability Rating	Overall Vulnerability Rating Description
Boone	34	0.507	4	$519,560	2	13	Medium
Buchanan	24	0.358	3	$65,153	1	13	Medium
Butler	44	0.657	5	$637,276	2	17	High
Caldwell	10	0.149	1	$45,560	1	11	Low Medium
Callaway	39	0.582	5	$50,265	1	15	Medium High
Camden	22	0.328	3	$118,399	1	13	Medium
Cape Girardeau	47	0.701	5	$268,485	1	15	Medium High
Carroll	15	0.224	2	$47,471	1	11	Low Medium
Carter	17	0.254	2	$364,507	2	15	Medium High
Cass	41	0.612	5	$469,356	2	15	Medium High
Cedar	20	0.299	2	$991,825	2	14	Medium
Chariton	18	0.269	2	$207,616	1	12	Low Medium
Christian	30	0.448	4	$1,358,687	3	15	Medium High
Clark	13	0.194	1	$51,578	1	10	Low
Clay	31	0.463	4	$1,704,605	3	17	High
Clinton	23	0.343	3	$6,307	1	11	Low Medium
Cole	9	0.134	1	$79,105	1	10	Low
Cooper	17	0.254	2	$17,351	1	9	Low
Crawford	19	0.284	2	$394,272	2	13	Medium
Dade	20	0.299	2	$83,731	1	11	Low Medium
Dallas	12	0.179	1	$112,463	1	11	Low Medium
Daviess	20	0.299	2	$46,418	1	11	Low Medium
DeKalb	18	0.269	2	$11,045	1	10	Low
Dent	13	0.194	1	$9,146	1	12	Low Medium
Douglas	27	0.403	3	$102,396	1	13	Medium
Dunklin	30	0.448	4	$415,349	2	16	Medium High
Franklin	25	0.373	3	$28,769	1	13	Medium
Gasconade	8	0.119	1	$377,616	2	11	Low Medium
Gentry	18	0.269	2	$157,657	1	12	Low Medium
Greene	43	0.642	5	$1,641,653	3	18	High
Grundy	13	0.194	1	$9,328	1	10	Low
Harrison	24	0.358	3	$90,486	1	13	Medium
Henry	13	0.194	1	$12,352	1	10	Low
Hickory	15	0.224	2	$26,425	1	15	Medium High
Holt	14	0.209	2	$4,251	1	10	Low
Howard	9	0.134	1	$15,299	1	10	Low
Howell	46	0.687	5	$599,276	2	17	High
Iron	15	0.224	2	$45,940	1	13	Medium
Jackson	39	0.582	5	$170,523	1	18	High
Jasper	45	0.672	5	$42,467,109	5	20	High
Jefferson	37	0.552	4	$130,040	1	14	Medium
Johnson	34	0.507	4	$96,347	1	12	Low Medium
Knox	9	0.134	1	$11,568	1	11	Low Medium
Laclede	19	0.284	2	$221,306	1	12	Low Medium
Lafayette	26	0.388	3	$55,199	1	12	Low Medium
Lawrence	21	0.313	2	$577,351	2	13	Medium
Lewis	15	0.224	2	$117,612	1	12	Low Medium
Lincoln	24	0.358	3	$48,135	1	12	Low Medium
Linn	14	0.209	2	$51,687	1	12	Low Medium
Livingston	10	0.149	1	$30,672	1	10	Low

County	Total Number of Tornadoes	Likelihood of Occurrence	Likelihood of Occurrence Rating	Total Annualized Property Loss	Total Annualized Property Loss Rating	Overall Vulnerability Rating	Overall Vulnerability Rating Description
Macon	15	0.224	2	$106,884	1	12	Low Medium
Madison	27	0.403	3	$16,455	1	13	Medium
Maries	9	0.134	1	$80,228	1	11	Low Medium
Marion	11	0.164	1	$6,007	1	10	Low
McDonald	20	0.299	2	$36,086	1	13	Medium
Mercer	17	0.254	2	$6,403	1	12	Low Medium
Miller	26	0.388	3	$57,616	1	13	Medium
Mississippi	25	0.373	3	$409,041	2	13	Medium
Moniteau	20	0.299	2	$380,038	2	10	Low
Monroe	27	0.403	3	$2,090	1	13	Medium
Montgomery	24	0.358	3	$66,791	1	13	Medium
Morgan	24	0.358	3	$29,374	1	14	Medium
New Madrid	28	0.418	4	$392,873	2	16	Medium High
Newton	53	0.791	5	$1,087,057	3	17	High
Nodaway	32	0.478	4	$52,426	1	12	Low Medium
Oregon	18	0.269	2	$143,672	1	13	Medium
Osage	10	0.149	1	$56,720	1	7	Low
Ozark	33	0.493	4	$418,942	2	15	Medium High
Pemiscot	36	0.537	4	$943,934	2	16	Medium High
Perry	23	0.343	3	$580,701	2	11	Low Medium
Pettis	38	0.567	5	$1,276,083	3	16	Medium High
Phelps	25	0.373	3	$138,922	1	12	Low Medium
Pike	24	0.358	3	$7,127	1	11	Low Medium
Platte	18	0.269	2	$531,419	2	11	Low Medium
Polk	32	0.478	4	$172,579	1	13	Medium
Pulaski	16	0.239	2	$1,520,299	3	12	Low Medium
Putnam	9	0.134	1	$4,455	1	9	Low
Ralls	11	0.164	1	$974	1	10	Low
Randolph	8	0.119	1	$81,011	1	9	Low
Ray	36	0.537	4	$96,310	1	11	Low Medium
Reynolds	13	0.194	1	$12,724	1	12	Low Medium
Ripley	24	0.358	3	$77,388	1	15	Medium High
Saline	24	0.358	3	$68,247	1	11	Low Medium
Schuyler	10	0.149	1	$38,325	1	10	Low
Scotland	14	0.209	2	$13,709	1	11	Low Medium
Scott	44	0.657	5	$536,211	2	16	Medium High
Shannon	14	0.209	2	$48,918	1	12	Low Medium
Shelby	19	0.284	2	$39,325	1	11	Low Medium
St. Charles	41	0.612	5	$2,099,000	3	17	High
St. Clair	24	0.358	3	$407,627	2	16	Medium High
St. Francois	22	0.328	3	$867,948	2	15	Medium High
St. Louis	44	0.657	5	$5,047,474	4	21	High
St. Louis City	8	0.119	1	$377,239	2	18	High
Ste. Genevieve	10	0.149	1	$4,590	1	9	Low
Stoddard	41	0.612	5	$109,687	1	14	Medium
Stone	30	0.448	4	$192,910	1	16	Medium High
Sullivan	8	0.119	1	$1,312	1	11	Low Medium
Taney	11	0.164	1	$237,623	1	13	Medium
Texas	29	0.433	4	$136,717	1	14	Medium
Vernon	29	0.433	4	$521,497	2	15	Medium High

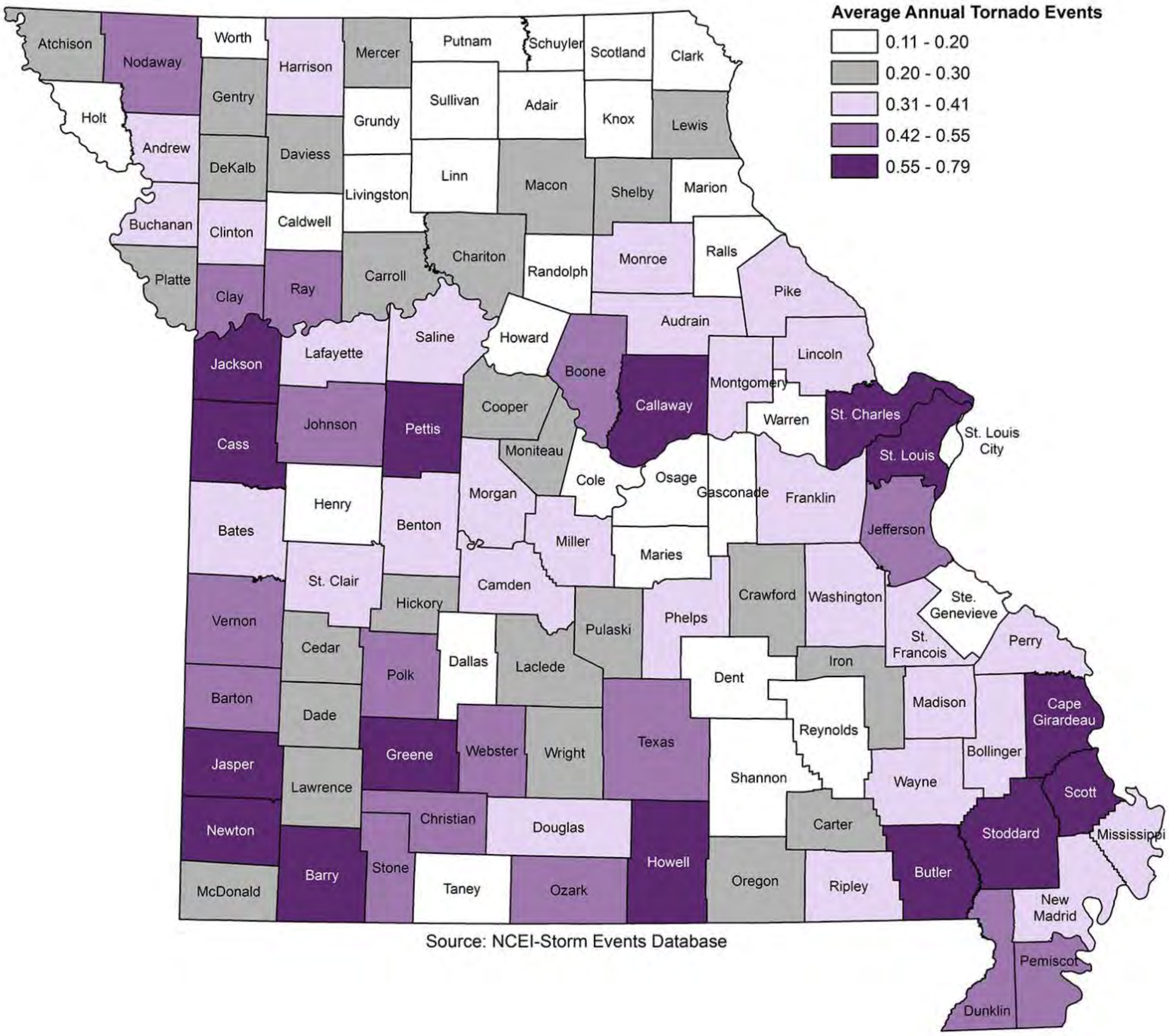
County	Total Number of Tornadoes	Likelihood of Occurrence	Likelihood of Occurrence Rating	Total Annualized Property Loss	Total Annualized Property Loss Rating	Overall Vulnerability Rating	Overall Vulnerability Rating Description
Warren	14	0.209	2	$49,187	1	11	Low Medium
Washington	25	0.373	3	$840,299	2	15	Medium High
Wayne	23	0.343	3	$57,761	1	15	Medium High
Webster	32	0.478	4	$281,874	1	12	Low Medium
Worth	13	0.194	1	$9,030	1	10	Low
Wright	16	0.239	2	$90,004	1	12	Low Medium

Figure 3.164. Percent of Mobile Homes per County



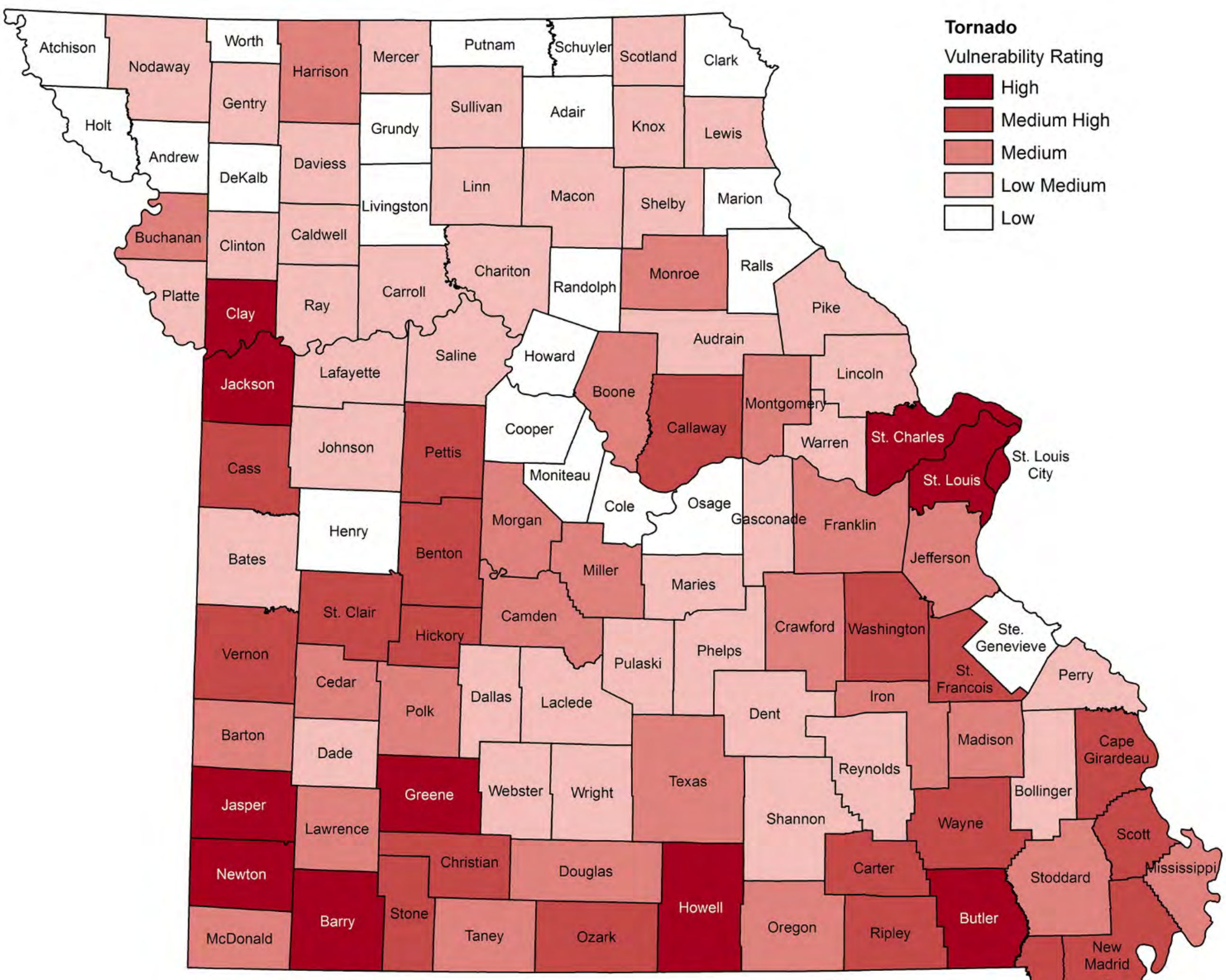
3 Risk Assessment

Figure 3.165. Average Annual Occurrence for Tornadoes



Source: NCEI-Storm Events Database

Figure 3.166. Overall Vulnerability to Tornadoes

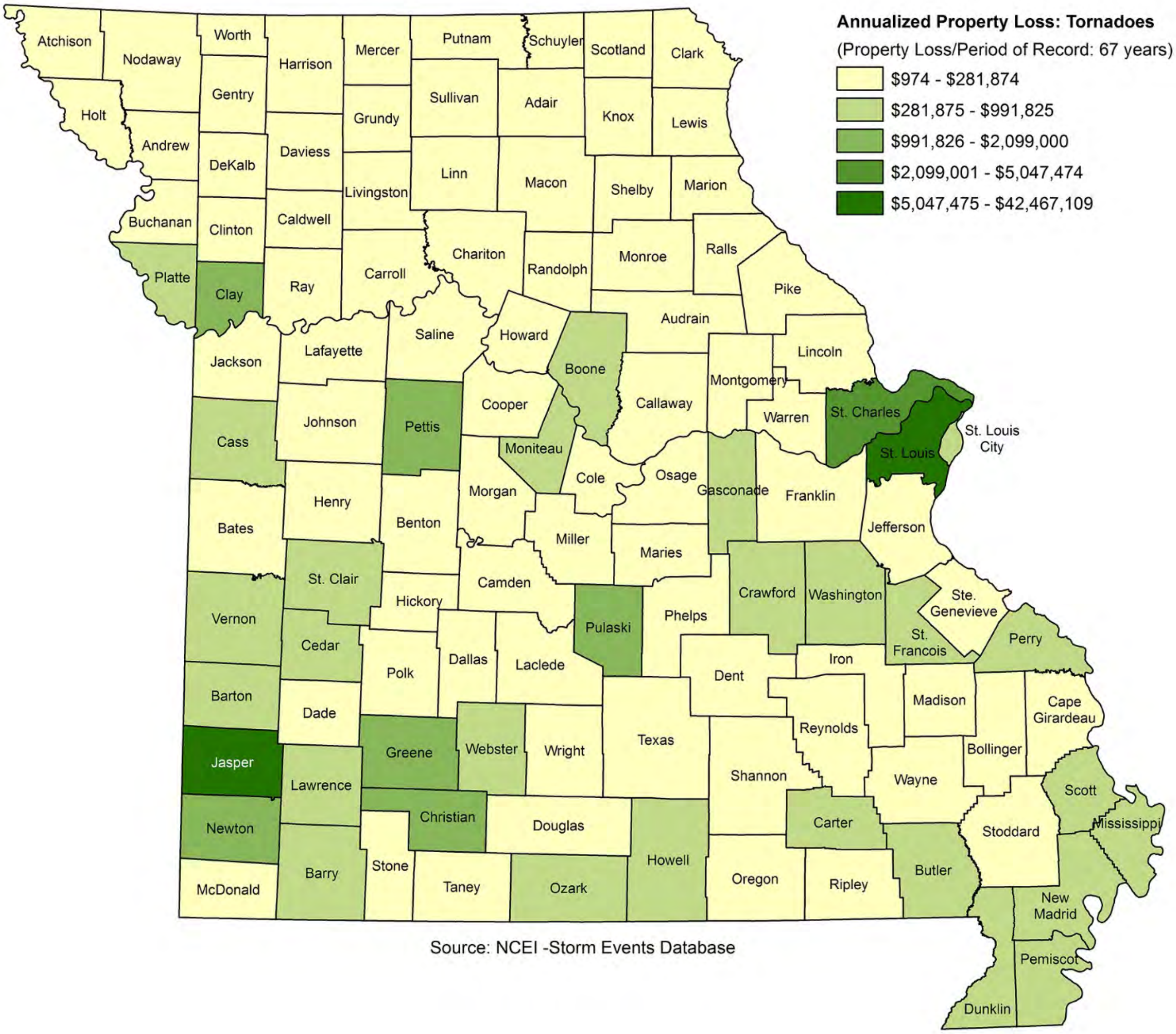


Source: NCEI -Storm Events Database,
HAZUS-Building Values, Social Vulnerability Index, 2015 ACS

State Estimates of Potential Losses

From the statistical data collected, annualized historical losses from 1950 to December 31, 2016 were considered in determining annualized tornado damages. See **Figure 3.167** for a list of historical losses by County.

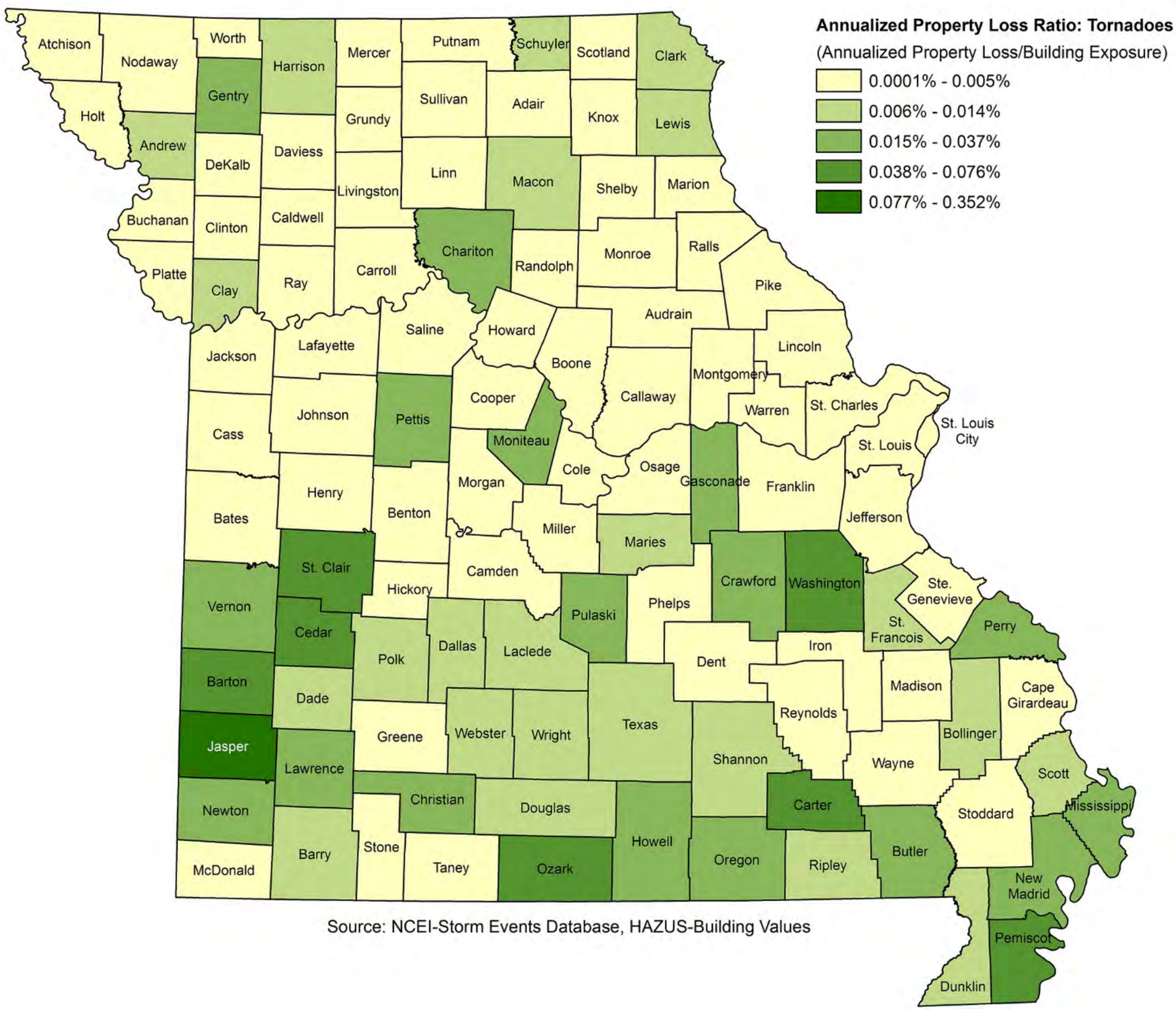
Figure 3.167. Annualized Property Loss for Tornadoes



Source: NCEI -Storm Events Database

3 Risk Assessment

Figure 3.168. Annualized Property Loss Ratio for Tornadoes



Hazard Impact on Future Growth and Development

Ten counties rated “High” in overall vulnerability to Tornado; Cass, Dunklin, Howell, Jackson, Mississippi, Newton, St. François, St. Louis, Texas, Vernon, and Washington, as well as the City of St. Louis. Of these counties and city, only St. Louis County rated in the top ten in population gain from 2010 to 2015, at ninth. Jackson County and St. Francois rated in the top ten in estimated housing gains from 2010 to 2015, at sixth and tenth, respectively. With growing population and increased development, there is potential for increased losses as a result of the increase in exposure. But, this will be dependent on where the severe thunderstorms occur which is a variable that cannot be predicted due to the random nature of this hazard.

EMAP Consequence Analysis

Table 3.118. EMAP Impact Analysis: Tornadoes

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

Risk Summary

The potential severity of effects from tornadoes will continue to be high. We will continue to experience deaths, injuries, and property damage from tornadoes. However, technological advances will facilitate earlier warnings than previously available. This, combined with a vigorous public education program and improved construction techniques, provides the potential for significant reductions in the number of deaths and injuries, as well as reduced property damage.

Problem Statement:

Using Overall Vulnerability to Tornado as a key indicator, the most vulnerable counties are Clay, Jackson, St. Louis City/County, Jasper, Newton, Barry, Greene, Howell and Butler. Mitigation efforts and dollars allocated, especially for saferooms, in these areas would likely be of the most benefit.

2018 risk assessment data and mapping is available through the Missouri Hazard Mitigation Viewer: http://bit.ly/MoHazardMitigationPlanViewer2018.

3.3.11. Wildfires

Probability	Severity
100% 3,200 events per year average	Low to Moderate

Description/Location

Fires can range in scope to include structural fires, urban fires, and wildfires. Urban/Structural fires are presented in Section 3.3.15. For the purpose of this analysis, wildfires include forest, prairie, and grassland locations. An example of wildfire is provided in **Figure 3.169**.

Figure 3.169. Wildfire in Crawford County, Easter Sunday, 1998

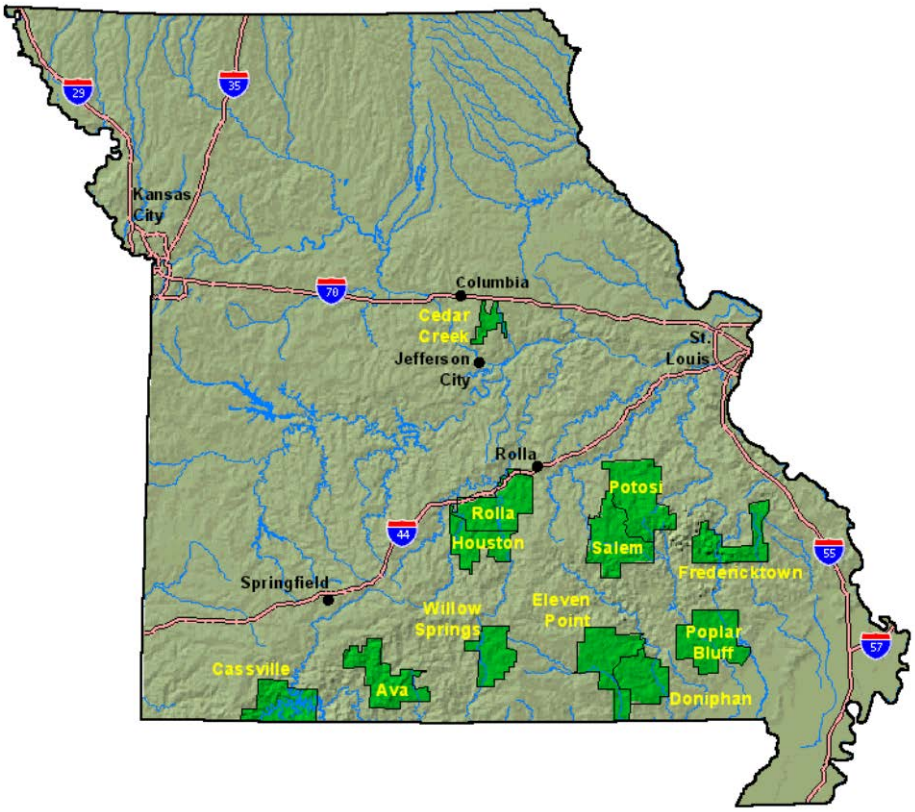
Photo Courtesy of Jim Lyon, mofire.org

The Forestry Division of the Missouri Department of Conservation (MDC) is responsible for protecting privately owned and state-owned forests and grasslands from the destructive effects of wildfires. To accomplish this task, eight forestry regions have been established in the State to assist with the quick suppression of fires (see **Figure 3.170**). The Forestry Division works closely with volunteer fire departments and federal partners to assist with fire suppression activities. Currently, approximately 700 rural fire departments have regional mutual aid agreements and over 300 have mutual aid agreements with the State to obtain assistance in wildfire protection if needed; a cooperative agreement with the Mark Twain National Forest is renewed annually. **Figure 3.171** illustrates the Mark Twain National Forests across Missouri.

Figure 3.170. Missouri Department of Conservation Forestry Regions

Source: Missouri Department of Conservation; https://mdc.mo.gov/regions

Figure 3.171. Mark Twain National Forests



Source: Missouri Department of Conservation

Forest and grassland fires can occur any day throughout the year. Each year, an average of about 3,200 wildfires burn more than 52,000 acres of forest and grassland in Missouri. Most of the fires occur during the spring season, normally between February 15 and May 10. The length and severity of burning periods largely depend on the weather conditions. Spring in Missouri is noted for its low humidity and high winds. These conditions, together with below-normal precipitation and high temperatures, result in extremely high fire danger. In addition, due to the continued 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 provide for adequate firefighting suppression. Spring is when many rural residents burn their garden spots, brush piles, and other areas. Some landowners also believe it is necessary to burn their forests in the spring to promote grass growth, kill ticks, and reduce brush. Therefore, with the possibility of extremely high fire dangers and the increased opportunities for fires, the 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.

In north and west-central Missouri, the MDC has limited firefighting forces. Forestry Division personnel, however, provide training and limited federal excess equipment to the many volunteer rural fire departments. See **Figure 3.170** for a map of the MDC forestry regions.

Extent

Wildfire events can range from small fires that can be managed by local firefighters to large fires impacting many acres of land. Large events may require evacuation from one or more communities and necessitate regional or national firefighting support. The impact of a severe wildfire can be devastating. A wildfire has the potential to kill people, livestock, fish and wildlife. The severity in Missouri is considered low to moderate.

Wildfires often destroy property, valuable timber, forage and recreational and scenic values. In addition to the risk wildfires pose to the general public and property owners, the safety of firefighters is also a concern. Although loss of life among firefighters does not occur often in Missouri, it is always a risk. More common firefighting injuries include falls, sprains, abrasions or heat-related injuries such as dehydration. Response to wildfires also exposes emergency responders to the risk of motor vehicle accidents and can place them in remote areas away from the communities that they are chartered to protect.

Previous Occurrences

At the present time, the forestry districts provide fire protection to approximately one-half of the State, or about 16 million acres. Within these districts, fairly accurate forest and grassland fire statistics are available from the MDC. In a typical year, approximately 3,200 wildfires occur.

In 2016, 2,811 wildfires occurred in Missouri, burning 27,881 acres. Debris burning (fires resulting from land clearing, burning trash, range, stubble, right-of-way, logging slash, etc.) is the major cause of forest and grass fires in Missouri. Incendiary fires (fires willfully set by anyone on property not owned or controlled by him and without the consent of the owner) continue to rank second in the number of wildfires that occur each year.

Table 3.119 lists the number and causes of forest and grassland fires in 2016 and the acres burned**. Table 3.120** shows the number of fires and acreage burned by forest and grassland fires yearly from 1993 to 2016. Additional information on reporting of wildfires can be found at http://mdc4.mdc.mo.gov/applications/FireReporting/Report.aspx.

Table 3.119. 2016 Statewide Forest and Grassland Fires by Cause

Cause	Number	Acres	% Number	% Acres
Debris Burning	1,114	9,548.2	39.6%	34.2%
Arson	111	4,325.8	3.9%	15.5%
Equipment Use	150	691.0	5.3%	2.5%
Lightning	8	609.1	0.3%	2.2%
Campfire	52	233.9	1.8%	0.8%
Smoking	41	129.3	1.5%	0.5%
Children	5	45.1	0.2%	0.2%
Railroad	6	10.9	0.2%	0.0%
Miscellaneous	1,324	12,287.8	47.1%	44.1%
Totals	**2,811**	**27,881.1**	**100%**	**100%**

Source: Missouri Department of Conservation

Table 3.120. Statewide Forest and Grassland Fires and Acres Burned, 1993–2016

Year	Fires	Acres	Year	Fires	Acres
1993	2,994	31,952	2005	1,610	38,921
1994	2,748	51,896	2006	3,553	52,419
1995	2,910	48,907	2007	3,058	36,922
1996	3,793	88,933	2008	2,825	37,534
1997	2,487	29,557	2009	5,384	88,911
1998	1,112	10,415	2010	2,798	32,864
1999	1,348	18,270	2011	4,195	80,925
2000	4,910	132,718	2012	5,306	89,150
2001	2,972	41,092	2013	2,381	18,498
2002	2,376	54,397	2014	5,940	95,797
2003	2,378	47,692	2015	4,204	38,992
2004	2,917	55,732	2016	2,811	27,881

Source: Missouri Department of Conservation

Despite the fact that Missouri experiences an average of 3,200 wildfires each year, Missouri has only received one fire management assistance declaration. This was for the Camden Fire Complex in 2000. At the time of the declaration, the complex consisted of 70 fires burning on 3,000 acres of grassland that had destroyed 17 homes and forced the evacuation of approximately 300 residents in Camden County communities from Macks Creek to Climax Springs.

Probability of Future Hazard Events

As noted, Missouri experiences an average of 3,200 wildfires each year, with most frequent events occurring during spring or late fall, or under conditions of excessive heat, dryness, or drought. However, the likelihood of one of those fires attaining significant size and intensity is unpredictable and highly dependent on environmental conditions and firefighting response. Due to the high percentage of wildfires caused by arson, the occurrence of future wildfire events will strongly depend on patterns of human activity. Events are more likely to occur in wildfire-prone areas experiencing new or additional development. Given the historical frequency of wildfire events and the recommendations of the SRMT, this hazard is determined to have a 100% probability of occurrence within the State.

Changing Future Conditions Considerations

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

Higher temperatures will also reduce the number of days prescribed burning can be performed. Reduction of prescribed burning will allow for growth of understory vegetation – providing fuel for destructive wildfires. Drought is also anticipated to increase in frequency and intensity during summer months under projected future scenarios. Drought can lead to dead or dying vegetation and landscaping material close to structures which creates fodder for wildfires within both the urban and rural settings.

State Vulnerability Overview

With over 14 million acres, Missouri ranks seventh in the northeast region of the U.S. in forest land area. Although the National Fire Incident Reporting System does capture data on wildfires, it was determined that the Department of Conservation historical wildfire data was the best resource. The Department of Conservation data has more individual events recorded per county. Therefore, this data appeared to be more comprehensive. Some fire departments report to both data sets. So, adding the two sets of data together would have double-counted fires. From the Department of Conservation wildfire data from 1993 to 2016, it was determined that the average annual number of wildfires in Missouri was 3,209 burning an average annual 52,099 acres.

From the data obtained from the Department of Conservation, the likelihood of occurrence and the annualized acres burned were determined for each county and are presented in **Table 3.121**.

Table 3.121. Statistical Data for Wildfire Vulnerability

County	Number of Wildfires 2004-2016	Likelihood of Occurrence (#/year)	Total Acres Burned	Average Annual Acreage Burned
Adair	156	12.00	1,643.38	126
Andrew	471	36.23	4,252.66	327
Atchison	208	16.00	1,808.25	139
Audrain	113	8.69	524.13	40
Barry	696	53.54	5,993.44	461
Barton	130	10.00	4,548.50	350
Bates	281	21.62	4,038.02	311
Benton	1,133	87.15	21,005.12	1,616
Bollinger	399	30.69	2,814.00	216
Boone	7	0.54	60.47	5
Buchanan	504	38.77	2,976.91	229
Butler	1,158	89.08	4,151.09	319
Caldwell	152	11.69	5,010.29	385

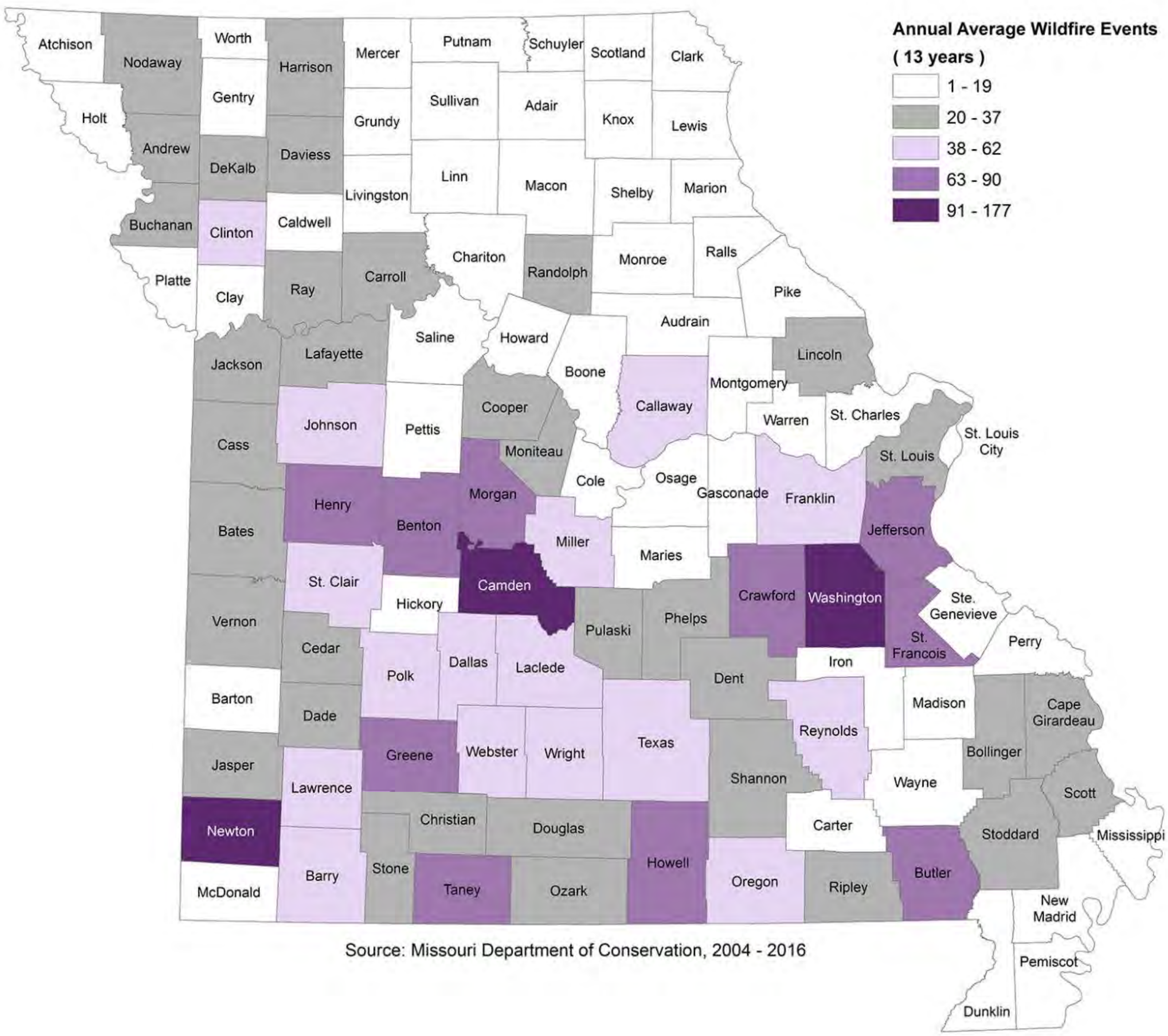
County	Number of Wildfires 2004-2016	Likelihood of Occurrence (#/year)	Total Acres Burned	Average Annual Acreage Burned
Callaway	589	45.31	3,997.45	307
Camden	2,307	177.46	61,333.24	4,718
Cape Girardeau	366	28.15	2,527.23	194
Carroll	340	26.15	11,697.25	900
Carter	113	8.69	6,249.97	481
Cass	380	29.23	2,244.25	173
Cedar	403	31.00	6,145.26	473
Chariton	239	18.38	3,422.98	263
Christian	290	22.31	2,550.33	196
Clark	210	16.15	1,296.08	100
Clay	191	14.69	726.58	56
Clinton	655	50.38	6,325.38	487
Cole	179	13.77	727.80	56
Cooper	459	35.31	3,082.81	237
Crawford	1,133	87.15	11,079.62	852
Dade	506	38.92	4,504.85	347
Dallas	675	51.92	39,531.21	3,041
Daviess	332	25.54	5,610.27	432
Dekalb	412	31.69	10,356.21	797
Dent	446	34.31	9,330.97	718
Douglas	378	29.08	10,445.02	803
Dunklin	14	1.08	23.60	2
Franklin	795	61.15	2,734.09	210
Gasconade	99	7.62	1,135.77	87
Gentry	212	16.31	6,857.11	527
Greene	936	72.00	4,874.94	375
Grundy	133	10.23	1,945.95	150
Harrison	280	21.54	9,829.66	756
Henry	1,001	77.00	23,818.31	1,832
Hickory	206	15.85	3,977.01	306
Holt	137	10.54	829.09	64
Howard	136	10.46	2,197.75	169
Howell	868	66.77	10,697.75	823
Iron	141	10.85	7,063.70	543
Jackson	355	27.31	462.41	36
Jasper	472	36.31	3,168.54	244
Jefferson	1,057	81.31	2,986.68	230
Johnson	754	58.00	3,777.86	291
Knox	21	1.62	552.60	43
Laclede	540	41.54	22,994.06	1,769
Lafayette	279	21.46	1,487.10	114
Lawrence	698	53.69	3,799.27	292
Lewis	166	12.77	1,353.40	104
Lincoln	423	32.54	2,198.16	169
Linn	152	11.69	3,240.85	249
Livingston	133	10.23	4,339.55	334
Macon	196	15.08	4,162.25	320
Madison	233	17.92	1,316.28	101

County	Number of Wildfires 2004-2016	Likelihood of Occurrence (#/year)	Total Acres Burned	Average Annual Acreage Burned
Maries	231	17.77	4,289.73	330
Marion	95	7.31	1,367.45	105
McDonald	260	20.00	2,803.00	216
Mercer	71	5.46	1,579.85	122
Miller	707	54.38	5,500.20	423
Mississippi	214	16.46	888.00	68
Moniteau	375	28.85	2,665.26	205
Monroe	227	17.46	3,375.00	260
Montgomery	205	15.77	1,227.39	94
Morgan	890	68.46	11,081.53	852
New Madrid	98	7.54	166.50	13
Newton	1,759	135.31	7,221.89	556
Nodaway	479	36.85	6,963.12	536
Oregon	622	47.85	6,918.55	532
Osage	211	16.23	1,421.78	109
Ozark	419	32.23	12,100.20	931
Pemiscot	74	5.69	302.30	23
Perry	42	3.23	544.85	42
Pettis	174	13.38	1,742.21	134
Phelps	362	27.85	3,518.90	271
Pike	172	13.23	2,322.72	179
Platte	80	6.15	387.19	30
Polk	599	46.08	4,908.96	378
Pulaski	463	35.62	3,513.45	270
Putnam	126	9.69	1,649.35	127
Ralls	90	6.92	2,095.80	161
Randolph	360	27.69	3,407.16	262
Ray	375	28.85	6,445.69	496
Reynolds	559	43.00	21,737.05	1,672
Ripley	418	32.15	4,899.55	377
Saline	116	8.92	1,805.45	139
Schuyler	70	5.38	1,264.85	97
Scotland	155	11.92	2,748.07	211
Scott	359	27.62	2,109.67	162
Shannon	510	39.23	13,437.08	1,034
Shelby	91	7.00	1,099.45	85
St. Charles	161	12.38	933.20	72
St. Clair	643	49.46	20,271.02	1,559
St. Francois	1,167	89.77	8,675.52	667
St. Genevieve	331	25.46	1,705.74	131
St. Louis	82	6.31	165.26	13
St. Louis City*	9	0.69	1.95	0
Stoddard	484	37.23	2,706.38	208
Stone	519	39.92	4,638.64	357
Sullivan	84	6.46	1,411.75	109
Taney	884	68.00	7,977.77	614
Texas	803	61.77	9,035.26	695
Vernon	278	21.38	7,872.96	606

County	Number of Wildfires 2004-2016	Likelihood of Occurrence (#/year)	Total Acres Burned	Average Annual Acreage Burned
Warren	124	9.54	405.19	31
Washington	1,492	114.77	23,679.13	1,821
Wayne	244	18.77	5,921.10	455
Webster	684	52.62	5,699.88	438
Worth	176	13.54	8,084.77	622
Wright	635	48.85	5,201.06	400
Totals	**47,306**	**3,639**	**657,731**	**50,595**

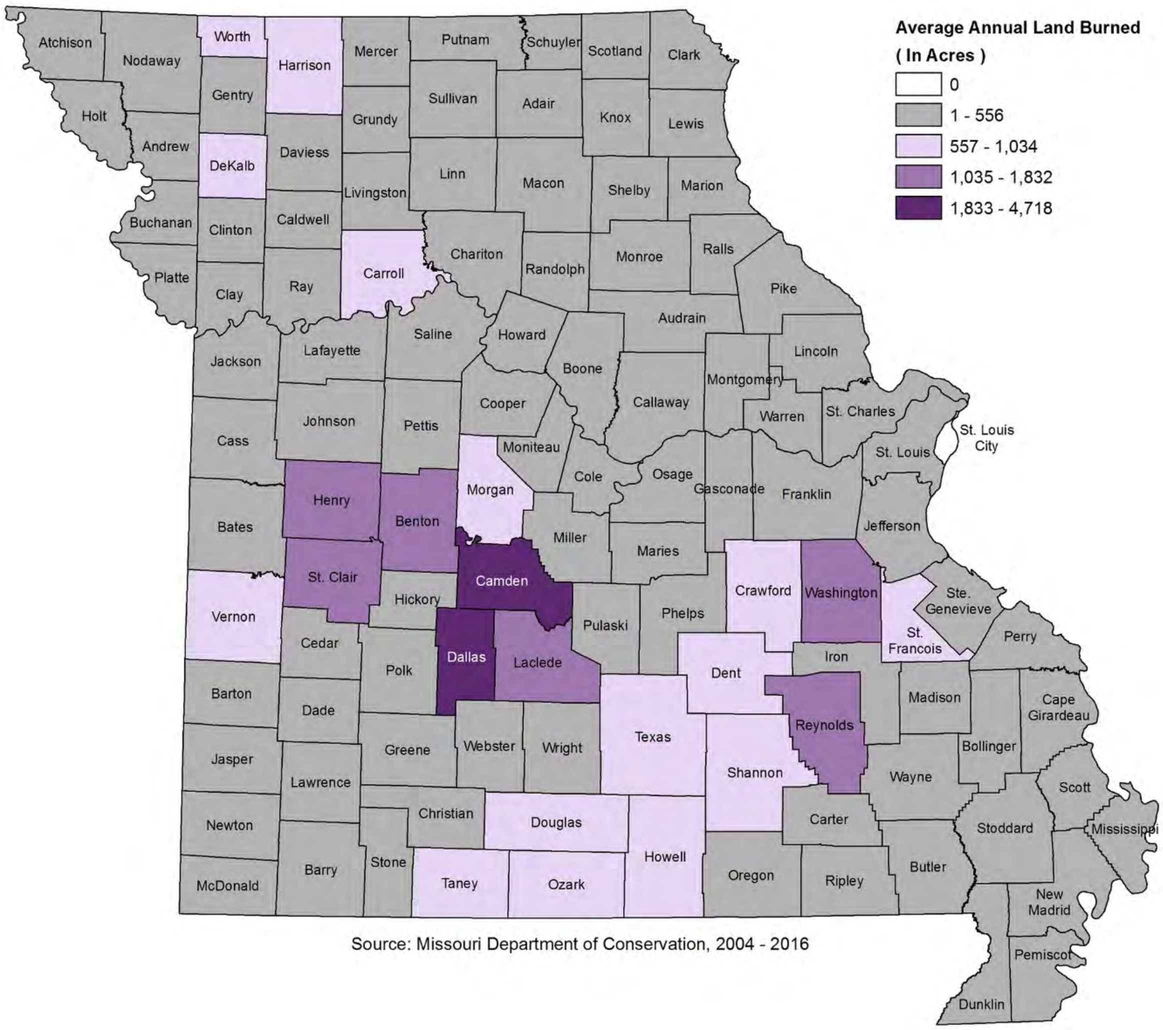
For the 5-year period from 2012-2016, a total of 1,172 buildings were reported damaged by wildfires in Missouri. This translates to an annualized average of 234 buildings damaged in this 5-year period statewide.

Figure 3.172. Likelihood of Wildfire Events, 2004-2016



Source: Missouri Department of Conservation, 2004 - 2016

Figure 3.173. Average Annual Acreage Burned

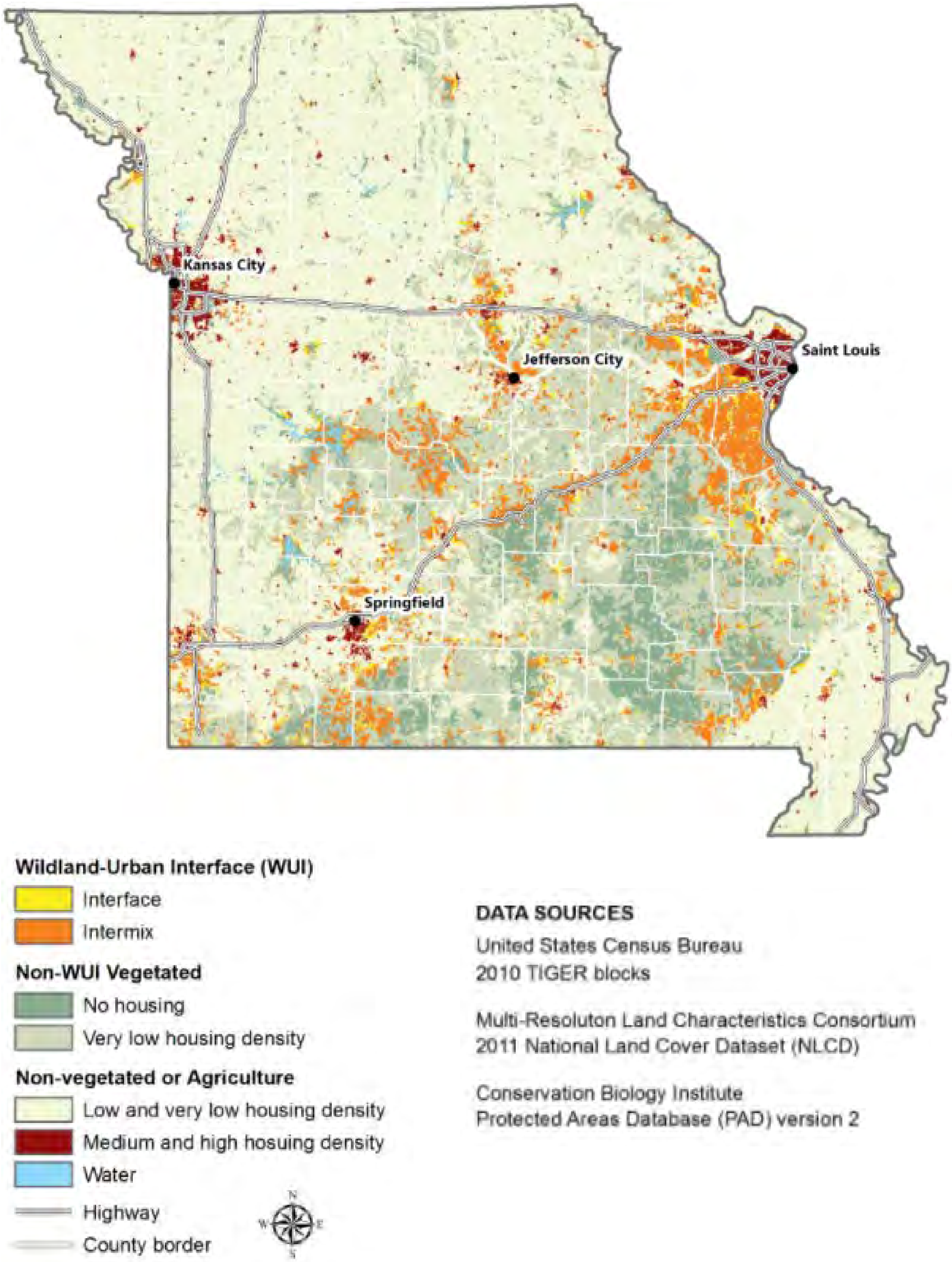


The method used to determine vulnerability to wildfires fires across Missouri was a GIS comparative analysis of wildland urban interface and intermix (WUI) areas against building exposure data to determine the types, numbers, and estimated values of buildings at risk to wildfire. This GIS-based analysis utilized data from several sources: the Missouri Spatial Data Inventory Service (MSDIS), HAZUS building exposure value data, and wildland urban interface and intermix area data from the University of Wisconsin-Madison SILVIS Lab.

To calculate estimated values of buildings at risk, buildings values available in the HAZUS census block data were used to determine an average value for each property type. This average value per property type was then applied to the number of structures in the WUI areas, by type, to calculate an overall estimated value of buildings at risk by type. In addition to counts and values of structures at risk, an estimated population impacted for each county was calculated based on the number of residential properties in the WUI areas multiplied by the average household size.

Figure 3.174 provides the results of the wildfire analysis with the numbers and values of various types of structures, and population within the mapped WUI areas. Error! Reference source not found. **and Figure 3.83** provides thematic maps of the analysis results.

Figure 3.174. Wildfire Urban Interface (WUI) Areas, 2010



Source: niversity of Wisconsin -Madison, SILVIS Lab, http://silvis.forest.wisc.edu/GeoData/WUI_cp12/maps/gifs/white/Missouri_WUI_cp12_white_2010.gif

Table 3.122. Estimated Numbers and Values of Structures and Population Vulnerable to Wildfire

County	Number of Structures	Value of Structures	Population
Adair	**5,103**	**$1,470,441,114**	**10,044**
Agriculture	356	$154,482,424	
Commercial	390	$230,692,247	
Education	34	$131,374,903	
Government	6	$3,568,320	
Industrial	61	$44,527,376	
Residential	4,256	$905,795,844	
Andrew	**812**	**$199,010,723**	**1,667**
Agriculture	82	$17,781,922	
Commercial	61	$34,484,808	
Education	1	$1,196,308	
Government	3	$2,191,500	
Industrial	1	$311,947	
Residential	664	$143,044,238	
Atchison	**68**	**$27,440,056**	**47**
Agriculture	43	$21,024,196	
Government	1	$473,091	
Industrial	2	$1,071,200	
Residential	22	$4,871,569	
Audrain	**266**	**$66,082,616**	**475**
Agriculture	56	$13,113,032	
Commercial	14	$9,098,007	
Education	1	$1,447,833	
Government	6	$3,780,529	
Industrial	2	$2,251,329	
Residential	187	$36,391,885	
Barry	**6,962**	**$1,583,681,764**	**9,718**
Agriculture	3,007	$823,495,965	
Commercial	231	$153,968,865	
Government	13	$9,873,000	
Industrial	2	$4,802,645	
Residential	3,709	$591,541,289	
Barton	**232**	**$49,166,855**	**278**
Agriculture	111	$25,255,295	
Commercial	6	$3,797,058	
Residential	115	$20,114,503	
Bates	**49**	**$21,219,177**	**68**
Agriculture	21	$16,267,622	
Residential	28	$4,951,555	
Benton	**7,254**	**$1,483,374,921**	**15,126**
Agriculture	93	$85,918,714	
Commercial	514	$337,633,490	
Education	2	$3,008,833	
Government	8	$5,801,882	
Industrial	3	$2,844,786	
Residential	6,634	$1,048,167,216	

County	Number of Structures	Value of Structures	Population
Bollinger	**2,440**	**$975,509,552**	**3,624**
Agriculture	958	$640,828,308	
Commercial	62	$36,103,579	
Education	6	$15,016,800	
Government	3	$1,497,000	
Industrial	1	$159,883	
Residential	1,410	$281,903,983	
Boone	**16,670**	**$4,605,907,873**	**33,762**
Agriculture	2,495	$747,576,941	
Commercial	115	$102,562,158	
Education	25	$80,605,029	
Government	9	$9,435,957	
Industrial	17	$9,101,769	
Residential	14,009	$3,656,626,018	
Buchanan	**6,868**	**$1,815,279,994**	**14,688**
Agriculture	845	$205,083,512	
Commercial	272	$260,042,538	
Education	5	$5,785,156	
Government	2	$1,769,041	
Industrial	51	$66,342,221	
Residential	5,693	$1,276,257,526	
Butler	**8,280**	**$1,958,767,835**	**16,047**
Agriculture	1,362	$478,179,414	
Commercial	319	$211,274,381	
Education	8	$12,912,930	
Government	5	$4,270,465	
Industrial	63	$54,573,675	
Residential	6,523	$1,197,556,970	
Caldwell	**83**	**$15,810,724**	**61**
Agriculture	58	$11,185,798	
Residential	25	$4,624,926	
Callaway	**7,002**	**$1,512,099,865**	**14,524**
Agriculture	952	$184,358,462	
Commercial	89	$55,861,568	
Education	1	$1,653,344	
Government	19	$12,257,192	
Industrial	13	$8,118,063	
Residential	5,928	$1,249,851,237	
Camden	**27,195**	**$7,603,700,922**	**58,898**
Agriculture	587	$140,579,341	
Commercial	2,362	$1,905,540,864	
Education	15	$25,025,625	
Government	29	$22,374,406	
Industrial	162	$107,324,372	
Residential	24,040	$5,402,856,314	
Cape Girardeau	**2,772**	**$671,830,034**	**4,644**
Agriculture	878	$219,337,570	

County	Number of Structures	Value of Structures	Population
Commercial	12	$9,912,452	
Government	2	$1,524,313	
Residential	1,880	$441,055,699	
Carroll	**48**	**$16,929,069**	**83**
Agriculture	9	$5,816,200	
Commercial	1	$658,562	
Government	5	$3,861,961	
Residential	33	$6,592,347	
Carter	**1,786**	**$140,444,442**	**3,697**
Agriculture	282	$95,316,000	
Commercial	43	$23,667,614	
Education	14	$18,484,667	
Government	1	$795,500	
Industrial	2	$1,841,833	
Residential	1,444	$338,827	
Cass	**678**	**$180,881,344**	**1,079**
Agriculture	261	$70,620,824	
Commercial	10	$5,452,915	
Residential	407	$104,807,606	
Cedar	**1,008**	**$239,282,053**	**1,379**
Agriculture	364	$118,482,000	
Commercial	26	$14,913,043	
Education	12	$14,962,000	
Government	2	$1,304,933	
Industrial	2	$1,706,937	
Residential	602	$87,913,140	
Chariton	**295**	**$86,596,883**	**630**
Agriculture	31	$31,817,481	
Commercial	15	$9,270,345	
Residential	249	$45,509,057	
Christian	**6,439**	**$1,529,982,186**	**11,672**
Agriculture	1,787	$366,032,972	
Commercial	177	$88,938,827	
Education	15	$28,386,500	
Government	18	$14,170,500	
Industrial	4	$3,945,880	
Residential	4,438	$1,028,507,507	
Clark	**512**	**$215,222,025**	**706**
Agriculture	230	$166,200,556	
Commercial	3	$1,598,250	
Residential	279	$47,423,220	
Clay	**1,857**	**$521,386,837**	**4,424**
Agriculture	109	$25,631,376	
Commercial	18	$19,015,825	
Education	1	$1,929,165	
Industrial	1	$1,114,630	
Residential	1,728	$473,695,841	
Clinton	**166**	**$38,940,240**	**355**
Agriculture	20	$3,552,041	
Commercial	4	$1,929,219	

County	Number of Structures	Value of Structures	Population
Residential	142	$33,458,981	
Cole	**6,411**	**$1,687,988,756**	**13,778**
Agriculture	741	$168,300,273	
Commercial	24	$19,194,791	
Education	1	$1,588,081	
Government	6	$8,436,429	
Industrial	38	$24,099,288	
Residential	5,601	$1,466,369,895	
Cooper	**760**	**$164,030,614**	**1,589**
Agriculture	69	$15,480,126	
Commercial	31	$16,274,600	
Government	4	$1,682,667	
Industrial	2	$1,391,582	
Residential	654	$129,201,640	
Crawford	**8,833**	**$1,844,404,260**	**17,607**
Agriculture	1,264	$261,268,800	
Commercial	589	$326,835,322	
Education	11	$20,667,900	
Government	26	$15,964,000	
Industrial	92	$69,476,063	
Residential	6,851	$1,150,192,175	
Dade	**648**	**$135,236,886**	**1,274**
Agriculture	107	$50,985,500	
Commercial	8	$3,954,685	
Residential	533	$80,296,701	
Dallas	**2,663**	**$678,311,875**	**3,556**
Agriculture	1,211	$427,014,226	
Commercial	47	$27,358,653	
Government	8	$4,075,200	
Industrial	8	$5,331,111	
Residential	1,389	$214,532,685	
Daviess	**117**	**$23,575,827**	**157**
Agriculture	53	$10,668,973	
Commercial	4	$1,822,863	
Residential	60	$11,083,992	
Dekalb	**46**	**$11,386,411**	**102**
Agriculture	3	$616,227	
Commercial	2	$1,107,981	
Residential	41	$9,662,203	
Dent	**1,996**	**$652,825,384**	**2,722**
Agriculture	868	$402,496,706	
Commercial	79	$60,793,263	
Education	1	$2,792,625	
Industrial	13	$16,116,905	
Residential	1,035	$170,625,885	
Douglas	**1,453**	**$700,628,428**	**2,023**
Agriculture	638	$560,082,250	
Commercial	19	$14,800,026	
Government	3	$2,917,500	
Industrial	18	$14,122,364	
Residential	775	$108,706,289	

County	Number of Structures	Value of Structures	Population
Dunklin	**266**	**$50,847,533**	**554**
Agriculture	36	$13,323,733	
Government	1	$447,263	
Residential	229	$37,076,537	
Franklin	**35,297**	**$7,013,077,111**	**67,551**
Agriculture	7,003	$22,320,458	
Commercial	1,521	$700,265,606	
Education	78	$67,098,518	
Government	78	$37,313,250	
Industrial	230	$451,573,202	
Residential	26,387	$5,734,506,076	
Gasconade	**2,875**	**$681,678,674**	**4,788**
Agriculture	617	$140,059,000	
Commercial	215	$118,532,088	
Education	12	$20,398,800	
Government	14	$11,194,105	
Industrial	22	$17,300,556	
Residential	1,995	$374,194,124	
Gentry	**15**	**$5,826,874**	**12**
Agriculture	10	$4,999,459	
Residential	5	$827,415	
Greene	**10,926**	**$2,812,545,446**	**15,967**
Agriculture	3,825	$971,166,404	
Commercial	117	$100,405,931	
Government	28	$26,245,333	
Industrial	14	$11,667,232	
Residential	6,942	$1,703,060,544	
Grundy	**1,134**	**$250,070,928**	**2,275**
Agriculture	119	$25,283,620	
Commercial	56	$33,785,366	
Education	3	$3,253,941	
Government	7	$4,332,563	
Industrial	1	$691,434	
Residential	948	$182,724,005	
Harrison	**112**	**$22,267,201**	**111**
Agriculture	65	$12,690,505	
Commercial	2	$1,343,732	
Residential	45	$8,232,964	
Henry	**4,236**	**$960,518,388**	**7,223**
Agriculture	867	$244,003,957	
Commercial	194	$124,038,431	
Education	6	$8,115,545	
Government	6	$4,621,125	
Industrial	9	$9,739,364	
Residential	3,154	$569,999,966	
Hickory	**3,710**	**$577,573,719**	**7,540**
Agriculture	58	$19,535,455	
Commercial	248	$151,545,103	
Education	6	$10,100,400	
Government	16	$9,556,800	
Industrial	1	$864,462	

County	Number of Structures	Value of Structures	Population
Residential	3,381	$385,971,500	
Holt	**241**	**$50,043,034**	**342**
Agriculture	72	$19,352,681	
Commercial	3	$1,367,012	
Government	1	$457,000	
Industrial	2	$1,081,026	
Residential	163	$27,785,316	
Howard	**269**	**$54,542,532**	**546**
Agriculture	42	$9,092,333	
Commercial	5	$2,112,519	
Residential	222	$43,337,680	
Howell	**7,053**	**$1,306,442,704**	**9,657**
Agriculture	2,966	$541,486,915	
Commercial	152	$85,538,810	
Education	5	$5,850,606	
Government	7	$5,184,156	
Industrial	91	$61,838,350	
Residential	3,832	$606,543,866	
Iron	**2,158**	**$494,535,117**	**3,354**
Agriculture	638	$177,728,571	
Commercial	96	$47,932,743	
Education	10	$14,422,500	
Government	18	$9,745,200	
Industrial	27	$29,902,213	
Residential	1,369	$214,803,890	
Jackson	**4,759**	**$1,440,990,144**	**10,687**
Agriculture	214	$62,158,281	
Commercial	144	$160,011,113	
Education	17	$37,776,006	
Government	1	$1,429,894	
Industrial	21	$24,985,877	
Residential	4,362	$1,154,628,972	
Jasper	**5,762**	**$1,457,598,967**	**11,172**
Agriculture	1,083	$337,279,364	
Commercial	186	$143,094,223	
Education	9	$20,804,250	
Government	24	$23,099,333	
Industrial	79	$74,736,447	
Residential	4,381	$858,585,350	
Jefferson	**92,286**	**$18,677,334,092**	**225,013**
Agriculture	4,863	$39,703,408	
Commercial	3,332	$1,342,033,410	
Education	129	$220,261,904	
Government	84	$61,206,953	
Industrial	230	$343,532,463	
Residential	83,648	$16,670,595,954	
Johnson	**3,159**	**$1,047,991,997**	**5,784**
Agriculture	279	$56,399,333	
Commercial	80	$50,710,638	
Education	10	$66,866,410	

County	Number of Structures	Value of Structures	Population
Government	412	$306,619,556	
Industrial	17	$13,099,687	
Residential	2,361	$554,296,372	
Knox	**30**	**$8,674,735**	**58**
Agriculture	3	$3,784,154	
Commercial	2	$1,001,867	
Residential	25	$3,888,715	
Laclede	**4,455**	**$845,360,050**	**7,651**
Agriculture	1,355	$294,988,920	
Commercial	59	$39,124,574	
Education	1	$1,499,286	
Government	2	$1,575,556	
Industrial	14	$12,032,215	
Residential	3,024	$496,139,500	
Lafayette	**814**	**$204,507,551**	**1,089**
Agriculture	345	$88,083,469	
Commercial	21	$14,190,567	
Government	2	$1,184,690	
Industrial	5	$2,979,332	
Residential	441	$98,069,494	
Lawrence	**999**	**$283,902,712**	**1,306**
Agriculture	460	$179,151,961	
Commercial	25	$12,944,944	
Government	2	$940,000	
Residential	512	$90,865,807	
Lewis	**1,131**	**$354,590,799**	**2,010**
Agriculture	239	$170,688,679	
Commercial	32	$15,100,624	
Government	3	$1,217,368	
Industrial	16	$12,755,692	
Residential	841	$154,828,435	
Lincoln	**8,185**	**$1,293,611,285**	**14,375**
Agriculture	2,999	$8,078,126	
Commercial	40	$63,585,052	
Education	2	$1,189,542	
Government	1	$1,374,650	
Industrial	9	$49,187,077	
Residential	5,134	$1,170,196,838	
Linn	**63**	**$12,802,800**	**95**
Agriculture	26	$5,831,766	
Residential	37	$6,971,034	
Livingston	**64**	**$13,977,706**	**119**
Agriculture	14	$3,637,387	
Commercial	1	$804,118	
Residential	49	$9,536,201	
Macon	**645**	**$145,197,680**	**1,066**
Agriculture	144	$29,718,906	
Commercial	41	$24,242,548	
Education	8	$10,855,579	
Government	3	$2,400,094	

County	Number of Structures	Value of Structures	Population
Industrial	1	$418,706	
Residential	448	$77,561,847	
Madison	**3,648**	**$756,028,515**	**8,129**
Agriculture	221	$53,066,520	
Commercial	238	$140,797,614	
Education	23	$28,098,333	
Government	24	$14,007,000	
Industrial	63	$48,870,542	
Residential	3,079	$471,188,505	
Maries	**1,767**	**$391,873,122**	**2,839**
Agriculture	436	$89,982,245	
Commercial	141	$83,370,713	
Education	2	$2,847,429	
Government	3	$1,552,200	
Industrial	2	$3,096,389	
Residential	1,183	$211,024,147	
Marion	**580**	**$148,765,167**	**1,147**
Agriculture	70	$15,552,250	
Commercial	28	$17,309,211	
Education	6	$10,154,483	
Government	2	$1,433,677	
Residential	474	$104,315,546	
McDonald	**4,942**	**$1,250,713,694**	**9,574**
Agriculture	1,328	$640,708,923	
Commercial	118	$53,357,409	
Education	3	$4,286,200	
Government	2	$904,556	
Industrial	22	$19,820,406	
Residential	3,469	$531,636,201	
Mercer	**120**	**$41,236,439**	**222**
Agriculture	23	$17,247,125	
Commercial	2	$989,526	
Residential	95	$22,999,788	
Miller	**6,254**	**$1,349,049,779**	**12,034**
Agriculture	704	$169,577,086	
Commercial	591	$318,764,007	
Education	9	$13,794,300	
Government	7	$3,640,000	
Industrial	31	$16,566,185	
Residential	4,912	$826,708,200	
Mississippi	**3**	**$487,645**	**8**
Residential	3	$487,645	
Moniteau	**378**	**$79,067,323**	**548**
Agriculture	168	$36,349,250	
Residential	210	$42,718,073	
Monroe	**568**	**$127,007,859**	**859**
Agriculture	196	$59,867,111	
Commercial	22	$8,652,235	
Government	1	$413,588	
Residential	349	$58,074,925	

County	Number of Structures	Value of Structures	Population
Montgomery	**1,679**	**$353,947,876**	**2,287**
Agriculture	625	$141,069,915	
Commercial	36	$19,061,209	
Government	1	$576,923	
Industrial	27	$20,909,200	
Residential	990	$172,330,629	
Morgan	**11,963**	**$2,543,526,954**	**23,031**
Agriculture	1,261	$281,158,754	
Commercial	1,264	$732,864,278	
Education	17	$11,081,167	
Government	2	$1,571,778	
Industrial	57	$26,925,815	
Residential	9,362	$1,489,925,163	
Newton	**13,315**	**$2,816,528,084**	**28,420**
Agriculture	1,755	$327,873,462	
Commercial	567	$360,237,070	
Education	38	$121,341,000	
Government	21	$15,611,289	
Industrial	45	$29,903,157	
Residential	10,889	$1,961,562,107	
Nodaway	**78**	**$20,283,431**	**132**
Agriculture	22	$6,725,661	
Residential	56	$13,557,770	
Oregon	**2,092**	**$659,070,303**	**2,728**
Agriculture	725	$359,568,450	
Commercial	185	$99,438,076	
Education	27	$33,943,743	
Government	4	$2,172,000	
Residential	1,151	$163,948,035	
Osage	**2,761**	**$1,040,941,031**	**4,737**
Agriculture	805	$509,537,241	
Commercial	97	$61,899,006	
Education	12	$39,724,800	
Government	9	$6,048,529	
Industrial	37	$57,481,913	
Residential	1,801	$366,249,542	
Ozark	**2,390**	**$620,317,890**	**3,447**
Agriculture	694	$269,936,510	
Commercial	199	$110,147,769	
Education	4	$6,299,111	
Government	6	$3,546,000	
Industrial	20	$17,999,375	
Residential	1,467	$212,389,125	
Pemiscot	**997**	**$204,568,765**	**2,363**
Agriculture	13	$3,286,400	
Commercial	57	$30,734,183	
Education	2	$3,416,500	
Government	8	$5,709,667	
Industrial	1	$1,145,215	
Residential	916	$160,276,800	

County	Number of Structures	Value of Structures	Population
Perry	**1,219**	**$186,409,268**	**1,890**
Agriculture	429	$2,239,578	
Commercial	15	$2,492,543	
Government	13	$5,200,000	
Industrial	3	$5,402,314	
Residential	759	$171,074,833	
Pettis	**690**	**$168,781,612**	**737**
Agriculture	396	$109,835,000	
Commercial	3	$2,270,344	
Government	1	$928,969	
Industrial	1	$1,018,637	
Residential	289	$54,728,662	
Phelps	**9,426**	**$2,210,312,924**	**19,610**
Agriculture	1,138	$215,457,023	
Commercial	397	$277,891,370	
Education	13	$26,415,740	
Government	25	$22,871,809	
Industrial	9	$5,535,996	
Residential	7,844	$1,662,140,987	
Pike	**1,805**	**$349,288,428**	**3,926**
Agriculture	85	$396,410	
Commercial	117	$41,393,601	
Education	1	$1,239,524	
Government	7	$1,583,264	
Industrial	12	$3,131,301	
Residential	1,583	$301,544,329	
Platte	**2,713**	**$895,216,222**	**6,061**
Agriculture	132	$32,917,381	
Commercial	87	$75,710,646	
Education	5	$8,479,182	
Government	11	$13,054,352	
Industrial	4	$3,606,703	
Residential	2,474	$761,447,958	
Polk	**2,150**	**$419,999,698**	**3,585**
Agriculture	693	$158,004,000	
Commercial	17	$8,545,169	
Education	2	$4,779,158	
Industrial	4	$1,451,936	
Residential	1,434	$247,219,434	
Pulaski	**13,588**	**$5,360,526,096**	**28,614**
Agriculture	666	$133,293,474	
Commercial	357	$228,206,195	
Education	25	$29,989,773	
Government	2,065	$1,945,023,500	
Industrial	32	$16,595,380	
Residential	10,443	$3,007,417,775	
Putnam	**279**	**$89,142,381**	**414**
Agriculture	61	$46,559,944	
Commercial	28	$14,192,967	
Residential	190	$28,389,470	

County	Number of Structures	Value of Structures	Population
Ralls	**2,115**	**$431,585,442**	**3,163**
Agriculture	791	$169,312,585	
Commercial	53	$21,929,658	
Government	3	$2,037,300	
Industrial	3	$3,890,831	
Residential	1,265	$234,415,068	
Randolph	**2,303**	**$540,448,002**	**5,027**
Agriculture	294	$139,703,455	
Commercial	54	$35,545,068	
Education	1	$3,117,286	
Government	11	$7,984,935	
Industrial	2	$2,447,815	
Residential	1,941	$351,649,444	
Ray	**572**	**$149,893,868**	**1,134**
Agriculture	137	$49,903,567	
Commercial	4	$2,223,591	
Residential	431	$97,766,710	
Reynolds	**1,788**	**$303,704,533**	**3,758**
Agriculture	92	$372,875	
Commercial	99	$28,032,950	
Education	2	$5,707,913	
Government	2	$2,626,000	
Industrial	53	$5,367,339	
Residential	1,540	$261,597,455	
Ripley	**4,904**	**$657,277,520**	**9,054**
Agriculture	1,136	$1,559,341	
Commercial	126	$83,756,602	
Education	8	$12,530,286	
Government	11	$8,322,417	
Industrial	30	$53,613,000	
Residential	3,593	$497,495,874	
Saline	**497**	**$122,732,893**	**1,131**
Agriculture	32	$13,583,529	
Commercial	9	$5,711,731	
Residential	456	$103,437,633	
Schuyler	**330**	**$84,355,932**	**654**
Agriculture	26	$18,616,000	
Commercial	36	$20,412,468	
Government	1	$666,417	
Residential	267	$44,661,048	
Scotland	**30**	**$11,068,308**	**57**
Agriculture	7	$6,882,400	
Residential	23	$4,185,908	
Scott	**669**	**$143,045,569**	**1,201**
Agriculture	193	$52,767,361	
Commercial	2	$1,322,209	
Government	3	$2,265,727	
Residential	471	$86,690,271	
Shannon	**2,552**	**$314,746,117**	**4,680**
Agriculture	295	$433,949	

County	Number of Structures	Value of Structures	Population
Commercial	306	$23,983,525	
Education	24	$3,278,943	
Government	24	$4,324,571	
Industrial	82	$6,667,364	
Residential	1,821	$276,057,765	
Shelby	**18**	**$3,799,140**	**23**
Agriculture	8	$1,959,495	
Residential	10	$1,839,645	
St Charles	**18,350**	**$5,403,999,608**	**44,703**
Agriculture	1,062	$15,580,603	
Commercial	329	$283,431,250	
Education	7	$17,997,826	
Government	10	$15,422,135	
Industrial	9	$19,346,772	
Residential	16,933	$5,052,221,022	
St Clair	**2,030**	**$628,733,269**	**2,560**
Agriculture	683	$318,814,643	
Commercial	213	$149,297,884	
Government	3	$2,285,438	
Industrial	8	$3,372,000	
Residential	1,123	$154,963,305	
St Francois	**19,052**	**$4,394,276,822**	**39,127**
Agriculture	847	$173,914,330	
Commercial	1,277	$919,808,021	
Education	23	$40,331,595	
Government	60	$58,182,000	
Industrial	124	$104,150,888	
Residential	16,721	$3,097,889,988	
St Louis	**49,456**	**$12,792,700,367**	**110,905**
Agriculture	905	$155,266,857	
Commercial	2,632	$1,169,446,175	
Education	78	$123,300,637	
Government	89	$65,602,259	
Industrial	112	$249,415,569	
Residential	45,640	$11,029,668,871	
St Louis City	**32**	**$13,155,056**	**64**
Industrial	3	$3,907,018	
Residential	29	$9,248,038	
Ste Genevieve	**4,797**	**$993,844,235**	**8,683**
Agriculture	1,230	$248,499,677	
Commercial	13	$9,031,100	
Industrial	10	$11,112,374	
Residential	3,544	$725,201,084	
Stoddard	**2,913**	**$665,339,237**	**4,570**
Agriculture	946	$234,461,207	
Commercial	45	$77,512,500	
Education	1	$1,722,500	
Government	5	$3,218,438	
Industrial	4	$2,664,725	
Residential	1,912	$345,759,867	

County	Number of Structures	Value of Structures	Population
Stone	**15,482**	**$3,284,580,856**	**30,021**
Agriculture	2,039	$537,302,641	
Commercial	656	$348,764,673	
Education	8	$11,386,000	
Government	41	$21,074,000	
Industrial	71	$26,777,013	
Residential	12,667	$2,339,276,529	
Sullivan	**143**	**$22,637,023**	**339**
Agriculture	2	$553,590	
Commercial	2	$994,217	
Government	1	$531,000	
Residential	138	$20,558,216	
Taney	**19,923**	**$5,455,219,208**	**39,097**
Agriculture	1,659	$348,716,773	
Commercial	2,101	$1,474,629,873	
Education	46	$54,205,037	
Government	88	$62,304,000	
Industrial	71	$25,257,130	
Residential	15,958	$3,490,106,395	
Texas	**6,556**	**$926,743,932**	**10,782**
Agriculture	2,026	$4,783,459	
Commercial	261	$88,561,460	
Education	24	$6,133,241	
Government	11	$4,257,846	
Industrial	55	$44,613,684	
Residential	4,179	$778,394,241	
Vernon	**731**	**$252,676,753**	**1,210**
Agriculture	226	$143,305,871	
Commercial	12	$9,196,943	
Education	1	$4,213,111	
Government	4	$2,832,000	
Industrial	6	$2,134,405	
Residential	482	$90,994,423	
Warren	**12,829**	**$2,753,420,083**	**26,132**
Agriculture	2,477	$500,505,037	
Commercial	128	$67,144,917	
Education	14	$22,689,333	
Government	22	$14,264,105	
Industrial	20	$17,896,080	
Residential	10,168	$2,130,920,610	
Washington	**9,827**	**$2,247,109,858**	**17,443**
Agriculture	2,697	$1,019,466,000	
Commercial	387	$251,030,466	
Education	12	$17,448,000	
Government	19	$14,879,533	
Industrial	29	$18,089,556	
Residential	6,683	$926,196,304	17,443
Wayne	**4,566**	**$741,562,361**	**8,404**
Agriculture	932	$214,308,222	
Commercial	76	$39,648,743	

County	Number of Structures	Value of Structures	Population
Education	8	$8,198,400	
Government	3	$1,306,400	
Industrial	1	$1,016,241	
Residential	3,546	$477,084,355	
Webster	**5,537**	**$1,118,664,502**	**8,960**
Agriculture	2,278	$547,345,824	
Commercial	47	$23,274,487	
Education	6	$6,557,063	
Government	4	$2,515,500	
Industrial	2	$1,101,091	
Residential	3,200	$537,870,537	
Worth	**2**	**$373,818**	**4**
Residential	2	$373,818	
Wright	**3,217**	**$369,942,393**	**4,707**
Agriculture	1,190	$3,133,556	
Commercial	101	$41,769,405	
Education	22	$9,036,063	
Government	5	$3,586,944	
Industrial	31	$8,567,869	
Residential	1,868	$303,848,556	
Grand Total	**595,042**	**$139,904,614,533**	**1,205,777**
Agriculture	226	$143,305,871	
Commercial	12	$9,196,943	
Education	1	$4,213,111	
Government	4	$2,832,000	
Industrial	6	$2,134,405	
Residential	482	$90,994,423	
Warren	**12,829**	**$2,753,420,083**	**26,132**
Agriculture	2,477	$500,505,037	
Commercial	128	$67,144,917	
Education	14	$22,689,333	
Government	22	$14,264,105	
Industrial	20	$17,896,080	
Residential	10,168	$2,130,920,610	
Washington	**9,827**	**$2,247,109,858**	**17,443**
Agriculture	2,697	$1,019,466,000	
Commercial	387	$251,030,466	
Education	12	$17,448,000	
Government	19	$14,879,533	
Industrial	29	$18,089,556	
Residential	6,683	$926,196,304	17,443
Wayne	**4,566**	**$741,562,361**	**8,404**
Agriculture	932	$214,308,222	
Commercial	76	$39,648,743	
Education	8	$8,198,400	
Government	3	$1,306,400	
Industrial	1	$1,016,241	
Residential	3,546	$477,084,355	
Webster	**5,537**	**$1,118,664,502**	**8,960**
Agriculture	2,278	$547,345,824	

County	Number of Structures	Value of Structures	Population
Commercial	47	$23,274,487	
Education	6	$6,557,063	
Government	4	$2,515,500	
Industrial	2	$1,101,091	
Residential	3,200	$537,870,537	
Worth	**2**	**$373,818**	**4**
Residential	2	$373,818	
Wright	**3,217**	**$369,942,393**	**4,707**
Agriculture	1,190	$3,133,556	
Commercial	101	$41,769,405	
Education	22	$9,036,063	
Government	5	$3,586,944	
Industrial	31	$8,567,869	
Residential	1,868	$303,848,556	
Grand Total	**595,042**	**$139,904,614,533**	**1,205,777**

Source: Missouri Department of Natural Resources, MSDIS Structure Inventory, HAZUS Values

According to this analysis, the following counties have more than 1,000 structures at risk and/or over 1,000 persons at risk to wildfires: Andrew, Buchanan, Crawford, Dent, Grundy, Laclede, Maries, Phelps, and Pulaski.

Figure 3.175. Number of Structures in WUI Interface and Intermix Areas by County

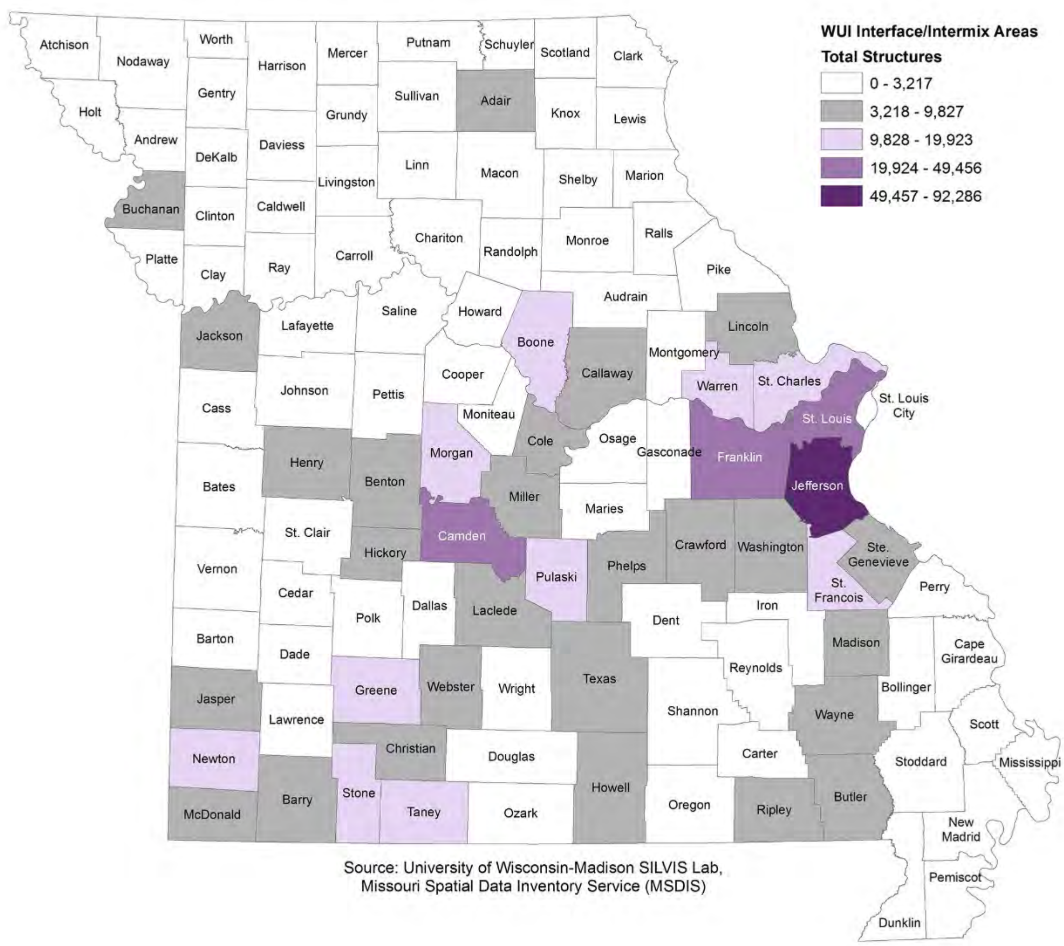
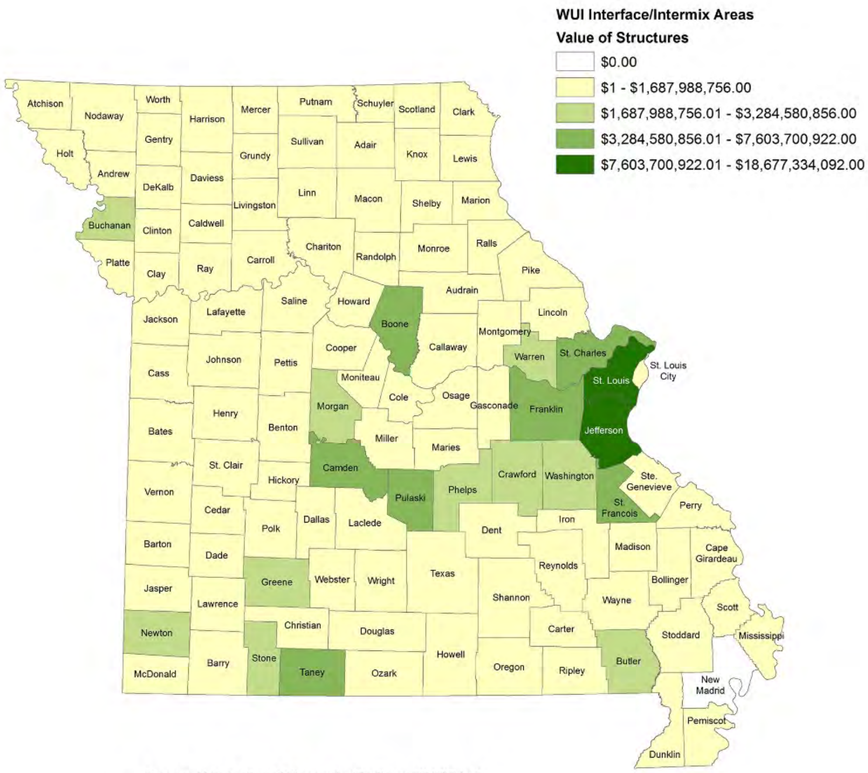


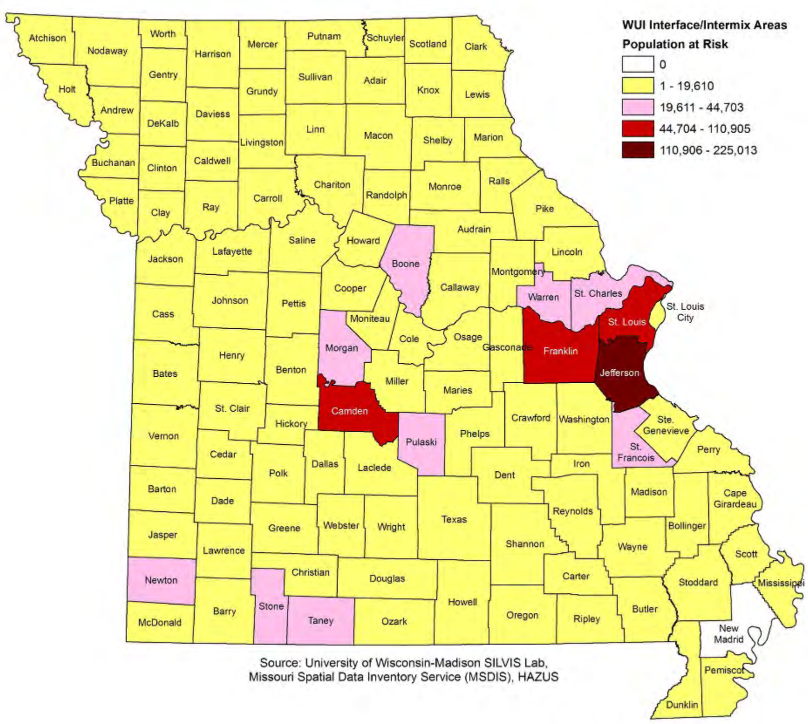
Figure 3.176. Value of Structures in WUI Interface and Intermix Areas by County



Source: University of Wisconsin-Madison SILVIS Lab, Missouri Spatial Data Inventory Service (MSDIS), HAZUS

Figure 3.86 provides the estimated population at risk to wildfire based on the average household size and the number of residential structures at risk to wildfire by county.

Figure 3.177. Population at Risk to Wildfire in WUI Interface and Intermix Areas



State Estimates of Potential Losses

For the wildfire hazard, the factors considered in determining future potential loss estimates were the average acreage burned each year per county as a result of wildfire and the average value of structures per acre in WU-Interface / Intermix areas. **Table 3.123** and Figure that follows provide the potential loss estimates based on this methodology.

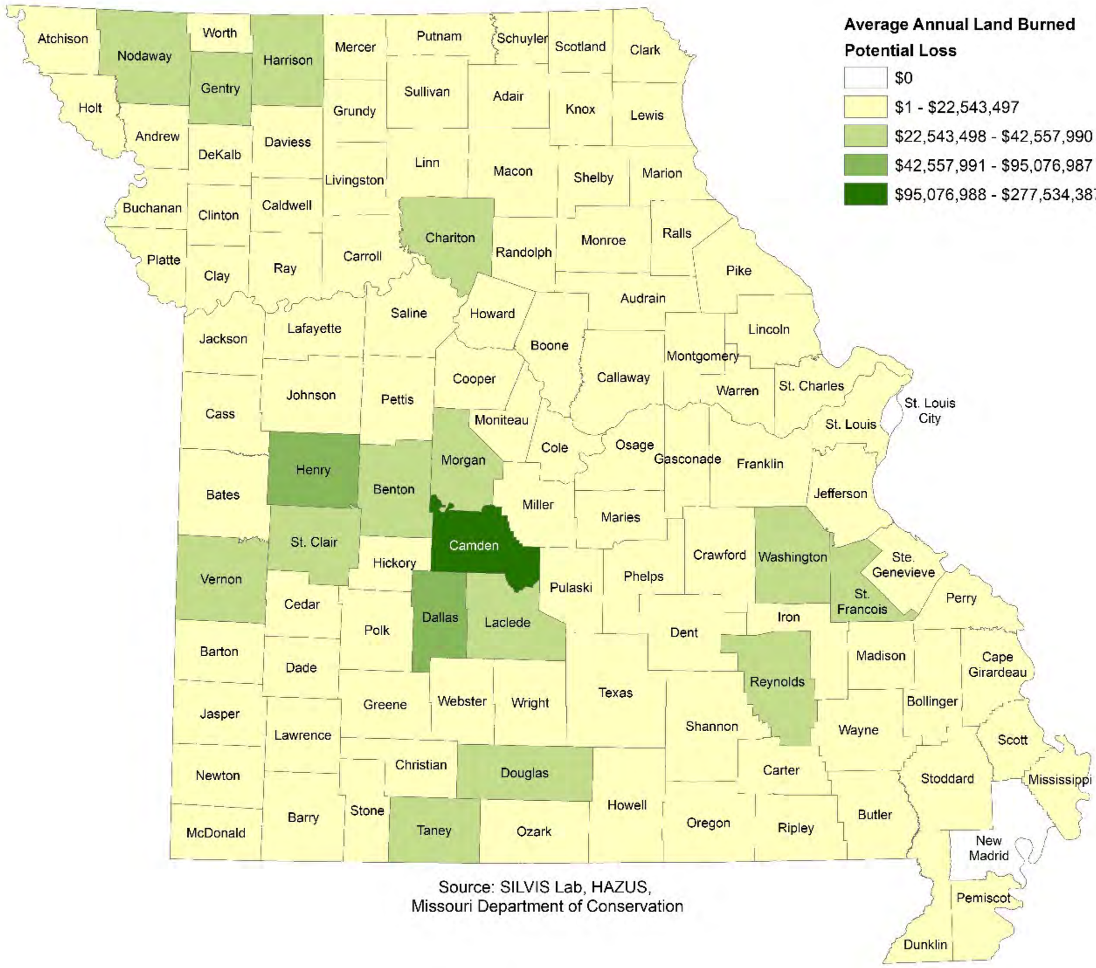
Table 3.123. Wildfire Potential Loss Estimates

County	Total WUI Acreage	Total Structure Value Within WUI	Average Value/Acre within WUI	Average Annual Acreage Burned	Potential Loss
Adair	14,601.51	$1,470,441,114	$100,705	126	$12,688,798
Andrew	8,703.93	$199,010,723	$22,864	327	$7,476,679
Atchison	490.83	$27,440,056	$55,905	139	$7,770,835
Audrain	2,157.85	$66,082,616	$30,624	40	$1,224,970
Barry	61,006.95	$1,583,681,764	$25,959	461	$11,967,117
Barton	2,302.44	$49,166,855	$21,354	350	$7,473,974
Bates	596.87	$21,219,177	$35,550	311	$11,056,204
Benton	56,326.29	$1,483,374,921	$26,335	1,616	$42,557,990
Bollinger	28,799.97	$975,509,552	$33,872	216	$7,316,329
Boone	124,198.33	$4,605,907,873	$37,085	5	$185,426
Buchanan	19,061.54	$1,815,279,994	$95,233	229	$21,808,268
Butler	70,670.02	$1,958,767,835	$27,717	319	$8,841,754
Caldwell	510.72	$15,810,724	$30,958	385	$11,918,646
Callaway	78,311.78	$1,512,099,865	$19,309	307	$5,927,776
Camden	129,260.60	$7,603,700,922	$58,825	4,718	$277,534,387
Cape Girardeau	30,737.90	$671,830,034	$21,857	194	$4,240,206
Carroll	675.86	$16,929,069	$25,048	900	$22,543,497
Carter	24,503.44	$140,444,442	$5,732	481	$2,756,909
Cass	4,539.45	$180,881,344	$39,847	173	$6,893,448
Cedar	20,476.54	$239,282,053	$11,686	473	$5,527,320
Chariton	619.17	$86,596,883	$139,860	263	$36,783,143
Christian	59,766.56	$1,529,982,186	$25,599	196	$5,017,463
Clark	6,141.73	$215,222,025	$35,043	100	$3,504,258
Clay	7,079.11	$521,386,837	$73,651	56	$4,124,483
Clinton	1,558.58	$38,940,240	$24,985	487	$12,167,455
Cole	47,598.82	$1,687,988,756	$35,463	56	$1,985,918
Cooper	5,667.60	$164,030,614	$28,942	237	$6,859,208
Crawford	83,803.60	$1,844,404,260	$22,009	852	$18,751,371
Dade	6,043.34	$135,236,886	$22,378	347	$7,765,112
Dallas	29,063.73	$678,311,875	$23,339	3,041	$70,973,207
Daviess	597.31	$23,575,827	$39,470	432	$17,051,157
Dekalb	670.25	$11,386,411	$16,988	797	$13,539,692
Dent	23,759.51	$652,825,384	$27,476	718	$19,728,046
Douglas	20,886.40	$700,628,428	$33,545	803	$26,936,415
Dunklin	1,990.07	$50,847,533	$25,551	2	$51,101

County	Total WUI Acreage	Total Structure Value Within WUI	Average Value/Acre within WUI	Average Annual Acreage Burned	Potential Loss
Franklin	227,202.99	$7,013,077,111	$30,867	210	$6,482,072
Gasconade	28,233.36	$681,678,674	$24,144	87	$2,100,566
Gentry	100.11	$5,826,874	$58,202	527	$30,672,449
Greene	82,526.68	$2,812,545,446	$34,080	375	$12,780,164
Grundy	1,951.87	$250,070,928	$128,119	150	$19,217,829
Harrison	546.75	$22,267,201	$40,727	756	$30,789,336
Henry	18,507.84	$960,518,388	$51,898	1,832	$95,076,987
Hickory	32,310.73	$577,573,719	$17,876	306	$5,469,934
Holt	770.87	$50,043,034	$64,917	64	$4,154,713
Howard	5,279.88	$54,542,532	$10,330	169	$1,745,813
Howell	72,776.48	$1,306,442,704	$17,951	823	$14,774,036
Iron	27,603.24	$494,535,117	$17,916	543	$9,728,300
Jackson	27,949.59	$1,440,990,144	$51,557	36	$1,856,043
Jasper	34,020.87	$1,457,598,967	$42,844	244	$10,453,998
Jefferson	325,665.09	$18,677,334,092	$57,351	230	$13,190,812
Johnson	17,852.07	$1,047,991,997	$58,704	291	$17,082,927
Knox	182.33	$8,674,735	$47,577	43	$2,045,796
Laclede	58,622.15	$845,360,050	$14,420	1,769	$25,509,846
Lafayette	6,070.04	$204,507,551	$33,691	114	$3,840,809
Lawrence	9,622.08	$283,902,712	$29,505	292	$8,615,558
Lewis	3,151.88	$354,590,799	$112,501	104	$11,700,147
Lincoln	70,149.18	$1,293,611,285	$18,441	169	$3,116,506
Linn	998	$12,802,800	$12,828	249	$3,194,287
Livingston	700.04	$13,977,706	$19,967	334	$6,668,943
Macon	4,131.03	$145,197,680	$35,148	320	$11,247,380
Madison	26,745.86	$756,028,515	$28,267	101	$2,854,979
Maries	18,145.40	$391,873,122	$21,596	330	$7,126,773
Marion	6,056.84	$148,765,167	$24,562	105	$2,578,960
McDonald	56,760.28	$1,250,713,694	$22,035	216	$4,759,564
Mercer	1,247.65	$41,236,439	$33,051	122	$4,032,250
Miller	58,644.02	$1,349,049,779	$23,004	423	$9,730,711
Mississippi	44.25	$487,645	$11,021	68	$749,403
Moniteau	6,156.81	$79,067,323	$12,842	205	$2,632,663
Monroe	5,076.19	$127,007,859	$25,020	260	$6,505,276
Montgomery	10,979.52	$353,947,876	$32,237	94	$3,030,286
Morgan	72,847.47	$2,543,526,954	$34,916	852	$29,748,254
New Madrid	0.00	$0	$0	13	$0
Newton	92,687.81	$2,816,528,084	$30,387	556	$16,895,314
Nodaway	383.98	$20,283,431	$52,825	536	$28,314,015
Oregon	16,945.24	$659,070,303	$38,894	532	$20,691,674

County	Total WUI Acreage	Total Structure Value Within WUI	Average Value/Acre within WUI	Average Annual Acreage Burned	Potential Loss
Osage	31,326.79	$1,040,941,031	$33,228	109	$3,621,903
Ozark	27,504.09	$620,317,890	$22,554	931	$20,997,455
Pemiscot	705.98	$204,568,765	$289,764	23	$6,664,578
Perry	19,820.37	$186,409,268	$9,405	42	$395,007
Pettis	5,893.29	$168,781,612	$28,640	134	$3,837,710
Phelps	81,168.38	$2,210,312,924	$27,231	271	$7,379,657
Pike	14,387.28	$349,288,428	$24,278	179	$4,345,689
Platte	11,059.97	$895,216,222	$80,942	30	$2,428,260
Polk	29,550.67	$419,999,698	$14,213	378	$5,372,463
Pulaski	92,929.66	$5,360,526,096	$57,684	270	$15,574,598
Putnam	996.52	$89,142,381	$89,453	127	$11,360,583
Ralls	25,092.88	$431,585,442	$17,200	161	$2,769,122
Randolph	15,850.10	$540,448,002	$34,097	262	$8,933,530
Ray	7,826.53	$149,893,868	$19,152	496	$9,499,397
Reynolds	20,394.53	$303,704,533	$14,891	1,672	$24,898,534
Ripley	62,591.62	$657,277,520	$10,501	377	$3,958,894
Saline	1,754.22	$122,732,893	$69,964	139	$9,725,030
Schuyler	769.96	$84,355,932	$109,558	97	$10,627,161
Scotland	463.4	$11,068,308	$23,885	211	$5,039,695
Scott	7,791.63	$143,045,569	$18,359	162	$2,974,139
Shannon	19,933.08	$314,746,117	$15,790	1,034	$16,327,004
Shelby	297.22	$3,799,140	$12,782	85	$1,086,481
St Charles	67,573.20	$5,403,999,608	$79,973	72	$5,758,022
St Clair	26,356.15	$628,733,269	$23,855	1,559	$37,190,375
St Francois	101,923.59	$4,394,276,822	$43,113	667	$28,756,666
Ste Genevieve	53,265.68	$993,844,235	$18,658	131	$2,444,230
St Louis	72,238.75	$12,792,700,367	$177,089	13	$2,302,159
St Louis City	111.85	$13,155,056	$117,610	0	$0
Stoddard	22,415.43	$665,339,237	$29,682	208	$6,173,897
Stone	93,682.12	$3,284,580,856	$35,061	357	$12,516,747
Sullivan	831.1	$22,637,023	$27,237	109	$2,968,866
Taney	102,134.16	$5,455,219,208	$53,412	614	$32,795,146
Texas	55,882.72	$926,743,932	$16,584	695	$11,525,692
Vernon	6,257.11	$252,676,753	$40,382	606	$24,471,718
Warren	87,266.04	$2,753,420,083	$31,552	31	$978,113
Washington	103,621.44	$2,247,109,858	$21,686	1,821	$39,489,771
Wayne	53,892.75	$741,562,361	$13,760	455	$6,260,785
Webster	68,601.58	$1,118,664,502	$16,307	438	$7,142,329
Worth	67.01	$373,818	$5,578	622	$3,469,715
Wright	24,606.21	$369,942,393	$15,035	400	$6,013,806

Figure 3.178. Annualized Wildfire Damages



As mentioned previously, an annualized 234 buildings were damaged in the 5-year period from 2012-2016 statewide. It is anticipated that building damage and the associated potential risk to life of inhabitants will continue.

Hazard Impact on Future Growth and Development

The top 10 counties for annualized loss include Benton, Camden, Chariton, Dallas, Gentry, Harrison, Henry, St. Clair, Taney, and Washington. Of these top 10 counties with structures and population located within the WU-Interface/Intermix areas, Taney is among the top 10 counties for greatest estimated housing unit gains. Housing units within these WUI areas are thus potentially growing and increasing the risk to wildfires.

EMAP Consequence Analysis

The information in **Table 3.133** is from the Impact Analysis of Potential for Detrimental Impacts of Hazards done for the Emergency Management Accreditation Program.

Table 3.124. EMAP Impact Analysis: Fires

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

Risk Summary

With sufficient mutual aid, local fire services have adequate day-to-day fire service capabilities. Wildfires may also be a cascading or secondary impact of another hazard such as earthquakes or tornadoes, as a result of damaged gas lines. In these circumstances, the possibility of numerous fires and reduced firefighting capabilities would greatly increase the severity of structural fires.

Problem Statement:

Using Annualized Wildfire Damage potential loss as a key indicator, the counties most at risk are Laclede, Pulaski, Nodaway, Gentry and Harrison. Mitigation efforts and dollars allocated focused on these counties would most likely be the most beneficial.

2018 risk assessment data and mapping is available through the Missouri Hazard Mitigation Viewer: http://bit.ly/MoHazardMitigationPlanViewer2018.

3.3.12. Chemical, Biological, Radiological, Nuclear and Explosive (CBRNE) Attack

Probability	Severity
<1%	High

Description/Location

Of all the possible disasters and hazards included in this risk assessment, a strategic chemical, biological, radiological nuclear, or explosives (CBRNE) attack 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.

Although the threat of all-out nuclear war has been significantly reduced with the dissolution of the former Soviet Union, several scenarios still exist that might subject a jurisdiction to widespread radioactive contamination or high-levels of radiation exposure. Over the past three decades, American and Russian leaders have employed a progression of bilateral agreements and other measures to limit and reduce their substantial nuclear warhead and strategic missile and bomber arsenals. Currently, the New START (Strategic Arms Reduction Treaty) agreement, signed April 8, 2010, reduces nuclear weapons in both Russia and the United States to 1,550 warheads. The treaty is expected to last through 2021.

While the threat of nuclear attack has diminished over the past several years, concerns over the use of chemical and biological warfare agents have increased. Recent events, such as the September 11, 2001, terrorist attacks on the World Trade Center buildings in New York City and the Pentagon in Washington DC, anthrax-related attacks in 2001, the Times Square bombing in New York City in 2008, and the Boston Marathon bombing in 2013, multiple failed bombing plots across the country and attacks on public venues overseas have increased awareness of the vulnerability of the United States to future attacks involving chemical or biological warfare agents. For more information on terrorism-related issues, see the Terrorism hazard analysis and vulnerability assessment sections.

Extent

Attacks against the United States as a whole, and against individual states or local entities, can be categorized as originating from either domestic or international sources. However, because the impacts on life and property would largely be the same regardless of the source of such an attack, similar preparedness, response, and recovery activities apply.

Biological and chemical weapons have often been used to terrorize an unprotected population, instead of actual use as weapons of war. However, the potential damage that can occur in the event of such an attack is huge, particularly to human health.

A single nuclear weapon detonation could cause massive destruction, and all aforementioned types of attacks could cause extensive casualties. An all-out nuclear attack could affect the entire population in the vicinity of the impacted area. Some areas would experience direct weapons effects: blast, heat, and initial nuclear radiation. Other areas would experience indirect weapons effects, primarily radioactive fallout. As long as world leaders maintain rational thinking, the probability of an attack by a nation-state remains low, but does not rule out attack by a terrorist group.

Secondary effects of these attacks, which could severely stress the country, include lack of adequate shelter, food, water, health and medical facilities and personnel, and mortuary services; disruption of communication systems; and power outages. Because of the potential devastation and significant secondary effects caused by this type of attack, the severity is rated high.

Previous Occurrences

During **World War I** (1915–1918), chemical and conventional weapons were used. The first poison gas, chlorine, was used by the Germans against Allied troops in 1915. The effects of the gas were devastating, causing severe choking attacks within seconds of exposure. The British subsequently retaliated with chlorine attacks of their own, although reportedly more British suffered than Germans, because the gas blew back into their own trenches. Phosgene was later used in the war because it caused less severe coughing, resulting in more of the agent being inhaled. Then, in September 1917, mustard gas was used in artillery shells by the Germans against the Russians. Mustard gas caused serious blisters, both internally and externally, several hours after exposure. In all, there were 1,240,853 gas-related casualties and 91,198 deaths from gas exposure during World War I.

During **World War II** (1941–1945), atomic (nuclear), chemical, and conventional weapons were used. Use of chemical weapons in World War II was not as prevalent as in World War I and was primarily limited to the Japanese Imperial Army. During the war, the Japanese used various chemical-filled munitions, including artillery shells, aerial bombs, grenades, and mortars, against Chinese military forces and civilians. Chemical agents used included phosgene, mustard, lewisite, hydrogen cyanide, and diphenyl cyan arsine. The war was brought to an abrupt end in 1945, when the United States dropped two atomic bombs on Japan: one on Hiroshima that obliterated the entire city and killed approximately 66,000 people and another on Nagasaki that destroyed about half the city and killed about 39,000 people.

During the **Vietnam War** (1964–1973), chemical and conventional weapons were used. Chemical weapons used during the Vietnam War are believed to have only involved tear agents used by the United States and possibly psychedelic agents, also by the United States. Although not directly used as warfare agents, toxic herbicides such as Agent Orange were commonly used as defoliants by the United States. Long-term exposure to Agent Orange, which contained the contaminant dioxin, was believed to cause illness and disease in humans.

In 1983, **Iraq** launched its first of 10 documented chemical attacks against Iran. The largest of these attacks was in February 1986, when mustard gas and the nerve agent tabun were used, impacting up to 10,000 Iranians. Although the exact number of chemical attacks implemented by Iraq during the war is unknown, the Iranian government estimates that more than 60,000 soldiers had been exposed to mustard gas and the nerve agents sarin and tabun by the time the war ended in 1988. Based on these data, the Iraqi chemical attacks during the Iran-Iraq war were the largest since World War I.

Although several isolated attacks involving biological agents have occurred over the last few decades, a series of incidents in the United States that gained nationwide exposure occurred between early October and early December 2001, when five people died from anthrax infection, and at least 13 others contracted the disease in Washington, DC; New York City; Trenton, New Jersey; and Boca Raton, Florida. Anthrax spores were found in a number of government buildings and postal facilities in these and other areas. Most of the confirmed anthrax cases were tied to contaminated letters mailed to media personalities and U.S. senators. Thousands of people were potentially exposed to the spores and took preventive antibiotics. Numerous mail facilities and government buildings were shut down for investigation and decontamination. In the wake of these incidents, federal, state, and local emergency response agencies across the United States responded to thousands of calls to investigate suspicious packages, unknown powders, and other suspected exposures. Fortunately, almost all of these incidents turned out to involve no actual biohazard.

The Global Terrorism Database provides information on more than 150,000 global and domestic terrorism incidents at https://www.start.umd.edu/gtd/. The following are brief descriptions of selected CBRNE related incidents that have occurred in the United States between 2004 and 2015 (2015 is the last year for available data).

- **February 2, 2004**: In Washington, DC, ricin was discovered in a United States Senator's Office. Fortunately there were no reports of illness or injury. No group claimed responsibility.
- **March 14, 2005:** Trace amounts of potential anthrax were found at a Department of Defense mail facility in Washington, DC. Workers were given antibiotics as a precautionary measure. No injuries or damages were reported and no group claimed responsibility.
- **May 5, 2005**: In New York City, New York, two small improvised explosive devices (IEDs) exploded outside of the building housing the British Consulate, causing damage, but no injuries. No group claimed responsibility.
- **October 26, 2007:** In New York City, New York, an unknown assailant threw two explosive devices into the compound of the Mexican Consulate causing minor damage, but no injuries. No group claimed responsibility.
- **December 12, 2008**: At about 5:30 pm in Woodburn, Oregon, an improvised explosive device (IED) located at a bank exploded killing two police officers, and injuring another police officer and a bank employee. The bank was damaged. No group claimed responsibility.
- **December 25, 2009**: A would-be suicide bomber on-board Northwest Flight 253 bound for Detroit, Michigan from Amsterdam, Netherlands detonated a device that was attached to his body while on the plane. The bomb was a six inch packet of high explosives containing pentaerythritol, triacetone triperoxide, other materials and a syringe. The explosives were sown into his underwear. The assailant was wounded and damage was done to the aircraft. A passenger who tried to put the explosion out was also injured. There were 290 people in total were on board. No other injuries or casualties were reported. Al Qaeda in the Arabian Peninsula claimed responsibility.
- **May 10, 2010:** A pipe bomb exploded at a mosque during evening prayers in Jacksonville, Florida. Sixty people were inside the building praying, but no one was injured or killed. There were no claims of responsibility.
- **January 7, 2011:** An envelope addressed to Homeland Security Secretary Janet Napolitano ignited at a postal sorting facility in Washington D.C. The envelope was not opened and therefore did not cause any casualties or property damage. No group claimed responsibility for the attack.
- **June 18, 2012:** An assailant attempted to bomb a natural gas pipeline in Plano, Texas. The assailant was critically injured when the explosive device detonated prematurely. Additionally, the pipeline was also damaged in the blast. No group claimed responsibility, however sources note that the assailant identified as part of the anti-government Sovereign Citizens movement.
- **August 12, 2012:** Assailants threw an explosive device containing acid and other chemicals at the College Preparatory School of America, an Islamic school in Lombard, Illinois. No casualties or property damage was reported. No group claimed responsibility for this attack.
- **April 15, 2013**: An explosive device consisting of a pressure cooker, nails, BBs and a detonator fashioned from the remote control of a toy car detonated near the finish line of the Boston Marathon. Two bombs detonated approximately 12 seconds and 100 yards apart. Approximately 264 people were wounded in the two attacks. The alleged assailants were identified and either arrested or killed.

- **November 4, 2014**: Two explosive devices planted in a backpack were discovered and safely defused in Vickery Creek Park in Roswell, Georgia. An individual claimed responsibility and stated that he planted the devices in order to demonstrate that incidents of terrorism can occur anywhere.
- **August 2, 2015**: An explosive device detonated in a mailbox outside Calvary Baptist Church in Las Cruces, New Mexico. There were no reported casualties in the blast. The was one of two similar blasts targeting churches in Las Cruces on the same day; a third device was discovered and safely defused outside of First Presbyterian Church in Las Cruces on August 14, 2015. No group claimed responsibility for these incidents.
- **November 1, 2015:** An assailant threw an explosive device at a Walmart in Tupelo, Mississippi. There were no reported casualties in the blast. An individual claimed responsibility for the incident; reports stated he targeted the Walmart because they stopped selling Mississippi state flags containing the Confederate flag symbol.
- **December 2, 2015**: Two assailants opened fire on a holiday party at the Inland Regional Center for Disabled People in San Bernardino, California; the assailants attempted to trigger an explosive device, though it failed to detonate. Fourteen people were killed and at least seventeen were wounded in the attack. No group claimed responsibility.

Probability of Future Hazard Events

Historically, the United States sees a handful of CBRNE type attacks or attempted attacks per year, and the odds that the State of Missouri will see an attack in any given year is low, and noted as <1-percent.

Changing Future Conditions Considerations

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 CBRNE attacks on the homeland.

State Vulnerability Overview

A strategic nuclear, biological, or chemical 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, however even attacks of that variety are rare. Attackers are likely to have either very specific targets such as Women's clinics, or desire large publicity from the attacks.

It is not possible to calculate a specific vulnerability for each county in Missouri. However, because of the desire for publicity following attacks, it is more likely that counties with greater population densities would be the target of attacks. Sparsely populated rural counties are less desirable targets for publicity-seeking terrorists, though this does not make these areas immune. It is expected that the likelihood of attack is directly related to population density or more likely to an event that is occurring or to a specific location of importance to the attacker. For example, a large venue event, such as a sporting event attended by tens of thousands of people might be considered a desirable target. Most large public venues occur in densely populated areas since those areas are able to provide the infrastructure support (hotels, eateries, etc) for large numbers of people.

The population is vulnerable to two separate categories of impacts associated with CBRNE types of attacks: direct and indirect.

Direct Effects

These are effects directly associated with detonation or use of the weapon.

- **Conventional Weapons**—Direct effects of conventional weapons generally are related to injuries inflicted by penetration of ammunition rounds or shrapnel from exploding ordnance (mortars, etc.). Injuries from shock waves/blast overpressure near the targets may also occur, along with damage caused by fires produced from incendiary warheads, grenades, and other munitions. In addition, some injuries may occur as a result of flying or falling debris where the weapons are used. Heavy artillery use can also damage roadways and buildings and disrupt utility services for lengthy periods of time.
- **Chemical and Biological Weapons**—Direct effects of chemical weapons involve initial spread of agents and fragmentation of the weapons. Chemical agents are toxins used to produce neurological and pulmonary injuries or death. Biological agents are infectious microbes used to produce illness or death. They can be dispersed as aerosols or airborne particles directly onto a population, producing an immediate effect (a few seconds to a few minutes for chemical agents) or a delayed effect (several hours to several days for biological agents). Severity of injuries depends on the type and amount of the agent used and duration of exposure. Because some biological agents take time to grow and cause disease, an attack using this type of agent may go unnoticed for several days.
- **Nuclear Weapons**—Direct effects 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 weapon size, altitude of burst, and atmospheric conditions.
- **Agroterrorism**—The direct effect of agroterrorism is the intentional introduction of a contagious animal disease or fast spreading plant disease that affects livestock and food crops and disrupts the food supply chain. Agroterrorism could cause disease in livestock, crops, and in some cases (anthrax, or monkey pox, for example), humans. Diseases that can be transmitted to humans from animals are called zoonotic. It would not only require the agriculture industry to destroy livestock and food crops, but also affect the consumer confidence in the food supply resulting in tremendous economic damage for, potentially, an extended period. The food supply could be severely affected not only for the immediate area and the United States, but the world market, since the United States exports huge quantities of food to other nations. Recently, the federal government recognized the vulnerability of the agricultural/food supply industry and potential debilitation from a terrorist incident and acted to protect the resources through presidential decision directives and encouraged complementary state and local actions.
- **Radiological Weapon**—Direct effects of a radiological weapon are the same as a conventional high explosive, but with the added danger posed by exposure to radiological materials. A radiological dispersion device (RDD) or “dirty bomb” will contaminate an area by spreading radiological dust and debris over a large area.
- **Explosive Weapon** (large amount of high explosive)—The direct results of an explosive weapon are immense destruction caused by the blast and could result in multiple fatalities. Instances of these effects include Oklahoma City, Kobhar Towers, the marine barracks in Lebanon, and the African Embassy bombings.

Indirect Effects

These are effects not directly associated with the detonation and use of the weapon.

- **Conventional Weapons**—Unexploded ordinance throughout a battle zone or explosion hazards to those in the area can persist after warfare has ended. Many conventional munitions also contain toxic compounds that can leach into surrounding soils and groundwater if left in place.
- **Chemical and Biological Weapons**—Indirect effects are generally limited to downwind areas. They can be geographically widespread and vary in intensity—depending on weapon size, type of chemical or biological agent, and wind patterns. The spread of these agents can contaminate food and water supplies, destroy livestock, and ravage crops.
- **Nuclear Weapons**—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 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.
- **Agroterrorism**—Agroterrorism's indirect effects are loss of breeding stock to replenish herds and flocks, loss of seed crops, and possibly loss of land use for a long period of time depending on the disease involved. Agroterrorism has a high probability of creating an economic disaster for states highly vested in food production, and potentially the nation.
- **Radiological Weapon**—The indirect effect of an RDD is inability to use the contaminated area for a short to long period of time, depending on the identity of the radioactive material. Because radioactive material from an RDD can penetrate wood, asphalt, concrete, and masonry (and radioactive dust and particles can enter the smallest crevices), decontamination will be extremely difficult or impossible.
- **Explosive Weapon** (large amount of high explosive)—The indirect effect of an explosive weapon is the fear, terror, and lasting psychological damage to survivors and other individuals.

State Estimates of Potential Losses

Potential losses for this hazard include all infrastructure, critical facilities and lifelines, humans and animals. The degree of impact would be directly related to the type of CBRNE 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, spread of disease, increased morbidity and mortality among the local and distant populations and public panic. CBRNE events are rare occurrences and specific amounts of estimated losses for previous occurrence are not available due to the complexity and multiple variables associated with these types of hazards.

As discussed previously, it is difficult to quantify potential losses in terms of the jurisdictions most threatened by CBRNE attack events due to the many variables and human element that come into play. Therefore, for the purposes of this plan, the loss estimates will take into account several hypothetical scenarios. Please note that these hypothetical scenarios are included to provide a sample methodology for local jurisdictions to estimate potential losses. The hypothetical scenarios include: a chemical attack, a biological attack, an IED attack, and a radiological attack. For comparative purposes, these hypothetical attack scenarios will all be staged at the same venue, a baseball game at a large stadium. The hypothetical stadium is situated on less than one square mile and has a seating capacity of over 45,000 persons. Surface area and parking structures are located adjacent to the stadium.

Analysis of vulnerable populations is aided by a program developed by Johns Hopkins University in 2006 called Electronic Mass Casualty Assessment and `Planning Scenarios (EMCAPS) http://www.hopkins-cepar.org/EMCAPS/EMCAPS.html which utilizes scenarios put together by the Department of Homeland Security.

****THE FOLLOWING HYPOTHETICAL SCENARIOS ARE FOR INSTRUCTIONAL AND ILLUSTRATIVE PURPOSES ONLY****

Chemical Attack – Mustard Gas

Scenario Overview: Mustard gas is released from a light aircraft onto a stadium during a sporting event. The agent directly contaminates the stadium and the immediate surrounding area. This particular type of attack would cause harm to humans and could render portions of the stadium unusable for a short time period in order to allow for a costly clean-up. There might also be a fear by the public of long-term contamination of the stadium and subsequent boycott of games resulting in a loss of revenue and tourism dollars.

Assumptions: (1) The population density at the stadium on game day is high – approximately 75 percent of the seats, 31,000, are filled. (2) Sulphur mustards are extremely toxic and may damage eyes, skin and respiratory tract. Death sometimes results from secondary respiratory infections. (3) The rate of "worried well" is equal to 9 times the number of infected cases.

Described Losses:

Severe Eye Injuries (1-2 hours)	23,250 persons
Severe Airway Injuries (1-2 hours)	23,250 persons
Severe Skin Injuries (2 hrs to days)	27,900 persons
Total "Worried Well" Cases (9 times the number of affected cases)	251,000 persons
Deaths	620 persons

Notes: Victims will require decontamination and both long and short term treatment. Services may need to be suspended at the area until all investigations are conducted.

Biological Attack – Pneumonic Plague

Scenario Overview: Canisters containing aerosolized pneumonic plague bacteria are opened in public bathrooms. Each release location will directly infect 110 people; hence, the number of release locations dictates the initial infected population. The secondary infection rate is used to calculate the total infected population. This particular weapon of mass destruction (WMD) attack method would not cause damages to buildings or other infrastructure, only to human populations.

Assumptions: (1) The population density at the stadium on game day is high. (2) The population density of the stadium city is high (5,724 persons / sq mile). (3) The number of dispersion devices is 30. Devices are assumed to be placed in crowded seating areas. (4) Pneumonic plague has a 1-15 percent mortality rate in treated cases and a 40-60 percent mortality rate in untreated cases. (5) The rate of "worried well" is equal to 9 times the number of infected cases.

Described Losses:

Initial Infected Populations	3300 persons
Secondary Infected Population	16,629 persons
Total Plague Cases	19,929 persons
Total Deaths (Treated Cases 7%)	1,395 persons
Total "Worried Well" Cases (9 times the number of infected cases)	179,361 persons

Improvised Explosive Device Attack – ANFO

Scenario Overview: An Improvised Explosive Device (IED) utilizing an ammonium nitrate/fuel oil (ANFO) mixture is carried in a panel van to a parking area during a time when stadium patrons are leaving their cars and entering the stadium and detonated. Potential losses with this type of scenario include both human and structural assets.

Assumptions: (1) The population density in the parking lot during the beginning and ending of the games is high, at least 1 person /50 square feet. (2) The quantity of ANFO used is 4,000 lbs, similar to that used by Timothy McVeigh in the Oklahoma City bombing. (3) The Lethal Air Blast Range for such a vehicle is 200 feet according to the Bureau of Alcohol, Tobacco, Firearms and Explosives (BATF) Standards. (4) The Falling Glass Hazard distance is 2,750 feet according to BATF Explosive Standards.

Described Losses:

Total Dead	695 persons
Total Traumatic Injuries	1,218 persons
Total Urgent Care Injuries	5,967 persons
Injuries not Requiring Hospitalization	2,233 persons
Structures and Other Physical Assets (Damages would certainly occur to vehicles and depending on the proximity of other structures, damages would occur to the stadium complex itself. The exact amount of these damages is difficult to predict because of the large numbers of factors, including the type of structures nearby and the amount of insurance held by vehicle owners.)	Vehicles – Replacement cost for approximately 100 vehicles @ $15,000 per vehicle inside the 200 ft BATF described Lethal Air Blast range = $ 150,000 Repair / repainting cost for approximately 500 vehicles @ $ 4,000 per vehicle inside the BATF described Falling Glass Hazard = $2,000,000

Radiological Dispersion Device – Dirty Bomb Attack

Scenario Overview: An Improvised Explosive Device (IED) utilizing an ammonium nitrate/fuel oil (ANFO) mixture is carried in a panel van to a parking area during a time when stadium patrons are leaving their cars and entering the stadium and detonated. Potential losses with this type of scenario include both human and structural assets. The bomb also contains 2,700 Curies of Cesium-137 (Cs-137).

Assumptions: (1) The population density in the parking lot during the beginning and ending of the games is high, at least 1 person /50 square feet. (2) The quantity of ANFO used is 4,000 lbs, similar to that used by Timothy McVeigh in the Oklahoma City bombing. (3) The Lethal Air Blast Range for such a vehicle is 200 feet according to the Bureau of Alcohol, Tobacco, Firearms and Explosives (BATF) Standards. (4) The Falling Glass Hazard distance is 2,750 feet according to BATF Explosive Standards.

Described Losses:

Total Dead	695 persons
Total Traumatic Injuries	1,218 persons
Total Urgent Care Injuries	5,967 persons
Injuries not Requiring Hospitalization	2,233 persons
Radiological Poisoning Injuries that Need Aggressive Treatment	6
Radiological Poisoning Injuries that Need Non-Critical Treatment	220
Radiological Poisoning Injuries that could Self-Medicate with Proper Public Information	31,188
Structures and Other Physical Assets (Damages would certainly occur to vehicles and depending on the proximity of other structures, damages would occur to the stadium complex itself. The exact amount of these damages is difficult to predict because of the large numbers of factors, including the type of structures nearby and the amount of insurance held by vehicle owners.)	Vehicles – Replacement cost for approximately 100 vehicles @ $15,000 per vehicle inside the 200 ft BATF described Lethal Air Blast range = $ 150,000 Repair / repainting cost for approximately 500 vehicles @ $ 4,000 per vehicle inside the BATF described Falling Glass Hazard = $2,000,000

Hazard Impact on Future Growth and Development

Unfortunately, areas of dense population and large public venues may make attractive targets for a CBRNE attack. As more and more large public events are held in Missouri, more potential may exist for these venues to become targets of attack. However, with manmade hazards such as this that can have multiple variables involved, increases in development is not necessarily always a factor in determining risk.

EMAP Consequence Analysis

The information in **Table 3.125** is from the Impact Analysis of Potential for Detrimental Impacts of Hazards done for the Emergency Management Accreditation Program (EMAP).

Table 3.125. EMAP Impact Analysis: Attack

Subject	Detrimental Impacts
Public	Adverse impact expected to be severe for unprotected personnel and moderate to light for protected personnel.
Responders	Adverse impact expected to be severe for unprotected personnel and moderate to light for trained and protected personnel.
Continuity of Operations including Continued Delivery of Services	Damage to facilities/personnel in the area of the incident may require relocation of operations and lines of succession execution. Disruption of communications lines and facilities may extensively postpone services.
Property, Facilities, and Infrastructure	Damage to facilities and infrastructure in the area of the incident may be extensive for explosion, moderate to light for radiological, chemical and biological.
Environment	May cause extensive damage, creating denial or delays in the use of some areas. Remediation needed.
Economic Condition of Jurisdiction	Local economy and finances adversely affected, possibly for an extended period of time.
Public Confidence in the Jurisdiction's Governance	Ability to respond and recover may be questioned and challenged if planning, response, and recovery not timely and effective.

Risk Summary

Even though the START treaties have reduced the overall number of nuclear weapons and the New START treaty continues to do so, and many chemical/biological weapons stockpiles have been destroyed, incidents involving these types of weapons continue to occur worldwide. Missouri and the Nation must continue to plan for, and be prepared for, this type of hazard. In many ways, while the risk of a nuclear exchange by the super powers is greatly reduced, the potential risk of proliferation of weapons of mass destruction is greater than during the Cold War era.

While it may not be possible to prevent such an attack, steps can be taken to lessen the likelihood and the potential effects of an incident by implementing certain measures:

- Identifying and organizing resources
- Conducting a risk or threat assessment and estimating losses
- Identifying mitigation measures that will reduce the effects of the hazards and developing strategies to deal with the mitigation measures in order of priority
- Implementing the measures and evaluating the results (and keeping the plan up-to-date)

Problem Statement:

While CBRNE attacks can happen anywhere at any time they generally happen in the more populated regions. Using Population as the key indicator, the counties most at risk are St. Louis, Jackson, St. Charles, St. Louis City, Greene, Clay, Jefferson, Boone, Jasper and Franklin. Mitigation strategies and limited resources would be most likely better allocated to these counties.

2018 risk assessment data and mapping is available through the Missouri Hazard Mitigation Viewer: http://bit.ly/MoHazardMitigationPlanViewer2018.

3.3.13. Civil Disorder

Probability	Severity
<1%	Low to High

Description/Location

Civil disorder is a term that generally refers to groups of people purposely choosing not to observe a law, regulation, or rule, usually in order to bring attention to a cause, concern, or agenda. In Missouri, state statutes define civil disorder as "any public disturbance involving acts of violence by assemblages of three or more persons, which cause an immediate danger of or results in damage or injury to the property or person of any other individual."

Civil disorder can take the form of small gatherings or large groups blocking or impeding access to a building or disrupting normal activities by generating noise and intimidating people. They can range from a peaceful sit-in to a full-scale riot in which a mob burns or otherwise destroys property and terrorizes individuals. Even in its more passive forms, a group that blocks roadways, sidewalks, or buildings interferes with public order. In the 1990s abortion clinics, for example, were targets for these disruptive-type activities.

Throughout this country's history, incidents that disrupted the public peace have figured prominently. The constitutional guarantees allow for ample expression of protest and dissent, and in many cases collide with the preamble's requirement of the government "to ensure domestic tranquility." Typical examples of such conflicting ideology include the protest movements for civil rights in the late 1960s and the Vietnam War protest demonstrations in the early 1970s. The balance between an individual's and group's legitimate expression of dissent and the right of the populace to live in domestic tranquility requires the diligent efforts of everyone to avoid such confrontations in the future.

In modern society, laws have evolved that govern the interaction of its members to peacefully resolve conflict. In the United States, a crowd itself is constitutionally protected under "the right of the people to peacefully assemble." However, assemblies that are not peaceable are not protected, and this is generally the dividing line between crowds and mobs. The laws that deal with disruptive conduct are generally grouped into offenses that disturb the public peace. They range from misdemeanors, such as blocking sidewalks or challenging another to fight, to felonies, such as looting and rioting. Missouri law makes "promoting civil disorder in the first degree" a class C felony, according to Section 574.070 of the Revised Missouri Statutes. As stated in one provision of the law, "Whoever teaches or demonstrates to any other person the use, application, or construction of any firearm, explosive, or incendiary device capable of causing injury or death to any person, knowing or intending that such firearm, explosive or incendiary device be used in furtherance of a civil disorder, is guilty of promoting civil disorder in the first degree."

Types of Crowds

A crowd may be defined as a casual, temporary collection of people without a strong, cohesive relationship. Crowds can be classified into four general categories:

- **Casual Crowd** — A casual crowd is merely a group of people who happen to be in the same place at the same time. Examples of this type include shoppers and sightseers. The likelihood of violent conduct is all but nonexistent.
- **Cohesive Crowd** — A cohesive crowd consists of members who are involved in some type of unified behavior. Members of this group are involved in some type of common activity, such as worshiping, dancing, or watching a sporting event. Although they may have intense internal discipline (e.g., rooting for a team), they require substantial provocation to arouse to action.

- **Expressive Crowd** — An expressive crowd is one held together by a common commitment or purpose. Although they may not be formally organized, they are assembled as an expression of common sentiment or frustration. Members wish to be seen as a formidable influence. One of the best examples of this type is a group assembled to protest something.
- **Aggressive Crowd** — An aggressive crowd is made up of individuals who have assembled for a specific purpose. This crowd often has leaders who attempt to arouse the members or motivate them to action. Members are noisy and threatening and will taunt authorities. They tend to be impulsive and highly emotional and require only minimal stimulation to arouse them to violence. Examples of this type of crowd include demonstrations and strikers.

Types of Mobs

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

- **Aggressive Mob**—An aggressive mob is one that 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 the 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 have lost their capacity to reason and are generally impossible to control. They are characterized by unreasonable 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 a lack of control by authorities in safeguarding property. Examples of acquisitive mobs would include the looting in South Central Los Angeles in 1992, or food riots in other countries.
- **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. Examples of this type of mob include the June 1994 riots in Canada following the Stanley Cup professional hockey championship, European soccer riots, and those occurring after other sporting events in many countries, including the United States.

Although members of mobs have differing levels of commitment, as a group they are far more committed than members of a crowd. As such, a "mob mentality" sets in, which creates a cohesiveness and sense of purpose that is lacking in crowds. Thus, any strategy that causes individual members to contemplate their personal actions will tend to be more effective than treating an entire mob as a single entity.

Location

Civil disorder can arise from a number of causes for a variety of reasons. Circumstances may be spontaneous, or may result from escalating tensions. Civil disorder can erupt anywhere, but the most likely locations are those areas with large population groupings or gatherings. Sites that are attractive for political or other rallies should be considered as probable locations for the epicenter of civil disorder events; arenas and stadiums are another type of venue where civil disorder can occur. Civil disorder can also occur in proximity to locations where a "trigger event" occurred.

Extent

The ultimate extent of any civil disorder incident will depend on the magnitude of that event and its location. The more widespread an incident is, the greater the likelihood of excessive injury, loss of life and property damage; additional factors, such as the ability of law enforcement to contain the event, are also critical in minimizing damages.

Previous Occurrences

Missouri

Events in Missouri's early history, as well as those from the late 1960s through this decade, indicate the State is not immune to riots, protests, and social upheaval. Some brief examples of Missouri's riotous events are provided below.

In 1906, on the night before Easter Sunday in Springfield, a mob of 6,000, fueled by alcohol, rumors of a woman's rape, and racial tension battered down the jailhouse doors and carried away three men and hanged them in the town square. In the months that followed, a grand jury indicted more than a dozen people for the hangings, and the story of the woman's attack proved to be untrue. In her book about the incident and its aftermath, "Many Thousand Gone," Katherine Lederer notes that until 1906, Springfield had a thriving black population, but the population never recovered after this incident.

On September 22, 1954, a full-scale riot broke out at the Men's State Penitentiary in Jefferson City at about 6:00 p.m., after an inmate released several prisoners. The inmate had obtained keys from a guard by a ruse. At 7:00 p.m., all available state highway patrolmen were directed to report to the penitentiary as quickly as possible to quell the riot. Several buildings and vehicles were burning at that time, and some 500 inmates were loose, hurling bricks, yelling, and attempting to escape. Both chapels were ablaze, as well as several prison shops and factories. Seeing the fires, which were visible at dusk from about 20 miles away, prisoners at the Algoa reformatory and the women's prison staged separate rebellions there. Damage to state property at those facilities was minimal, but at the main prison, only cell houses and buildings equipped with sprinklers survived. By 11:30 p.m., 285 patrolmen in 202 cars were on the scene, and by midnight, some 100 St. Louis policemen carrying submachine guns had arrived by special train. They surrounded cell houses B and C—the only halls in which guards were still held hostage. Highway patrolmen and arriving National Guardsmen took positions on rooftops overlooking the quadrangle—a yard between the larger cell houses. From that vantage point, they opened fire, seriously wounding many inmates in the exchange. Shortly after 7:00 a.m. the next day, the last guard taken hostage was released, and the rioters, having no alternative, gave up shortly thereafter. By mid-morning, 2,000 police officers and National Guardsmen were on duty at the prison. When the riot was over, 3 inmates had been killed and 21 wounded by gunfire. One other prisoner was murdered by stabbing and beating, and eight others were injured in fighting with each other. Five buildings were completely destroyed, and two others partially destroyed, resulting in more than $10 million in losses to state property.

On October 23, 1954, another riot occurred at the State Penitentiary while state troopers were still technically operating the institution. This melee was reportedly fueled by racial tension among inmates and started over food. Bricks began to fly, followed by gunfire from the troopers. Approximately 35 prisoners were wounded in that incident.

On the evening of March 19, 1958, at the Algoa Intermediate Reformatory, east of Jefferson City, quick action by then Governor James T. Blair and a contingent of state highway patrolmen with riot guns quelled a potential inmate uprising. The governor himself and the patrolmen entered the facility amid reports of unrest following the resignation of the institution's acting superintendent. When no trouble occurred, the troopers were removed after about two hours.

On April 9, 1968, the Kansas City Police Department requested the help of the Missouri Highway Patrol in quelling rioting, bombing, and looting in the eastern part of the city in the wake of the assassination of Martin Luther King, Jr. Over 200 officers reported to the staging area at District Four of the State Highway Department to receive their assignments and began patrolling the downtown area. Officers arrested numerous persons for charges ranging from curfew violations to felonious assault. They remained on duty for 10 days until peace was restored.

Twice in May 1969, demonstrations at Lincoln University in Jefferson City resulted in about 200 highway patrolmen being called to the scene to combat arson, sniper fire, and vandalism on campus. The Student Union was burned during those demonstrations.

On February 17, 1975, at Algoa Intermediate Reformatory, a minor riot broke out, resulting in tear gas being thrown into dormitories at the institution. Three prison officials suffered minor injuries, and one inmate required stitches to close a wound. The incident resulted in about $5,000 in property damage.

In December 1977 and January 1978 in Southeast Missouri, farmers making up an American Agricultural Movement staged demonstrations to protest what they felt were unfair prices for their products, as maintained by government price supports. The rallies continued through April 1978 with picketing, tractorcades, and stoppage of highway traffic throughout the area, despite high winds, ice, and snow. More than 300 farm tractors were involved in at least one of these actions. On January 11, highway patrol troopers on Interstate 55 near Hayti arrested seven farmers and charged them with failure to obey a reasonable request, assault, and damaging state property. Four others were arrested on I-55 near Caruthersville for driving their pickup trucks slowly side by side, preventing traffic from passing. Twenty-five farmers with their tractors were involved in a fracas with 12 officers near Hayti. Two patrol cars were damaged, and one officer sustained minor injuries when shoved by an irate farmer into the path of a road grader.

On April 29, 1992, in Warrensburg, racial tensions mounted following the announcement of the controversial Rodney King verdict. The Johnson County Emergency Operations Center was activated for several hours as police remained on alert status for a potential serious disturbance. Military police from nearby Whitman Air Force Base were also placed on standby alert status, but no major problems occurred.

Unrest in Ferguson in August 2014 began when 18 year old Michael Brown was fatally shot by a white Ferguson police officer on August 9th. The disputed circumstances of the shooting sparked existing tensions in the predominately black city, where protests and civil unrest erupted. As the details emerged, a dozen buildings were burned down; there was gunfire, looting, vandalism, and destruction of two St. Louis County Police patrol cars, as well as burning of non-police cars. The events received considerable attention in the US and elsewhere, attracting protesters from outside the region, and raised many questions about relationships between the community and law enforcement, and the militarization of law enforcement. Reporting by local media estimated damages and costs at $5.7 million; the St. Louis County Chief Financial Officer estimated final costs at over $20 million.

In late September 2015, simmering racial tensions reached a breaking point as African-American students at the University of Missouri began to peacefully protest against racist attitudes they saw as prevalent amongst the student body and administration. Specifically, protestors railed against feeling unsafe on campus because of their race, and institutional racism inherent in the university structure. Protests continued through 2015, and resulted in the resignations of the University’s President and Chancellor. While no widespread violence or destruction took place during the protests, they did cause major disruption to the operations at the university.

Since 2010, civil unrest has again trended toward race relations as a cause. From controversial shootings of African American men by white police officers to the resulting Black Lives Matter movement, these trends may continue into the future as the country finds ways to improve race relations. As detailed previously in this chapter, Missouri has experienced specific incidents of racial unrest and violence as part of this trend, and may continue to see these types of incidents in the future.

Specific incidents can in a single jurisdiction can cause civil unrest nationally. The Michael Brown shooting incident in Ferguson is an example of this. On November 25, 2014, CNN reported that thousands of people in more than 170 U.S. cities rallied to protest the grand jury decision not to indict the officer involved. Protests also took place internationally, with demonstrations held in several major cities in Canada, and as far away as London.

Probability of Future Hazard Events

In their article on "Understanding Riots" published in the *Cato Journal* (Vol. 14, No 1), David D. Haddock and Daniel D. Polsby note that a large crowd itself is not an incipient riot merely because it assembles a great many people. Haddock and Polsby explain that "starting signals" must occur for civil disorder to erupt; these starting signals include certain kinds of high profile events. In fact, incidents can become signals simply because they have been signals in the past. In Detroit, for example, Devils Night (the night before Halloween) has in recent years become a springboard for multiple, independent, and almost simultaneous acts of arson. With any conventional triggering event, such as news of an assassination or unpopular jury verdict, crowds form spontaneously in various places as word of the incident spreads, without any one person having to recruit them. But since not every crowd threatens to evolve into a riot, the authors reason that a significant number of people must expect and desire that the crowd will become riotous. In addition, "someone has to serve as a catalyst—a sort of entrepreneur to get things going." A typical action is the breaking of a window (a signal that can be heard by many who do not necessarily see it). Someone will throw the first stone, so to speak, when he calculates the risk of being apprehended has diminished to an acceptable level. This diminished risk is generally based on two variables—the size of the crowd relative to the police force and the probability that others will follow if someone leads. The authors conclude that once someone has taken a risk to get things started, the rioting will begin and spread until civil authorities muster enough force to make rioters believe they face a realistic prospect of arrest.

Nationwide, riots are apt to be a recurrent, if unpredictable, feature of social life. Without question, Missouri will continue to experience future episodes of marches, protests, demonstrations, and gatherings in various cities and communities that could lead to some type of disruptive civil disorder. However, based on the State's general history of civil disturbance and the various human factors noted above, the probability that such incidents will develop into full-scale, widespread riots is considered low, and noted as <1-percent.

Regarding penal institutions, much has been done in Missouri and other states to alleviate poor living conditions, which are underlying factors in many riots (prison overcrowding, poor treatment of inmates, lack of grievance procedures, etc.). The state has been building new prisons for several years and expanding facilities to create more space and otherwise improve facilities for its inmate population. The number of individuals on probation as of December 2016 was 42,490. The number in institutions was 32,461, and the number on parole was 16,075. One federal prison, the United States Medical Center for Federal Prisoners, is located in the State, in Springfield. A map of the correctional institutions and probation and parole offices in the State is provided as **Figure 3.179**.

Should Missouri experience future incidents of disruptive civil disorder or rioting, the severity of a given event could range from low to high, depending on many factors. A spirited demonstration that gets out of hand may result in several arrests, minor damage to property (police vehicles with broken windows, etc.), some injuries, and manpower/overtime costs for police, fire, and other response services. To a greater extent, the threat of urban or intercity riots has the potential for millions of dollars in property damage, possible loss of life, and serious injuries, and extensive arrests. Sustaining police at the scene for extended periods, and possibly mobilizing state highway patrol and National Guard units, can add to the extensive manpower costs. Still, such riots tend to be confined to a single site or general area of a community rather than multiple locations or several areas of the State at the same time. Once a riot has occurred, police in other cities are generally on standby for possible riotous conditions and are better able to alleviate potential disturbances before they develop into full-scale riots.

Changing Future Conditions Considerations

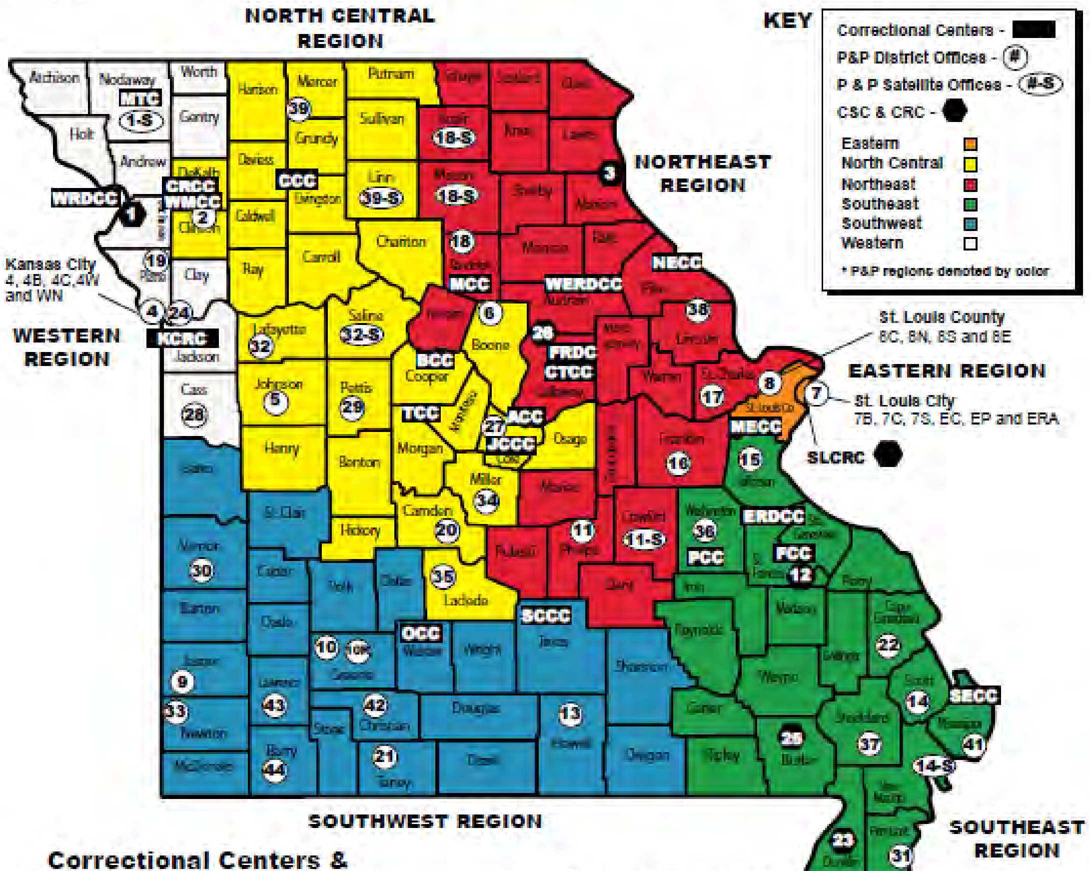
As a human-caused hazard, any changes in climate would not have a direct impact on civil disorder. Far more relevant, though, could be the implications of future climate change as a cause for civil disorder. Climate change impact forecasts include increasingly extreme weather patterns that exacerbate issues of drought, flooding, severe weather and other weather hazards globally that could affect whole ecosystems. Incidents of civil disobedience could be a secondary result related to societal unrest as a result of other climate-impacted hazards.

State Vulnerability Overview

When rioting does break out, it generally proves extremely difficult for first-responder law enforcement authorities to quell the mob promptly. The rules of constitutional law set stringent limits on how police officers can behave toward the people they try to arrest. Restraint also plays a crucial part in avoiding any action that “fans the flames.” Initial police presence is often undermined because forces may be staffed below the peak loads needed to bring things back under control. At a result, the riot may continue until enough state police or National Guard units arrive to bolster the arrest process and subsequently restore order. In many cases, damage to life and property may already be extensive.

Figure 3.179. Correctional Institutions and Probation and Parole Offices

Correctional Institutions and Probation & Parole Offices



Correctional Centers & Institutional Parole Region

ACC - Algoa Correctional Center, Jefferson City
BCC - Boonville Correctional Center, Boonville
CCC - Chillicothe Correctional Center, Chillicothe
CRCC - Crossroads Correctional Center, Cameron
ERDCC - Eastern Reception, Diagnostic & Correctional Center, Bonne Terre
FCC - Farmington Correctional Center, Farmington
FRDC - Fulton Reception & Diagnostic Center, Fulton
CTCC - Cremer Therapeutic Community Center, Fulton
JCCC - Jefferson City Correctional Center, Jefferson City
KCRC: Kansas City Reentry Center, Kansas City
MTC - Maryville Treatment Center, Maryville
MECC - Missouri Eastern Correctional Center, Pacific
MCC - Moberly Correctional Center, Moberly
NECC - Northeast Correctional Center, Bowling Green
OCC - Ozark Correctional Center, Fordland
PCC - Potosi Correctional Center, Potosi
SCCC - South Central Correctional Center, Licking
SECC - Southeast Correctional Center, Charleston
TCC - Tipton Correctional Center, Tipton
WMCC - Western Missouri Correctional Center, Cameron
WRDCC - Western Reception, Diagnostic & Correctional Center, St. Joseph
WERDCC - Women's Eastern Reception, Diagnostic & Correctional Center, Vandalia

Probation and Parole District Offices

1. St. Joseph Community Supervision Center (CSC) (Maryville Satellite)
2. Cameron
3. Hannibal Community Supervision Center (CSC)
4. Kansas City (5 offices)
5. Warrensburg
6. Columbia
7. St. Louis City (6 offices)
8. St. Louis County (4 offices)
9. Joplin
10. Springfield (2 offices)
11. Rolla (Steelville Satellite)
12. Farmington Community Supervision Center (CSC)
13. West Plains
14. Sikeston (New Madrid Satellite)
15. Hillsboro
16. Union
17. St. Charles
18. Moberly (Macon and Kirksville Satellites)
19. Liberty
20. Camdenton
21. Branson
22. Cape Girardeau
23. Kennett Community Supervision Center (CSC)
24. Independence
25. Poplar Bluff Community Supervision Center (CSC)
26. Fulton Community Supervision Center (CSC)
27. Jefferson City
28. Belton
29. Sedalia
30. Nevada
31. Caruthersville
32. Lexington (Marshall Satellite)
33. Neosho
34. Lake Ozark
35. Lebanon
36. Potosi
37. Dexter
38. Troy
39. Trenton (Brookfield Satellite)
41. Charleston
42. Nixa
43. Aurora
44. Cassville

SLCRC: St. Louis Community Release Center (CRC)

Source: Missouri Department of Corrections Division of Adult Institutions http://doc.mo.gov/Documents/mapinstpp.pdf

State Estimates of Potential Losses

Providing estimates of potential loss for future incidents of civil disorder is difficult, as good records of damages are not generally consolidated and the parameters of future incidents might be totally different. In order to estimate some level of potential loss, this chapter uses the recent unrest in Ferguson as an example of baseline impacts. According to the St. Louis CBS affiliate, the unrest of Ferguson cost an estimated $5.7 million. Costs incurred include property damage, police overtime, food and supplies for first responders, and Missouri National Guard activation. More than 80 arrests were made, 13 injuries occurred and as many as 25 buildings were burned and looted.

Hazard Impact on Future Growth and Development

Prison construction in Missouri, as in many other states, was a growth industry during the 1980s and early 1990s. With the added prison capacity, the number of offenders incarcerated in the Missouri Department of Corrections (DOC) grew form 19,266 in 1995 to 28,567 in 2001. This growth seemed to have no end until a tightening state budget and competing priorities signaled an end to new prison construction. According to several sources, Missouri's prison population has reached an all-time high. The cause of the increase in inmates is unknown, but contributing factors include changes in funding, the economy, and higher crime and conviction rates.

EMAP Consequence Analysis

Table 3.126. EMAP Impact Analysis: Civil Disorder

Subject	Detrimental Impacts
Public	Localized impact expected to be severe for unprotected personnel and moderate to light for protected personnel.
Responders	Localized impact expected to be severe for unprotected personnel and moderate to light for protected personnel.
Continuity of Operations including continued delivery of services	Damage to facilities/personnel in the area of the incident may require temporary relocation of operations; localized disruption of lines of communication and destruction of facilities may postpone delivery of some services.
Property, Facilities, and Infrastructure	Localized impact to facilities and infrastructure in the area of the incident. Some severe damage possible.
Environment	May cause extensive damage in isolated cases and some denial or delays in the use of some areas. Remediation needed.
Economic Condition of Jurisdiction	Local economy and finances adversely affected, possibly for an extended period of time, depending on damage.
Public Confidence in the Jurisdiction's Governance	Ability to respond and recover may be questioned and challenged if planning, response, and recovery not timely and effective.

Risk Summary

In the wake of numerous urban riots in the late 1960s and beyond, a unique approach in law enforcement began to emerge as a viable means to reduce the risk of such future riots. Known as "community policing," its philosophy rests on the belief that reducing and controlling serious crime requires the police to pay renewed attention to all problems that allow serious crime to occur. In its comprehensive report following the devastating 1967 Detroit riot for example, the Kerner Commission noted that police "cannot, and should not, resist becoming involved in community service matters." The benefits to law enforcement and public order, the commission says, include the following:

- Because of their "front-line position" in dealing with neighborhood problems, police will be better able to identify problems in their community that may lead to disorder.
- They will be better able to handle incidents requiring police intervention.
- Willing performance of such work can gain police the respect and support of the community.
- Development of non-adversary contacts can provide the police with a vital source of information and intelligence concerning the communities they serve.

In his paper entitled "Preventing Civil Disturbances: A Community Policing Approach," Michigan State University professor Robert C. Trojanowicz says community policing can reduce the potential for riots beyond simply reducing racial tensions between the police and the black community. The organizational strategy of community policing, he writes, "requires freeing some police officers from the isolation of the patrol car, so they can work directly in the community and enlist them as partners in the process of policing themselves. It addresses the need that everyone in the United States deserves to live in a safe and stable community, free of drugs and violence, and reminds us that "until we are all safe, no one is safe." Four basic ways community policing can help in riot prevention, the author says, are as follows:

- It provides a means of gathering superior intelligence that allows us to identify areas at risk, the level of threat in those areas, and weaknesses and strengths within the community.
- It provides the police with a way to address those weaknesses, which often include crime, violence, drugs, fear of crime, disorder, neighborhood decay, and juveniles at risk.
- It reaches out to law-abiding people in the community and involves them in the police process, serving as the vital link required to enlist their help in actively promoting order and stability.
- It reduces the overall risk to riots by improving the relations between the police and the black community.

A community policing officer (CPO), the author notes, is a full-fledged law enforcement officer who makes arrests but is further challenged to find new ways to address old problems. CPOs act as community advocates for needed neighborhood services (prompt trash pickup, demolition of abandoned buildings, etc.) and serve as community liaison to public and private agencies, Trojanowicz writes. "This can mean linking troubled families to affordable counseling services, linking the homeless to shelter, or tapping local business to provide donated supplies for projects to beautify the area." The initiatives are bounded only by the collective imagination of the CPO and the people in the community and their local needs, the author concludes.

Problem Statement:

Using Population as the key indicator for Civil Disorder, the counties most at risk are St. Louis, Jackson, St. Charles, St. Louis City, Greene, Clay, Jefferson, Boone, Jasper and Franklin. Mitigation strategies and limited resources would be most likely better allocated to these counties.

2018 risk assessment data and mapping is available through the Missouri Hazard Mitigation Viewer: http://bit.ly/MoHazardMitigationPlanViewer2018.

3.3.14. Cyber Disruption

Probability	Severity
100%	Low to High

Description/Location

Cyber disruption is an emerging hazard that has gained increasing notoriety as the vulnerability to disruption grows parallel with the dependence for cybernetic systems. An official definition for cyber disruption has not been solidified amongst professionals and can only be described as an interruption or disruption of the normal operations, use and/or function of a cybernetic system.

Disruptions can typically fall into two very general categories; un-intentional disruption and intentional disruption. Un-intentional disruptions are the more common type of disruption as they usually occur when a portion of the system fails. This can look like a typo or mistake in the code used to design the system or a physical failure of hardware or network. Disruption can also be a cascading effort of a failure of other systems supporting the network, i.e. power.

Intentional disruption is typically a directed 'attack' on a cybernetic system to achieve an intended goal, which is usually malicious in intent. These types of disruptions are the most worrisome to governments as they pose the potential to cause irreparable harm to the function and capability of critical systems or supporting systems that are used in daily operations.

The FBI defines this intentional disruption as a threat: "a cyber-threat is any circumstance or event with the potential to adversely impact operations (including mission, functions, image, or reputation), agency assets, or individuals through an information system via unauthorized access, destruction, disclosure, modification of information, and/or denial of service."

There are many types of cyber disruptions producing a wide variety of societal impacts. Incidents can range from purposeful criminal activities meant to steal money or information, to making public statements (defacto internet protests), to purposefully causing infrastructure damage or injuring persons through disruptions. The most severe cyber-disruption is defined as Cyberterrorism - a terrorist act designed to cause disruptions to computer-based information systems with the express purpose to cause fear, injury or economic loss. In addition to these disruptions, some government entities and businesses are susceptible to cyber activities with some becoming ongoing targets of "hackers" looking to cause harm or promote a personal or political agenda. In many cases, nationally, there are individuals and groups whose mission is to purposefully disrupt and hack systems to cause disruptions and damage.

The most common type of attack cyber criminal's use is the direct denial of service or DDoS attack. This is where a server or website will be pinged rapidly with information requests overloading the system and causing it to crash. DDoS attacks have been a commonly used tool of organizations labeled by the FBI as cyber terrorists such as Anonymous and Lulz Security. Additionally, these organizations have organized website defacements largely as protests perceived injustices and/or groups they consider hate groups.

More sinister attacks have been carried out by other cyber terrorist groups. For example, Russian and Ukrainian hackers attacked a public hospital and stole a more than $1 million from the hospital's payroll system. Additionally, identity theft has been an all too common result of cyber-attacks. In 2011 an unknown percentage of Sony's 77 million persons PlayStation Network had their credit card information stolen off the network. According to certain known hacker websites, the list of information was worth hundreds of thousands of dollars to those who stole it.

Though it is an emerging hazard, cyber disruption has not gone unnoticed. The risks associated with the Nation's dependence on these networked technologies led to the development of Presidential Policy Directive 41 (PPD-41): United States Cyber Incident Coordination, which sets forth principles governing the Federal Governments to any cyber incident, whether involving government or private sector entities.

PPD-41 recognizes that the frequency of cyber incidents is increasing, and this trend is unlikely to be reversed anytime soon. The National Cyber Incident Response Plan (NCIRP) was developed according to the direction of PPD-41). In 2010, the Department of Homeland Security (DHS) issued the NCIRP Interim Version. This plan was recently updated in December of 2016 (https://www.us-cert.gov/ncirp).

In Missouri, the Information Technology Services Division (ITSD), which is part of the Office of Administration (OA), provides direct IT support to nearly all the state government agencies that are under the umbrella of Missouri's 14 IT-consolidated departments. During the 2016 legislative session, ITSD received additional ongoing funding for cyber security from Governor Nixon and the General Assembly. These funds are being used by ITSD's team of cyber security professionals as they enhance the state's cyber security systems and train state employees in cyber security best practices. Within ITSD, the Office of Cyber Security (OCS) is responsible for managing all cyber security related events within the enterprise and ensuring proper administrative and technical controls are implemented to safeguard the State of Missouri's information system (State of Information Technology in Missouri, 2015, https://oa.mo.gov/information-technology-itsd)

Cyber disruption events can occur and/or impact virtually any location in the State that computing devices are used. A disruption to a cybernetic system can have far-reaching effects beyond the location of the system. As a result, cyber disruption that occurs outside of the state or even the nation can impact Missouri. The converse is true as well; an event that impacts systems in Missouri can cause impacts outside the State.

Extent

The extent or magnitude/severity of a cyber disruption event is variable depending on the nature of the disruption. Impacts of disruption of a small, isolated cybernetic system could impact only a few functions/processes. However, impacts of disruption of large, integrated cybernetic systems could impact many functions/processes, as well as many individuals that rely on those systems.

The State of Missouri categorizes the severity of a cyber disruption ranging from low to high depending upon the system disrupted and the intention of the attacker. Some systems have redundant capabilities or are not critical to daily operations. As such the severity of a disruption to that system is low. However, there are other systems that are integral to operations, contain sensitive information, or provide access/control to critical systems. A disruption to those systems would have a severe impact on the state.

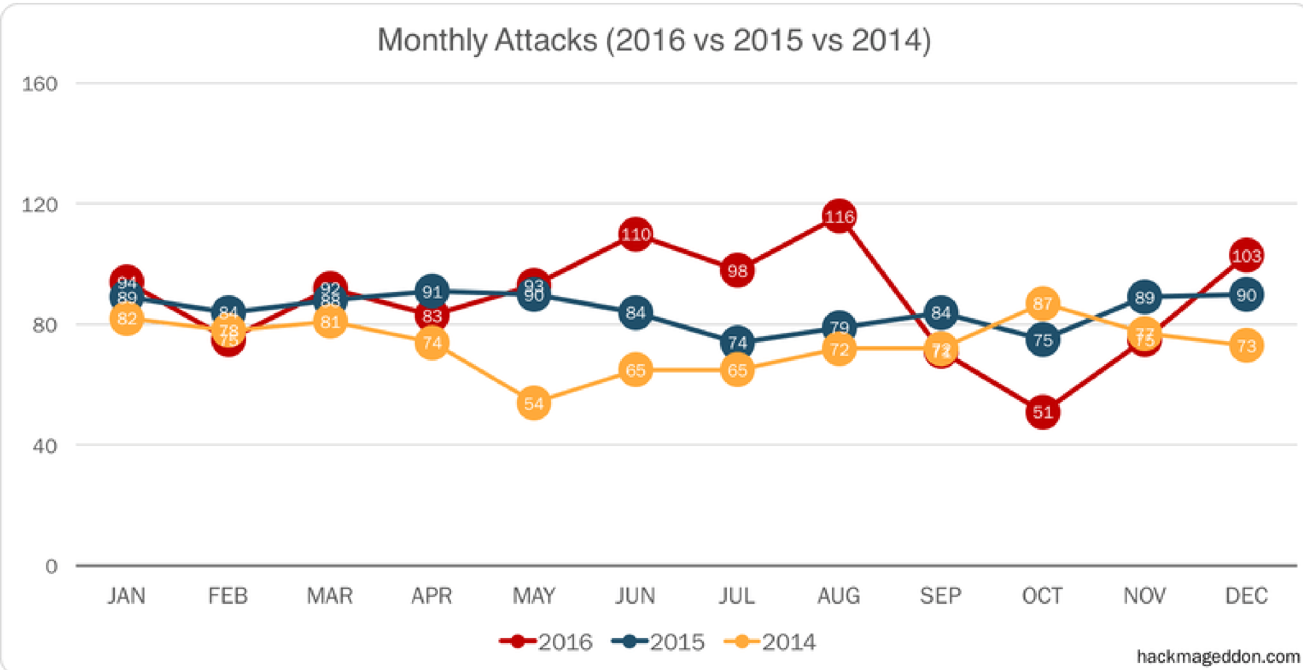
Though a cyber disruption can have limited impacts within a system's own operations, it also can have extended cascading affects throughout multiple systems. The system that is disrupted and the source of the disruption are major factors in the impact. If it is an intentional disruption and the system is critical then the impact has the potential to quite devastating.

Previous Occurrences

As cyber disruption is an emerging hazard, the reporting and tracking of disruptive events is difficult. In most cases, it is not required to report an event, and when it is reported most of the information is protected due to the sensitive nature of the systems that have been disrupted. However, there currently exist several complex databases that track cyber disruption occurrences. Each system makes use of its own definitions and tracking methods. Hackmageddon is one online source that tracks Cyber Attack Statistics. Hackmageddon was developed by Paolo Passeri, an expert in the computer security industry for more than

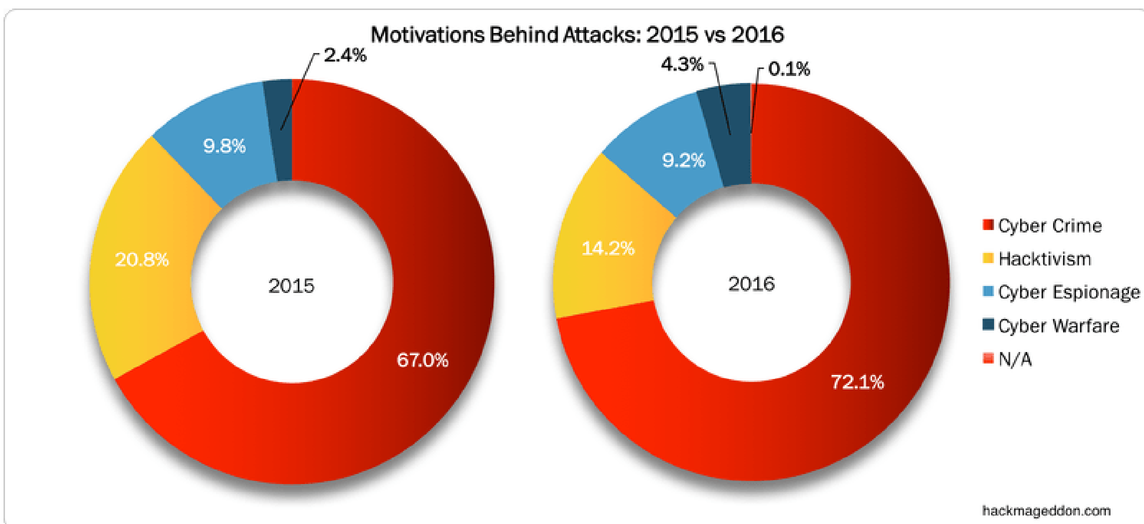
15 years and current Principal Sales Engineer at OpenDNS (now part of Cisco). The data for the statistics is derived from timelines that are generally built on a bi-weekly basis. The timelines collect the major cyber events of the related months chosen among events published by open sources (such as blogs or news sites). It should be noted that this database collects cyber attacks worldwide and this data is provided to show how this hazard is trending in general. During 2016, this database collected reports of a total of 1,061 cyber attacks. The graphic in **Figure 3.180** provides a comparison of the number of attacks collected during 2014, 2015, and 2016 and **Figure 3.181** that follows provides the breakdown of reported cyber attack motivations for 2015 and 2016. During 2016, the percentage of events motivated by cyber crime raised from 67% to 72.1%, while hacktivism dropped from 20.8% to 14.2%. Cyber espionage was essentially stable (9.8% vs 9.2%), whereas cyber warfare has nearly doubled its share (2.4% vs. 4.3%) even if the overall value is still low.

Figure 3.180. Monthly Attacks Collected by Hackmageddon (2014-2016)



Source: Hackmageddon, http://www.hackmageddon.com/2017/01/19/2016-cyber-attacks-statistics/

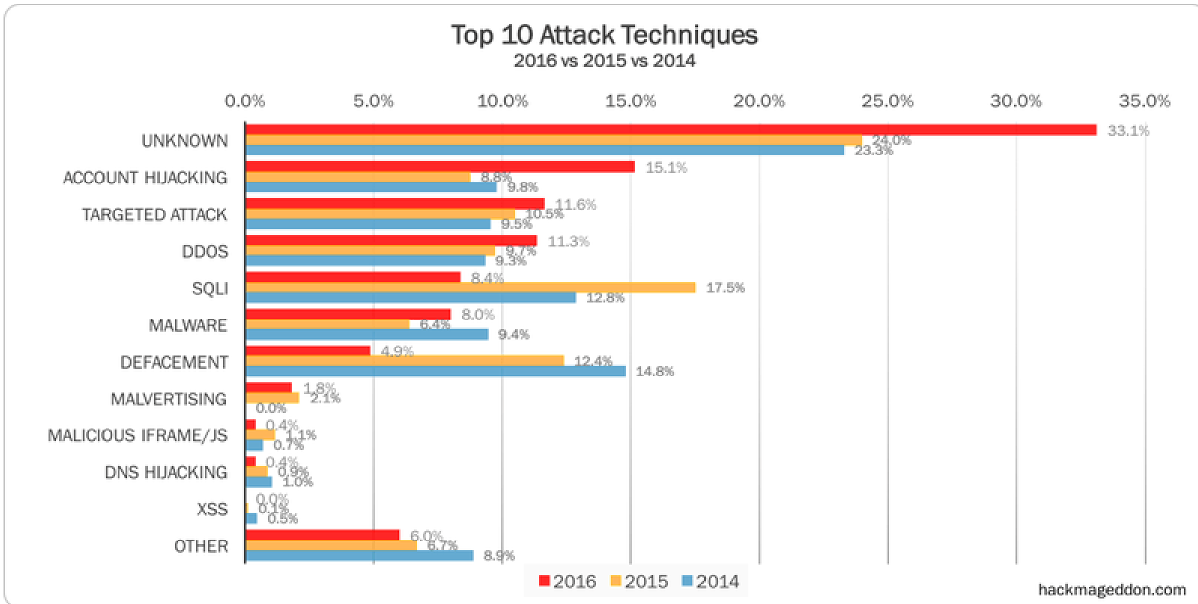
Figure 3.181. Motivations Behind Attacks 2014 vs. 2016



Source: Hackmageddon, http://www.hackmageddon.com/2017/01/19/2016-cyber-attacks-statistics/

Figure 3.182 shows the top 10 attack techniques for 2014-2016. The main finding from the top 10 attack techniques is the percentage of unknown attacks soaring to 33.1% in 2016. Account hijackings also experienced a noticeable growth from 8.8% in 2015 to 15.1% in 2016. Targeted attacks reported a light growth (11.6% vs 10.5%), similarly to Distributed Denial of Service (DDoS) (11.3% vs 9.7%) and malware (8.0% vs 6.4%). Finally, both SQL Injection (SQLi) and defacement attacks reported a considerable drop (maybe related to the decreasing impact of hacktivism among the motivations); while malvertising is essentially stable (2.1% in 2015 to 1.8% in 2016.

Figure 3.182. Top 10 Attack Techniques (2014-2016)



Source: Hackmageddon, http://www.hackmageddon.com/2017/01/19/2016-cyber-attacks-statistics/ ; DDOS=Distributed Denial of Service, SQLI=SQL Injection or malicious payload that controls a web application's database server; DNS=Domain Name Server, XXS=cross-site scripting

There have been some notable disruption events that attained national attention in the last few years:

- June 2016, Voter information. MacKeeper Security Researcher Chris Vickery reported an IP address based out of Serbia had been interacting with an online database holding 154 million U.S. voters' information as early as April 2016 (Chris Vickery, "Another U.S. Voter Database Leak," MacKeeper, June 26, 2016, https://mackeeper.com/blog/post/239-another-us-voter-database-leak).
- February 2016, U.S. Department of Homeland Security, Federal Bureau of Investigation. A hacker with the Twitter handle @DotGovs released online the names and contact information of 29,000 Department of Homeland Security and FBI employees(Lorenzo Franceschi-Bicchierai, "Hacker Publishes Personal Info of 20,000 FBI Agents," Motherboard, February 8, 2016, https://motherboard.vice.com/read/hacker-publishes-personal-info-of-20000-fbi-agents).
- According to Symantec's 2016 Internet security report:
- In 2015, there were a record-setting total of nine cyber-attacks classified as mega-breaches resulting half a billion personal records stolen or lost. While this number is high, it is considered that many companies do not reveal the full extent of their data breaches.
- There were over one million web attacks against people each day in 2015 due to an estimated 75 percent of all legitimate websites having unpatched vulnerabilities.
- In 2015, ransomware was developed with the capability to target smart phones, Mac, and Linux systems. Symantec even demonstrated proof-of-concept against smart watches and televisions (https://www.symantec.com/security-center/threat-report).

- Bowman Dam. Iranian hackers reportedly gained control of this New York dam's sluice system in 2013, although the controls were manually disconnected at the time of the cyber breach. In March 2016, the Department of Justice (DOJ) indicted one of the hackers employed at an Iran-based computer company with possible ties to the Islamic Revolutionary Guard Corps (http://www.heritage.org/defense/report/cyber-attacks-us-companies-2016).
- In early January 2013, a series of US bank websites were taken down by denial of service attacks, including Capital One, 5th3rd, and PNC banks (http://www.huffingtonpost.com/2013/03/18/florida-cyberattack-election_n_2901969.html).
- During the 2012 election, requests for absentee ballots in Miami-Dade Florida were discovered to be the first officially documented instance than an election was attempted to be altered by a cyber-attack (http://hackmageddon.com/2012-cyber-attacks-statistics-master-index/).
- In May of 2011, Lockheed Martin was attacked. The attack was detected early and 100,000 accounts were locked as a precaution (http://hackmageddon.com/2012-cyber-attacks-statistics-master-index/)

According to the 2015 State of Information Technology in Missouri report published by ITSD, during an average month, the state's intrusion prevention system blocks over two million attacks. In early 2015, the OCS developed a threat intelligence (intel) sharing portal for internal state staff and associated business partners with the state. The portal enables OCS to share threat intel to others quickly and effectively. The portal is meant to raise awareness throughout the state community about the adversaries the state faces and to provide meaningful and actionable intel so others can quickly protect themselves from similar attacks. Since the launch of this portal, OCS has shared over 1,200 pieces of intelligence.

Probability of Future Hazard Events

Every second of every day, there will always exist a possibility for both intentional and un-intentional disruptions. To date, historical events within Missouri have tended to be un-intentional. The number of targets for intentional cyber-attacks would seem now to be limited to a couple power plants and government databases. Though they are targets, Missouri is not aware of a current threat against any of the critical facilities or databases. Moving forward, awareness of the growing threat from both domestic and international cyber-attacks does impress the need to develop robust defense and counter attack systems to protect against the increasing likelihood of an attack.

It is difficult to quantify an exact probability or severity of a disruption due to the limited information available and the many unknown factors. The intent of an intentional disruptor could range from something as minor as leaving a message to a major issue with sensitive data collection or control of a critical facility. The probability of an error or failure is also hard to quantify as most systems are properly updated, replaced, and maintained as needed. Usually it is an extenuating circumstance that drives a failure, which cannot be measured. The probability is thus noted as <1-percent.

Changing Future Conditions Considerations

Cyber Disruption is considered a human-caused/technological hazard and is not impacted by changes in weather patterns/climate.

State Vulnerability Overview

Cyber disruptions have the potential to undermine the confidence that people have in their own security when dealing with any number of cyber systems. Intentional events would also succeed in building doubt in their government's ability to protect them from harm. The potential for a major cyber disruption, through intentional attacks, is the scenario that is more likely to occur, based on currently available information. Attacks of that variety are minimal, though increasing in frequency as the threat evolves. Attackers are likely to have either very specific targets, or desire wide-spread publicity from the attacks that would lead towards the targeting of popular, iconic, or critical systems.

State Estimates of Potential Losses

Due to the variables involved, it is not possible to generate quantitative loss estimates for cyber disruption incidents. The remainder of this section provides a selection of hypothetical scenarios with brief discussions of potential impacts in qualitative terms:

- **Failure of a medical research database:** This would most likely be a localized event that would have minimal losses associated with it if adequate data backup systems are in place. Losses would consist of staff time to restore data from backup as well as down time while the system is inaccessible. Depending on the period of time before the system is brought back on line, associated costs could range from hundreds to thousands of dollars. With this scenario, there are no anticipated injuries or loss of life.
- **Government intranet failure due to hardware failure:** This would also be fairly localized, though external users could also be impacted. Hardware failures are typically able to be replaced within a day or two. Losses would depend on the functionality that is lost while the system is down. Assuming the site is used for general information, inquiries, and some on-line data transactions, the magnitude could be estimated to be in the range of hundreds to thousands of dollars, with no injuries or losses to life.
- **Breach of sensitive database for the justice offices:** This type of event could have broad-reaching effects, depending on if and how the breached data is utilized and whether the public is made aware. Potential losses would be influenced not so much by the event itself, but rather the government's reaction to the event. A partial or complete rebuild of the system and its security processes would occur. In addition, increased security for individuals impacted, as well as resources deployed to identify and prosecute those responsible. A loss of public trust could also entail necessary changes to processes and resources spent to assure the public and re-brand the agency. The magnitude of this type of event could be estimated to be in the range of tens to hundreds of thousands of dollars. Specifically-targeted injuries or deaths could result for those whose personal information was revealed.
- **Utility/Infrastructure services remotely accessed and controlled:** This event would be on the scale of a worst-case situation that could have wide-ranging impacts as a result of a coordinated strike on supervisory control and data acquisition (SCADA) industrial control systems impacting utility and infrastructure controls. Targeting of these areas would have the largest health and safety concerns. Losing direct control of any type of utility could have far-reaching impacts to the safety of the public as well as the functionality of any related systems. This domino effect could negatively influence the daily life activities of the public and could take government services completely off-line. Public safety could be put at risk. For example, if electric utility is the target, individuals that rely on power for health-related treatments could be at risk. Prolonged outages would result in loss of automated traffic control and other power-dependent safety measures. Other utility outages, such as loss of communications would cause additional cascading impacts. This type of event could produce the same impacts as a worse-case natural hazard. The magnitude of losses for this event could reach upwards of millions to billions of dollars. Large scale injuries or deaths could be expected to occur.

Hazard Impact on Future Growth and Development

All areas of the state are considered prone to this hazard. As the populace and infrastructure within Missouri increasingly rely on cyber systems in daily operations, the risk for cyber disruption will only increase. This is a newly developing threat so as more resources are devoted to countering the hazard; the risk to a disruption would hopefully decrease. As infrastructure and facilities are upgrade while new development occurs, planners will need to keep in mind the potential for disruption to essential services due to cyber disruption.

EMAP Consequence Analysis

The information in **Table 3.127** provides the impact analysis of potential for detrimental impacts of hazards completed for the Emergency Management Accreditation Program.

Table 3.127. EMAP Impact Analysis: Cyber Disruption

Subject	Detrimental Impacts
Public	Depending upon the system the impacts could be potentially severe.
Responders	Depending upon the system the impacts could be potentially severe.
Continuity of Operations including continued delivery of services	Depending upon the system the impacts could be potentially severe.
Property, Facilities, and Infrastructure	Depending upon the system the impacts could be potentially severe.
Environment	Depending upon the system the impacts could be potentially severe.
Economic Condition of Jurisdiction	Depending upon the system the impacts could be potentially severe.
Public Confidence in the Jurisdiction's Governance	Depending upon the system the impacts could be potentially severe.

Risk Summary

Cyber Disruption is an emerging hazard that has gained an increasing notoriety as the vulnerability to disruption grows parallel with the dependence for cybernetic systems. Due to the variables involved in the type of disruption (un-intentional vs. intentional), motives of intentional attacks, methods of intentional attacks, and targets of intentional attacks, it is not possible to predict when, how, or where cyber disruption can occur. Mitigation opportunities for this hazard include continued diligence of the States ITSD OCS as well as other government and private-sector entities to continue to monitor, block, and report cyber-attacks as well as continually assess the vulnerability of systems to intentional or unintentional disruptions. Private citizens must also maintain an awareness of potential threats and vulnerabilities to protect private systems.

Problem Statement:

Using Population as the key indicator for Cyber Disruption, the counties most at risk are St. Louis, Jackson, St. Charles, St. Louis City, Greene, Clay, Jefferson, Boone, Jasper and Franklin. Mitigation strategies and limited resources would be most likely better allocated to these counties.

2018 risk assessment data and mapping is available through the Missouri Hazard Mitigation Viewer: http://bit.ly/MoHazardMitigationPlanViewer2018.

3.3.15. Structural and Urban Fires

Probability	Severity
100% 22,412 events per year average	Moderate

Description/Location

Structural fires are a major problem that can affect any area of the State. The Missouri Division of Fire Safety (MDFS) indicates that approximately 73 percent of the fire departments in Missouri are staffed with volunteers dedicated to the task of fire prevention and suppression. Whether paid or volunteer, these departments are often limited by lack of resources and financial assistance. The impact of a fire to a single-story building in a small community may be as great as that of a larger fire to a multistory building in a large city.

Because fires can occur anywhere in the State, the MDFS continues to actively promote the enactment of a statewide fire code. Although no statewide code has been enacted to date, successful legislative efforts to improve fire safety have included the following:

- Fire, Safety, Health, and Sanitation Inspections of Child Care Facilities (RSMo 210.252)
- Boiler and Pressure Vessel Safety Act (RSMo 650.200)
- Elevator Safety Act (RSMo 701.350)
- Fireworks Safety Act (RSMo 320-111)
- Amusement Ride Safety Act (RSMo 316.200-211)
- Inspections of Long Term Care Facilities (RSMo 198.074)
- Missouri Blasting Safety Act (RSMo 319.300)

Fires impact many aspects of society in terms of economic, social, and other indirect costs. According to the MDFS, the costliest crime in the State is arson. This should be a great concern to citizens, law enforcement, the judicial system, and the fire service sector. Fires caused by arson impact citizens through higher insurance premiums, lost jobs, loss of lives, injuries, and property loss. Primary duties of the State Fire Marshal include the investigation of fires, explosions, and any related occurrences. The investigative staff is responsible for investigating any fire requested by fire service and law enforcement within the State. This also includes explosions, bombings, and all other related offenses.

Presently, the MDFS investigative staff includes 1 law enforcement manager, 2 fire investigator supervisors, and multiple field investigators. This staff must cover all 114 counties and is dedicated to assisting any local or state agency and conducting quality investigations. The investigators are trained in several fields of expertise, including arson for fraud, explosives recognition, and post-blast training.

The MDFS Training Unit develops and oversees the training curriculum being provided regionally for state certification of firefighters, fire investigators, fire inspectors, and fire service instructors. Although firefighter certification is not mandatory in Missouri, MDFS has issued more than 71,000 certifications at various levels to more than 28,000 individuals.

Also, the MDFS coordinates a statewide fire mutual aid system. This system enhances the ability of volunteer or career fire departments to handle major fires or incidents within their jurisdictions. To complement the Statewide fire mutual aid system, an incident support team (IST) concept has been developed in regions of the State. The teams are available to assist agencies in the management of major fires and manmade or natural disasters. **Figure 3.183** shows the Fire/Rescue Mutual Aid Regions in Missouri.

Figure 3.183. Missouri Fire and Mutual Aid Regions, 2016

Source: MDFS, Missouri Systems Concept of Operational Planning for Emergencies (MoSCOPE), http://dfs.dps.mo.gov/documents/forms/MO_815-F0072.pdf

Through the mutual aid system, MDFS coordinates K9 team resources. Handlers who wish to be considered for mutual aid deployment must complete a registration form and return it to the Division of Fire Safety for inclusion in the mutual aid resource database. MDFS is primarily interested in registering area and disaster search K9/handler teams, for both live and human remains detection, while tracking/trailing, accelerant detection, bomb detection, and law enforcement K9 teams are also encouraged.

The MDFS is responsible for the enforcement of fireworks laws throughout Missouri. In addition to conducting inspections of any facilities involved with fireworks, over 1,200 permits are issued seasonally to manufacturers, wholesalers, and retailers of fireworks who can sell to the public from approximately June 20th to July 10th and from Dec. 20th to Jan. 2nd each year. Persons conducting public fireworks shows are required to obtain a fireworks operator license issued by the MDFS. Illegal fireworks are a concern, because they can be dangerous, causing loss of lives, severe injuries, and property damage.

Extent

As defined by the National Fire Protection Agency (NFPA), a structure fire is defined as “any fire inside, on, under, or touching a structure.” This definition includes any mobile living structure such as a mobile or modular residence, but does not include roadworthy vehicles such as recreation vehicles (National Fire Protection Agency, 2011). A variety of factors will determine the extent of damage to the individual structure. Damage can range from minor to substantial with damages far exceeding the value of the structure. Factors include:

- Structure type and age
- Building codes addressing fire prevention, detection, and extinguishments
- Density of development
- Presence of flammable substances
- Fire department response speed
- Firefighting technology
- Training of local fire management officials and fire fighters
- Public information about common fire hazards and use of smoke alarms
- Notification techniques and procedures
- Water pressure and availability

There are additional economic consequences related to this hazard. Urban fires and explosions may result in lost wages due to temporarily or permanently closed businesses, destruction and damage involving business and personal assets, loss of tax base, recovery costs, and lost investments in destroyed property.

The secondary effects of urban fire and explosion events relate to the ability of public, private, and nonprofit entities to provide post-incident relief. Human services agencies (community support programs, health and medical services, public assistance programs and social services) can be affected by urban fire and explosion events as well. Effects may consist of physical damage to facilities and equipment, disruption of emergency communications, loss of health and medical facilities and supplies, and an overwhelming load of victims who are suffering from the effects of urban fire, including the loss of their home or place of business.

Previous Occurrences

Because buildings exist anywhere people live and work, fires can occur at anytime and anyplace throughout the State. The frequency of structural fires depends on a wide range of factors. These factors include, but are not limited to, population or building density, building use, lack of fire codes, lack of enforcement when fire codes exist, fire safety practices (or lack thereof) by building occupants, lack of adequately equipped fire departments, and criminal intent related to arson.

Data on the frequency of structural fires is included in the National Fire Incident Reporting System Statistics (NFIRS) data provided by the MDFS (See **Table 3.128)**. This table also shows the change in fire statistics from year to year. Out of nearly 771 registered fire departments in the State, 450 are currently NFIRS user agencies. This translates to approximately 60 percent of departments are actively reporting data used to compile the NFIRS. Without 100 percent reporting, definitive conclusions are not possible; however, fire departments, law enforcement offices, and other agencies spend considerable manpower and funding to respond to and investigate structural fires. Additional information on NFIRS can be found at [http://dfs.dps.mo.gov/programs/resources/fire-incident-reporting-system.php.](http://dfs.dps.mo.gov/programs/resources/fire-incident-reporting-system.php)

Table 3.128. Missouri Structural and Urban Fire Statistics (2002-2016)

Year	Total Fires	Δ	Total Fire Dollar Loss	Δ	Fire Related Injuries	Δ	Fire Related Deaths	Δ
2002	19,749		$80,184,764		225		39	
2003	22,097	2,348	$68,193,344	($11,991,420)	272	47	48	9
2004	30,731	8,634	$103,699,511	$35,506,167	371	99	86	38
2005	24,182	-6,549	$99,120,053	($4,579,458)	319	-52	51	-35
2006	29,865	5,683	$1,238,056,662	$1,138,936,609	377	58	70	19
2007	27,324	-2,541	$4,156,015,816	$2,917,959,154	375	-2	70	0
2008	24,647	-2,677	$9,343,081,187	$5,187,065,371	12	-363	68	-2
2009	25,795	1,148	$2,399,531,780	($6,943,549,407)	287	275	57	-11
2010	24,785	-1,010	$6,132,675,694	$3,733,143,914	382	95	78	21
2011	22,429	-2,356	$127,256,829	($6,005,418,865)	288	-94	50	-28
2012	19,293	-3,136	$4,152,595,091	$4,025,338,262	317	29	44	-6
2013	18,970	-323	n/a	n/a	592	275	225	181
2014	18,970	0	n/a	n/a	592	0	225	0
2015	8,379	-10,591	**$1,137,228,082**	n/a	310	-282	46	-179
2016	18,970	10,591	n/a	n/a	592	282	225	179
AVG.	**22,412**		**$2,419,803,234**		**354**		**92**	

Source: NFIRS; data for 2013, 2014, and 2016 was not independently available, data provided is annualized.

Significant historical structural and urban fire events include the following:

- 1914 – Missouri Athletic Club fire in St. Louis, Missouri, killed 30 on March 9
- 1927 – Buckingham Hotel arson fire in St. Louis, Missouri, killed 7 on December 5
- 1952 – Nursing home fire in Hillsboro, Missouri, killed 20 on October 31
- 1956 – Reagan Nursing Home fire in Puxico, Missouri, killed 12 on July 31
- 1957 – Warrenton Nursing Home Fire in Warrenton, Missouri, killed 72 on February 17
- 1973 – National Archives Fire in St. Louis, Missouri, destroyed approximately 16-18 million official military personnel files
- 1979 – Nursing home fire in Farmington, Missouri, kills 26 on April 2

Probability of Future Hazard Events

According to the NFRIS data (2002-2016), the average annual number of structural and urban fires in Missouri is 22,412 causing estimated total annual average damages in the amount of $2.4 billion. Even with the limited data in the NFIRS statistics, the probability of structural fires is very high. Many factors contribute to the cause of structural and urban fires. Due to the various factors, urban areas in Missouri are considered at risk to one degree or another. Minor urban fires can be expected often in Missouri. Major fires will continue to occur several times a year, particularly in dense, urban areas with aging building stock. Similar to the various factors related to extent of the hazard, the probability of future occurrences may decrease with the construction of new buildings to building codes that address fire prevention, detection, and extinguishments. Also, continued efforts to increase public awareness of the dangers of urban fires will help to mitigate injury, death, and property loss. The probability of future occurrence may increase in communities whose populations are growing and where new areas are developed.

Changing Future Conditions Considerations

Changing future conditions with respect to climate are not likely to impact the probability or severity of this hazard.

State Vulnerability Overview

Structural and urban fires are a daily occurrence throughout the State. According to the U.S Fire Administration, approximately 5.3 fatalities per 1,000 fires occur annually in Missouri, as well as numerous injuries affecting the lives of the victims, their families, and many others—especially those involved in fire and medical services. Unlike other disasters, structural fires are often insidious and despicable due to the prevalence of arson. All citizens pay the costs of arson whether through increased insurance rates, higher costs to maintain fire and medical services, or the costs of supporting the criminal justice system.

The method used to determine vulnerability to structural and urban fires across Missouri was statistical analysis of data from several sources: HAZUS building exposure value data, housing density data from the U.S. Census (2015 ACS), the calculated Social Vulnerability Index for Missouri Counties from the Hazards and Vulnerability Research Institute in the Department of Geography at the University of South Carolina, and structural fire incident data (2002-2012) from the National Fire Incident Reporting System (NFIRS). The statewide percent of fire departments reporting to the NFIRS in 2015 was 60%. Although not all departments report to this system, it is the best available data from which to perform the statistical analysis. The incident types considered for structural and urban fire were those in the incident series 100-139. These incident types include all fires in the following categories:

1) Fires-other
2) Structure fire
3) Fire in mobile property used as a fixed structure
4) Mobile property (vehicle) fire

The fire incident types not considered for structural and urban fire are the considered wildfire incident types in the incident series 140-173 which include: natural vegetation fire, outside rubbish fire, special outside fire, and cultivated vegetation, crop fire.

From the statistical data collected, six factors were considered in determining overall vulnerability to structural and urban fire as follows: housing density, building exposure, social vulnerability, likelihood of occurrence, annual property loss, and number of deaths/injuries. Based on natural breaks in the statistical data, a rating value of 1 through 5 was assigned to each factor. These rating values correspond to the following descriptive terms:

1) Low
2) Low-medium
3) Medium
4) Medium-high
5) High

Table 3.114 provides the factors considered and the ranges for the rating values assigned.

Table 3.129. Ranges for Structural and Urban Fire Vulnerability Factor Ratings

Factors Considered	Low (1)	Low Medium (2)	Medium (3)	Medium High (4)	High (5)
Building Exposure ($)	$269,532-$3,224,641	$3,224,642-$8,792,829	$8,792,830-$22,249,768	$22,249,769-$46,880,213	$46,880,214-$138,887,850
Housing Density (# per sq. mile)	4.11-44.23	44.24-134.91	134.92-259.98	259.99-862.69	862.70-2836.23
Social Vulnerability	1	2	3	4	5
Structural and Urban Fire Likelihood of Occurrence (# of events/ yrs. of data)	0 to 49	50 to 99	100 to 299	300 to 499	500+
Total Annualized Property Loss	$0 - $1,418,838	$1,418,839 - $4,742,961	$4,742,962 - $11,010,704	$11,010,705 - $500,454,576	$500,454,577 - $3,093,587,180
Death/Injury (2X # of deaths + # of injuries)	0 to 4	5 to 9	10 to 19	20 to 49	50+

Once the ranges were determined and applied to all factors considered in the analysis, the ratings were combed to determine an overall vulnerability rating for structural and urban fire. **Table 3.130** provides the calculated ranges applied to determine overall vulnerability of Missouri counties to structural and urban fire. The figures that follow provide the mapped results of this analysis by county.

Table 3.130. Ranges for Structural and Urban Fire Combined Vulnerability Rating

	Low (1)	Low-medium (2)	Medium (3)	Medium-High (4)	High (5)
Structural and Urban Fire Combined Vulnerability	7-10	11-13	14-16	17-21	22-27

The table below provides the housing density, building exposure, SOVI index ranking and associated vulnerability rating.

Table 3.131. Building Exposure, Housing Density, and SOVI Data by County

County	Total Building Exposure (Hazus)	Exposure Rating	Housing Density	Housing Density Rating	SOVI Index Ranking	SOVI Rating
Adair	$2,599,614,000	1	19.93	1	Medium	3
Andrew	$1,724,819,000	1	16.88	1	Medium Low	2
Atchison	$806,754,000	1	5.42	1	Medium High	4
Audrain	$2,689,090,000	1	15.62	1	Medium High	4
Barry	$3,736,121,000	2	22.40	1	Medium	3
Barton	$1,414,960,000	1	9.42	1	Medium	3
Bates	$1,650,150,000	1	9.36	1	Medium	3
Benton	$2,478,458,000	1	19.93	1	Medium High	4
Bollinger	$1,035,129,000	1	9.45	1	Medium Low	2
Boone	$18,473,209,000	3	105.32	2	Low	1
Buchanan	$10,579,076,000	3	94.32	2	Medium	3
Butler	$4,144,110,000	2	28.30	1	Medium High	4
Caldwell	$984,103,000	1	10.80	1	Medium	3

3 Risk Assessment

County	Total Building Exposure (Hazus)	Exposure Rating	Housing Density	Housing Density Rating	SOVI Index Ranking	SOVI Rating
Callaway	$4,410,445,000	2	22.21	1	Medium Low	2
Camden	$8,325,943,000	2	62.86	2	Medium High	4
Cape Girardeau	$8,792,829,000	2	56.87	2	Medium	3
Carroll	$1,199,939,000	1	6.63	1	Medium	3
Carter	$519,266,000	1	6.38	1	Medium High	4
Cass	$10,922,958,000	3	58.01	2	Low	1
Cedar	$1,307,607,000	1	15.13	1	Medium High	4
Chariton	$938,756,000	1	5.53	1	Medium High	4
Christian	$7,747,900,000	2	57.48	2	Medium Low	2
Clark	$709,999,000	1	6.84	1	Medium Low	2
Clay	$27,589,080,000	4	237.97	3	Medium Low	2
Clinton	$2,282,850,000	1	21.20	1	Medium	3
Cole	$10,724,282,000	3	82.94	2	Medium Low	2
Cooper	$1,797,081,000	1	13.21	1	Medium Low	2
Crawford	$2,389,455,000	1	16.06	1	Medium	3
Dade	$738,641,000	1	8.05	1	Medium	3
Dallas	$1,358,763,000	1	14.04	1	Medium	3
Daviess	$958,602,000	1	7.42	1	Medium	3
DeKalb	$1,090,102,000	1	10.21	1	Low	1
Dent	$1,451,544,000	1	9.65	1	Medium High	4
Douglas	$1,047,849,000	1	7.95	1	Medium	3
Dunklin	$2,976,060,000	1	26.53	1	High	5
Franklin	$11,417,093,000	3	47.40	2	Medium Low	2
Gasconade	$1,888,630,000	1	15.77	1	Medium	3
Gentry	$689,499,000	1	6.52	1	Medium High	4
Greene	$32,106,732,000	4	189.79	3	Medium	3
Grundy	$1,175,303,000	1	11.49	1	Medium High	4
Harrison	$1,024,720,000	1	6.07	1	Medium High	4
Henry	$2,536,896,000	1	15.64	1	Medium	3
Hickory	$865,580,000	1	16.92	1	High	5
Holt	$622,760,000	1	6.01	1	Medium	3
Howard	$1,086,442,000	1	9.79	1	Medium Low	2
Howell	$3,550,892,000	2	19.47	1	Medium	3
Iron	$978,688,000	1	9.62	1	Medium High	4
Jackson	$89,309,906,000	5	519.48	4	Medium	3
Jasper	$12,070,483,000	3	80.05	2	Medium	3
Jefferson	$22,249,768,000	3	134.91	2	Low	1
Johnson	$6,044,509,000	2	26.18	1	Low	1
Knox	$438,423,000	1	4.51	1	Medium High	4
Laclede	$3,218,581,000	1	20.62	1	Medium	3
Lafayette	$3,841,393,000	2	23.42	1	Medium Low	2
Lawrence	$3,495,760,000	2	27.09	1	Medium	3
Lewis	$995,873,000	1	8.94	1	Medium	3
Lincoln	$4,719,921,000	2	33.63	1	Low	1
Linn	$1,551,785,000	1	10.36	1	Medium High	4
Livingston	$1,711,120,000	1	12.66	1	Medium High	4
Macon	$1,634,837,000	1	9.52	1	Medium High	4

County	Total Building Exposure (Hazus)	Exposure Rating	Housing Density	Housing Density Rating	SOVI Index Ranking	SOVI Rating
Madison	$1,135,602,000	1	12.03	1	Medium High	4
Maries	$955,863,000	1	8.71	1	Medium	3
Marion	$3,224,641,000	1	29.49	1	Medium High	4
McDonald	$1,683,620,000	1	18.26	1	Medium	3
Mercer	$401,520,000	1	4.67	1	Medium High	4
Miller	$2,404,472,000	1	21.50	1	Medium High	4
Mississippi	$1,114,534,000	1	13.86	1	Medium High	4
Moniteau	$1,508,058,000	1	14.80	1	Medium Low	2
Monroe	$979,485,000	1	7.43	1	Medium	3
Montgomery	$1,397,445,000	1	11.45	1	Medium High	4
Morgan	$2,872,295,000	1	25.80	1	Medium High	4
New Madrid	$1,765,289,000	1	12.64	1	High	5
Newton	$5,509,504,000	2	38.96	1	Medium Low	2
Nodaway	$2,447,800,000	1	10.96	1	Medium	3
Oregon	$891,037,000	1	6.89	1	Medium High	4
Osage	$1,611,790,000	1	10.85	1	Low	1
Ozark	$926,358,000	1	7.55	1	Medium	3
Pemiscot	$1,642,290,000	1	16.48	1	High	5
Perry	$2,233,009,000	1	18.14	1	Medium Low	2
Pettis	$4,468,128,000	2	26.68	1	Medium	3
Phelps	$4,743,488,000	2	29.35	1	Medium Low	2
Pike	$1,861,578,000	1	11.68	1	Medium Low	2
Platte	$11,360,168,000	3	94.90	2	Low	1
Polk	$2,708,704,000	1	20.98	1	Medium	3
Pulaski	$5,334,660,000	2	33.60	1	Low	1
Putnam	$532,020,000	1	5.73	1	Medium	3
Ralls	$1,155,646,000	1	10.93	1	Medium Low	2
Randolph	$2,425,165,000	1	22.11	1	Medium Low	2
Ray	$2,537,055,000	1	17.52	1	Medium Low	2
Reynolds	$669,647,000	1	4.97	1	Medium High	4
Ripley	$1,131,335,000	1	10.40	1	Medium High	4
Saline	$2,437,646,000	1	13.35	1	Medium	3
Schuyler	$401,800,000	1	6.79	1	Medium	3
Scotland	$541,487,000	1	5.38	1	Medium High	4
Scott	$4,036,288,000	2	40.47	1	Medium	3
Shannon	$678,728,000	1	4.11	1	Medium	3
Shelby	$786,622,000	1	6.37	1	Medium	3
St. Charles	$41,845,005,000	4	259.98	3	Low	1
St. Clair	$936,097,000	1	8.36	1	Medium High	4
St. Francois	$6,180,166,000	2	64.59	2	Medium Low	2
St. Louis	$138,887,850,000	5	862.69	4	Medium Low	2
St. Louis City	$46,880,213,000	4	2836.23	5	High	5
Ste. Genevieve	$2,163,144,000	1	17.27	1	Medium Low	2
Stoddard	$2,989,130,000	1	16.52	1	Medium	3
Stone	$3,936,498,000	2	44.23	1	Medium High	4
Sullivan	$624,603,000	1	5.16	1	Medium High	4
Taney	$6,120,612,000	2	47.41	2	High	5

County	Total Building Exposure (Hazus)	Exposure Rating	Housing Density	Housing Density Rating	SOVI Index Ranking	SOVI Rating
Texas	$2,293,426,000	1	9.86	1	Medium	3
Vernon	$2,251,400,000	1	11.47	1	Medium High	4
Warren	$3,478,576,000	2	34.75	1	Medium Low	2
Washington	$1,730,986,000	1	14.34	1	Medium	3
Wayne	$1,256,590,000	1	10.54	1	Medium High	4
Webster	$2,782,115,000	1	24.42	1	Medium Low	2
Worth	$269,532,000	1	4.78	1	Medium High	4
Wright	$1,602,331,000	1	12.66	1	Medium	3

Table 3.132 provides additional data obtained from the National Fire Incident Reporting System to complete the overall vulnerability analysis and the total overall vulnerability rating for structural and urban fires.

Table 3.132. Likelihood of Occurrence, Annual Property Loss, Death/Injury Rating and Overall Vulnerability Rating for Structural and Urban Fires, 2002-2012

County	Likelihood of Occurrence	Likelihood of Occurrence Rating	Total Annualized Property Loss	Total Annualized Property Loss Rating	# of Deaths/Injuries	# of Deaths/Injuries Rating	Overall Vulnerability Rating	Overall Vulnerability Rating Description
Adair	2	1	$91,750	1	0	1	8	Low
Andrew	18	1	$43,438	1	2	1	7	Low
Atchison	24	1	$209,750	1	0	1	9	Low
Audrain	40	1	$127,354	1	0	1	9	Low
Barry	235	3	$2,348,775	2	73	5	16	Medium
Barton	68	2	$1,250	1	6	2	10	Low
Bates	65	2	$617,283	1	23	4	12	Low Medium
Benton	92	2	$600,846	1	17	3	12	Low Medium
Bollinger	32	1	$26,350	1	0	1	7	Low
Boone	250	3	$1,703,748	2	17	3	14	Medium
Buchanan	453	4	$4,742,961	2	90	5	19	Medium High
Butler	375	1	$1,013	1	46	4	13	Low Medium
Caldwell	33	1	$190,355	1	23	4	11	Low Medium
Callaway	161	3	$933,628	1	25	4	13	Low Medium
Camden	247	3	$823,724	1	123	5	17	Medium High
Cape Girardeau	131	3	$1,018,812	1	14	3	14	Medium
Carroll	91	2	$246,388	1	192	5	13	Low Medium
Carter	3	1	$6,250	1	0	1	9	Low
Cass	314	4	$2,922,337	2	40	4	16	Medium
Cedar	101	3	$280,773	1	17	3	13	Low Medium

County	Likelihood of Occurrence	Likelihood of Occurrence Rating	Total Annualized Property Loss	Total Annualized Property Loss Rating	# of Deaths/Injuries	# of Deaths/Injuries Rating	Overall Vulnerability Rating	Overall Vulnerability Rating Description
Chariton	39	1	$77,711	1	0	1	9	Low
Christian	318	4	$1,154,653	1	24	4	15	Medium
Clark	26	1	$199,013	1	5	2	8	Low
Clay	301	4	$2,821,315	2	56	5	20	Medium High
Clinton	133	3	$762,583	1	20	4	13	Low Medium
Cole	64	2	$338,115	1	3	1	11	Low Medium
Cooper	81	2	$1,139,950	1	17	3	10	Low
Crawford	195	3	$500,454,576	4	124	5	17	Medium High
Dade	46	1	$56,600	1	7	2	9	Low
Dallas	35	1	$385,418	1	10	3	10	Low
Daviess	69	2	$498,838	1	6	2	10	Low
DeKalb	61	2	$432,096	1	3	1	7	Low
Dent	66	2	$883,313	1	4	1	10	Low
Douglas	39	1	$481,425	1	5	2	9	Low
Dunklin	108	3	$903,143	2	10	3	15	Medium
Franklin	497	4	$2,720,556	2	34	4	17	Medium High
Gasconade	65	2	$530,075	1	5	2	10	Low
Gentry	1	1	$0	1	0	1	9	Low
Greene	1308	5	$7,497,115	3	167	5	23	High
Grundy	98	2	$906,142	1	16	3	12	Low Medium
Harrison	41	1	$398,913	1	8	2	10	Low
Henry	149	3	$1,403,733	1	49	4	13	Low Medium
Hickory	24	1	$103,625	1	4	1	10	Low
Holt	21	1	$220,081	1	0	1	8	Low
Howard	89	2	$4,681	1	524	5	12	Low Medium
Howell	255	3	$1,589,394	2	224	5	16	Medium
Iron	61	2	$165,975	1	2	1	10	Low
Jackson	3195	5	$3,093,587,180	5	236	5	27	High
Jasper	629	5	$3,556,000	2	66	5	20	Medium High
Jefferson	632	5	$2,553,764	2	99	5	18	Medium High
Johnson	191	3	$818,586	1	36	4	12	Low Medium
Knox	7	1	$61,250	1	2	1	9	Low
Laclede	113	3	$223,308	1	75	5	14	Medium
Lafayette	162	3	$538,540	1	16	3	12	Low Medium
Lawrence	137	3	$1,223,428	1	41	4	14	Medium
Lewis	45	1	$250,225	1	0	1	8	Low
Lincoln	248	3	$1,163,485	1	14	3	11	Low Medium
Linn	49	1	$226,838	1	11	3	11	Low Medium
Livingston	39	1	$223,220	1	8	2	10	Low
Macon	33	1	$353,298	1	20	4	12	Low Medium

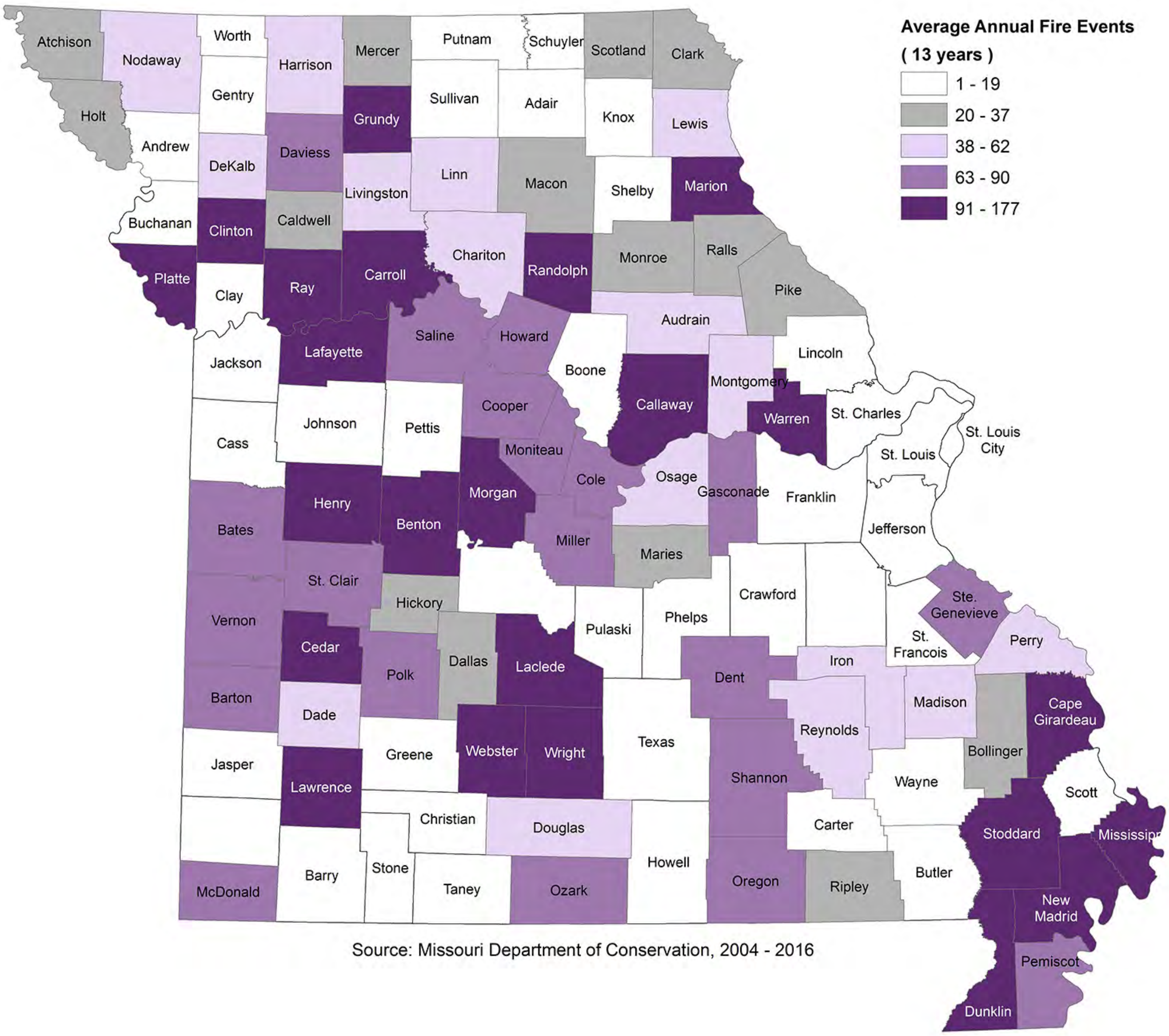
County	Likelihood of Occurrence	Likelihood of Occurrence Rating	Total Annualized Property Loss	Total Annualized Property Loss Rating	# of Deaths/Injuries	# of Deaths/Injuries Rating	Overall Vulnerability Rating	Overall Vulnerability Rating Description
Madison	61	2	$500	1	3	1	10	Low
Maries	28	1	$94,725	1	2	1	8	Low
Marion	176	3	$1,086,442	1	56	5	15	Medium
McDonald	74	2	$76,838	1	5	2	10	Low
Mercer	31	1	$11,025	1	8	2	10	Low
Miller	80	2	$2,120,003	2	7	2	12	Low Medium
Mississippi	106	3	$1,747,609	2	4	1	12	Low Medium
Moniteau	88	2	$1,201,209	1	0	1	8	Low
Monroe	36	1	$76,925	1	0	1	8	Low
Montgomery	61	2	$602,800	1	16	3	12	Low Medium
Morgan	113	3	$978,530	1	16	3	13	Low Medium
New Madrid	140	3	$1,249,658	1	42	4	15	Medium
Newton	277	3	$1,678,486	2	28	4	14	Medium
Nodaway	51	2	$704,963	1	9	2	10	Low
Oregon	66	2	$128,950	1	6	2	11	Low Medium
Osage	41	1	$194,863	1	39	4	9	Low
Ozark	83	2	$892,031	1	22	4	12	Low Medium
Pemiscot	82	2	$1,418,838	1	12	3	13	Low Medium
Perry	47	1	$738,138	1	2	1	7	Low
Pettis	190	3	$313,200	1	12	3	13	Low Medium
Phelps	201	3	$1,020,777	1	187	5	14	Medium
Pike	25	1	$22,476	1	46	4	10	Low
Platte	158	3	$666,891	1	43	4	14	Medium
Polk	69	2	$2,075	1	3	1	9	Low
Pulaski	185	3	$426,824	1	145	5	13	Low Medium
Putnam	13	1	$209,819	1	15	3	10	Low
Ralls	25	1	$3,375	1	0	1	7	Low
Randolph	139	3	$1,241,845	1	20	4	12	Low Medium
Ray	149	3	$458,450	1	9	2	10	Low
Reynolds	44	1	$112,275	1	17	3	11	Low Medium
Ripley	24	1	$144,450	1	0	1	9	Low
Saline	82	2	$686,711	1	2	1	9	Low
Schuyler	0	1	$0	1	0	1	8	Low
Scotland	30	1	$761,613	1	3	1	9	Low
Scott	222	3	$1,415,352	1	25	4	14	Medium
Shannon	64	2	$427,514	1	0	1	9	Low
Shelby	7	1	$1,163	1	0	1	8	Low
St. Charles	676	5	$8,001,810	3	166	5	21	Medium High
St. Clair	72	2	$395,611	1	24	4	13	Low Medium
St. Francois	297	3	$1,542,971	2	29	4	15	Medium

County	Likelihood of Occurrence	Likelihood of Occurrence Rating	Total Annualized Property Loss	Total Annualized Property Loss Rating	# of Deaths/Injuries	# of Deaths/Injuries Rating	Overall Vulnerability Rating	Overall Vulnerability Rating Description
St. Louis	1,637	5	$11,010,704	3	195	5	24	High
St. Louis City	11,647	5	$6,481,025	3	174	5	27	High
Ste. Genevieve	69	2	$484,900	1	22	4	11	Low Medium
Stoddard	139	3	$669,575	1	12	3	12	Low Medium
Stone	253	3	$187,032	1	148	5	16	Medium
Sullivan	3	1	$31,500	1	0	1	9	Low
Taney	332	4	$3,004,301	2	18	3	18	Medium High
Texas	179	3	$1,188,786	1	25	4	13	Low Medium
Vernon	77	2	$664,808	1	12	3	12	Low Medium
Warren	152	3	$937,188	1	9	2	11	Low Medium
Washington	301	4	$388,550	1	27	4	14	Medium
Wayne	17	1	$0	1	0	1	9	Low
Webster	132	3	$306,850	1	3	1	9	Low
Worth	15	1	$273,675	1	0	1	9	Low
Wright	130	3	$3,388,852	2	14	3	13	Low Medium

0 provides the statewide results for the likelihood factor followed Figure 3.186 that provides the overall vulnerability rating calculated by assigning an equal weight to each of the six contributing factors.

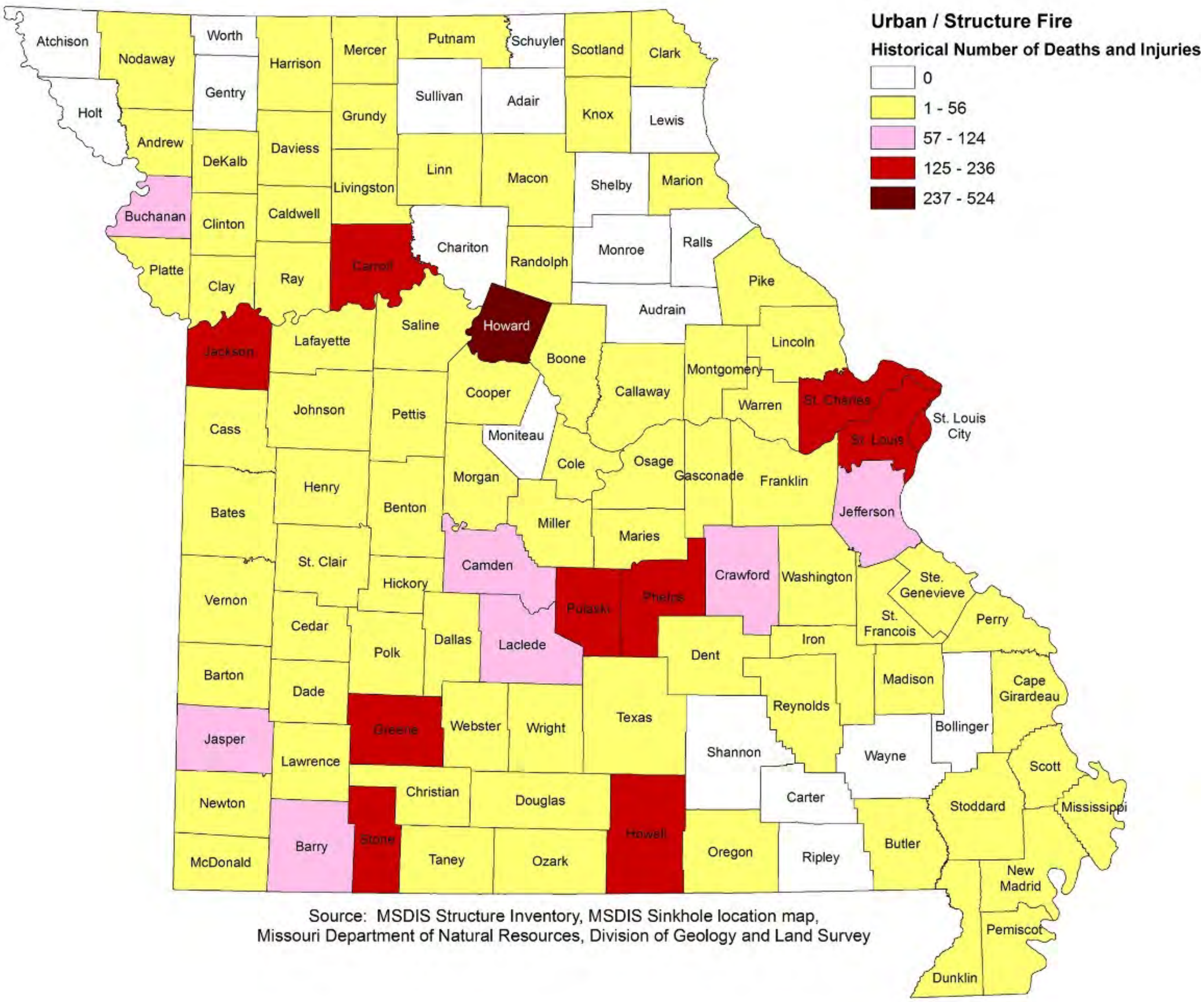
It should be noted that there are limiting factors inherent to the NFIRS source data. MDFS was not able to provide detailed county data for 2012-2016, only statewide summary data was available. Additionally, with 60-percent of Missouri Fire Departments reporting to the system, the available data does not present the complete hazard impact. Other factors to consider if data is available are the age of structures, building materials used, surrounding terrain and vegetation, occupancy status and status of regulatory oversight. These types of details are not consistently available on a statewide level. However, they may be more readily available at the local level.

Figure 3.184. Average Annual Structural and Urban Fire Events



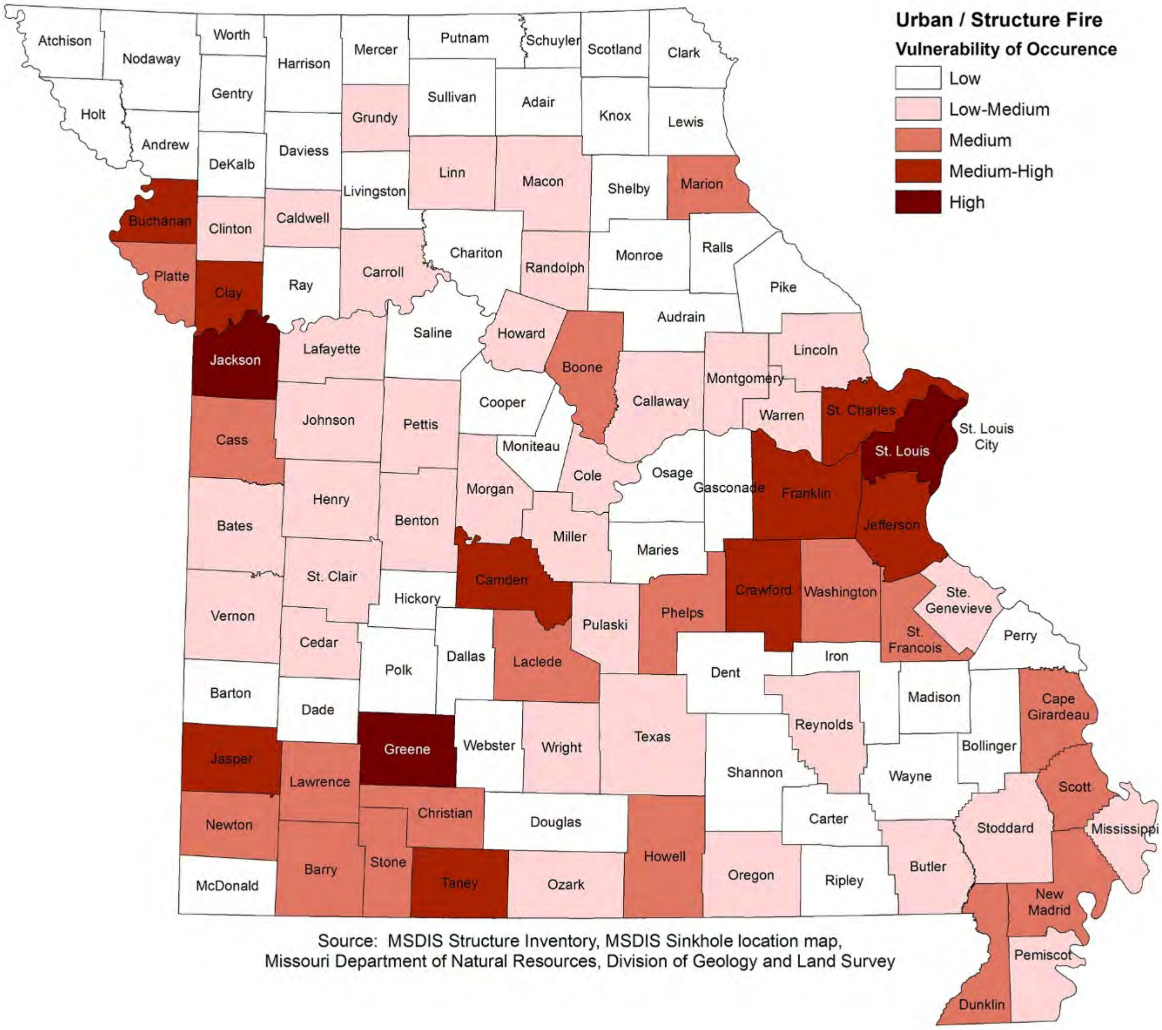
Source: Missouri Department of Conservation, 2004 - 2016

Figure 3.185. Historical Number of Deaths and Injuries due to Structural and Urban Fires



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

Figure 3.186. Vulnerability to Structural and Urban Fire



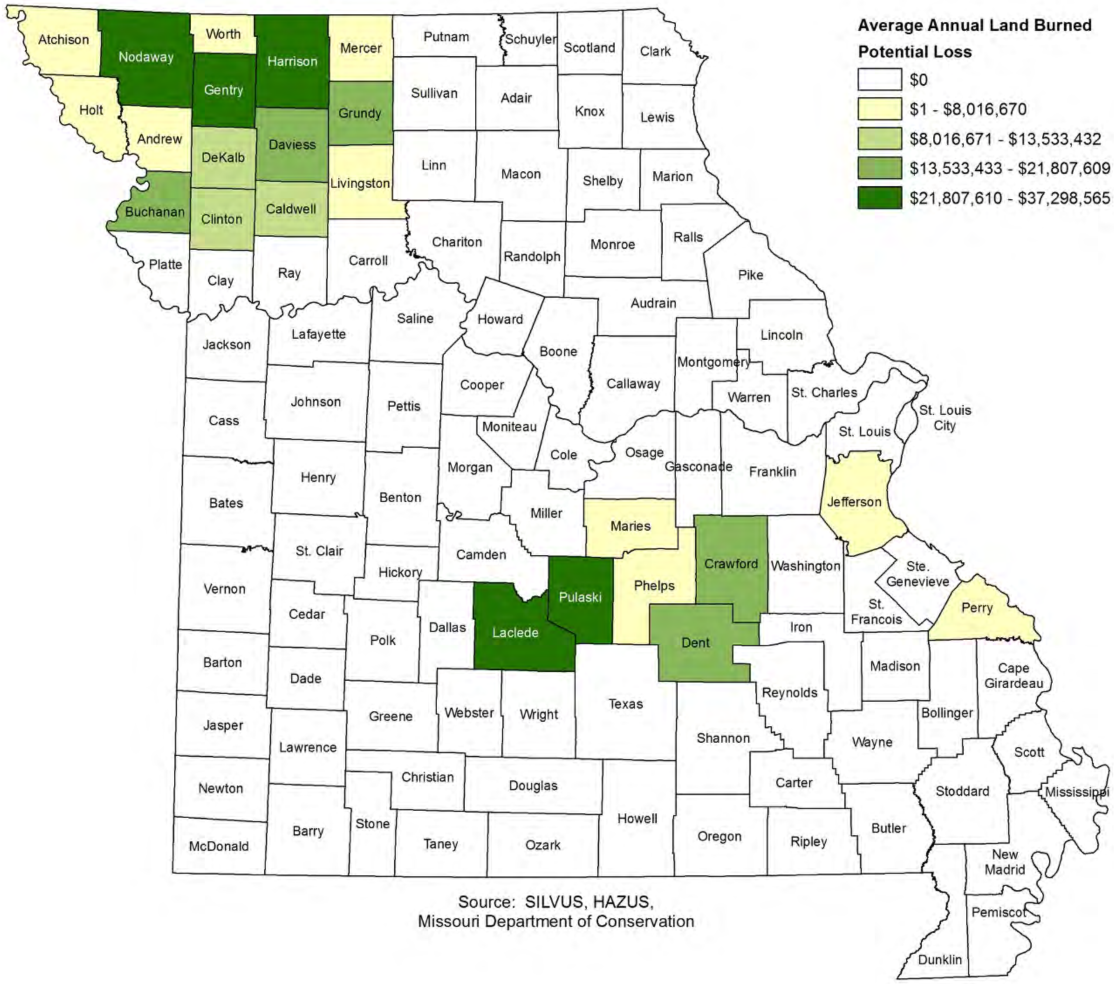
According to this vulnerability analysis, the following counties have a high vulnerability to structural and urban fires: Greene, Jackson, St. Louis, and the City of St. Louis.

State Estimates of Potential Losses

Structural and urban fires caused a total of 764 deaths and 2,403 injuries during the 5-year period from 2012-2016. This translates to an annualized occurrence of 153 deaths and 481 injuries statewide. With so many variables involved in death and injury occurrences, it is difficult to predict where future losses will occur.

To determine potential financial loss estimates to structural and urban fire in Missouri, the available historical loss data was annualized. In the case of this type of frequently occurring hazard, annualized historical loss data is considered to be the best resource for determining future potential losses**. Table 3.132** provides the annualized total property losses for all counties in Missouri. **Figure 3.187** that follows provides this same information in map format.

Figure 3.187. Annualized Property Loss due to Structural and Urban Fire



Hazard Impact on Future Growth and Development

Of the top 10 counties vulnerable to structural and urban fire according to this statistical analysis methodology, the following also had population increases over from 2010-2015: Buchanan, Crawford, Davis, Dent, Harrison, Laclede, Nodaway and Pulaski.

EMAP Consequence Analysis

The information in **Table 3.133** is from the Impact Analysis of Potential for Detrimental Impacts of Hazards done for the Emergency Management Accreditation Program.

Table 3.133. EMAP Impact Analysis: Structural and Urban Fires

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

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

Risk Summary

With sufficient mutual aid, local fire services have adequate day-to-day fire service capabilities. The greatest risk of interaction by fires with other hazards may involve damaging earthquakes. In these circumstances, the possibility of numerous fires and reduced firefighting capabilities would greatly increase the severity of structural and urban fires.

Problem Statement:

Using Vulnerability to Structural and Urban Fire as the key indicator, the counties most at risk are Jackson, Greene and St. Louis City/County. Mitigation resources allocated to these counties would be the most beneficial.

2018 risk assessment data and mapping is available through the Missouri Hazard Mitigation Viewer: http://bit.ly/MoHazardMitigationPlanViewer2018.

3.3.16. Hazardous Materials Release (Fixed Facility and Transportation Accidents)

Probability	Severity
Fixed Facility – 100% 69 events per year average	Moderate
Transportation – 100% 806 events per year average	Moderate

Description/Location

A hazardous material is any substance or material in a quantity or form that may pose a reasonable risk to health, the environment, or property. The category of hazardous materials release includes incidents involving substances such as toxic chemicals, fuels, nuclear wastes and/or products, and other radiological and biological or chemical agents. For the purposes of this analysis, only accidental or incidental releases of hazardous materials from two different kinds of incidents are addressed: fixed facility and transportation-related accidents. In consideration of recent worldwide and national events, incidents involving terrorism or national attacks, which involve hazardous materials of any type, are addressed in Section 2.1 CBRNE Attack, Section 3.5.2 Terrorism, and Section 2.8 Special Events.

Hazardous Materials Fixed-Facility Accident

Generally, with a fixed facility, the hazards are pre-identified. The Emergency Planning and Community Right-to-Know Act (EPCRA) of 1986 requires industries to report on the storage, use and releases of hazardous substances to federal, state, and local governments. Facilities in Missouri must submit an emergency and hazardous chemical inventory form to the Missouri Emergency Response Commission, their Local Emergency Planning Committee (LEPC), and local fire departments annually. The inventory forms require basic facility identification information, employee contact information for both emergencies and non-emergencies, and information about chemicals stored or used at the facility.

Table 3.134 and **Figure 3.188** present the number of facilities reporting hazardous material storage per county along with the number of facilities reporting storage of extremely hazardous substances (EHS), as defined by the EPA.

Table 3.134. Tier II Reporting Facilities within Missouri, 2016

County	No. of Tier II	No. of Tier II with EHS	County	No. of Tier II	No. of Tier II with EHS
Adair County	41	9	Livingston County	44	10
Andrew County	31	4	Macon County	43	6
Atchison County	37	13	Madison County	18	2
Audrain County	68	25	Maries County	18	0
Barry County	89	28	Marion County	71	14
Barton County	38	11	McDonald County	46	12
Bates County	36	8	Mercer County	27	11
Benton County	44	4	Miller County	62	5
Bollinger County	16	2	Mississippi County	38	12
Boone County	202	57	Moniteau County	39	5
Buchanan County	165	55	Monroe County	25	8

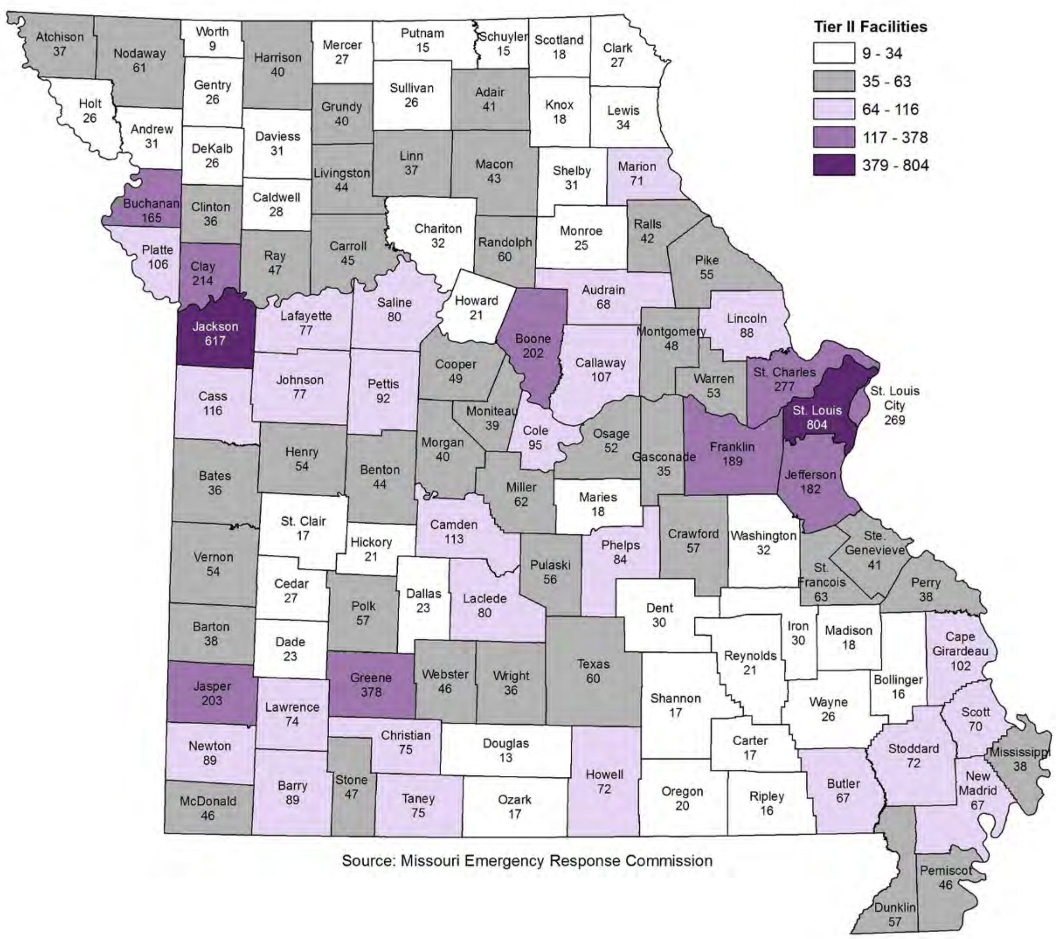
County	No. of Tier II	No. of Tier II with EHS
Butler County	67	15
Caldwell County	28	4
Callaway County	107	33
Camden County	113	14
Cape Girardeau County	102	28
Carroll County	45	15
Carter County	17	0
Cass County	116	23
Cedar County	27	6
Chariton County	32	13
Christian County	75	8
Clark County	27	9
Clay County	214	64
Clinton County	36	7
Cole County	95	13
Cooper County	49	15
Crawford County	57	8
Dade County	23	6
Dallas County	23	1
Daviess County	31	7
DeKalb County	26	6
Dent County	30	3
Douglas County	13	3
Dunklin County	57	19
Franklin County	189	27
Gasconade County	35	5
Gentry County	26	5
Greene County	378	105
Grundy County	40	8
Harrison County	40	8
Henry County	54	12
Hickory County	21	0
Holt County	26	10
Howard County	21	7
Howell County	72	7
Iron County	30	4
Jackson County	617	179
Jasper County	203	68
Jefferson County	182	45

County	No. of Tier II	No. of Tier II with EHS
Montgomery County	48	18
Morgan County	40	9
New Madrid County	67	20
Newton County	89	21
Nodaway County	61	18
Oregon County	20	2
Osage County	52	11
Ozark County	17	1
Pemiscot County	46	11
Perry County	38	7
Pettis County	92	32
Phelps County	84	31
Pike County	55	13
Platte County	106	29
Polk County	57	15
Pulaski County	56	4
Putnam County	15	3
Ralls County	42	12
Randolph County	60	17
Ray County	47	12
Reynolds County	21	3
Ripley County	16	2
Saline County	80	33
Schuyler County	15	4
Scotland County	18	4
Scott County	70	14
Shannon County	17	0
Shelby County	31	3
St. Charles County	277	75
St. Clair County	17	1
St. Francois County	63	9
St. Louis County	804	242
St. Louis City*	269	90
Ste. Genevieve County	41	8
Stoddard County	72	15
Stone County	47	5
Sullivan County	26	10
Taney County	75	14
Texas County	60	7

County	No. of Tier II	No. of Tier II with EHS	County	No. of Tier II	No. of Tier II with EHS
Johnson County	77	19	Vernon County	54	19
Knox County	18	4	Warren County	53	20
Laclede County	80	17	Washington County	32	3
Lafayette County	77	19	Wayne County	26	3
Lawrence County	74	10	Webster County	46	10
Lewis County	34	8	Worth County	9	2
Lincoln County	88	24	Wright County	36	9
Linn County	37	7	**TOTAL**	**8,394**	**2,110**

Source: Missouri Department of Natural Resources; Missouri Environmental Emergency Response Tracking System (MEERTS). Fixed Facilities includes bulk chemical plants, bulk petroleum plants, and manufacturing facilities.

Figure 3.188. Tier II Reporting Facilities within Missouri, 2016



The Environmental Protection Agency (EPA) also maintains a National Priority List (NPL) which serves primarily informational purposes, identifying for the States and the public 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 judgment of the activities of its owner or operator, it does not require those persons to undertake any action, nor does it assign liability to any person. In Missouri, there are currently 33 active NPL sites. Those sites are listed in **Table 3.135** by county.

Table 3.135. Missouri Active National Priority List Sites by County

County	Site Name
Cape Girardeau County	Missouri Electric Works
Clay County	Armour Road
	Lee Chemical
Dunklin County	Bee Cee Manufacturing Plant
Franklin County	Oak Grove Village Well
	Riverfront
Greene County	Compass Plaza Well TCE
	Fullbright Landfill
	Solid State Circuits, Inc
Iron County	Annapolis Lead Mine
Jackson County	Conservation Chemical Company
	Lake City Army Ammunition Plant
Jasper County	Oronogo-Duenweg Mining Belt
Jefferson County	Minker/Stout/Romaine Creek
	Southwest Jefferson County Mining
Lawrence County	Syntex Facility, Inc
Madison County	Madison County Mine
Maries County	Vienna Wells
Newton County	Newton County Mine Tailings Site
	Newton County Wells
	Pools Prairie
Scott County	Quality Plating
St. Charles County	Weldon Spring Former Army Ordnance Works
	Weldon Springs Quarry / Plant / Pits (USDOE)
St. Francois County	Big River Mine Tailings / St. Joe Minerals
St. Louis County	Ellisville Site
	St. Louis Airport/Hazelwood Interim Storage/Futura Coatings Co.
	Valley Park, TCE
	West Lake Landfill
Washington County	Washington County Lead District - Furnace Creek
	Washington County Lead District - Old Mines
	Washington County Lead District - Potosi
	Washington County Lead District - Richwoods

Source: United States Environmental Protection Agency, National Priorities List, Superfund Program, https://www.epa.gov/superfund/national-priorities-list-npl-sites-state#MO

Hazardous Materials Transportation Accidents

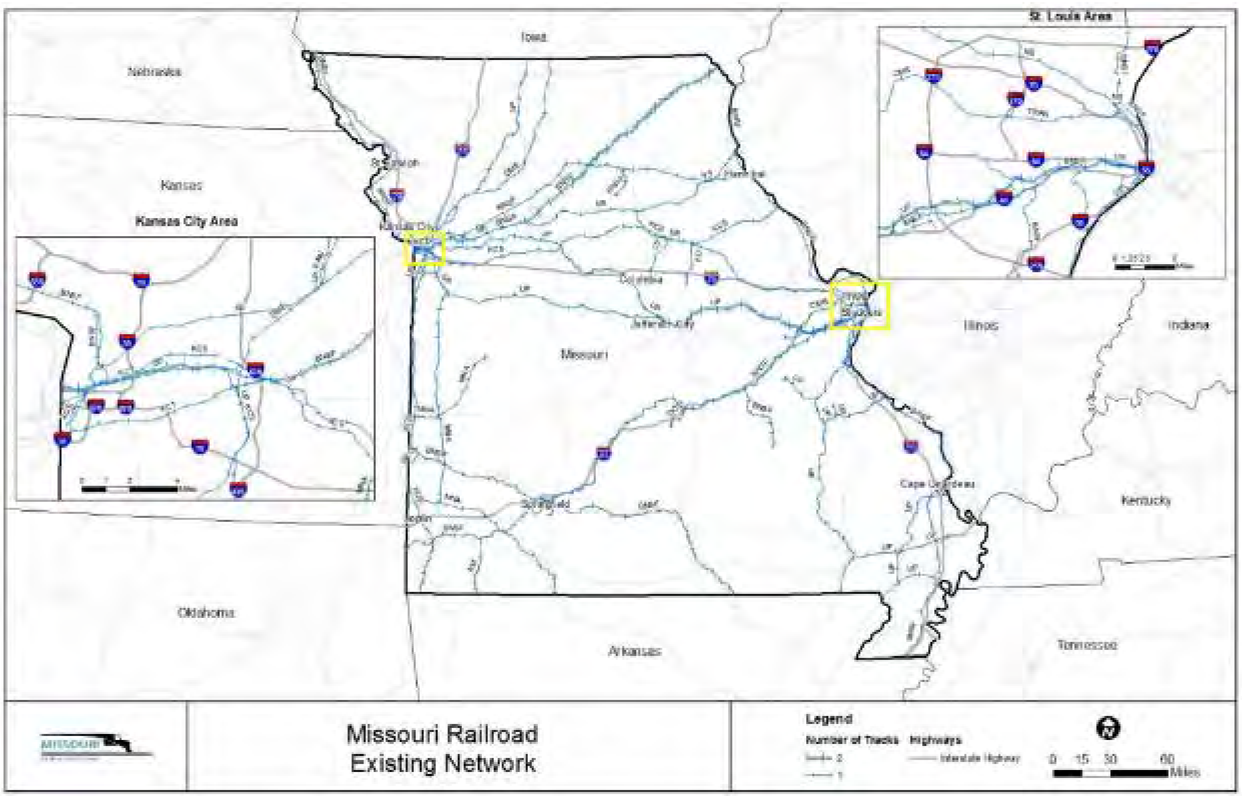
Transportation accidents address the transport of hazardous materials by rail, road, water, pipeline, and air. In these events, the exact location of a hazardous materials accident is not possible to predict. The close proximity of railroads, highways, waterways, pipelines, airports, and industrial facilities to populated areas, schools, and businesses could put a large number of individuals in danger at any time. In addition, essential service facilities, such as police and fire stations, hospitals, nursing homes, and schools near major transportation routes in the State are also at risk from potential hazardous materials transportation incidents.

Railways

The railroad systems in Missouri transport voluminous types and amounts of hazardous materials on their 4,822 miles of rails that traverse the State (see **Figure 3.189**). Though individual cars may be placarded to reveal contents such as hazardous materials, only estimates can be obtained concerning volumes of such materials, because only the interstate traffic is counted or measured. Interstate shipments are accounted for where they originate and terminate. The 2012 Missouri State Rail Plan forecasts inbound and outbound freight to the year 2031. Hazardous materials are anticipated to grow from 2011 to 2031 by 5.1-percent annually for a total net change of 1,633,298 tons.

Rail is also used to transport radioactive materials. The Union Pacific route between St. Louis and Kansas City and the Norfolk Southern route from Hannibal to Kansas City are both used for large radioactive material shipments. The switching yards at St. Louis and Kansas City process more of these transcontinental trains than any other yards in the country.

Figure 3.189. Missouri Rail Freight Carriers System Map, 2012



Source: Missouri Department of Transportation
http://www.modot.org/othertransportation/rail/documents/Missouri_State_Rail_Plan_FINAL.pdf

Roadways

Federal Highway Administration statistics indicate that 1 of 10 motor vehicles is engaged in the transport of hazardous materials of some type. Missouri is particularly at risk because of the highway system and geographical location. With Interstate highways such as I-29, I-35, I-44, I-55, and I-70, Missouri offers premium routes for commercial carriers traversing the continental United States. Even arterial highways in Missouri, such as U.S. Highways 71, 13, 63, 54, and 61 are maintained to provide more favorable traveling conditions than in other central states. In addition, U.S. Highway 36 crosses the northern counties, while U.S. Highway 60 crosses the southern counties.

Rail and truck transport is used for shipment of radioactive products and wastes across Missouri due to the locations of nuclear facilities in relation to mines and fuel processing plants. Missouri is also at the crossroads for rail and truck transport of nuclear waste to the Yucca Mountain, Nevada, test site. Truck shipments alone affect 25 different states, 266 counties, and two Indian reservations.

The federal government has finalized development of long-term repositories for spent fuel and other high-level radioactive wastes, and for transuranics (known as TRU waste), at Yucca Mountain, Nevada, and Carlsbad, New Mexico, respectively. Speculations have suggested that up to 3,600 shipments per year may go to these facilities, depending on several variables.

A large number of hazardous material shipments come from two corporations in Missouri. Covidian Medical in Maryland Heights (St. Louis County) and Tri-State Motor Transit in Joplin (Jasper County). Covidian Medical is one of the largest manufacturers of radiopharmaceuticals in the world. Tri-State is one of the largest single private carriers of radioactive materials in the world, in addition to transporting all classes of explosive materials and other toxic and hazardous materials.

Vessel

The U.S. Army Corps of Engineers indicates that over 9,000 tons of petroleum products and over 200,000 tons of chemicals and related products are shipped annually by river barge via the Missouri River between Omaha and Kansas City.

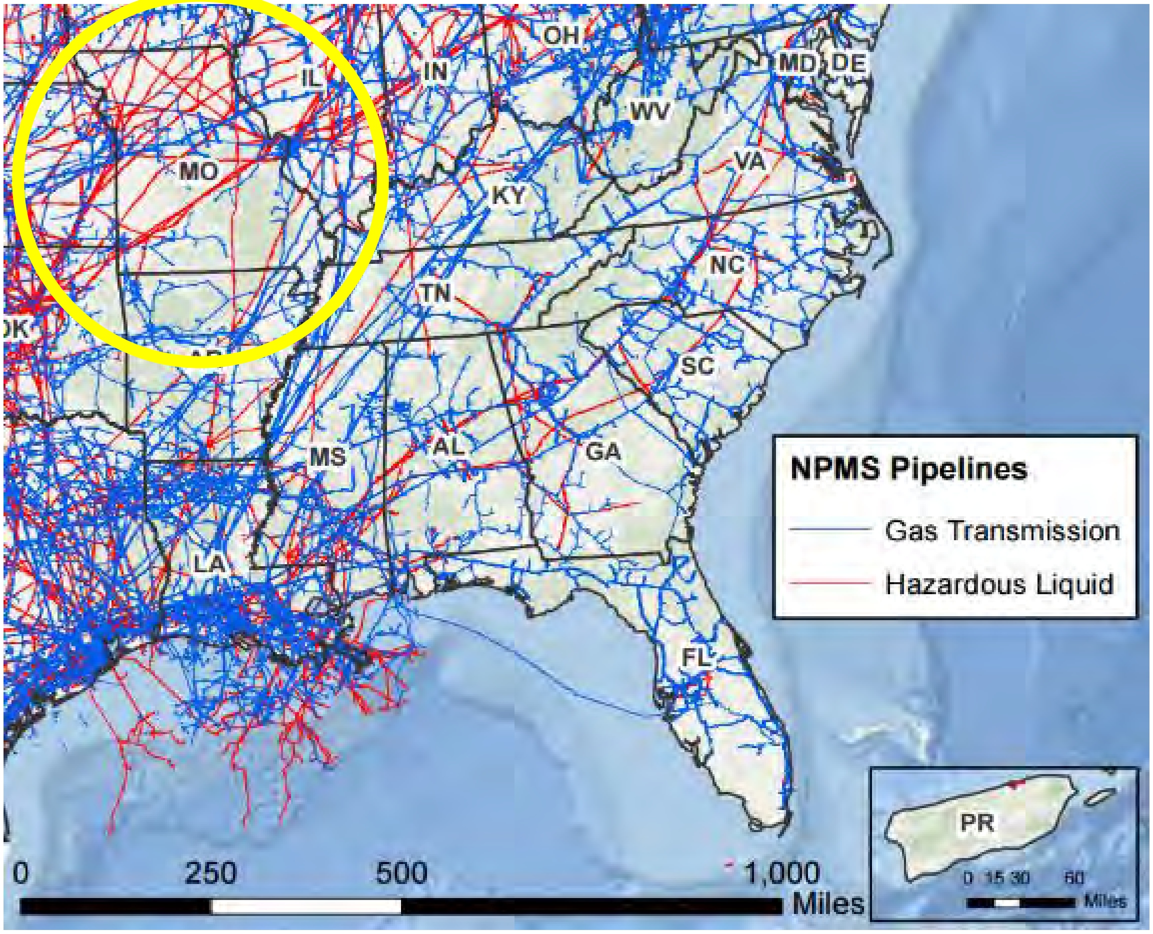
Pipeline

Pipelines in Missouri include both large-diameter lines carrying energy products to population centers, as well as small-diameter lines delivering natural gas to local businesses and residences. For the purposes of hazardous materials incidents, pipeline transport focuses on hazardous liquids, including crude oil, petroleum products, anhydrous ammonia and carbon dioxide. Within Missouri, there are approximately 1,847 miles of pipeline carrying crude oil, 1,372 miles of pipeline carrying highly volatile liquids, flammables, and toxic liquids; and 1,913 miles of pipeline carrying refined petroleum products (see **Figure 3.190**).

Air

Approximately 20 flights each day out of Lambert Airport in St. Louis carry nuclear medicines, and Tri-State Motor Transit Company of Joplin has approximately 25 shipments of high explosives each week.

Figure 3.190. Missouri Gas Transmission and Hazardous Liquid Pipelines, 2016



Source: Pipeline and Hazardous Materials Safety Administration
https://www.npms.phmsa.dot.gov/Documents/NPMS_Pipelines_Map.pdf

Extent

The entire State of Missouri is susceptible to this type of hazard. However, 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 (responsible party) will be required to minimize the potential impacts to public health and the environment.

Hazardous Materials Fixed-Facility Accident

The severity of consequences is rated as moderate but may be either low or high depending on the type and amount of chemical released. This means the chemical is expected to move into the surrounding environment at a concentration sufficient to cause serious injuries and/or death, unless prompt and effective corrective actions are taken. Injuries and/or death would be expected only for personnel exposed over an extended period or when individual personal health conditions create complications.

Hazardous Materials Transportation Accident

The severity of the consequences is rated as moderate, but may be either low or high depending on the location of the accident and the time of day. This rating means injuries and/or death are expected only for exposed personnel over extended periods of time or when individual personal health conditions create complications.

Previous Occurrences

Hazardous Materials Spill Incidents

Under the Missouri Spill Bill (260.500 – 260.550 RSMo) responsible parties/spillers are required to report releases of hazardous substances to the department's 24-Hour Environmental Emergency Response (EER) Hotline 573-634-2436 or to the National Response Center 800-424-8802. EER Duty Officers maintaining the EER Hotline provide technical assistance regarding the chemical and necessary cleanup actions, work with the responsible party/spiller to ensure that proper cleanup is completed and impact to the public health and environment is minimized, conduct notifications to various agencies, and determine if an on-site response is needed by EER staff. EER Duty Officers complete and submit an EER Incident Report into the Missouri Environmental Emergency Response Tracking System (MEERTS) on each incident reported on the 24-Hour Environmental Emergency Response Hotline or via fax from the National Response Center. Once the EER Incident Report is finalized, it is made available. During the period from 2007-2011, an average annual 959 incidents were reported through MEERTS for hazardous substance emergencies/releases at fixed facilities (bulk chemical plant, bulk petroleum plant, and manufacturing facilities); aircraft/airports; pipeline/pumpstations; railroad/railyards; road/highway/right-of-way; and water/waterway/marinas. For the following five-year period of 2012-2016, the average annual number of incidents decreased to 842. While the majority of counties presented with a decrease in the total number incidents, the following counties noted had increases: Adair, Christian, Crawford, Franklin, Greene, Jackson, Marion, and Ralls.

The EER Section provides a weekly report via email that summarizes the reported incidents for a given week. The EER section also provides the MEERTS database to the public. The MEERTS database provides specific details on all reported releases of hazardous substances such as date, county, material released, property use, incident cause, clean-up method and more. Specific information from this database was used to prepare **Table 3.136** comparing fixed facility (bulk chemical plant, bulk petroleum plant, and manufacturing facilities); aircraft/airport; pipeline/pump station; railroad/railyard; road/highway/right-of-way; and water/waterway/marina incidents reported between 1/1/2007 and 12/31/2011 and those incidents reported between 1/1/2012 and 12/31/2016. The decrease in reported incidents is noted as red text within parentheses. Please check the website at http://dnr.mo.gov/env/esp/meerts.htm for further information.

Table 3.136. Comparison of Reported Hazardous Materials Incidents for Selected Incident Types in Missouri from 2007-2011 and 2012-2016

County	Fixed Facility			Aircraft/Airport			Railroad/Railyard			Road/Highway/ ROW			Water/Waterway/ Marina			Pipeline/ Pump Station			Total Incidents		
	2007-2011	2012-2016	Δ	2007-2011	2012-2016	Δ	2007-2011	2012-2016	Δ	2007-2011	2012-2016	Δ	2007-2011	2012-2016	Δ	2007-2011	2012-2016	Δ	2007-2011	2012-2016	Δ
Adair County	1	0	(1)	0	0	0	0	0	0	36	73	37	2	0	(2)	2	0	(2)	41	73	32
Andrew County	0	0	0	0	0	0	0	3	3	20	7	(13)	1	1	0	1	0	(1)	22	11	(11)
Atchison County	1	2	1	0	0	0	0	0	0	9	5	(4)	0	0	0	0	0	0	10	7	(3)
Audrain County	10	9	(1)	0	0	0	2	6	4	25	13	(12)	2	1	(1)	11	0	(11)	50	29	(21)
Barry County	8	3	(5)	0	0	0	1	0	(1)	13	16	3	4	6	2	1	0	(1)	27	25	(2)
Barton County	0	0	0	0	1	1	1	3	2	5	2	(3)	0	0	0	1	0	(1)	7	6	(1)
Bates County	1	0	(1)	0	0	0	2	2	0	1	7	6	0	0	0	3	0	(3)	7	9	2
Benton County	0	0	0	0	0	0	0	0	0	3	6	3	6	5	(1)	0	0	0	9	11	2
Bollinger County	0	0	0	0	0	0	0	0	0	3	2	(1)	0	1	1	1	0	(1)	4	3	(1)
Boone County	9	6	(3)	0	1	1	0	1	1	65	59	(6)	12	11	(1)	14	4	(10)	100	82	(18)
Buchanan County	27	20	(7)	0	0	0	19	33	14	25	19	(6)	4	2	(2)	2	3	1	77	77	0
Butler County	2	0	(2)	0	0	0	10	17	7	59	19	(40)	1	2	1	4	1	(3)	76	39	(37)
Caldwell County	0	0	0	0	0	0	4	4	0	4	7	3	0	0	0	0	0	0	8	11	3
Callaway County	2	3	1	1	0	(1)	0	0	0	22	30	8	2	4	2	1	0	(1)	28	37	9
Camden County	1	1	0	0	0	0	1	0	(1)	9	24	15	54	43	(11)	3	0	(3)	68	68	0
Cape Girardeau County	2	9	7	0	0	0	3	1	(2)	79	24	(55)	8	8	0	1	0	(1)	93	42	(51)
Carroll County	1	1	0	0	0	0	3	4	1	7	6	(1)	0	0	0	5	6	1	16	17	1
Carter County	0	0	0	0	0	0	0	0	0	8	3	(5)	0	0	0	0	0	0	8	3	(5)
Cass County	7	2	(5)	0	0	0	7	5	(2)	17	11	(6)	4	7	3	13	4	(9)	48	29	(19)
Cedar County	6	0	(6)	0	0	0	0	0	0	7	3	(4)	2	6	4	0	0	0	15	9	(6)
Chariton County	0	1	1	0	0	0	1	4	3	3	3	0	1	2	1	2	2	0	7	12	5
Christian County	2	2	0	0	0	0	0	2	2	7	27	20	0	3	3	0	0	0	9	34	25
Clark County	0	1	1	0	0	0	3	0	(3)	26	8	(18)	0	1	1	1	1	0	30	11	(19)
Clay County	11	5	(6)	0	0	0	28	28	0	26	39	13	10	11	1	2	2	0	77	85	8
Clinton County	4	0	(4)	0	0	0	0	0	0	7	11	4	1	0	(1)	2	0	(2)	14	11	(3)

County	Fixed Facility			Aircraft/Airport			Railroad/Railyard			Road/Highway/ ROW			Water/Waterway/ Marina			Pipeline/ Pump Station			Total Incidents		
	2007-2011	2012-2016	Δ	2007-2011	2012-2016	Δ	2007-2011	2012-2016	Δ	2007-2011	2012-2016	Δ	2007-2011	2012-2016	Δ	2007-2011	2012-2016	Δ	2007-2011	2012-2016	Δ
Cole County	5	6	1	0	0	0	14	14	0	14	19	5	6	16	10	0	5	5	39	60	21
Cooper County	0	0	0	0	0	0	1	2	1	18	14	(4)	4	0	(4)	17	0	(17)	40	16	(24)
Crawford County	0	2	2	0	0	0	1	1	0	73	98	25	0	1	1	0	0	0	74	102	28
Dade County	0	0	0	0	0	0	0	0	0	2	3	1	1	3	2	0	1	1	3	7	4
Dallas County	1	0	(1)	0	0	0	0	0	0	10	19	9	1	0	(1)	1	0	(1)	13	19	6
Daviess County	0	0	0	0	0	0	2	0	(2)	12	9	(3)	1	2	1	0	0	0	15	11	(4)
DeKalb County	0	0	0	1	0	(1)	0	0	0	12	12	0	0	0	0	2	0	(2)	15	12	(3)
Dent County	1	0	(1)	0	0	0	0	0	0	12	8	(4)	2	0	(2)	1	0	(1)	16	8	(8)
Douglas County	2	2	0	0	0	0	0	0	0	6	2	(4)	1	0	(1)	0	0	0	9	4	(5)
Dunklin County	0	0	0	0	0	0	3	2	(1)	13	11	(2)	2	4	2	1	0	(1)	19	17	(2)
Franklin County	6	4	(2)	0	0	0	6	11	5	126	150	24	7	6	(1)	1	1	0	146	172	26
Gasconade County	1	0	(1)	0	0	0	7	1	(6)	26	12	(14)	2	0	(2)	1	1	0	37	14	(23)
Gentry County	0	2	2	0	0	0	0	0	0	3	3	0	0	0	0	0	0	0	3	5	2
Greene County	19	7	(12)	1	1	0	8	15	7	59	114	55	6	5	(1)	1	0	(1)	94	142	48
Grundy County	2	1	(1)	0	0	0	5	2	(3)	1	2	1	1	1	0	0	0	0	9	6	(3)
Harrison County	0	1	1	1	0	(1)	0	0	0	7	10	3	0	2	2	2	2	0	10	15	5
Henry County	2	1	(1)	0	0	0	0	0	0	26	9	(17)	1	4	3	0	0	0	29	14	(15)
Hickory County	0	0	0	0	0	0	0	0	0	1	2	1	2	4	2	0	0	0	3	6	3
Holt County	0	2	2	0	0	0	1	0	(1)	17	10	(7)	2	0	(2)	1	1	0	21	13	(8)
Howard County	0	0	0	0	0	0	0	0	0	3	6	3	3	2	(1)	10	1	(9)	16	9	(7)
Howell County	0	0	0	0	2	2	2	3	1	31	21	(10)	0	0	0	0	0	0	33	26	(7)
Iron County	1	2	1	0	0	0	5	3	(2)	13	5	(8)	2	0	(2)	2	1	(1)	23	11	(12)
Jackson County	28	32	4	1	1	0	182	211	29	85	121	36	20	21	1	8	5	(3)	324	391	67
Jasper County	31	21	(10)	0	0	0	6	6	0	167	63	(104)	3	1	(2)	2	3	1	209	94	(115)
Jefferson County	10	9	(1)	0	0	0	17	15	(2)	404	356	(48)	18	13	(5)	1	8	7	450	401	(49)
Johnson County	1	3	2	1	1	0	7	4	(3)	17	5	(12)	0	1	1	8	4	(4)	34	18	(16)
Knox County	0	0	0	0	0	0	0	0	0	9	9	0	0	1	1	4	0	(4)	13	10	(3)

County	Fixed Facility			Aircraft/Airport			Railroad/Railyard			Road/Highway/ ROW			Water/Waterway/ Marina			Pipeline/ Pump Station			Total Incidents		
	2007-2011	2012-2016	Δ	2007-2011	2012-2016	Δ	2007-2011	2012-2016	Δ	2007-2011	2012-2016	Δ	2007-2011	2012-2016	Δ	2007-2011	2012-2016	Δ	2007-2011	2012-2016	Δ
Laclede County	0	1	1	0	0	0	1	1	0	34	37	3	1	0	(1)	0	0	0	36	39	3
Lafayette County	0	1	1	0	0	0	5	3	(2)	29	22	(7)	2	0	(2)	1	0	(1)	37	26	(11)
Lawrence County	1	1	0	0	0	0	0	3	3	20	28	8	1	2	1	1	2	1	23	36	13
Lewis County	2	0	(2)	0	0	0	0	0	0	7	21	14	3	7	4	0	0	0	12	28	16
Lincoln County	0	1	1	0	0	0	1	1	0	60	10	(50)	3	2	(1)	1	1	0	65	15	(50)
Linn County	0	0	0	0	0	0	2	1	(1)	12	13	1	0	0	0	1	0	(1)	15	14	(1)
Livingston County	1	0	(1)	1	0	(1)	0	0	0	8	6	(2)	2	0	(2)	0	0	0	12	6	(6)
Macon County	4	5	1	0	0	0	2	3	1	14	23	9	2	7	5	2	1	(1)	24	39	15
Madison County	0	0	0	0	0	0	0	0	0	3	2	(1)	0	1	1	1	1	0	4	4	0
Maries County	0	1	1	0	0	0	0	0	0	20	17	(3)	1	0	(1)	0	0	0	21	18	(3)
Marion County	17	28	11	0	0	0	3	6	3	45	79	34	3	7	4	0	1	1	68	121	53
McDonald County	1	6	5	0	0	0	0	0	0	12	20	8	1	2	1	1	1	0	15	29	14
Mercer County	1	0	(1)	0	0	0	1	4	3	0	2	2	0	0	0	0	0	0	2	6	4
Miller County	0	1	1	0	0	0	0	1	1	19	7	(12)	17	11	(6)	1	0	(1)	37	20	(17)
Mississippi County	1	0	(1)	0	0	0	0	0	0	16	9	(7)	6	8	2	0	0	0	23	17	(6)
Moniteau County	0	7	7	0	0	0	5	1	(4)	4	0	(4)	0	0	0	0	1	1	9	9	0
Monroe County	0	0	0	0	0	0	5	4	(1)	5	11	6	0	3	3	0	0	0	10	18	8
Montgomery County	1	1	0	0	0	0	1	1	0	50	35	(15)	3	0	(3)	6	0	(6)	61	37	(24)
Morgan County	1	0	(1)	0	0	0	0	0	0	12	5	(7)	9	9	0	0	0	0	22	14	(8)
New Madrid County	2	6	4	1	0	(1)	5	3	(2)	60	26	(34)	6	5	(1)	0	0	0	74	40	(34)
Newton County	4	0	(4)	1	0	(1)	1	1	0	45	42	(3)	2	0	(2)	0	2	2	53	45	(8)
Nodaway County	3	0	(3)	0	0	0	0	0	0	14	4	(10)	0	1	1	1	0	(1)	18	5	(13)
Oregon County	0	0	0	0	0	0	2	1	(1)	8	3	(5)	0	1	1	0	0	0	10	5	(5)
Osage County	0	0	0	0	0	0	2	3	1	5	17	12	1	1	0	3	1	(2)	11	22	11
Ozark County	0	1	1	0	0	0	0	0	0	3	3	0	0	1	1	0	0	0	3	5	2
Pemiscot County	2	3	1	1	0	(1)	0	4	4	31	15	(16)	7	3	(4)	2	0	(2)	43	25	(18)
Perry County	0	3	3	0	1	1	0	1	1	25	14	(11)	4	3	(1)	0	0	0	29	22	(7)

County	Fixed Facility			Aircraft/Airport			Railroad/Railyard			Road/Highway/ ROW			Water/Waterway/ Marina			Pipeline/ Pump Station			Total Incidents		
	2007-2011	2012-2016	Δ	2007-2011	2012-2016	Δ	2007-2011	2012-2016	Δ	2007-2011	2012-2016	Δ	2007-2011	2012-2016	Δ	2007-2011	2012-2016	Δ	2007-2011	2012-2016	Δ
Pettis County	11	13	2	0	0	0	10	5	(5)	17	12	(5)	2	2	0	21	6	(15)	61	38	(23)
Phelps County	1	3	2	0	0	0	3	3	0	70	80	10	6	1	(5)	2	0	(2)	82	87	5
Pike County	4	3	(1)	0	0	0	1	2	1	9	12	3	4	2	(2)	10	2	(8)	28	21	(7)
Platte County	4	0	(4)	5	3	(2)	4	2	(2)	17	15	(2)	5	1	(4)	2	2	0	37	23	(14)
Polk County	1	1	0	0	0	0	0	0	0	4	15	11	1	0	(1)	0	0	0	6	16	10
Pulaski County	1	0	(1)	0	0	0	1	1	0	25	27	2	1	2	1	1	0	(1)	29	30	1
Putnam County	0	0	0	0	0	0	0	1	1	12	4	(8)	0	0	0	0	0	0	12	5	(7)
Ralls County	2	7	5	0	0	0	2	1	(1)	32	62	30	1	6	5	2	0	(2)	39	76	37
Randolph County	0	1	1	0	0	0	4	5	1	15	14	(1)	1	0	(1)	0	1	1	20	21	1
Ray County	3	1	(2)	0	0	0	1	3	2	7	3	(4)	1	1	0	1	0	(1)	13	8	(5)
Reynolds County	1	0	(1)	0	0	0	0	0	0	3	2	(1)	4	0	(4)	0	0	0	8	2	(6)
Ripley County	0	1	1	1	1	0	0	0	0	11	4	(7)	0	0	0	0	2	2	12	8	(4)
Saline County	5	2	(3)	0	0	0	3	3	0	9	11	2	0	2	2	0	1	1	17	19	2
Schuyler County	0	0	0	0	0	0	0	0	0	4	12	8	0	1	1	1	0	(1)	5	13	8
Scotland County	1	0	(1)	0	0	0	1	1	0	11	1	(10)	0	0	0	0	1	1	13	3	(10)
Scott County	4	5	1	0	1	1	3	12	9	64	21	(43)	3	4	1	1	3	2	75	46	(29)
Shannon County	0	0	0	0	0	0	0	1	1	7	4	(3)	3	0	(3)	0	0	0	10	5	(5)
Shelby County	1	0	(1)	0	0	0	0	1	1	14	7	(7)	1	1	0	0	2	2	16	11	(5)
St. Charles County	8	5	(3)	0	0	0	5	6	1	106	105	(1)	24	13	(11)	0	3	3	143	132	(11)
St. Clair County	1	0	(1)	0	0	0	0	0	0	5	11	6	1	1	0	0	0	0	7	12	5
St. Francois County	6	2	(4)	1	0	(1)	8	11	3	57	27	(30)	5	7	2	0	2	2	77	49	(28)
St. Louis County	33	28	(5)	16	14	(2)	24	40	16	134	84	(50)	56	62	6	13	12	(1)	276	240	(36)
St. Louis City*	35	22	(13)	0	1	1	39	74	35	56	40	(16)	59	46	(13)	5	0	(5)	194	183	(11)
Ste. Genevieve County	3	2	(1)	0	0	0	0	11	11	25	14	(11)	4	6	2	2	4	2	34	37	3
Stoddard County	5	8	3	0	1	1	16	17	1	11	16	5	1	4	3	1	2	1	34	48	14
Stone County	0	0	0	0	0	0	0	0	0	8	7	(1)	6	13	7	0	0	0	14	20	6
Sullivan County	5	1	(4)	0	0	0	1	1	0	7	3	(4)	1	1	0	5	0	(5)	19	6	(13)

County	Fixed Facility			Aircraft/Airport			Railroad/Railyard			Road/Highway/ ROW			Water/Waterway/ Marina			Pipeline/ Pump Station			Total Incidents		
	2007-2011	2012-2016	Δ	2007-2011	2012-2016	Δ	2007-2011	2012-2016	Δ	2007-2011	2012-2016	Δ	2007-2011	2012-2016	Δ	2007-2011	2012-2016	Δ	2007-2011	2012-2016	Δ
Taney County	1	2	1	0	0	0	1	0	(1)	3	14	11	7	3	(4)	0	0	0	12	19	7
Texas County	5	0	(5)	0	0	0	0	1	1	18	14	(4)	2	0	(2)	0	0	0	25	15	(10)
Vernon County	5	5	0	0	0	0	0	1	1	7	11	4	0	1	1	1	0	(1)	13	18	5
Warren County	3	1	(2)	0	0	0	0	1	1	67	48	(19)	3	3	0	1	0	(1)	74	53	(21)
Washington County	0	1	1	0	0	0	0	0	0	43	27	(16)	4	2	(2)	1	0	(1)	48	30	(18)
Wayne County	0	3	3	0	0	0	2	4	2	10	9	(1)	2	2	0	1	0	(1)	15	18	3
Webster County	2	1	(1)	0	0	0	1	0	(1)	14	31	17	1	0	(1)	1	0	(1)	19	32	13
Worth County	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	1	1
Wright County	1	2	1	0	0	0	0	2	2	7	14	7	0	2	2	0	0	0	8	20	12
TOTAL	**398**	**346**	**(52)**	**33**	**29**	**(4)**	**518**	**655**	**137**	**3123**	**2770**	**(353)**	**482**	**464**	**(18)**	**226**	**110**	**(116)**	**4780**	**4374**	**(406)**

Source: Missouri Department of Natural Resources; Missouri Environmental Emergency Response Tracking System (MEERTS). Fixed Facilities includes bulk chemical plants, bulk petroleum plants, and manufacturing facilities.

The Missouri Department of Natural Resources' role in emergency response is to minimize damages in a hazardous substance emergency, with the highest priority being the protection of people and then the environment.

The department's mandate to address environmental emergencies includes "any chemical, petroleum, or other material spilled on to the land, water, or atmosphere" that might impact the public health/safety and/or the environment. The Missouri "Spill Bill"* (Section 260.500 to 260.550 RSMo) requires the department to maintain a 24-hour EER Hotline, and provides the authority to initiate a cleanup or provide cleanup oversight for chemical releases.

Pipeline Incidents

Pipeline incidents are also tracked through the Pipeline and Hazardous Materials Safety Administration (PHMSA). The table below presents significant incidents reported to PHMSA for a 20-year period. Significant Incidents include (1) fatality or injury requiring in-patient hospitalization; (2) $50,000 or more in total costs, measured in 1984 dollars; (3) highly volatile liquid releases of 5 barrels or more or other liquid releases of 50 barrels or more; or (4) liquid releases resulting in an unintentional fire or explosion.

Table 3.137. Pipeline Incidents reported to PHMSA, 1997-2016

Year	Number of Incidents	Fatalities	Injuries	Total Cost as Reported	Barrels Spilled	Net Barrels Lost
1997	1	0	0	$250,116	143	0
1998	3	0	1	$17,070,369	309	99
1999						
2000						
2001	4	0	0	$1,106,932	14,885	13,983
2002	1	0	0	$109,600	13	12
2003						
2004	2	0	0	$144,492	131	0
2005	1	0	0	$437,907	3,113	3,113
2006						
2007	1	0	0	$3,309,011	4,169	0
2008	3	0	0	$3,528,872	114	54
2009	2	0	0	$232,242	3,658	3,658
2010	4	0	1	$343,302	761	658
2011						
2012	2	0	0	$620,559	23	1
2013	3	0	0	$676,365	55	16
2014	3	0	0	$1,656,766	362	89
2015	3	0	0	$412,897	10	0
2016	3	0	0	$2,042,599	5,667	5,097
TOTAL	**36**	**0**	**2**	**$31,942,031**	**33,412**	**26,779**

Source: PHMSA; http://opsweb.phmsa.dot.gov/primis_pdm/significant_inc_trend.asp

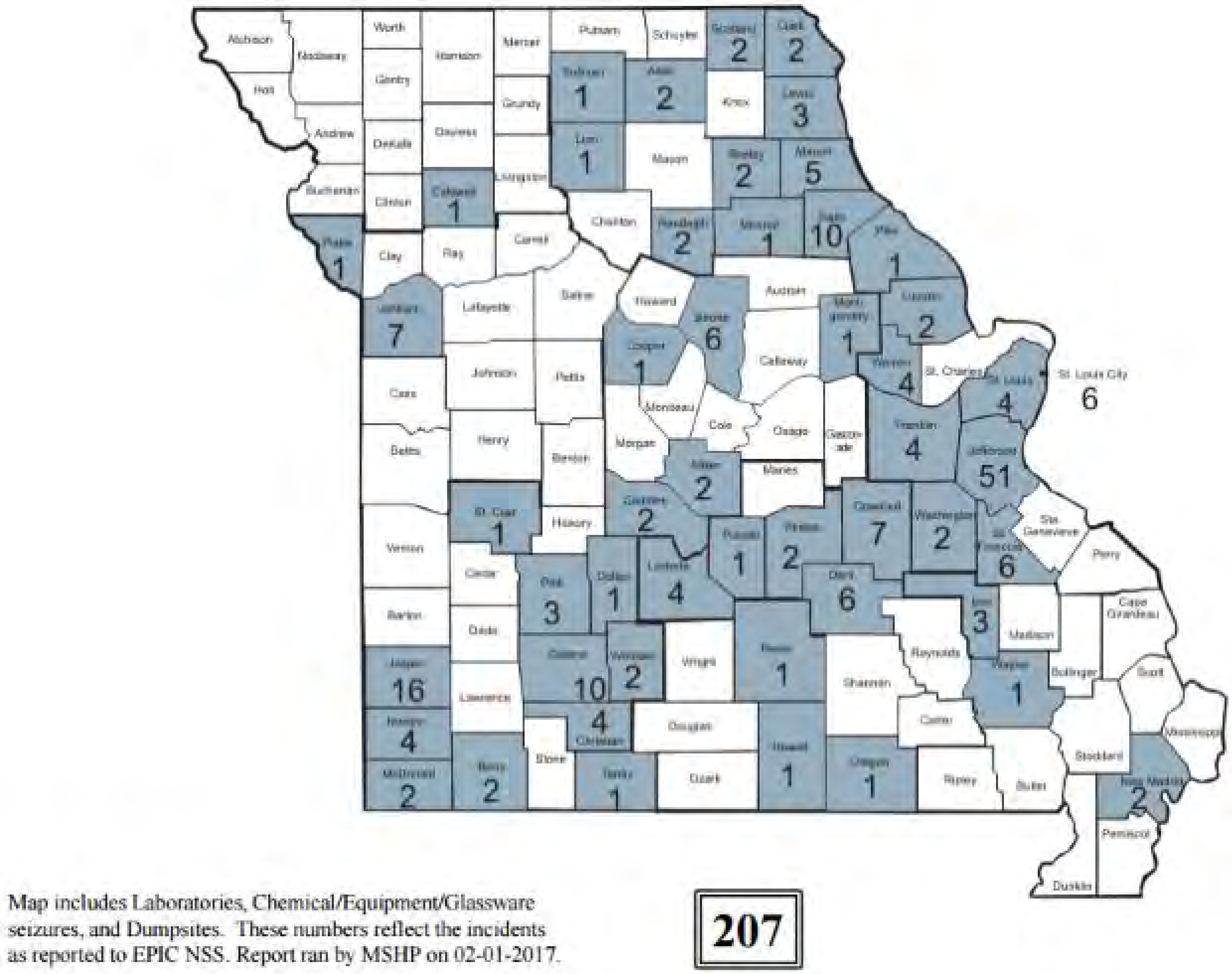
Methamphetamine Laboratory Incidents

The Missouri Highway Patrol's Division of Drug and Crime Control serves as the collection and entry point for statewide methamphetamine laboratory seizures. The data reflected in **Figure 3.191** are cumulative totals of the three types of seizure classifications occurring in each separate county for 2016. The three types of seizures are: operational laboratories, chemical/equipment/glassware and dumpsite seizures. The statistics reflected have been extracted from methamphetamine seizure incidents entered into the National Clandestine Laboratory Seizure System.

The department's involvement in the methamphetamine laboratory crisis in Missouri began in 1997. Law enforcement agencies were being inundated with large quantities of hazardous waste, chemicals and debris associated with the production of methamphetamine. At the direction of the governor, the Missouri Methamphetamine Enforcement and Environmental Protection Task Force was formed to address this and other issues related to the burgeoning problem. Numerous local, state and federal agencies and organizations banded together and, under the direction of the Meth/Special Projects Unit, created the Clandestine Drug Lab Collection Station (CDLCS) Program. Local fire service and law enforcement agencies operate collection stations throughout the State with technical and financial assistance provided by the department.

The Meth/Special Projects Unit provides a variety of supplies, personal protective equipment and air monitoring equipment to law enforcement at no cost. Examples of packaging/cleanup supplies available include 5-gallon chemical overpack buckets, hazardous materials labels, eye wash bottles, safety goggles, safety glasses, absorbent material, pH paper, hand sanitizer, etc. Personal protective equipment includes chemical protective coveralls, boot covers, nitrile gloves, air-purifying respirators, cartridges, self-contained breathing apparatus and air cylinders. Drager pumps and tubes along with organic vapor meters and multi-gas meters have been provided to collection station operators, drug task forces and law enforcement agencies throughout the State. Inquiries concerning supplies and equipment procurement may be made by e-mail or by calling 573-526-3349. Information about the Meth/Special Projects Unit can be found at http://www.dnr.mo.gov/env/esp/meth-special-projects.htm

Figure 3.191. Missouri Methamphetamine Laboratory Incidents, 2016



Source: Missouri Highway Patrol, Methamphetamine Statistics, http://www.mshp.dps.missouri.gov/MSHPWeb/Publications/Reports/2016StatewideLabIncidents.pdf

Probability of Future Hazard Events

For the noted five-year periods from 2007 to 2011 and 2012 to 2016, there was an annual average of 80 and 69 fixed facility incidents, respectively. For the transportation-related incidents, the annual average was significantly higher at 876 and 806, respectively.

Changing Future Conditions Considerations

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 change is of a secondary nature. It may exacerbate the natural hazard event by triggering release of hazardous materials.

State Vulnerability Overview

The entire State of Missouri is susceptible to this type of hazard, depending on a number of factors such as the type of chemical, amount released/spilled, method of release, location of release, time of day, and weather conditions. Figure 3.188 presented a comparison of the number of facilities reporting hazardous material storage per county.

This hazard could have a 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 government (county or municipal) is more often directly impacted by hazardous materials incidents than state or federal government. Local responders are generally the first on scene for any incident. Therefore, they have the responsibility for treating any injured victims and transporting them to a hospital for more complete medical care. Also, local first responders have the initial responsibility for controlling exposure of emergency workers and the public to any radioactive materials and to contain the spread of radioactive contamination as much as possible. 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 traverse the State on the thousands of streets, roads, and highways. Every day, dozens of chemical cargos cross the State on the railroads. These trucks and railcars constitute potential hazards on wheels. In addition, every day, the 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 toxics heavier than air settle on the ground and the people in proximity can breathe these toxics and be affected; the toxics lighter than air spread for several miles and impact distant people.

The State of Missouri has seven environmental emergency response and hazardous waste disposal companies currently under state contract to provide services to the department as needed. Use of the contract is mandatory for all state government agencies and optional for all local governmental agencies. Some of the contractors provide services only to specific parts of Missouri and others provide services statewide. Services available from the contract include emergency response, including personnel and specialized equipment, on-site technical management of clean-up activities and disposal of hazardous wastes. This hazard could have a significant impact on the public health, the environment, private property, and the economy.

State Estimates of Potential Losses

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.

As mentioned, it is difficult to determine the potential losses to existing development because of the variable nature of a hazardous materials spill. For example, a spill of a toxic airborne chemical in a populated area could have great potential for loss of life and by contrast, the spill of a very small amount of a chemical in a remote agricultural area where remediation of soil would be easier could be less costly.

For the purposes of this discussion, the materials needed for a very small spill of a less hazardous chemical in an easily remediated area are listed below in **Table 3.138**. The cost for the essential personnel and equipment are taken from the current State of Missouri contract for Hazardous Substance Cleanup and Disposal Services (C313018001-C313018003).

Table 3.138. 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 tape	$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 (19 lb 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: The maximum cost for the essential personnel and equipment are taken from the current State of Missouri contracts for Hazardous Substance Cleanup and Disposal Services (C313018001-C313018003).

As previously noted, the planning team obtained information from the Missouri Department of Natural Resources Environmental Emergency Response Tracking System (MEERTS). According to MEERTS, during the last 10 years (2007-2016), Emergency Response has received an average of 900 incidents each year at fixed facilities (bulk chemical plant, bulk petroleum plant, and manufacturing facilities); aircraft/airports; pipeline/pump stations; railroad/railyards; road/highway/right-of-way; and water/waterway/marinas. **Figure 3.192** provides the yearly incidents reported during this time period.

To estimate a potential cost, the estimated $11,456 cost per incident was then applied to the average annual number of reported incidents of 900 to calculate an average annual minimal cost. The annual cost of remediation of spills is calculated as follows: 900 average annual incidents X $11,456 per incident = $10,309,941. The majority of the cost of chemical clean-ups is borne by the party responsible for the spill, in some instances private, for-profit companies.

Because the nature of this hazard is so variable, it is difficult to create a potential dollar loss estimate for each county or for any geographic region. The damage that would be expected would be based on the type of chemical released, weather conditions, location of the spill, size of the spill, etc.

Figure 3.192. Hazardous Substances Emergencies/Releases Reported to MEERTS (2007-2016)

Source: Missouri Department of Natural Resources; Missouri Environmental Emergency Response Tracking System (MEERTS).

Hazard Impact on Future Growth and Development

As the infrastructure and population of Missouri increase along with industries and the number and type of hazardous chemicals stored and transported through the State, the amount of potential losses will increase. Because of the nature of the hazard, it is not possible to determine a geographic variability in future potential loss.

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 numbers of people. 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.

EMAP Consequence Analysis

The information in **Table 3.139** is from the Impact Analysis of Potential for Detrimental Impacts of Hazards done for the Emergency Management Accreditation Program.

Table 3.139. EMAP Impact Analysis: Hazardous Materials

Subject	Detrimental Impacts
Public	Localized impact expected to be severe for plume area and moderate to light for other adversely affected areas.
Responders	Adverse impact expected to be severe for unprotected personnel and moderate to light for protected personnel.
Continuity of Operations	Damage to facilities/personnel in the area of the incident may require temporary relocation of some operations. Localized disruption of roads and/or utilities may postpone delivery of some services.
Property, Facilities, and Infrastructure	Localized impact to facilities and infrastructure in the plume area of the incident, possibly for extended period.
Environment	Localized impact expected to be severe for plume area. Remediation required.
Economic Condition of Jurisdiction	Local economy and finances adversely affected, possibly for an extended period of time, depending on damage, extent of cleanup, and length of investigation.
Public Confidence in the Jurisdiction's Governance	Localized impact expected to primarily adversely affect HazMat source owner and local entities.

Risk Summary

Any disaster or emergency incident, such as an earthquake or a flood, could result in additional concerns when it involves hazardous materials. For example, during the floods of 1993, a large propane tank farm in St. Louis was threatened by rising floodwaters, forcing evacuations of nearby residents in several areas. Another hazardous materials incident related to the 1993 floods involved an on-going ammonia release from the La Roche Industries, Inc., facility near Crystal City, Missouri, caused by power failure and failure of the cooling system on a large ammonia tank, which ultimately resulted in off-gassing of ammonia through the tank's pressure relief check valves. The ammonia cloud over the plant led to a declaration of restricted air space in the plant vicinity for several days. In addition, thousands of chemical containers ranging from household products and 55-gallon drums to 10,000-gallon fuel storage tanks were displaced statewide as a result of the flood damage. A federal disaster declaration was issued, the Federal Response Plan (FRP) was implemented, and Emergency Support Function #10—Hazardous Materials Annex was activated to support the statewide response to hazardous materials incidents like these and others that resulted from the flooding.

Each emergency event will need to be evaluated on an incident-specific basis, and top priority must be given to the protection of the public, then the environment, and property.

Tier II Forms are filed and maintained by the Missouri Emergency Response Commission at SEMA. Site-specific plans are on file with each county's local emergency planning commission. Transportation and evacuation routes are addressed in each county emergency operations plan. Regional Coordinators with SEMA serve as liaisons to local jurisdictions for emergency management activities including emergency operations plan development and revision, training and exercises. There are nine regional coordinators providing assistance to Missouri's 114 counties and their associated jurisdictions, and the independent City of St. Louis. A map of the nine areas is included in Section 3.5.7, Terrorism, which correspond with the Missouri State Highway Patrol troops.

Problem Statement:

Using the County of Tier II Facilities and the major transportation corridors for the State as key indicators, the counties at most risk for Hazardous Materials Release are Jackson, St. Louis, Buchanan, Clay, Boone, St. Charles, Jefferson, Franklin Green and Jasper. Mitigation strategies and limited resources would best be allocated in these counties.
2018 risk assessment data and mapping is available through the Missouri Hazard Mitigation Viewer: http://bit.ly/MoHazardMitigationPlanViewer2018.

3.3.17. Mass Transportation

Probability	Severity
100%	Moderate

Description/Location

For the purpose of this plan, mass transportation is defined as the means, or system, that transfers large groups of individuals from one place to another. This profile addresses only transportation accidents involving people, not materials. Mass transportation accidents include public airlines, railroad passenger cars, metro rail travel, tour buses, city bus lines, school buses, riverboat casinos, and other means of public transportation.

Airlines

Missouri serves as a transportation crossroad for the United States. Missouri is centrally located in the nation making it a natural hub for many major airlines (five primary airports in the State offer commercial service) and other types of tourist and business travel. Many cross-country travelers use Missouri terminals to connect with transport changes. The state's airways, railways, and highways are used as nonstop thoroughfares as well. **Table 3.140** shows primary and non-primary commercial service airports in the State. Primary airports are classified as having more than 10,000 passenger boardings each year.

Table 3.140. Primary and Non-Primary Commercial Service Airports

Location	Airport Name	Status
Columbia	Columbia Regional Airport	Primary
Joplin	Joplin Regional Airport	Primary
Kansas City	Kansas City International Airport	Primary
Springfield	Springfield-Branson National Airport	Primary
St. Louis	Lambert-St. Louis International	Primary
Cape Girardeau	Cape Girardeau Regional Airport	Non-Primary
Fort Leonard Wood	Waynesville-St. Robert Regional Airport – Forney Field	Non-Primary
Kirksville	Kirksville Regional	Non-Primary

Source: Federal Aviation Administration (FAA) https://www.faa.gov/airports/central/about_airports/ce_airports/missouri/

Commercial Vehicles

Tour bus travel in the State is on the increase, and more bus traffic can be expected. The Passenger Carrier Inspection Division of the Missouri Department of Transportation has developed a comprehensive passenger carrier safety inspection program. Passenger carrier safety is a primary concern for the Division because Missouri, and especially Branson, is among the top tourist destinations in North America. Division inspectors conduct safety inspections at destinations or carrier terminals when buses do not have passengers on board.

The Passenger Carrier Inspection Division has two classifications of passenger carriers: for-hire and private. For-hire passenger carriers provide service to the general public and are required to register with the division. Private carriers provide passenger service in furtherance of a commercial enterprise. Examples include, but are not limited to, hotel courtesy buses, airport passenger shuttle services, buses operated by professional musicians, and buses for civic and other groups such as scout groups where no fees are collected.

Railroads

Amtrak, the State's major passenger rail carrier, uses tracks that cross the entire state from east to west, with stations in Hemann, Kansas City and St. Louis. Although Amtrak has experienced a decline in passengers since the year 2000, it continues to carry a large number of passengers daily. Peak periods for rail companies in North America is somewhere between April and September of any given year.

Other Mass Transit

In 1993, Missouri's largest city, St. Louis, began operating a Metro transportation system. Metro operates three modes of transportation service, which include bus, rail and demand-response operations, MetroBus, MetroLink and Metro Call-A-Ride, respectively**.** The Metro recorded 44 million passenger boardings for fiscal year 2016, and operates in a service area that includes the City of St. Louis and St. Louis County in Missouri, and St. Clair and Monroe Counties in Illinois. The MetroBus system remains the largest component of the multi-modal system, operating with a fleet of 395 buses on 62 Missouri routes and 17 Illinois routes. MetroLink operates 87 light rail vehicles, with 26 stations in Missouri and 11 stations in Illinois. Normally, the largest numbers of people are transported during the morning and evening rush hours.

Extent

There is no uniform extent rating for a mass transportation incident, as different modes of transportation have unique characteristics. Depending on the parameters of the incident, it is reasonable to assume that a large-scale mass transportation incident involving a train derailment or a plane crash could cause hundreds of fatalities, hundreds of injuries, millions in property damage and a potentially long-term loss of service. Based on the latest available information, the severity of a mass transportation incident is rated as moderate.

Previous Occurrences

Railroads

On May 14, 1997, about 9:00 pm, a Missouri and Northern Arkansas Railroad (M&NA) train, the Cotter North local, was traveling northbound in non-signaled territory when it entered a siding track and collided with an unattended and unoccupied Branson Scenic Railway (BSR) excursion train. The collision occurred in downtown Branson, Missouri, on the M&NA Aurora Subdivision at milepost (MP) 447.3. When the collision occurred, the lead locomotive unit of the striking train derailed and caught fire. Also, both locomotive units of the parked train derailed. Both train crewmembers of the M&NA train sustained minor injuries. The costs associated with the accident were $410,625.

On July 29, 2001, an Amtrak train derailed in on a section of rural track that had been undermined by heavy rains. A locomotive and three cars derailed near Sabula in Iron County. Ten people were treated for minor injuries at local hospitals.

An Amtrak train carrying 103 people on September 29, 2005 derailed in eastern Missouri near Blackwell after striking boulders from a rockslide; approximately 20 people sustained minor injuries. The severity of the derailment was mitigated by the slow speeds required to wind through the area; slow speeds were attributed as the reason no cars were overturned.

Commercial Vehicles

Commercial motor vehicles have been involved in a significant number of Missouri traffic accidents. Statistics from the Missouri State Highway Patrol Statistical Analysis Center show that in 2015, 9 percent of all traffic accidents involved a commercial motor vehicle. Of fatal traffic accidents, 13 percent involved a commercial motor vehicle. A total of 117 persons were killed and 3,279 were injured in commercial motor vehicle-related accidents in 2015.

The Missouri State Highway Patrol Statistical Analysis Center tracks traffic incident statistics. **Table 3.141** shows all crashes involving commercial vehicles, including injuries, fatalities, property damage-only crashes and a percentage of annual change. The amount of crashes has reduced on an average annual basis of -2% annually.

Table 3.141. Commercial Motor Vehicle Crash Data 2002-2015

Year	Fatal Crashes	Personal Injury Crashes	Property Damage Only Crashes	Total Crashes	Total Crashes Percent Change
2002	181	3529	13014	16724	-
2003	169	3338	12689	16196	-3.26
2004	162	3382	12899	16443	1.50
2005	171	3368	12501	16040	-2.51
2006	143	2935	12096	15174	-5.71
2007	150	3051	12021	15222	0.32
2008	115	2562	10720	13397	-13.62
2009	89	2173	9754	12016	-11.49
2010	95	2312	9851	12258	1.97
2011	103	2162	9521	11786	-4.00
2012	101	2068	8970	11139	-5.81
2013	81	2112	9636	11829	5.83
2014	97	2061	9928	12086	2.13
2015	108	2326	10748	13182	8.31

Source: Missouri State Highway Patrol Statistical Analysis Center, http://www.mshp.dps.missouri.gov/ibi_apps/WFServlet

Airlines

Information from the Federal Aviation Administration regarding primary, non-primary commercial service and general aviation airports found at http://www.faa.gov/airports/planning_capacity/passenger_allcargo_stats/passenger/ shows that there are a total of 127 airports in Missouri that are considered public use, of which eight are considered commercial. Of these, the top five are listed below including the number of enplanements for calendar year 2015.

Table 3.142. Top Five Airports by Number of Enplanements for 2015

Airport	County	2015 Enplanements
Lambert St. Louis International	St. Louis	6,239,248
Kansas City International	Platte	5,135,127
Springfield – Branson National	Greene	447,843
Columbia Regional	Boone	64,707
Joplin Regional	Kiowa	28,306

Source: Federal Aviation Administration, https://www.faa.gov/airports/planning_capacity/passenger_allcargo_stats/passenger/

The National Traffic Safety Board records aircraft incidents involving fatalities in the United States. The NTSB records one such incident in Missouri, in 2004. On October 19, 2004, a plane flying between St. Louis and Kirksville crashed on the approach to the Kirksville Airport, killing thirteen people and injuring two.

Probability of Future Hazard Events

A major accident can occur at any time, even though all safety precautions are in place. Accidents involving commercial vehicles occur on an annual basis, however these are usually considered minor in nature. Based on the latest available information for different modes of transportation, the probability of a mass transportation accident is 100%.

Changing Future Conditions Considerations

Changing future conditions with respect to climate are not likely to impact the probability or severity of this hazard. The exception would be accidents caused by precipitation or other severe weather, such as high winds.

Changes in precipitation patterns, particularly more extreme precipitation events and drought, have the potential to affect transportation systems across the country. Storm drainage systems for highways, tunnels, airports, and city streets could prove inadequate, resulting in localized flooding. Bridge piers are subject to scour as runoff increases stream and river flows, potentially weakening bridge foundations.

State Vulnerability Overview

Mass transportation systems have strict plans and protocols in place to ensure the safety and security of their passengers. Even with these protocols in place, a major accident could occur at any time. Mass transportation systems can also serve as attractive targets for terrorism, with high numbers of people congregated in small spaces and the potential for disruption in daily lives.

State Estimates of Potential Losses

It is difficult to determine the actual risk to each county in Missouri, as no specific mass transportation studies have been conducted to date. Certainly, the counties in and surrounding 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. The Branson area would also have a greater risk because of the large numbers of tourists visiting the area and arriving by mass transportation. However, an accident could occur in any area in Missouri.

Although there are other types of mass transportation incidents, the commercial vehicle accident was chosen for the loss estimate scenario since it is the most common mass transportation incident. Using the Missouri Department of Transportation's 2015 Missouri State Highway System Traffic Crash Statistics as a basis for the number of vehicle crashes and the Federal Highway Administration's costs of a traffic crash, a potential loss estimate has been calculated. The crash numbers are for 2015 and it is assumed that 2015 was a typical year for crashes. Based on these assumptions, **Table 3.143** lists the potential costs associated with mass transportation accidents in Missouri. It is assumed that injuries are evident injuries rather than incapacitating injuries, which the FHWA estimates cause $36,000 in costs per injury. The FHWA estimates that a fatality causes $2.6 million in cost per fatality.

Table 3.143. Annual Loss Estimates for Mass Transportation Accidents (Vehicle Accidents) in 2015

Type of Vehicle	Injuries	Cost per Injury	Fatalities	Cost per Fatality
Bus (Small/Large)	354	$12,744,000	3	$7,800,000
Limousine	1	$36,000	0	$0
School Bus	187	$6,732,000	1	$2,600,000
Passenger Van	38	$1,368,000	3	$7,800,000

Type of Vehicle	Injuries	Cost per Injury	Fatalities	Cost per Fatality
Totals	**580**	**$20,880,000**	**7**	**$18,200,000**

Sources: Missouri State Highway Patrol Statistical Analysis Center, 2015 data
http://www.mshp.dps.missouri.gov/MSHPWeb/SAC/Compendium/TrafficCompendium.html
FHWA Accident Costs https://safety.fhwa.dot.gov/facts_stats/t75702.cfm

The Centers for Disease Control estimates economic losses from fatalities caused by traffic crashes. According to the CDC, traffic-related fatalities cause an estimated $981 million in economic costs per year, including $8 million in health care costs and $973 million in work loss costs.

Hazard Impact on Future Growth and Development

As the amount of tourism increases and personal travel through Missouri via mass transit increases, the number of accidents can be expected to increase. Costs increase each year as well.

EMAP Consequence Analysis

A mass transportation accident, which could include those involving buses, could burden a local jurisdiction's available medical services. To minimize this problem, mutual aid agreements with adjoining jurisdictions should be developed between ambulance services and the hospitals. This type of hazard could involve hazardous materials or a fire, which would compound the impacts of the incident. Severe weather could also hamper response efforts.

The information in **Table 3.156** is from the Impact Analysis of Potential for Detrimental Impacts of Hazards done for the Emergency Management Accreditation Program.

Table 3.144. EMAP Impact Analysis: Mass Transportation

Subject	Detrimental Impacts
Public	Dependent on area impacted, though localized impact expected to be severe for incident area and moderate to light for other adversely affected areas.
Responders	Adverse impact expected to be moderate to light for trained, equipped, and protected personnel.
Continuity of Operations including continued delivery of services	Damage to facilities/personnel in the area of the incident may require temporary relocation of some operations; localized disruption of roads and/or utilities caused by incident may postpone delivery of some services, with length of postponement dependent on incident type and severity.
Property, Facilities, and Infrastructure	Localized impact to facilities and infrastructure in the area of the incident. Some severe damage possible.
Environment	Localized impact expected to be severe for incident areas and moderate to light for other areas affected by smoke or HazMat remediation.
Economic Condition of Jurisdiction	Local economy and finances may be adversely affected, depending on damage and length of investigation.
Public Confidence in the Jurisdiction's Governance	Ability to respond and recover may be questioned and challenged if planning, response, and recovery not timely and effective

Risk Summary

Missouri serves as transportation crossroads for the United States. Bus systems, passenger rail, airlines and other mass transportation systems are generally operated in a safe manner. While Missouri has a history of minor incidents involving mass transportation, these tend to have little long-term impact to those systems or the State. Impacts from these types of incidents can and have included injuries, fatalities, property damage and system disruptions.

Problem Statement:

Using the major transportation corridors for the State as key indicators, the counties at most risk for Hazardous Materials Release are Jackson, St. Louis, Buchanan, Clay, Boone, St. Charles, Jefferson, Franklin Green and Jasper. Mitigation strategies and limited resources would best be allocated in these counties.

2018 risk assessment data and mapping is available through the Missouri Hazard Mitigation Viewer: http://bit.ly/MoHazardMitigationPlanViewer2018.

3.3.18. Nuclear Power Plants

Probability	Severity
<1%	Low to High

Description/Location

There are presently four fixed nuclear facilities or reactors that, under extreme circumstances and conditions, could pose a threat to citizens of Missouri. These four reactors fall into two categories: research reactors and commercial nuclear power reactors. The first category, research reactors, represents a hazard only to personnel or others on-site at the facility. Therefore, these reactors are not included in state radiological plans involving off-site emergency preparedness. For the second category, commercial nuclear power reactors, a worst-case scenario involving a significant release of radioactive material could force the evacuation of the general population within a 10-mile radius of the facility. A release of this magnitude could also contaminate food and water sources within a 50-mile radius.

The magnitude of releases from nuclear plant sites varies depending on the nature of the accident type, reactor design, and meteorological conditions during the release. The Nuclear Regulatory Commission and FEMA have developed regulatory guidance that both the State and utility must meet to protect the health and safety of the general population within the 10-mile emergency planning zone (EPZ). Four classes of emergency action levels are used for early notification of incidents, with clear instructions for emergency organizations within the EPZ. The four emergency classifications listed in progression of severity are notification of unusual event, alert, site area emergency, and general emergency. These levels are discussed below.

- **Notification of Unusual Event**—This classification describes unusual events that are in process or have occurred and indicates a potential degradation of the safety level of the plant. No releases of radioactive material requiring off-site response or monitoring are expected unless safety systems are further degraded.
- **Alert**—This classification describes unusual events that are in process or have occurred and indicate a potential degradation of the level of plant safety. Any releases are expected to be limited to small fractions of the U.S. Environmental Protection Agency (EPA) Protective Action Guideline (PAG) exposure levels.
- **Site Area Emergency**—This classification level describes events in process or having occurred that involve actual or likely major failures of the plant functions needed to protect the public. No releases are expected to exceed EPA PAG exposure levels except near the site boundary.
- **General Emergency**—This classification describes an event in process or having occurred that involves actual or imminent substantial core degradation or melting, with the potential for loss of containment integrity. Releases can reasonably be expected to exceed the EPA PAG exposure levels off-site for more than the immediate site area.

Extent

The consequences of a radiological incident originating from one of the commercial nuclear power plants affecting the State can range in severity from a relatively small, insignificant incident, to a high degree of radioactive contamination within the two to 10-mile radius surrounding the facility. The most crucial concerns during a severe incident are safe evacuation and controlled access to the areas affected by a release of radioactive materials. In the aftermath, the main concerns are as follows: the extent of property needing to be decontaminated, contaminated food sources, and the time required to reach acceptable exposure rates and to allow the safe reentry of the public.

An incident at a nuclear power plant resulting in a “general emergency” and evacuation (one where a release from the site boundary would be expected) could have a dramatic psychological impact on the uninformed population within the evacuation zone. The utilities and the State have an active Radiological Emergency Preparedness program to prepare local jurisdictions and the general population surrounding the plant for responding to such an incident. This program includes in-depth training of resources both from the State and local jurisdictions, and regularly scheduled drills and exercises evaluated by FEMA. Extensive planning has focused on implementation of the emergency response plan for both the State and local jurisdictions. Emphasis is placed on prompt notification of emergency organizations and the public; evacuation routes; reception and care centers for evacuees; monitoring for radiological contamination; emergency worker preparedness; and public information in the form of brochures distributed to residents within the emergency preparedness zone. The State developed a Missouri Nuclear Power Plant Accident Plan in 2015 to lay out response to a nuclear incident with impacts within its borders. These programs are essential to the protection of the general public.

An accident involving radioactive materials could occur in Missouri from a variety of sources, including nuclear reactors, materials in transit, industrial and medical uses, and lost or stolen sources where the public could be exposed, or contaminated, with a high level of radiation. Although the chance of a nuclear power plant release is highly unlikely, radiological accidents can cause injury or death, contaminate property and valuable environmental resources, as well as disrupt the functioning of communities and their economies.

Previous Occurrences

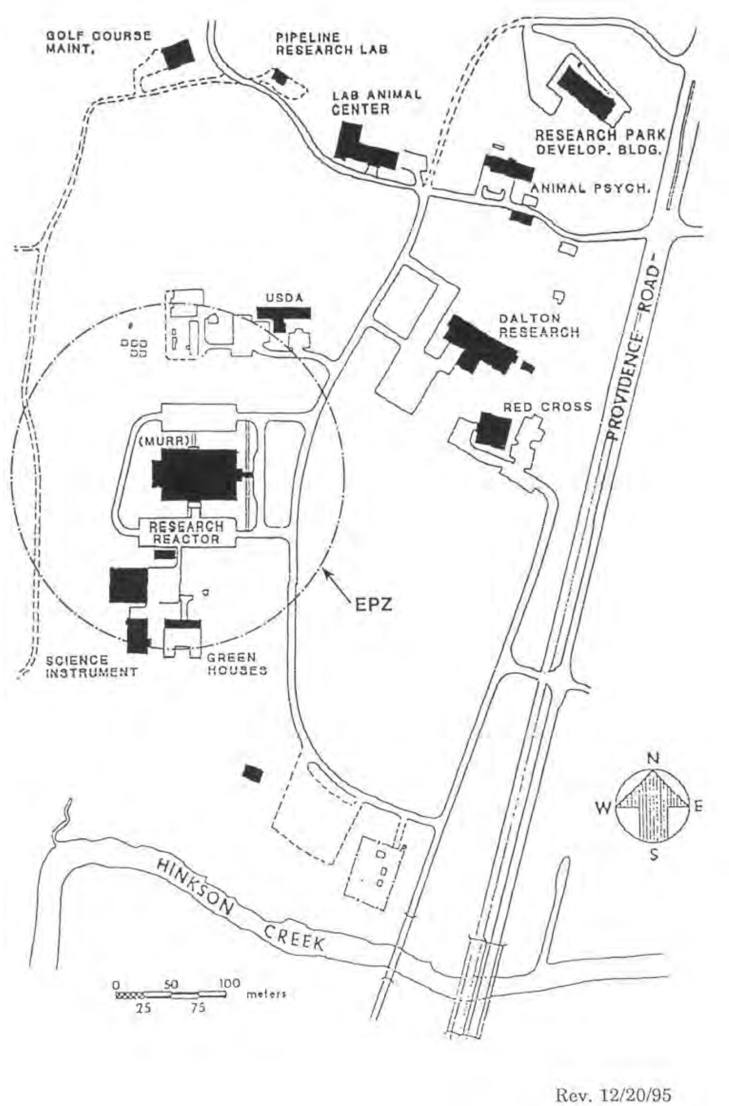
Research Reactors

Two research reactors are located in Missouri: the Missouri S&T Reactor (MSTR) and the University of Missouri–Columbia Research Reactor (MURR). The maximum hypothetical accident from either research reactor would place at risk only personnel working at the facilities or the public within the site boundary of the respective facilities. Both research reactors have emergency plans approved by the Nuclear Regulatory Commission (NRC) that conform with regulatory requirements in 10 CFR 50, Appendix E, and follow the guidance provided by Revision I to NRC Regulatory Guide 2.6, Emergency Planning for Research and Test Reactors, March 1983, and ANSI/ANS-15.16, Emergency Planning for Research and Test Research Reactors, 2015.

The MSTR is a water-moderated pool-type reactor licensed to operate at 200 kilowatts. The MSTR is used for training and research purposes. Because the reactor is mainly used for training, it is not operated for long periods of time. The reactor is located on the Missouri University of Science and Technology campus in Rolla, Missouri. Due to the low power of licensing (200 kilowatts), prevailing standards and guidelines do not require the establishment of an emergency planning zone. Therefore, no classification higher than a “site area emergency” has been included in the MSTR emergency plans. The MSTR has been in operation since 1961 and has never had an incident that would be considered an emergency action level. The reactor is available for use by students, faculty and outside researchers.

The MURR is a 10 megawatts pressurized water-moderated pool-type reactor with a containment building. The MURR is used to provide research, training, and services to the four campuses of the University of Missouri system as well as other universities, government agencies, and private industry, and operates 6.5 days per week, 52 weeks per year. In operation since 1967, the reactor averages 8,060 hours of operation per year (155 hours per week) at peak flux due to the service work that it performs. The reactor is located on a 550-acre tract of land south of the University of Missouri–Columbia campus on Providence Road. The MURR has an emergency planning zone encompassing the area within a 100-meter radius from the exhaust stack (see **Figure 3.193**). No credible potential accidents have been identified for the MURR facility that would result in exceeding the classification of “notification of unusual events.” As a result, no classification higher than a “site area emergency” is included in the emergency plan for the MURR; the reactor has an impeccable record with over 50 years without incident.

Figure 3.193. Emergency Planning Zone for MURR



Source: State Hazard Analysis, December 2012

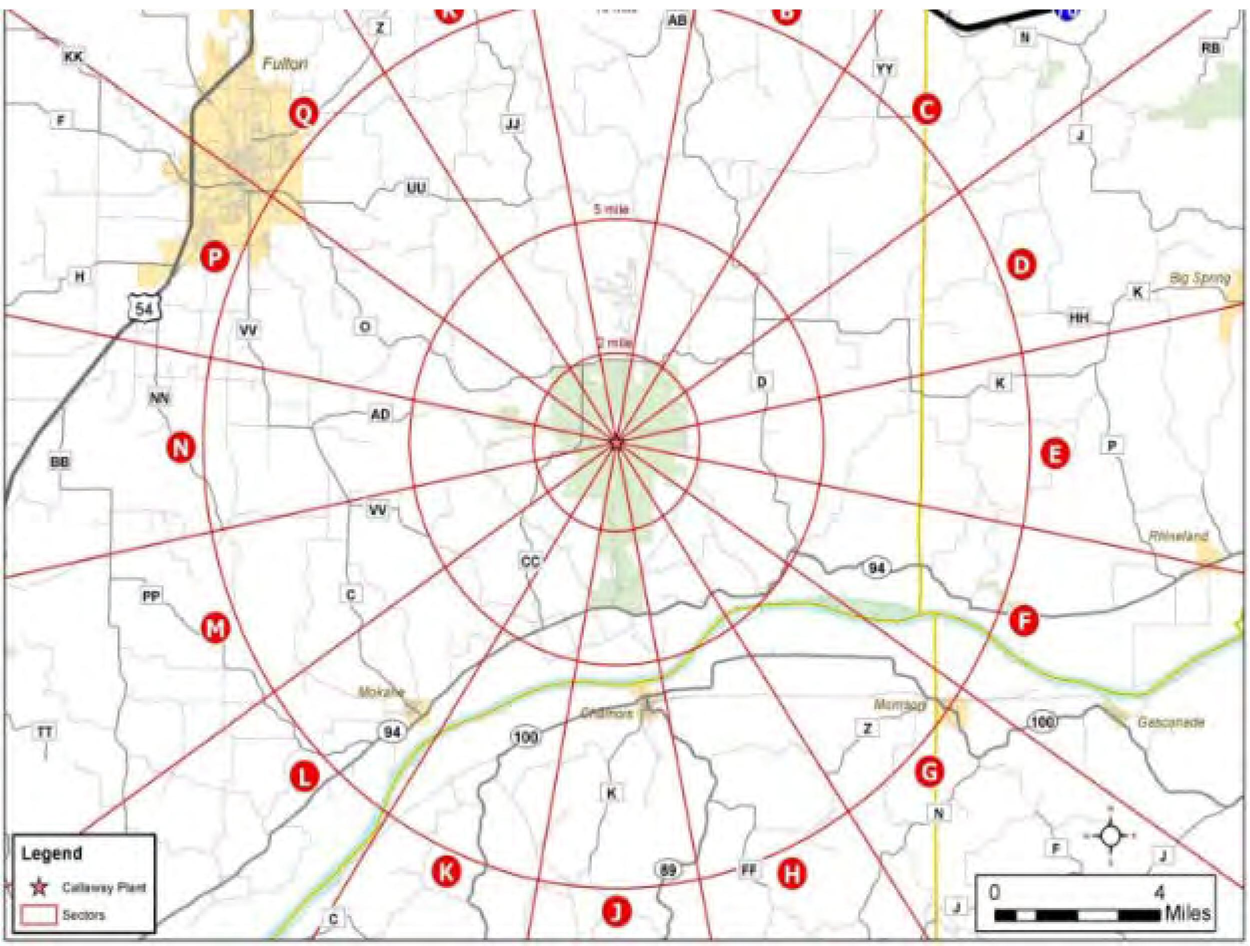
Commercial Nuclear Power Reactors

Two commercial nuclear power reactors could have an impact on the health and safety of Missouri citizens. These reactors are the Callaway Energy Center and the Cooper Nuclear Station, both of which are used for electrical power generation. Both utilities have emergency plans that conform to NUREG-0654, FEMA-REP-1 Rev.1, Criteria for Preparation and Evaluation of Radiological Emergency Response Plans and Preparedness in Support of Nuclear Power Plants. The utilities and the State are required to demonstrate annually various elements of preparedness through radiological emergency drills evaluated by inspectors representing FEMA and the NRC.

The **Callaway Energy Center (CEC)** consists of one unit with a pressurized water reactor capable of providing 1360 megawatts of electricity. The physical plant is located in Callaway County, Missouri, and is owned and operated by Ameren Missouri. The 525-acre site is located 10 miles southeast of Fulton, 25 miles northeast of Jefferson City, 5 miles north of the Missouri River, and 80 miles west of St. Louis. The area within a ten mile radius of the CEC site lies within four counties; approximately 60% lies in Callaway County, 20% in Montgomery County, 20% in Osage County, and approximately 1% in Gasconade County.

The population within the 2.5 mile radius of the plant is approximately 90 residents. Approximately 8,000 people reside within a 10-mile radius of the plant, according to the 2010 census. The plume exposure pathway has been expanded beyond the 10-mile radius to include the City of Fulton (population 12,112). Thus, the population within the plume exposure pathway is approximately 20,000. Any noticeable fluctuations in the region would be of very short duration and can primarily be attributed to lodging facilities and recreational areas. Land within a five-mile radius of the plant site is mostly rural/undeveloped. **Figure 3.194** illustrates the emergency planning zone for the Callaway Nuclear Power Plant. The plant began operating in December 1984. The plant's operating license was renewed by the Nuclear Regulatory Commission in 2015, extending its life to the year 2044.

Figure 3.194. Emergency Planning Zone for Callaway Nuclear Power Plant

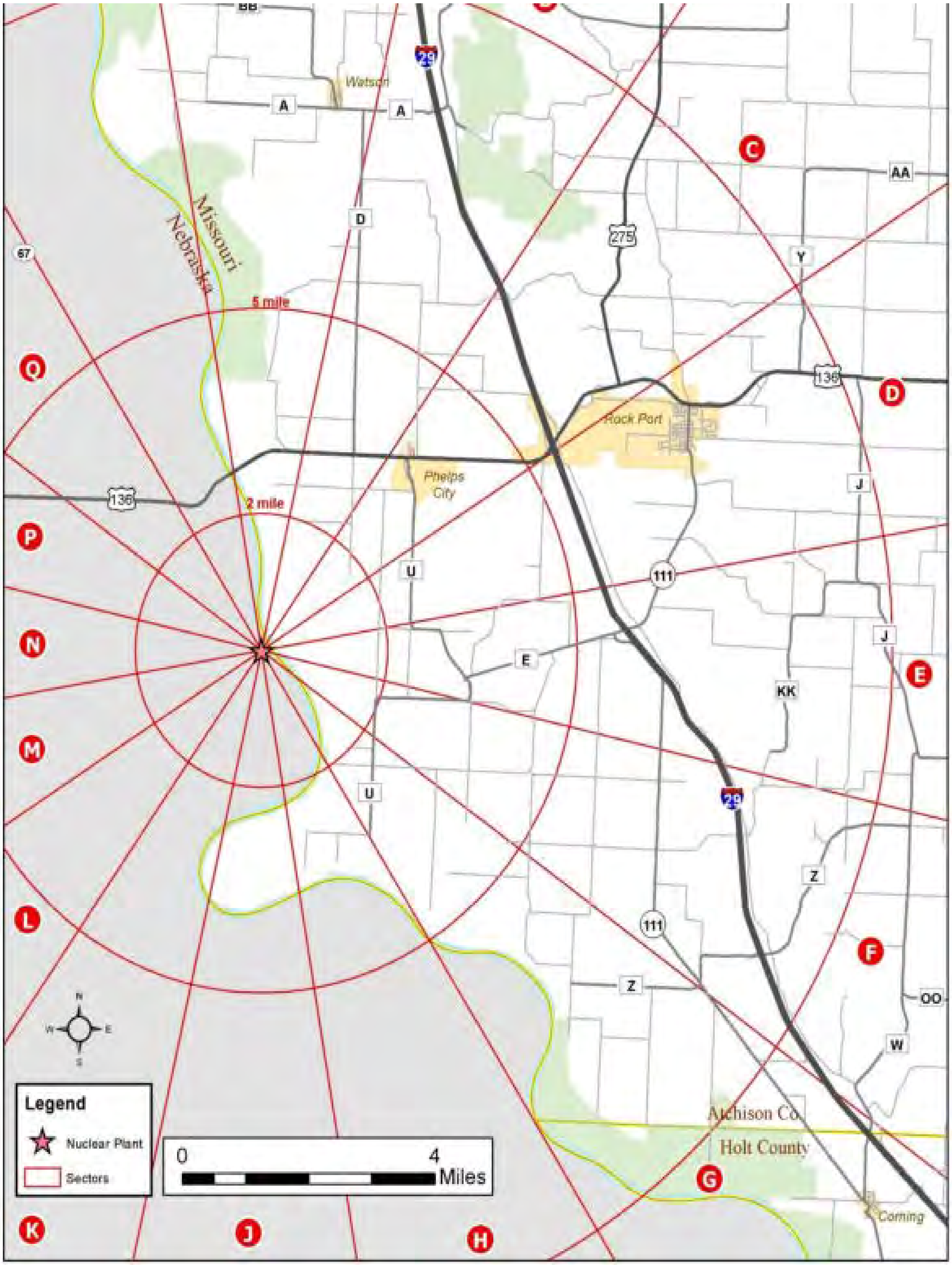


Source: Missouri Nuclear Power Plant Accident Plan, 2015

The **Cooper Nuclear Station** is a direct-cycle boiling water-type reactor and at full power, the station generates 815 megawatts of electricity. Commissioned in July 1974, the facility is operated by the Nebraska Public Power District. The plant is located on the Nebraska side of the Missouri River in Brownville, Nebraska, approximately seven miles southwest of Rock Port, Missouri. The emergency planning zone within the Missouri side of the river is predominantly rural land, except for the towns of Rock Port, Phelps City, Langdon, and Watson.

Atchison County is primarily affected by the emergency planning zone (see **Figure 3.195**) and is intersected by several major highways, including Interstate 29, U.S. Highway 136, U.S. Highway 275, and Missouri Highway 111. The total population at risk from a radiological incident in Atchison County is as follows: no people within 2 miles; approximately 286 people within 5 miles; and approximately 2,110 people within 10 miles.

Figure 3.195. Emergency Planning Zone for Cooper Nuclear Station



Source: Missouri Nuclear Power Plant Action Plan 2015

Probability of Future Hazard Events

Historically, due to their safe operation records, fixed nuclear facilities have not represented a high risk to the State. The Reactor Safety Study conducted by the NRC rated the chances of a major nuclear disaster as very low (a probability of one in one million per plant operating year). The report concluded that the worst accident type that could affect a nuclear power plant would be one resulting in a meltdown, which could be expected to occur once in 20,000 years of reactor operation. The report also stated that a meltdown would likely cause less than one fatality or injury. This low hazard rating is due to diverse and redundant barriers and numerous safety systems in the plant, the training and skills of the reactor operators, testing and maintenance activities, all the added safety engineered instrumentation used to monitor and shut down nuclear plant systems before any severe damage occurs, and the regulatory requirements and oversight of the U.S. Nuclear Regulatory Commission. The probability is thus noted as <1-percent.

Changing Future Conditions Considerations

Generally, an incident involving a nuclear reactor would not have an impact on climate change, nor would climate change have a measurable effect on the impacts of a nuclear power plant incident. An influx of population or development in the areas around the plants would create added risk.

The production of nuclear power requires access to large volumes of water to cool the reactor and a supply of energy to move the water. For this reason, nuclear power plants are typically sited near large bodies of water, often seas or estuaries. It is this attachment to water that makes nuclear power vulnerable to changing future conditions.

One cause for concern is floods. All nuclear power plants are designed to withstand a certain level of flooding based on historical data, but these figures do not take changing climate conditions into account. Floods due to heavy rain are likely to increase in frequency. Loss of power, loss of communications, blockage of evacuation routes and equipment malfunction are all safety issues associated with flooding and nuclear power plants.

Heat waves are another serious concern, for two reasons. One, the colder the cooling water entering a reactor, the more efficient the production of electricity. And two, once the cooling water has passed through the system it is often discharged back where it came from in a much warmer state. Heat waves may to lead to a shut down or reduction in power production due to regulations governing receiving water temperatures and the protection of aquatic ecosystems.

The final concern is drought. Climate models predict droughts will become longer and larger in the future. Prolonged drought could impact water levels causing issues for water intake pipes that are necessary for reactor cooling systems. Furthermore, legal battles may also ensue over scarce water resources.

State Vulnerability Overview

The consequences of a radiological incident originating from one of the commercial nuclear power plants affecting the State can range in severity from insignificant to a high degree of radioactive contamination within the two to 10-mile radius surrounding the facility. The most crucial concerns during a severe incident are safe evacuation and controlled access to the areas affected by a release of radioactive materials; these processes are managed under the State of Missouri Nuclear Power Plant Action Plan. In the aftermath of a radiological incident, the main concerns include the extent of property needing to be decontaminated, contaminated food sources, and the time required to reach acceptable exposure rates and to allow the safe reentry of the public. Due to their safe operation records, fixed nuclear facilities have not historically represented a high risk to the State. The Reactor Safety Study conducted by the NRC rated the chances of a major nuclear disaster as very low (a probability of one in one million per plant operating year). The report concluded that the worst accident type that could affect a nuclear power plant would be one resulting in a meltdown, which could be expected to occur once in 20,000 years of reactor operation. The report also stated that a meltdown would likely cause less than one fatality or injury. This low hazard rating is due to all of the added safety engineered instrumentation used to monitor and shut down nuclear plant systems before any severe damage occurs.

An incident at a nuclear power plant resulting in a "general emergency" and evacuation (one where a release from the site boundary would be expected) could have a dramatic psychological impact on the uninformed population within the evacuation zone. The utilities and the State have an active Radiological Emergency Preparedness program to prepare local jurisdictions and the general population surrounding the plant for responding to such an incident. This program includes in-depth training of resources both from the State and local jurisdictions, and regularly scheduled drills and exercises evaluated by FEMA. Extensive planning has focused on implementation of the emergency response plan for both the State and local jurisdictions. Emphasis is placed on prompt notification of emergency organizations and the public; evacuation routes; reception and care centers for evacuees; monitoring for radiological contamination; emergency worker preparedness; and public information in the form of brochures distributed to residents within the emergency preparedness zone. These programs are essential to the protection of the general public.

Overview and Analysis of Vulnerability

An accident involving radioactive materials could occur in Missouri from a variety of sources: nuclear reactors, transportation accidents (see Section 3.3.16 Hazardous Materials), industrial and medical uses, and lost or stolen sources where the public could be exposed, or contaminated, with a high level of radiation. Although the chance of a nuclear power plant release is unlikely, radiological accidents have the potential to cause injury or death, contaminate property and valuable environmental resources, as well as disrupt the functioning of communities and their economies.

Local and state governments, federal agencies, and the electric utilities have emergency response plans in place in the event of a nuclear power plant incident. The plans define two "emergency planning zones." One zone covers an area within a 10-mile radius of the plant, where it is possible that people could be harmed by direct radiation exposure. The second zone covers a broader area, usually up to a 50-mile radius from the plant, where radioactive materials could contaminate water supplies, food crops, and livestock.

The potential danger from an accident at a nuclear power plant is exposure to radiation. This exposure could come from the release of radioactive material from the plant into the environment, usually characterized by a plume (cloud-like formation) of radioactive gases and particles. The major hazards to people in the vicinity of the plume are radiation exposure to the body from the cloud and particles deposited on the ground, inhalation of radioactive materials, and ingestion of radioactive materials.

There are several Missouri counties included in 10-mile and 50-mile emergency planning zones (EPZ) for nuclear power plants. There are two commercial plants that could pose a threat to Missouri: The Callaway Nuclear Generating Station in Callaway County and the Cooper Nuclear Station in Nemaha County, Nebraska. There are also Missouri University of Science and Technology research reactors that support education, research, training, and regional industries.

Counties within the 10-mile EPZ for commercial nuclear power plants have a relatively higher radiological risk than other counties, but the potential for an incident is extremely low. These counties include portions of Callaway, Osage, and Montgomery for the Callaway plant, and Atchison and Holt for the Cooper plant. Counties within the 50 mile ingestion pathway are at lower risk. For the Cooper plant, those counties include

Andrew County and Nodaway County, in addition to those in the 10 mile EPZ. For the Callaway plant, counties within the 50 mile ingestion pathway include Audrain County, Boone County, Crawford County, Cole County, Cooper County, Franklin County, Gasconade County, Howard County, Lincoln County, Maries County, Miller County, Monroe County, Moniteau County, Pike County, Randolph County, Ralls County, St. Charles County, and Warren County.

State Estimates of Potential Losses

Table 3.145 below lists the counties within the 10-mile radius of the two nuclear power plants (Callaway and Cooper) that could impact Missouri in the event of an emergency or accident. This table provides counts and values of state-owned facilities as well as counts and rent value of state-leased facilities. It should be noted that this analysis considers all facilities that fall within counties that are wholly or partially in the radius zones.

Table 3.145. Counties within 10 mile radius

County	Total Facilities	Critical Facilities (Owned)	Critical Facilities (Rented)	Total Replacement Value	State-Leased Total Annual Rent
Callaway	91	41	-	$116,186,784	-
Montgomery	3	2	-	$124,962	-
Atchison	4	-	3	-	$34,328
Total	**98**	**43**	**3**	**$116,311,746**	**$34,328**

Hazard Impact on Future Growth and Development

None of the counties within the 10 mile EPZ for the Cooper or Callaway plants are in the top 10 counties for housing unit and population gains between 2010 and 2015. Boone and St. Charles Counties are within the 50 mile ingestion pathway for the Callaway plant and are among the top 10 counties for housing and population gains from 2010 to 2015. Lincoln County, in the Callaway 50-mile ingestion pathway is in the top 10 for population gains between 2010 and 2015.

EMAP Consequence Analysis

The information in **Table 3.146** is from the Impact Analysis of Potential for Detrimental Impacts of Hazards done for the Emergency Management Accreditation Program.

Table 3.146. EMAP Impact Analysis: Nuclear Power Plants

Subject	Detrimental Impacts
Public	Adverse impact expected to be severe for unprotected people and moderate to light for protected people; most impacts will occur within a ten-mile range from the impacted plant.
Responders	Adverse impact expected to be severe for unprotected personnel and moderate to light for trained and protected personnel; responders in the immediate area should be issued potassium iodide upon recognition of the potential for a release.
Continuity of Operations including Continued Delivery of Services	Damage to facilities/personnel in the area of the incident may require temporary or extended relocation of operations, or temporary discontinuation of services.
Property, Facilities, and Infrastructure	Localized impact to facilities and infrastructure in the area of the incident. Some severe radioactive damage possible. Potential prolonged deficit in local energy availability.
The Environment	May cause extensive damage in isolated cases and some denial or delays in the use of some areas. Remediation needed.

Subject	Detrimental Impacts
Economic Condition of the Jurisdiction	Local economy and finances adversely affected, possibly for an extended period of time, depending on damage and length of investigation.
Public Confidence in the Jurisdiction's Governance	Ability to respond and recover may be questioned and challenged if planning, response, and recovery not timely and effective. Early and consistent messaging is essential to calm public fear.

Risk Summary

Nuclear reactors have been designed to survive natural disasters such as tornadoes and earthquakes without damage to critical systems. Considerable emphasis is placed on multiple-level governmental reviews of the design, construction, and operation of each nuclear power plant. These safety reviews begin prior to construction and continue throughout the operating life of the plant. Radiological planning and preparedness programs monitored by state and federal agencies are in place to ensure that emphasis is placed on the safety of the general public within the emergency planning zone. In addition, the historical record for nuclear power plants gives no indication that a serious accident involving a nuclear power plant will occur.

Problem Statement:

Using the Counties within a 10-mile radius of nuclear plants as the key indicator, the counties as most risk from fallout are Callaway, Montgomery and Atchison. Mitigation strategies and limited resources would best be expended in these counties first.

2018 risk assessment data and mapping is available through the Missouri Hazard Mitigation Viewer: http://bit.ly/MoHazardMitigationPlanViewer2018.

3.3.19. Public Health Emergencies/Environmental Issues

Probability	Severity
<1%	Low to High

Description/Location

Public health emergencies can take many forms—disease epidemics, large-scale incidents of food or water contamination, or extended periods without adequate water and sewer services. There can also be harmful exposure to chemical, radiological, or biological agents, and largescale infestations of disease-carrying insects or rodents. The first part of this section focuses on emerging public health concerns and potential pandemics, while the second part addresses natural and human-caused air and water pollution.

Public health emergencies can occur as primary events by themselves, or they may be secondary to another disaster or emergency, such as tornado, flood, or hazardous material incident. For more information on those particular incidents, see Sections 3.3.10 (Tornadoes/Severe Thunderstorms), 3.3.1 (Riverine Flooding), and 3.3.16 (Hazardous Materials). The common characteristic of most public health emergencies is that they adversely impact, or have the potential to adversely impact, a large number of people. Public health emergencies can be worldwide or localized in scope and magnitude.

In particular, two public health hazards have recently emerged as issues of great concern, with far reaching consequences. One pertains to the intentional release of a radiological, chemical, or biological agent, as a terrorist act of sabotage to adversely impact a large number of people. For more information on biochemical terrorism, see Section 3.3.21. The second hazard concerns a deadly outbreak (other than one caused by an act of terrorism) that could kill or sicken thousands of people across the county or around the globe. The primary communicable, or infectious, disease addressed within this plan is influenza:

- **Influenza** - Whether natural or manmade, health officials say the threat of a dangerous new strain of influenza (flu) virus in pandemic proportions is a very real possibility in the years ahead. Unlike most illnesses, the flu is especially dangerous because it is spread through the air. A classic definition of influenza is a respiratory infection with fever. Each year, flu infects humans and spreads around the globe. There are three types of influenza virus: Types A, B, and C. Type A is the most common, most severe, and the primary cause of flu epidemics. Type B cases occur sporadically and sometimes as regional or widespread epidemics. Type C cases are quite rare and hence sporadic, but localized outbreaks have occurred. Seasonal influenza usually is treatable, and the mortality rate remains low. Each year, scientists estimate which particular strain of flu is likely to spread, and they create a vaccine to combat it. A flu pandemic occurs when the virus suddenly changes or mutates and undergoes an —antigenic shift, permitting it to attach to a person‘s respiratory system and leave the body‘s immune system defenseless against the invader.

Additional diseases of public health concern include tuberculosis, Smallpox, St. Louis Encephalitis, Meningitis, Lyme disease, West Nile, SARS, Zika, and Ebola. These communicable diseases are introduced within this plan, but full vulnerability analyses are not included at this time.

- **Tuberculosis -** Tuberculosis, or TB, is the leading cause of infectious disease worldwide. It is caused by a bacteria called Mycobacterium tuberculosis that most often affects the lungs. TB is an airborne disease spread by coughing or sneezing from one person to another. The World Health Organization (WHO) estimates that one-third of the world's population, approximately two billion people, has latent TB, which means people have been infected by TB bacteria but are not yet ill with the disease and cannot transmit the disease. In 2015, 10.4 million people fell ill with TB and 1.8 million died from the disease (including 0.4 million among people with HIV). Over 95% of TB deaths occur in low- and middle- income countries. In 2015, Missouri reported a total of 2,934 cases of TB infection and 93 cases of TB disease.

- **Smallpox** - Smallpox is a contagious, sometimes fatal, infectious disease. There is no specific treatment for smallpox disease, and the only prevention is vaccination. Smallpox is caused by the variola virus that emerged in human populations thousands of years ago. It is generally spread by face- to-face contact or by direct contact with infected bodily fluids or contaminated objects (such as bedding or clothing). A person with smallpox is sometimes contagious with onset of fever, but the person becomes most contagious with the onset of rash. The rash typically develops into sores that spread over all parts of the body. The infected person remains contagious until the last smallpox scab is gone. Smallpox outbreaks have occurred periodically for thousands of years, but the disease is now largely eradicated after a worldwide vaccination program was implemented. After the disease was eliminated, routine vaccination among the general public was stopped. The last case of smallpox in the United States was in 1949.
- It should be noted that after recent terrorist events in the United States, there is heightened concern that the variola virus might be used as an agent of bioterrorism. For this reason, the U.S. government is taking precautions for dealing with a smallpox outbreak. For further information on this issue, see Section 3.3.19 Terrorism.
- **St. Louis Encephalitis** - In the United States, the leading type of epidemic flaviviral Encephalitis is St. Louis encephalitis (SLE), which is transmitted by mosquitoes that become infected by feeding on birds infected with the virus. SLE is the most common mosquito-transmitted pathogen in the United States. There is no evidence to suggest that the virus can be spread from person to person.
- **Meningitis**- Meningitis is an infection of fluid that surrounds a person's spinal cord and brain. High fever, headache, and stiff neck are common symptoms of meningitis, which can develop between several hours to one to two days after exposure. Meningitis can be caused by either a viral or bacterial infection; however, a correct diagnosis is critically important, because treatments for the two varieties differ. Meningitis is transmitted through direct contact with respiratory secretions from an infected carrier. Primary risk groups include infants and young children, household contact with patients, and refugees. In the United States, periodic outbreaks continue to occur, particularly among adolescents and young adults. About 2,600 people in the United States get the disease each year. Generally, 10 to 14 percent of cases are fatal, and 11 to 19 percent of those who recover suffer from permanent hearing loss, mental retardation, loss of limbs, or other serious effects. Two vaccines are available in the United States.
- **Lyme Disease** - Lyme disease was named after the town of Lyme, Connecticut, where an unusually large frequency of arthritis-like symptoms was observed in children in 1977. It was later found that the problem was caused by bacteria transmitted to humans by infected deer ticks, causing an average of more than 16,000 reported infections in the United States each year (however, the disease is greatly under-reported). Lyme disease bacteria are not transmitted from person to person. Following a tick bite, 80 percent of patients develop a red —bulls-eye rash accompanied by tiredness, fever, headache, stiff neck, muscle aches, and joint pain. If untreated, some patients may develop arthritis, neurological abnormalities, and cardiac problems, weeks to months later. Environmental issues addressed in this profile focus on air and water pollution, because contamination of those media can have widespread impacts on public health and devastating consequences. Particular issues of primary concern associated with sources of air and water pollution change over time depending on recent industrial activity, economic development, enforcement of environmental regulations, new scientific information on adverse health effects of particular

contaminants or concentrations, and other factors. Lyme disease is rarely fatal. During early stages of the disease, oral antibiotic treatment is generally effective, while intravenous treatment may be required in more severe cases.

- **West Nile Virus** - West Nile virus is a flavivirus spread by infected mosquitoes and is commonly found in Africa, West Asia, and the Middle East. It was first documented in the United States in 1999. Although it is not known where the U.S. virus originated, it most closely resembles strains found in the Middle East. It is closely related to St. Louis encephalitis and can infect humans, birds, mosquitoes, horses, and other mammals.
- Most people who become infected with West Nile virus will have either no symptoms or only mild effects. However, on rare occasions, the infection can result in severe and sometimes fatal illness. There is no evidence to suggest that the virus can be spread from person to person.
- An abundance of dead birds in an area may indicate that West Nile virus is circulating between the birds and mosquitoes in that area. Although birds are particularly susceptible to the virus, most infected birds survive. The continued expansion of West Nile virus in the United States indicates that it is permanently established in the Western Hemisphere.
- **Severe Acute Respiratory Syndrome** - Severe acute respiratory syndrome (SARS) is a respiratory illness that has recently been reported in Asia, North America, and Europe. Although the cause of SARS is currently unknown, scientists have detected in SARS patients a previously unrecognized coronavirus that appears to be a likely source of the illness. In general, humans infected with SARS exhibit fevers greater than 100.4 F, headaches, an overall feeling of discomfort, and body aches. Some people also experience mild respiratory symptoms. After two to seven days, SARS patients may develop a dry cough and have trouble breathing. The primary way that SARS appears to spread is by close person-to-person contact; particularly by an infected person coughing or sneezing contaminated droplets onto another person, with a transfer of those droplets to the victim's eyes, nose, or mouth.
- **Zika Virus** - Discovered in the Zika forest of Uganda in 1947, the Zika virus is a member of the flavivirus family. It is transmitted to humans through the bite of an infected Aedes species mosquito (Ae. aegypti and Ae. albopictus). Zika virus can also be transmitted from an infected pregnant woman to her baby during pregnancy and can result in serious birth defects, including microcephaly. Less commonly, the virus can be spread through intercourse or blood transfusion. However, most people infected with the Zika virus do not become sick.
- **Ebola –** previously known as Ebola hemorrhagic fever, is a rare and deadly disease caused by infection with one of the Ebola virus species. It was first discovered in 1976 near the Ebola River in what is now the Democratic Republic of the Congo. Since then, outbreaks have appeared sporadically in Africa.

Additional **environmental concerns** addressed in this hazard profile focus on air and water pollution, because contamination of those media can have widespread impacts on public health and devastating consequences. Particular issues of primary concern associated with sources of air and water pollution change over time depending on recent industrial activity, economic development, enforcement of environmental regulations, new scientific information on adverse health effects of particular contaminants or concentrations, and other factors.

Air Pollution

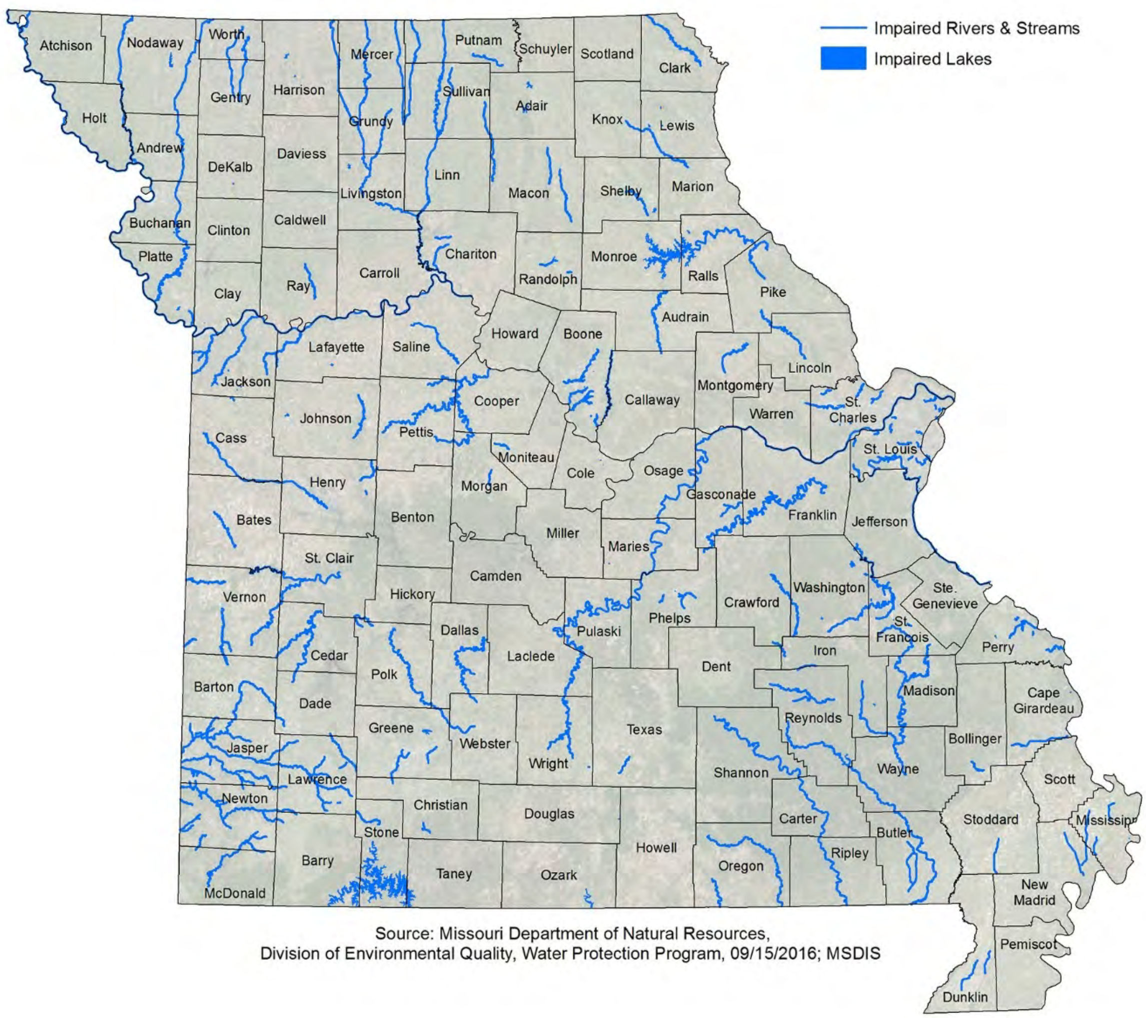
Because of high amounts of ozone, carbon dioxide, nitrogen compounds, and other vehicular pollutants in the St. Louis metropolitan area, vehicles registered in St. Louis City, Franklin County, Jefferson County, St. Charles County and St. Louis County are required to have their exhaust systems routinely checked to determine whether emissions standards are being achieved. In addition, all service stations around St. Louis are now required to have new gas nozzles that recapture gasoline vapors, thus preventing them from being released to the atmosphere. These vapors (unburned hydrocarbons) chemically react with nitrogen oxides when exposed to the sunlight and form ozone, which is the basis for smog. For more information on Missouri's Air Pollution Control Program, contact the Missouri Department of Natural Resources at http://dnr.mo.gov/env/apcp/.

Water Pollution

There are currently 115,772 miles of classified streams in Missouri and 142,666 miles of unclassified streams. There are 363,653 acres of classified lakes and 68,302 acres of unclassified lakes. **Figure 3.196** on the following page presents the streams and lakes deemed impaired due to contamination.

The Environmental Protection Agency (EPA) also maintains the National Pollutant Discharge Elimination System (NPDES). Authorized by the Clean Water Act, the NPDES permit program controls water pollution by regulating point sources that discharge pollutants into waters of the United States. Point sources are discreet conveyances such as pipes or man-made ditches. Individual homes that are connected to a municipal system, use a septic system, or do not have a surface discharge do not need an NPDES permit; however, industrial, municipal, and other facilities must obtain permits if their discharges go directly to surface waters. In most cases, the NPDES permit program is administered by authorized states. Since its introduction in 1972, the NPDES permit program is responsible for significant improvements to our Nation's water quality. To view NPDES storm water outfalls, animal feeding operations, and waste water outfalls, visit the Missouri Department of Natural Resources Stormwater Internet Map Viewer.

Figure 3.196. Streams and Lakes Deemed Impaired by the 2016 Missouri Water Quality Report

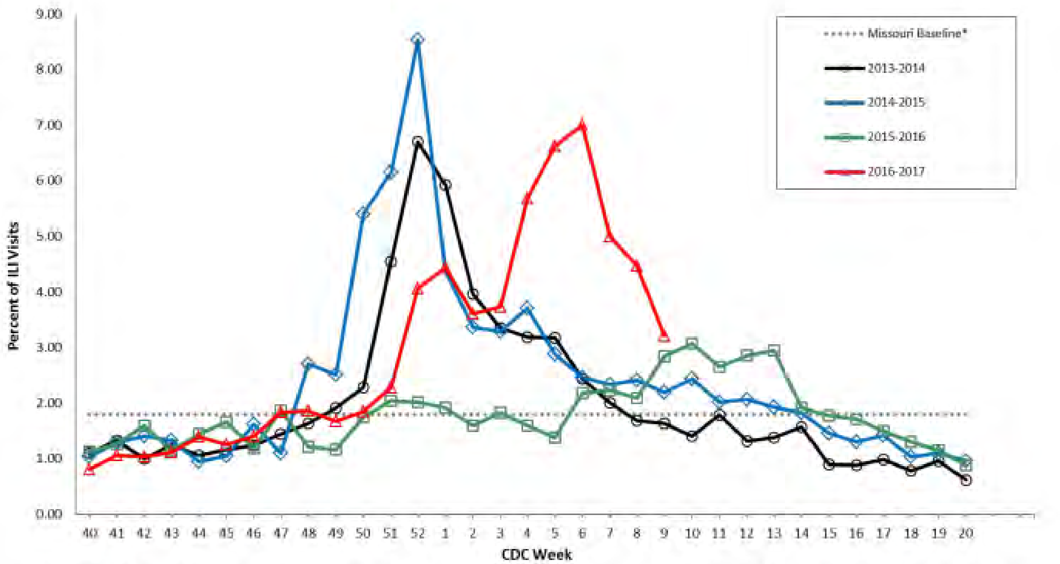


Source: Missouri Department of Natural Resources, Division of Environmental Quality, Water Protection Program, 09/15/2016; MSDIS

Extent

All of Missouri is at risk to public health emergencies. The Missouri Department of Health and Senior Services tracks the spread of influenza and other communicable diseases within the State through reporting from hospitals, laboratories, and healthcare providers. Reporting can be based on a positive laboratory test, clinical symptoms, or epidemiologic criteria. A public health investigation may also be conducted to determine and implement appropriate public health interventions. Specific Information regarding the current situation as of March 2017 with H1N1 in Missouri are included in **Figure 3.197** and **Figure 3.198**. Currently the estimated influenza activity in Missouri is widespread with outbreaks of influenza or increases in influenza-like illness (ILI) cases and recent laboratory-confirmed influenza cases occurring in at least half the regions of the State. ILI activity is above baseline for both the Missouri Outpatient ILI Surveillance Network (ILINet) and the hospital emergency room visit chief complaint data reported through ESSENCE. The reported percentage of visits for ILI was 3.21% and 3.37% through ILINet and ESSENCE respectively.

Figure 3.197. Percentage of Outpatient Visits for Influenza-like-Illness (ILI) Reported by the Missouri Outpatient ILI Surveillance Network (ILINet) 2013-2017 Season-To-Date as compared to the previous three influenza seasons Through the Week Ending March 4, 2017 (Week 9)

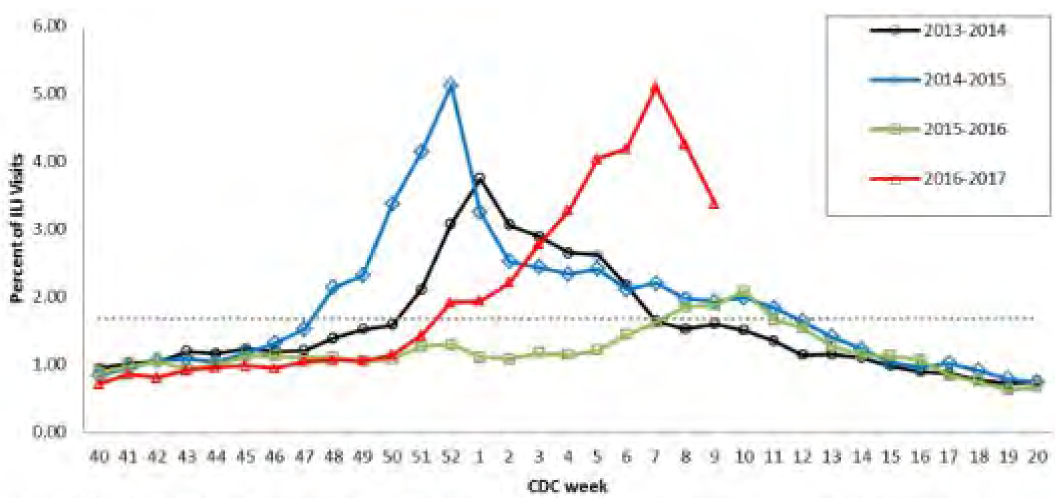


*The ILINet Region 7 (MO, IA, KS, NE) baseline is the mean percentage of patient visits for ILI during non-influenza weeks for the previous three seasons, plus two standard deviations. A non-influenza week is defined as periods of two or more consecutive weeks in which each week accounted for less than 2% of the season's total number of specimens that tested positive for influenza.
Data Source: U.S. Outpatient Influenza-like Illness Surveillance Network (ILINet), Centers for Disease Control and Prevention (CDC).

†2016-2017 season-to-date through the week ending May 20, 2017 (Week 20). The 2014-2015 season had 53 weeks rather than the usual 52. The percentage of outpatient visits for ILI during Week 53 was 7.63.

Source: Missouri Department of Health and Senior Services
http://health.mo.gov/living/healthcondiseases/communicable/influenza/pdf/week91617.pdf

Figure 3.198. Weekly Percentage of Influenza-like Illness (ILI) in ESSENCE Participating Hospitals, 2013-2017 Through the Week Ending March 4, 2017 (Week 9)



*The ESSENCE ILI Baseline is the mean percent of ILI visits for each week during the previous three years (2013-15) when percentage of ILI visits were less than 2% of total visits, plus two standard deviations.
Data Source: Missouri Department of Health and Senior Services (DHSS), Bureau of Reportable Disease Informatics, ESSENCE.

†The 2014-2015 season had 53 weeks rather than the usual 52. The percentage of visits for ILI in ESSENCE participating hospitals during Week 53 was 4.3.

Source: Missouri Department of Health and Senior Services
http://health.mo.gov/living/healthcondiseases/communicable/influenza/pdf/week91617.pdf

The Missouri Department of Health and Senior Services prepares for pandemics with its Missouri Pandemic Influenza Response plan. Additional activities include enhanced surveillance for the H1N1 virus by requiring immediate, detailed reporting of all diagnosed or suspected cases; conducting more frequent analysis of surveillance data; and activating additional surveillance providers. The State Public Health Laboratory in Jefferson City is a state-of-the-art facility that handles many kinds of infectious agents.

The Pandemic Influenza Response Plan is available here:
http://health.mo.gov/emergencies/panflu/pdf/panfluplan.pdf

The Department's flu website provides specific advice for child care centers, employers, nursing homes, schools, pregnant women, restaurant workers and customers and stroke patients. The department also provides advice, information and leadership to local public health agencies and to the medical community on ways to deal with pandemic outbreak and works closely with the news media to disseminate information about the virus.

The DHSS website for influenza advice and prevention is available here:
http://health.mo.gov/living/healthcondiseases/communicable/influenza/index.php

Previous Occurrences

Public Health Emergencies - Influenza Pandemics

Since the early 1900s, four lethal pandemics have swept the globe: Spanish Flu of 1918-1919; Asian Flu of 1957-1958; Hong Kong Flu of 1968-1969; and Swine Flu of 2009-2010. The Spanish Flu was the most severe pandemic in recent history. The number of deaths was estimated to be 50-100 million worldwide and 675,000 in the United States. Its primary victims were mostly young, healthy adults. The 1957 Asian Flu pandemic killed about 70,000 people in the United States, mostly the elderly and chronically ill. The 1968 Hong Kong Flu pandemic killed 34,000 Americans. The 2009 Swine Flu caused 12,469 deaths in the United States. These historic pandemics are further defined in the following paragraphs along with several "pandemic scares".

Spanish Flu (H1N1 virus) of 1918-1919

In 1918, when World War I was in its fourth year, another threat began that rivaled the war itself as the greatest killer in human history. The Spanish Flu swept the world in three waves during a two-year period, beginning in March 1918 with a relatively mild assault.

The first reported case occurred at Camp Funston (Fort Riley), Kansas, where 60,000 soldiers trained to be deployed overseas. Within four months, the virus traversed the globe, as American soldiers brought the virus to Europe. The first wave sickened thousands of people and caused many deaths (46 died at Camp Funston), but it was considered mild compared to what was to come. The second and deadliest wave struck in the autumn of 1918 and killed millions. At Camp Funston alone, there were 14,000 cases and 861 deaths reported during the first three weeks of October 1918.

Outbreaks caused by a new variant exploded almost simultaneously in many locations including France, Sierra Leone, Boston, and New York City, where more than 20,000 people died that fall. The flu gained its name from Spain, which was one of the hardest hit countries. From there, the flu went through the Middle East and around the world, eventually returning to the United States along with the troops.

Of the 57,000 Americans who died in World War I, 43,000 died as a result of the Spanish Flu. At one point, more than 10 percent of the American workforce was bedridden. By a conservative estimate, a fifth of the human race suffered the fever and aches of influenza between 1918 and 1919 and 20 million people died.

In 1918, Missouri's influenza death rate was 293.83 per 100,000 people, for a total of 9,677 deaths statewide from that cause alone. That figure represents 18.6 percent of Missouri's total deaths that year. While the cause of the Spanish Flu remains somewhat a mystery, the epidemic was generally traced to pigs on Midwest farms, which then spread the deadly virus to arm families. As fall crops were ready for harvest in 1918, there were no field hands to get the crops in, thereby creating an agricultural disaster, as well.

A third wave of the Spanish Flu, much less devastating than its predecessors, made its way through the world in early 1919 and then died out. Missouri's flu death rate in 1919 dropped to less than half that of the previous year (107.21 per 100,000), and by 1921, it was reduced to 87.24 deaths per 100,000 people, state statistics show.

Asian Flu (H2N2 virus) of 1957-1958

This influenza pandemic was first identified in February 1957 in the Far East. Unlike the Spanish Flu, the 1957 virus was quickly identified, and vaccine production began in May 1957. A number of small outbreaks occurred in the United States during the summer of 1957, with infection rates highest among school children, young adults, and pregnant women; however, the elderly had the highest rates of death. A second wave of infections occurred early the following year, which is typical of many pandemics.

Hong Kong Flu (H3N2 virus) of 1968-1969

This influenza pandemic was first detected in early 1968 in Hong Kong. The first cases in the United States were detected in September 1968, although widespread illness did not occur until December. This became the mildest pandemic of the twentieth century, with those over the age of 65 the most likely to die. People infected earlier by the Asian Flu virus may have developed some immunity against the Hong Kong Flu virus. Also, this pandemic peaked during school holidays in December, limiting student-related infections.

Pandemic Flu Threats: Swine Flu of 1976, Russian Flu of 1977, and Avian Flu of 1997 and 1999

Three notable flu scares occurred in the twentieth century. In 1976, a swine-type influenza virus appeared in a U.S. military barracks (Fort Dix, New Jersey). Scientists determined it was an antigenically drifted variant of the feared 1918 virus. Fortunately, a pandemic never materialized, although the news media made a significant argument about the need for a Swine Flu vaccine.

In May 1977, influenza viruses in northern China spread rapidly and caused epidemic disease in children and young adults. By January 1978, the virus, subsequently known as the Russian Flu, had spread around the world, including the United States. A vaccine was developed for the virus for the 1978–1979 flu season. Because illness occurred primarily in children, this was not considered a true pandemic.

In March 1997, scores of chickens in Hong Kong's rural New Territories began to die—6,800 on three farms alone. The Avian Flu virus was especially virulent, and made an unusual jump from chickens to humans. At least 18 people were infected, and six died in the outbreak. Chinese authorities acted quickly to exterminate over one million chickens and successfully prevented further spread of the disease. In 1999, a new avian flu virus appeared. The new virus caused illness in two children in Hong Kong. Neither of these avian flu viruses started pandemics.

Swine Flu (H1N1 virus) of 2009–2010

This influenza pandemic emerged from Mexico in 2009. The first U.S. case of H1N1, or Swine Flu, was diagnosed on April 15, 2009. The U.S. government declared H1N1 a public health emergency on April 26. By June, approximately 18,000 cases of H1N1 had been reported in the United States. A total of 74 countries were affected by the pandemic.

The CDC estimates that 43 million to 89 million people were infected with H1N1 between April 2009 and April 2010. There were an estimated 8,870 to 18,300 H1N1 related deaths. On August 10, 2010, the World Health Organization (WHO) declared an end to the global H1N1 flu pandemic.

Public Health Emergencies – Other Pandemics

St. Louis Encephalitis, 1964-2005

Between 1964 and 2005, there were 4,651 confirmed cases of SLE in the United States. Seventy-five of these cases were in Missouri. According to the U.S. Geological Survey, there was one case of SLE in Missouri in 2006. It should be noted, however, that less than 1 percent of SLE infections are clinically apparent, so the vast majority of infections remain undiagnosed. Illnesses range from mild headaches and fever to convulsions, coma, and paralysis. The last major outbreak of SLE occurred in the Midwest from 1974 to 1977, when over 2,500 cases were reported in 35 states. The most recent outbreak of St. Louis encephalitis was in 1999 in New Orleans, Louisiana, with 20 reported cases. The disease is generally milder in children than in adults, with the elderly at highest risk for severe illness and death. Approximately 3 to 30 percent of cases are fatal; no vaccine against SLE exists. In 2011, one probably case was reported in Boone County, MO.

Meningitis, 1996-1997, 2005

During 1996 and 1997, 213,658 cases of meningitis were reported, with 21,830 deaths, in Africa. According to the Missouri Department of Health and Senior Services, there were 28 cases in Missouri in 2005.

Lyme Disease, 2015

In the United States, Lyme disease is mostly found in the northeastern, mid-Atlantic, and upper north-central regions, and in several counties in northwestern California. In 2015, 95-percent of confirmed Lyme Disease cases were reported from 14 states: Connecticut, Delaware, Maine, Maryland, Massachusetts, Minnesota, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, Vermont, Virginia, and Wisconsin. Lyme disease is the most commonly reported vector-borne illness in the United States. In 2015, it was the sixth most common nationally notifiable disease. However this disease does **not** occur nationwide and is concentrated heavily in the northeast and upper Midwest.

Severe Acute Respiratory Syndrome, 2003

During November 2002-July 2003, a total of 8,098 probable SARS cases were reported to the World Health Organization (WHO) from 29 countries. In the United States, only 8 cases had laboratory evidence of infection. There were no confirmed cases in Missouri. Since July 2003, when SARS transmission was declared contained, active global surveillance for SARS disease has detected no person-to-person transmission. CDC has therefore archived the case report summaries for the 2003 outbreak.

Zika Virus, 2015

In May 2015, the Pan American Health Organization issued an alert noting the first confirmed case of a Zika virus infection in Brazil. Since that time, Brazil and other Central and South America countries and territories, as well as the Caribbean, Puerto Rico, and the U.S. Virgin Islands have experienced ongoing Zika virus transmission. In August 2016, the Centers for Disease Control and Prevention (CDC) issued guidance for people living in or traveling to a 1-square-mile area Miami, Florida, identified by the Florida Department of Health as having mosquito-borne spread of Zika. In October 2016, the transmission area was expanded to include a 4.5-square-mile area of Miami Beach and a 1-squre mile area of Miami-Dade County. In addition, all of Miami-Dade County was identified as a cautionary area with an unspecified level of risk. In Missouri, there have been 32 confirmed travel-associated cases of Zika virus, but no locally acquired cases.

Ebola, 2014-2016

Most recently, in March 2014, West Africa experienced the largest outbreak of Ebola in history. Wide spread transmission was found in Liberia, Sierra Leone, and Guinea with the number of cases totaling 28,616 and the number of deaths totaling 11,310. In the United States, four cases of Ebola were confirmed in 2014 including a medical aid worker returning to New York from Guinea, two healthcare workers at Texas Presbyterian Hospital who provided care for a diagnosed patient, and the diagnosed patient who traveled to Dallas, Texas from Liberia. All three healthcare workers recovered. The diagnosed patient passed away in October 2014.

In March 2016, the WHO terminated the public health emergency for the Ebola outbreak in West Africa.

Environmental Issues

The EPA maintains a list of facilities that release the most toxic chemicals each year. Missouri's top 10 facilities for 2014 are shown in Table 3.109. The top 10 chemicals released in the State are shown in **Table 3.147**. The information is recorded by onsite and off-site releases. The onsite releases are based upon detected releases of material into the air, land and water. Off-site releases are divided between publicly own treatment works and disposal.

Table 3.147. Top 10 Facilities in Missouri Showing Greatest Releases (2014)
(All figures are in pounds)

	On-Site Releases				Off-Site Releases		
Facility	**County**	**Air**	**Land**	**Water**	**POTW***	**Disposal**	**Total****
Buick Mine/Mill	Iron	6,931	20,754	13,114,000	-	-	13,141,685
Brushy Creek Mine/Mill	Reynolds	1,334	2,255	11,054,000	-	-	11,057,589
Fletcher Mine/Mill	Reynolds	2,073	33,746	7,610,000	-	-	7,645,819
Sweetwater Mine/Mill	Reynolds	806	6,577	5,286,000	-	-	5,293,383
Buick Resource Recycling Facility Llc	Iron	3,358	225	3,874,254	-	257,656	4,135,493
Ameren Missouri Labadie Energy Cntr.	Franklin	681,066	12	2,094,948	-	-	2,776,026
Associated Electric Cooperative Inc New Madrid Power Plant	New Madrid	324,864	3,250	1,903,142	-	35	2,231,291
Iatan Generating Station	Platte	25,774	-	1,859,113	-	-	1,884,887
Thomas Hill Energy Center - Power Div	Randolph	378,845	4,053	1,457,785	-	-	1,840,682
National Beef Leathers LLC	Buchanan	255	-	-	750	1,607,612	1,608,617

Source: Missouri Toxic Resources Inventory Database 2015
Notes: *Releases to POTWs (publicly owned treatment works) of metals or metal compounds only
**None of the values in this table include Dioxin or Dioxin-like compounds

Table 3.148. Top 10 Chemicals Reported in Missouri (2014) (All figures are in pounds)

Chemical	On-Site Releases			Off-Site Releases		
	Air	Land	Water	POTW*	Disposal	Total*
Lead Compounds	28,887	22,225,221	15,475	239	361,605	22,631,428
Zinc Compounds	31,586	13,567,550	47,965	4,595	983,971	14,635,667
Barium Compounds	63,320	10,079,465	7,485	-	123,427	10,273,696
Copper Compounds	11,703	5,607,798	1,210	2,113	64,918	5,687,742
Nitrate Compounds	3,202	247,016	1,944,123	-	27,380	2,221,721
Chromium Compounds (Except Chromite Ore Mined In The Transvaal Region)	4,162	101,537	277	955	1,871,199	1,978,130
Hydrogen Fluoride	1,425,744	-	5	-	30,929	1,456,678
Sulfuric Acid (1994 And After Acid Aerosols Only)	1,315,097	5	0	-	0	1,315,102
Hydrochloric Acid (1995 And After Acid Aerosols Only)	1,090,113	5	0	-	0	1,090,118
N-Hexane	869,092	-	7	-	1,077	870,176

Source: Missouri Toxic Resources Inventory Database 2015
Note: *These numbers include transfers of non-metals to POTWs (publicly owned treatment works), but transfers of non-metals to POTWs are considered off-site treatment, not releases to the environment, and are NOT included in the Total Releases column

For information regarding historical incidents involving air and water pollution in Missouri, see Section 3.3.16 Hazardous Materials.

Probability of Future Hazard Events

It is impossible to predict when the next pandemic will occur or its impact, thus noted as <1-percent. The CDC continually monitors and assesses pandemic threats and prepares for an influenza pandemic. Novel influenza A viruses with pandemic potential include Asian lineage avian influenza A (H5N1) and (H7N9) viruses. These viruses have all been evaluated using the Influenza Risk Assessment Tool (IRAT) to assess their potential pandemic risk. Because the CDC cannot predict how severe a future pandemic will be, advance planning is needed at the national, state and local level. The Missouri Department of Health and Senior Service maintains a Pandemic Influenza Plan for the State.

Today, a much larger percentage of the world's population is clustered in cities, making them ideal breeding grounds for epidemics. Additionally, the explosive growth in air travel means the virus could literally be spread around the globe within hours. Under such conditions, there may be very little warning time. Most experts believe we will have just one to six months between the time that a dangerous new influenza strain is identified and the time that outbreaks begin to occur in the United States. Outbreaks are expected to occur simultaneously throughout much of the nation, preventing shifts in human and material resources that normally occur with other natural disasters. These and many other aspects make influenza pandemic unlike any other public health emergency or community disaster.

Environmental concerns are also on the rise, with recent scientific data emphasizing the long-term impacts that air and water pollution can have on the ecology of affected areas. With continued enforcement of regulatory standards for airborne releases and discharges to waterways, routine emissions by industrial facilities are relatively easy to monitor and control. However, the potential always remains for unauthorized dumping and releases and for failure of systems to control industrial discharges, resulting in potential environmental emergencies.

Changing Future Conditions Considerations

According to the U.S. Global Change Research Program, 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.

Hot days can be unhealthy—even dangerous. High air temperatures can cause heat stroke and dehydration, and affect people's cardiovascular and nervous systems. Midwestern cities like St. Louis are vulnerable to heat waves, because many houses and apartments lack air conditioning, and urban areas are typically warmer than their rural surroundings. In recent decades, severe heat waves have killed hundreds of people across the Midwest. Heat stress is expected to increase as climate change brings hotter summer temperatures and more humidity. Certain people are especially vulnerable, including children, the elderly, the sick, and the poor.

Higher temperatures and wetter conditions tend to increase mosquito and tick activity, leading to an increased risk of zoonotic diseases. Mosquitos are known to carry diseases such as West Nile virus (WNV), La Crosse/California encephalitis, Jamestown Canyon virus, St. Louis encephalitis, and Eastern equine encephalitis. The two major concerns associated with warmer and wetter conditions are that the mosquito species already found in Missouri and the diseases that they carry will become more prevalent, and that new species carrying unfamiliar diseases will start to appear for the first time.

Warmer winters with fewer hard freezes in areas that already see WNV-carrying mosquitos are likely to observe both a higher incidence of WNV and a longer WNV season, ultimately leading to an increase in human cases. Non-native mosquito species may move into Missouri if the climate becomes more suitable for them, bringing with them diseases such as Jamestown Canyon virus, Chikungunya, and Dengue Fever.

Ticks are also well-known disease vectors in Missouri, carrying pathogens such as Lyme disease, anaplasmosis, Ehrlichiosis, Powassan virus, and Babesiosis. Warmer, wetter weather can lead to an increase in algal blooms and declining beach health. An increase in flood events may also be associated with an increased incidence of mold problems in homes and businesses, as well as contamination of wells and surface waters due to sewer overflows and private septic system failures.

If these predictions come true, communities must contend with the human health impacts related to the increased prevalence of infectious diseases, heat waves, and changes in air and water quality. Public health officials will need to focus on spreading information and enacting pest and disease reduction. Floodprone communities will need to focus on continuously improving flood controls and mitigation strategies, including restricting building and chemical storage in floodplains, upgrading well and septic requirements, and providing water testing kits to residents.

State Vulnerability Overview

Public Health Emergencies

For planning purposes, it is reasonable to assume a rapid movement of a pandemic flu virus from major metropolitan areas to rural areas of the State. The effect of a pandemic on individual communities would likely be relatively prolonged—weeks to months. The impact of the next pandemic could have a devastating effect on the health and well-being of Missouri citizens and the American public. For such an outbreak in the future, the Centers for Disease Control and Prevention estimate that in the United States alone:

- Up to 200 million persons will be infected
- Between 40 and 100 million persons will become clinically ill
- Between 18 and 45 million persons will require outpatient care
- Between 300,000 and 800,000 persons will be hospitalized
- Between 88,000 and 300,000 people will die nationwide
- Effective preventive and therapeutic measures, including vaccines and antiviral agents, likely will be in short supply, as well as some antibiotics to treat secondary infections
- Economic losses from the next pandemic may range from $71 to 166 billion, depending on the attack rate.

Compared to public health emergencies, as previously described, environmental incidents involving air and water pollution would likely impact a more localized area; however, long-term effects on the environment in the impacted area could linger for many years.

As previously noted, all of Missouri is at risk to public health emergencies. There are a few special populations that are at increased risk for infectious diseases. Those special populations include: the institutionalized elderly, prison populations and children, especially un-immunized children (for vaccine preventable diseases). Special populations in Missouri have been estimated as follows:

- The Missouri DHSS reports that in April 2017 there were a total of 1,169 licensed adult care homes in Missouri with a census of 56,137 persons. The total available licensed adult care home beds for the State was 81,272.
- http://health.mo.gov/seniors/nursinghomes/pdf/BEDCENSUS.pdf
- The Missouri Department of Corrections 2016 annual report indicates 32,330 incarcerated offenders as of December 31, 2016. Of this population 3,676 individuals are over the age of 55 years.
- http://doc.mo.gov/Documents/publications/AR2016.pdf
- The Missouri Department of Elementary and Secondary Education 2015-2016 statistics of Missouri Public Schools indicates that 885,204 children are enrolled in elementary and secondary education institutions.
- https://mcds.dese.mo.gov/quickfacts/District%20and%20School%20Information/Missouri%20School%20Statistics.pdf

Vaccine preventable diseases are rare, but they do occur. The consequences of vaccine preventable childhood diseases can be quite serious and include liver damage, hearing loss, blindness, coma and death. Childhood immunization rates are fairly high for Missouri yet approximately 4 to 29 percent are not adequately immunized against certain diseases. Childhood immunizations are safe with only minimal side effects of pain, redness and swelling at the injection site, compared to the horrible consequences of the diseases themselves. The U.S. National Immunization Survey for 2015 showed Missouri predominately above the nation in select vaccination coverages. Data from the survey is displayed in **Table 3.149** below.

Table 3.149. Estimated vaccination coverage for the 4:3:1:3:3:1 and 4:3:1:3:3:1:4 vaccination series and selected individual vaccines among children aged 19--35 months (N = 18,430), 2015

	≥3 Hib	≥1 HepB	≥1 PCV	≥1 HepA	4:3:1:3:3:1	4:3:1:3:3:1:4
United States	86.0	94.3	84.5	85.8	75.1	72.2
Missouri	88.5	96.4	88.1	84.1	76.0	71.0

Source: National Immunization Survey (NIS), United States, 2015; Data available on ChildVaxView: https://www.cdc.gov/vaccines/imz-managers/coverage/childvaxview/data-reports/index.html

Environmental Issues

Although Missouri has never had an environmental disaster of large proportions, there are many instances where hazardous substances can impact the environment with considerable consequences to either air or water. Floods often temporarily interrupt community water supplies, creating the need for emergency potable water for thousands of people. In July 1993, for example, St. Joseph's municipal water plant was forced to shut down for an extended period when contaminated floodwater threatened to enter the system. Floodwaters also disrupt wastewater treatment facilities, resulting in the discharge of raw or improperly treated sewage. Periodically, water pollutants cause fish kills in Missouri streams, and excessive air pollutants associated with smog in large metropolitan areas create public health problems.

State Estimates of Potential Losses

Public Health Emergencies

Buildings, infrastructure, and critical facilities are not vulnerable to this hazard. It affects only persons susceptible to the illness. The lasting impacts and potential losses are largely economic and are dependent on the type, extent, and duration of the illness. A 2007 study prepared by the Trust for America's Health, a non-profit 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

For this State Hazard Mitigation Plan Update, pandemic influenza was used as the worst case scenario for estimating potential losses. The Missouri Department of Health and Senior Service's Pandemic Influenza Plan assumes the clinical disease attack rate would be 30 percent in the overall population. Combining this assumption with an estimate of age distribution for influenza cases and the estimated direct and indirect health care costs, the economic impact of pandemic influenza can be calculated for each county within Missouri. **Table 3.150** below presents the estimates for age distribution and disease outcome.

Table 3.150. Estimate of Age Distribution of Cases and Percentage of Hospitalizations

Age Group	Age Distribution of Cases[1]		Distribution of Disease Outcomes for 1918-type Pandemic Rates per 1,000 Persons[2]		Economic Impact[1]
	Percentage of All Cases	Percentage of High Risk Cases	Hospitalizations NOT at High Risk	Hospitalizations AT High Risk	Hospitalization Costs (in 2016 US$)
0-19	40.0	6.4	4.110	23.838	$4,618
20-64	53.1	14.4	12.042	24.578	$9,462
65+	6.8	40.0	18.495	69.871	$10,783

Source: [1]The Economic Impact of Pandemic Influenza in the United States: Priorities for Intervention; Martin I. Meltzer, Nancy J. Cox, and Keiji Fukuda; https://www.ncbi.nlm.nih.gov/pubmed/10511522; and
[2]CDC Flu Surge Model; https://www.cdc.gov/flu/pandemic-resources/tools/downloads/pandemic-impact-estimate-instructions.pdf

Rankings of vulnerability were assigned based on potential hospital charges and grouped according to natural breaks in the data:

- Low: $66,725 - $846,502
- Low-medium: $846,503 - $2,157,778
- Medium: $2,157,779 - $5,675,812
- Medium-High: $5,675,813 - $12,507,780
- High: $12,507,781 - $32,547,087

Table 3.151 below displays the results of the analysis and Figure 3.169 portrays this analysis in a statewide map.

Environmental Issues

According to the Missouri Department of Natural Resources 2016 Missouri Integrated Water Quality Report, "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.
- 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.

Table 3.151. Potential Vulnerability of Missouri Counties for Pandemic Influenza

County	Population	Potential Population Affected	Total Hospitalizations per Age Groups (#)			Economic Impact per Age Group ($)			Total Economic Impact ($)	Vulnerability
			0-19	20-64	65+	0-19	20-64	65+		
Adair	25,378	7,613	16.36	55.98	20.21	$75,557.30	$529,684.88	$217,970.16	**$823,212.34**	**Low**
Andrew	17,296	5,189	11.15	38.15	13.78	$51,494.96	$360,998.88	$148,554.33	**$561,048.18**	**Low**
Atchison	5,306	1,592	3.42	11.70	4.23	$15,797.42	$110,745.84	$45,572.92	**$172,116.19**	**Low**
Audrain	26,096	7,829	16.82	57.56	20.79	$77,694.98	$544,670.84	$224,137.02	**$846,502.84**	**Low**
Barry	35,829	10,749	23.10	79.03	28.54	$106,672.81	$747,816.20	$307,733.19	**$1,162,222.20**	**Low-medium**
Barton	11,880	3,564	7.66	26.21	9.46	$35,370.03	$247,957.14	$102,036.63	**$385,363.80**	**Low**
Bates	16,446	4,934	10.60	36.28	13.10	$48,964.27	$343,257.84	$141,253.73	**$533,475.85**	**Low**
Benton	18,670	5,601	12.04	41.18	14.87	$55,585.74	$389,676.76	$160,355.54	**$605,618.03**	**Low**
Bollinger	12,182	3,655	7.85	26.87	9.70	$36,269.17	$254,260.43	$104,630.49	**$395,160.09**	**Low**
Boone	174,974	52,492	112.81	385.97	139.37	$520,945.82	$3,652,024.67	$1,502,841.46	**$5,675,811.95**	**Medium**
Buchanan	89,100	26,730	57.44	196.54	70.97	$265,275.25	$1,859,678.57	$765,274.70	**$2,890,228.52**	**Medium**
Butler	42,951	12,885	27.69	94.74	34.21	$127,876.96	$896,465.26	$368,903.63	**$1,393,245.85**	**Low-medium**
Caldwell	9,014	2,704	5.81	19.88	7.18	$26,837.16	$188,138.53	$77,420.72	**$292,396.41**	**Low**
Callaway	44,834	13,450	28.90	98.90	35.71	$133,483.17	$935,766.88	$385,076.61	**$1,454,326.66**	**Low-medium**
Camden	44,237	13,271	28.52	97.58	35.24	$131,705.74	$923,306.41	$379,949.01	**$1,434,961.16**	**Low-medium**
Cape Girardeau	78,572	23,572	50.66	173.32	62.58	$233,930.50	$1,639,940.12	$674,850.32	**$2,548,720.93**	**Medium**
Carroll	8,992	2,698	5.80	19.84	7.16	$26,771.66	$187,679.35	$77,231.76	**$291,682.77**	**Low**
Carter	6,263	1,879	4.04	13.82	4.99	$18,646.68	$130,720.17	$53,792.54	**$203,159.39**	**Low**
Cass	101,603	30,481	65.50	224.12	80.93	$302,500.13	$2,120,638.85	$872,662.23	**$3,295,801.22**	**Medium**
Cedar	13,934	4,180	8.98	30.74	11.10	$41,485.36	$290,827.85	$119,678.31	**$451,991.52**	**Low**
Chariton	7,589	2,277	4.89	16.74	6.04	$22,594.54	$158,396.19	$65,181.48	**$246,172.21**	**Low**
Christian	83,279	24,984	53.69	183.70	66.33	$247,944.53	$1,738,183.75	$715,278.47	**$2,701,406.74**	**Medium**
Clark	6,801	2,040	4.38	15.00	5.42	$20,248.45	$141,949.20	$58,413.39	**$220,611.05**	**Low**
Clay	235,637	70,691	151.92	519.78	187.69	$701,556.29	$4,918,171.49	$2,023,872.43	**$7,643,600.20**	**Medium-High**
Clinton	20,609	6,183	13.29	45.46	16.42	$61,358.67	$430,147.20	$177,009.50	**$668,515.37**	**Low**
Cole	76,720	23,016	49.46	169.23	61.11	$228,416.58	$1,601,285.52	$658,943.60	**$2,488,645.70**	**Medium**

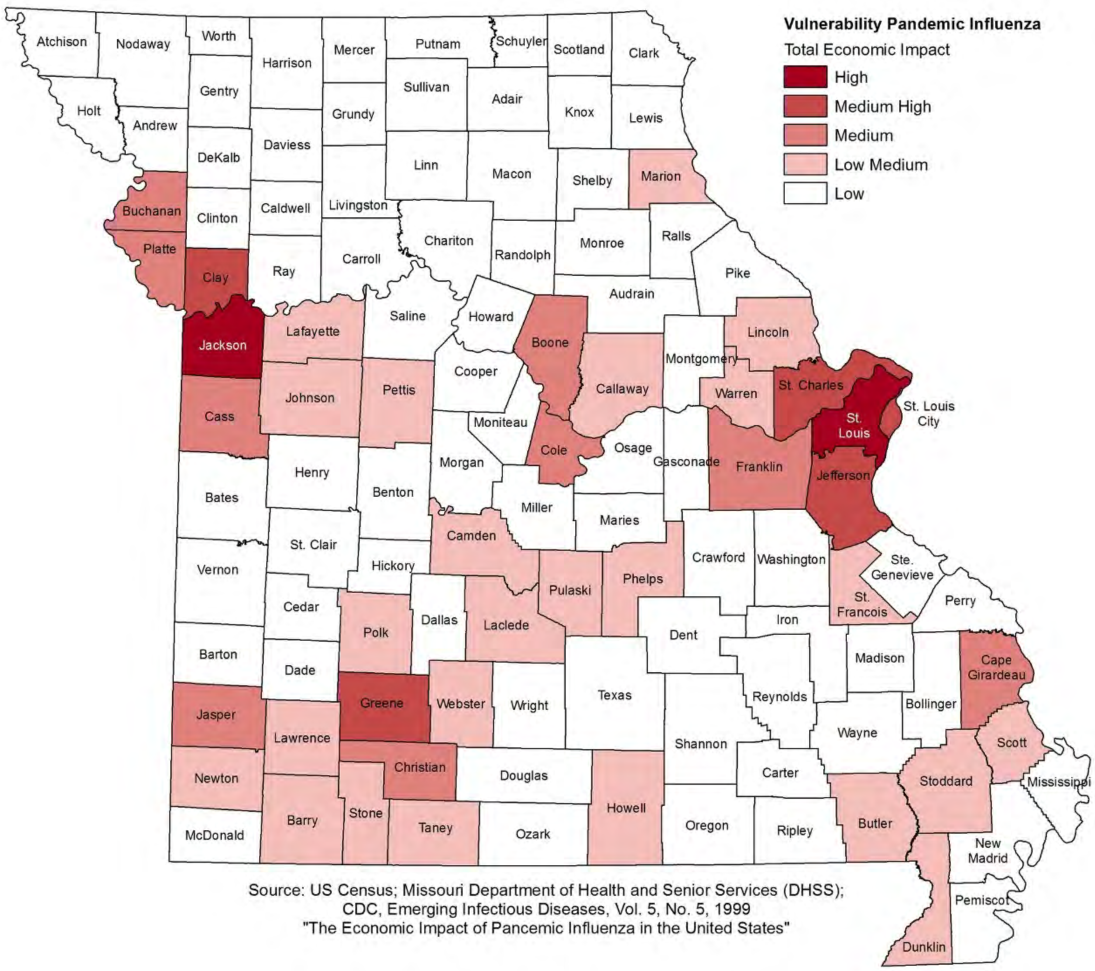
County	Population	Potential Population Affected	Total Hospitalizations per Age Groups (#)			Economic Impact per Age Group ($)			Total Economic Impact ($)	Vulnerability
			0-19	20-64	65+	0-19	20-64	65+		
Cooper	17,642	5,293	11.37	38.92	14.05	$52,525.10	$368,220.53	$151,526.11	**$572,271.73**	Low
Crawford	24,526	7,358	15.81	54.10	19.54	$73,020.66	$511,902.09	$210,652.38	**$795,575.14**	Low
Dade	7,595	2,279	4.90	16.75	6.05	$22,612.41	$158,521.42	$65,233.01	**$246,366.84**	Low
Dallas	16,393	4,918	10.57	36.16	13.06	$48,806.48	$342,151.64	$140,798.52	**$531,756.63**	Low
Daviess	8,253	2,476	5.32	18.20	6.57	$24,571.46	$172,255.08	$70,884.53	**$267,711.07**	Low
DeKalb	12,687	3,806	8.18	27.99	10.11	$37,772.70	$264,800.70	$108,967.90	**$411,541.29**	Low
Dent	15,593	4,678	10.05	34.40	12.42	$46,424.66	$325,454.19	$133,927.37	**$505,806.21**	Low
Douglas	13,373	4,012	8.62	29.50	10.65	$39,815.11	$279,118.76	$114,859.92	**$433,793.78**	Low
Dunklin	30,895	9,269	19.92	68.15	24.61	$91,982.93	$644,834.67	$265,355.35	**$1,002,172.95**	Low-medium
Franklin	102,426	30,728	66.04	225.94	81.58	$304,950.43	$2,137,816.36	$879,730.93	**$3,322,497.71**	Medium
Gasconade	14,858	4,457	9.58	32.77	11.83	$44,236.36	$310,113.40	$127,614.49	**$481,964.26**	Low
Gentry	6,692	2,008	4.31	14.76	5.33	$19,923.93	$139,674.18	$57,477.20	**$217,075.30**	Low
Greene	288,072	86,422	185.72	635.45	229.46	$857,669.73	$6,012,585.02	$2,474,233.58	**$9,344,488.33**	Medium-High
Grundy	10,097	3,029	6.51	22.27	8.04	$30,061.55	$210,742.70	$86,722.54	**$327,526.79**	Low
Harrison	8,615	2,585	5.55	19.00	6.86	$25,649.23	$179,810.67	$73,993.73	**$279,453.63**	Low
Henry	21,737	6,521	14.01	47.95	17.31	$64,717.04	$453,690.61	$186,697.82	**$705,105.47**	Low
Hickory	9,201	2,760	5.93	20.30	7.33	$27,393.91	$192,041.55	$79,026.85	**$298,462.32**	Low
Holt	4,484	1,345	2.89	9.89	3.57	$13,350.10	$93,589.21	$38,512.81	**$145,452.13**	Low
Howard	10,139	3,042	6.54	22.37	8.08	$30,186.60	$211,619.32	$87,083.28	**$328,889.19**	Low
Howell	40,117	12,035	25.86	88.49	31.95	$119,439.36	$837,314.54	$344,562.57	**$1,301,316.47**	Low-medium
Iron	10,125	3,038	6.53	22.33	8.06	$30,144.92	$211,327.11	$86,963.03	**$328,435.06**	Low
Jackson	687,623	206,287	443.32	1,516.80	547.71	$2,047,243.17	$14,351,938.92	$5,905,953.78	**$22,305,135.87**	High
Jasper	118,596	35,579	76.46	261.61	94.46	$353,092.98	$2,475,313.58	$1,018,614.12	**$3,847,020.67**	Medium
Jefferson	224,124	67,237	144.50	494.39	178.52	$667,278.91	$4,677,874.30	$1,924,987.94	**$7,270,141.15**	Medium-High
Johnson	53,951	16,185	34.78	119.01	42.97	$160,626.99	$1,126,055.20	$463,381.99	**$1,750,064.19**	Low-medium
Knox	3,910	1,173	2.52	8.62	3.11	$11,641.15	$81,608.79	$33,582.76	**$126,832.70**	Low

County	Population	Potential Population Affected	Total Hospitalizations per Age Groups (#)			Economic Impact per Age Group ($)			Total Economic Impact ($)	Vulnerability
			0-19	20-64	65+	0-19	20-64	65+		
Laclede	35,473	10,642	22.87	78.25	28.26	$105,612.90	$740,385.84	$304,675.52	**$1,150,674.26**	Low-medium
Lafayette	32,701	9,810	21.08	72.13	26.05	$97,359.89	$682,529.17	$280,866.98	**$1,060,756.04**	Low-medium
Lawrence	38,180	11,454	24.62	84.22	30.41	$113,672.38	$796,885.83	$327,925.79	**$1,238,484.01**	Low-medium
Lewis	10,207	3,062	6.58	22.52	8.13	$30,389.05	$213,038.60	$87,667.33	**$331,094.98**	Low
Lincoln	54,696	16,409	35.26	120.65	43.57	$162,845.07	$1,141,604.70	$469,780.75	**$1,774,230.52**	Low-medium
Linn	12,308	3,692	7.94	27.15	9.80	$36,644.31	$256,890.28	$105,712.69	**$399,247.28**	Low
Livingston	15,028	4,508	9.69	33.15	11.97	$44,742.50	$313,661.61	$129,074.61	**$487,478.72**	Low
Macon	15,335	4,601	9.89	33.83	12.21	$45,656.52	$320,069.26	$131,711.42	**$497,437.20**	Low
Madison	12,408	3,722	8.00	27.37	9.88	$36,942.04	$258,977.46	$106,571.59	**$402,491.08**	Low
Maries	8,963	2,689	5.78	19.77	7.14	$26,685.32	$187,074.06	$76,982.68	**$290,742.07**	Low
Marion	28,880	8,664	18.62	63.71	23.00	$85,983.72	$602,777.97	$248,048.63	**$936,810.32**	Low-medium
McDonald	22,643	6,793	14.60	49.95	18.04	$67,414.45	$472,600.47	$194,479.40	**$734,494.33**	Low
Mercer	3,694	1,108	2.38	8.15	2.94	$10,998.06	$77,100.48	$31,727.55	**$119,826.08**	Low
Miller	25,113	7,534	16.19	55.40	20.00	$74,768.32	$524,153.85	$215,694.09	**$814,616.26**	Low
Mississippi	14,036	4,211	9.05	30.96	11.18	$41,789.04	$292,956.77	$120,554.38	**$455,300.20**	Low
Moniteau	15,963	4,789	10.29	35.21	12.71	$47,526.25	$333,176.76	$137,105.27	**$517,808.28**	Low
Monroe	8,583	2,575	5.53	18.93	6.84	$25,553.96	$179,142.77	$73,718.89	**$278,415.62**	Low
Montgomery	11,703	3,511	7.55	25.82	9.32	$34,843.06	$244,262.83	$100,516.38	**$379,622.27**	Low
Morgan	20,171	6,051	13.00	44.49	16.07	$60,054.63	$421,005.35	$173,247.54	**$654,307.51**	Low
New Madrid	18,208	5,462	11.74	40.16	14.50	$54,210.23	$380,033.98	$156,387.45	**$590,631.66**	Low
Newton	58,615	17,585	37.79	129.30	46.69	$174,513.01	$1,223,401.34	$503,440.81	**$1,901,355.16**	Low-medium
Nodaway	22,810	6,843	14.71	50.32	18.17	$67,911.66	$476,086.06	$195,913.76	**$739,911.48**	Low
Oregon	10,953	3,286	7.06	24.16	8.72	$32,610.10	$228,608.97	$94,074.68	**$355,293.75**	Low
Osage	13,628	4,088	8.79	30.06	10.86	$40,574.31	$284,441.07	$117,050.10	**$442,065.48**	Low
Ozark	9,409	2,823	6.07	20.75	7.49	$28,013.19	$196,382.89	$80,813.35	**$305,209.43**	Low
Pemiscot	17,482	5,245	11.27	38.56	13.92	$52,048.73	$364,881.04	$150,151.88	**$567,081.65**	Low

County	Population	Potential Population Affected	Total Hospitalizations per Age Groups (#)			Economic Impact per Age Group ($)			Total Economic Impact ($)	Vulnerability
			0-19	20-64	65+	0-19	20-64	65+		
Perry	19,183	5,755	12.37	42.31	15.28	$57,113.08	$400,384.00	$164,761.67	**$622,258.74**	**Low**
Pettis	42,255	12,677	27.24	93.21	33.66	$125,804.78	$881,938.47	$362,925.73	**$1,370,668.98**	**Low-medium**
Phelps	44,794	13,438	28.88	98.81	35.68	$133,364.08	$934,932.01	$384,733.05	**$1,453,029.14**	**Low-medium**
Pike	18,348	5,504	11.83	40.47	14.61	$54,627.05	$382,956.03	$157,589.90	**$595,172.98**	**Low**
Platte	96,096	28,829	61.95	211.97	76.54	$286,104.27	$2,005,697.78	$825,362.93	**$3,117,164.98**	**Medium**
Polk	31,229	9,369	20.13	68.89	24.87	$92,977.34	$651,805.86	$268,224.06	**$1,013,007.26**	**Low-medium**
Pulaski	53,221	15,966	34.31	117.40	42.39	$158,453.58	$1,110,818.78	$457,112.06	**$1,726,384.42**	**Low-medium**
Putnam	4,858	1,457	3.13	10.72	3.87	$14,463.60	$101,395.27	$41,725.08	**$157,583.95**	**Low**
Ralls	10,196	3,059	6.57	22.49	8.12	$30,356.30	$212,809.01	$87,572.85	**$330,738.16**	**Low**
Randolph	25,104	7,531	16.18	55.38	20.00	$74,741.53	$523,966.00	$215,616.79	**$814,324.32**	**Low**
Ray	22,810	6,843	14.71	50.32	18.17	$67,911.66	$476,086.06	$195,913.76	**$739,911.48**	**Low**
Reynolds	6,432	1,930	4.15	14.19	5.12	$19,149.84	$134,247.50	$55,244.07	**$208,641.41**	**Low**
Ripley	13,802	4,141	8.90	30.45	10.99	$41,092.36	$288,072.77	$118,544.57	**$447,709.70**	**Low**
Saline	23,258	6,977	14.99	51.30	18.53	$69,245.48	$485,436.64	$199,761.60	**$754,443.71**	**Low**
Schuyler	4,436	1,331	2.86	9.79	3.53	$13,207.19	$92,587.36	$38,100.54	**$143,895.10**	**Low**
Scotland	4,854	1,456	3.13	10.71	3.87	$14,451.70	$101,311.78	$41,690.72	**$157,454.20**	**Low**
Scott	39,008	11,702	25.15	86.05	31.07	$116,137.57	$814,167.70	$335,037.43	**$1,265,342.69**	**Low-medium**
Shannon	8,258	2,477	5.32	18.22	6.58	$24,586.34	$172,359.43	$70,927.48	**$267,873.26**	**Low**
Shelby	6,128	1,838	3.95	13.52	4.88	$18,244.74	$127,902.47	$52,633.03	**$198,780.25**	**Low**
St. Charles	385,590	115,677	248.59	850.56	307.13	$1,148,007.69	$8,047,962.51	$3,311,809.99	**$12,507,780.19**	**Medium-High**
St. Clair	9,440	2,832	6.09	20.82	7.52	$28,105.48	$197,029.92	$81,079.61	**$306,215.01**	**Low**
St. Francois	66,520	19,956	42.89	146.73	52.98	$198,048.37	$1,388,393.02	$571,336.39	**$2,157,777.79**	**Low-medium**
St. Louis, City	315,685	94,706	203.53	696.36	251.45	$939,881.24	$6,588,918.40	$2,711,400.02	**$10,240,199.67**	**Medium-High**
St. Louis	1,003,362	301,009	646.88	2,213.27	799.20	$2,987,285.18	$20,941,984.40	$8,617,817.60	**$32,547,087.19**	**High**
Ste. Genevieve	17,919	5,376	11.55	39.53	14.27	$53,349.80	$374,002.02	$153,905.24	**$581,257.07**	**Low**
Stoddard	29,862	8,959	19.25	65.87	23.79	$88,907.40	$623,274.09	$256,482.97	**$968,664.47**	**Low-medium**

County	Population	Potential Population Affected	Total Hospitalizations per Age Groups (#)			Economic Impact per Age Group ($)			Total Economic Impact ($)	Vulnerability
			0-19	20-64	65+	0-19	20-64	65+		
Stone	30,943	9,283	19.95	68.26	24.65	$92,125.84	$645,836.52	$265,767.62	**$1,003,729.98**	**Low-medium**
Sullivan	6,353	1,906	4.10	14.01	5.06	$18,914.63	$132,598.63	$54,565.55	**$206,078.81**	**Low**
Taney	54,592	16,378	35.20	120.42	43.48	$162,535.43	$1,139,434.04	$468,887.50	**$1,770,856.96**	**Low-medium**
Texas	25,690	7,707	16.56	56.67	20.46	$76,486.21	$536,196.89	$220,649.91	**$833,333.00**	**Low**
Vernon	20,826	6,248	13.43	45.94	16.59	$62,004.74	$434,676.39	$178,873.30	**$675,554.42**	**Low**
Warren	33,513	10,054	21.61	73.92	26.69	$99,777.44	$699,477.08	$287,841.20	**$1,087,095.72**	**Low-medium**
Washington	24,788	7,436	15.98	54.68	19.74	$73,800.71	$517,370.51	$212,902.68	**$804,073.90**	**Low**
Wayne	13,405	4,022	8.64	29.57	10.68	$39,910.38	$279,786.66	$115,134.76	**$434,831.80**	**Low**
Webster	37,483	11,245	24.17	82.68	29.86	$111,597.22	$782,338.18	$321,939.30	**$1,215,874.70**	**Low-medium**
Worth	2,057	617	1.33	4.54	1.64	$6,124.26	$42,933.32	$17,667.45	**$66,725.03**	**Low**
Wright	18,268	5,480	11.78	40.30	14.55	$54,388.87	$381,286.29	$156,902.78	**$592,577.94**	**Low**

Figure 3.199. Potential Vulnerability of Missouri Counties to Pandemic Influenza



Hazard Impact on Future Growth and Development

Public Health Emergencies

As populations increase and the cost of health care climbs, potential losses can be expected to rise.

Environmental Issues

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

Table 3.152. EMAP Impact Analysis: Public Health Emergenices

Subject	Detrimental Impacts
Public	Adverse impact expected to be severe for unprotected personnel and moderate to light for protected personnel.
Responders	Adverse impact expected to be severe for unprotected personnel and uncertain for trained and protected personnel, depending on the nature of the incident.
Continuity of Operations including continued delivery of services	Danger to personnel in the area of the incident may require relocation of operations and lines of succession execution. Disruption of lines of communication and destruction of facilities may extensively postpone delivery of services.
Property, Facilities, and Infrastructure	Access to facilities and infrastructure in the area of the incident may be denied until decontamination completed.
Environment	Incident may cause denial or delays in the use of some areas. Remediation needed.
Economic Condition of Jurisdiction	Local economy and finances adversely affected, possibly for an extended period of time.
Public Confidence in the Jurisdiction's Governance	Ability to respond and recover may be questioned and challenged if planning, response, and recovery not timely and effective.

Risk Summary

Public Health Emergencies

Preparing for, responding to and recovering from pandemic influenza will require a strategy with many similarities to other disease outbreaks, be they naturally occurring or resulting from terrorist action. The time-honored public health activities to lessen the impact on morbidity and mortality such as education, vaccination, prophylaxis, isolation/quarantine and the closure of public facilities are common to all, despite the particular disease of concern. In addition, clear, concise communication with the public, within the Missouri Department of Health and Senior Services (DHSS), and with other agencies remains a critical component, as does the ability of the involved agencies to achieve collaboration and coordination. By its very nature, an influenza pandemic, once started, will not be stopped until it has run its course. This course can be shortened and weakened by many things, with vaccination being the gold standard for protecting the population. Pandemic plans describe strategies of preparedness, response and recovery to attempt to decrease illnesses and deaths during the pandemic period to manageable levels (i.e., that do not overwhelm the critical infrastructures of the State), and to promote community resiliency and rapid recovery.

DHSS has emergency response plans in place, internally, and as part of the State response through the Missouri State Emergency Operations Plan (SEOP) that have been tried, tested and exercised for all aspects of response and recovery, including those mentioned above relating to disease surveillance, investigation and control. Where necessary, details or public information templates unique to pandemic influenza have been added into plans. The current 2011 Pandemic Influenza Response Plan gives background information related to pandemic influenza, outlines the DHSS concept of operations for response, lists primary and support functional areas and provides technical support annexes outlining the available resources (i.e., "tools") available to temper the pandemic and promote community resiliency and recovery. Components of other all-hazard plans incorporated through partnership with the State Emergency Management Agency and other local, state, and federal agencies are expected to be utilized in accordance with need.

A broad, diverse and geographically dispersed group of agencies and organizations, representing the length, breadth and interests of the State collaborated with the DHSS in working to prepare for pandemic influenza. With committees organized under the umbrella of the Missouri Homeland Security Council, over four hundred representatives from hospitals, livestock corporations, local public health agencies (LPHAs), other state agencies, funeral homes, laboratories, financial institutions, fire departments, local and state governments, school boards, utility companies, universities, nursing homes and coroner's offices, among others, engaged with DHSS providing input and expertise to produce a meaningful plan.

DHSS has primary responsibility to safeguard the health of the people of the State and all its subdivisions and will respond in the event of pandemic influenza to attempt to limit the impact on public health by reducing morbidity and mortality. These actions may also limit the impact on the social and economic infrastructure of the State. DHSS will serve to support the LPHAs in this effort, and lead the State-level response of a coordinated multitude of federal, state and private organizations and agencies. DHSS reserves the flexibility to modify the plan during the pandemic in response to the actual behavior of the disease and the effectiveness of the ongoing response. Lessons learned from previous waves will be incorporated going forward and modifications in planning may be made across all sectors to meet the key goals in public health and critical infrastructure support. Such changes will be rapidly and effectively communicated from DHSS to all partnered agencies and organizations per the communications plan to ensure best practices are consistently implemented statewide.

Environmental Issues

There are many instances where hazardous substances can impact the environment with considerable consequences to either air or water. Floods often temporarily interrupt community water supplies, creating the need for emergency potable water for thousands of people. Environmental disasters of significant proportions in Missouri include the following events:

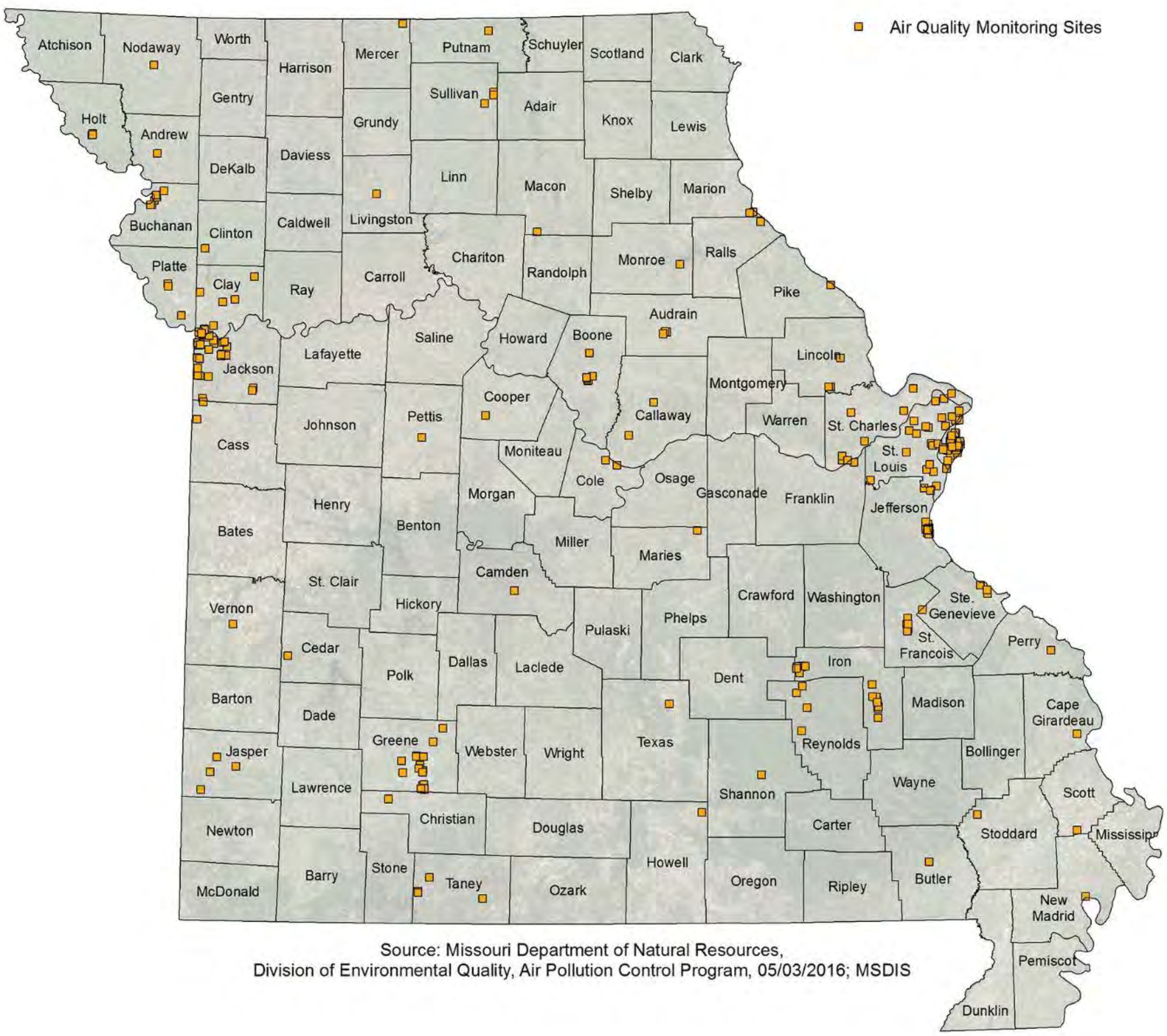
- In July 1993, St. Joseph's municipal water plant was forced to shut down for an extended period when contaminated floodwater threatened to enter the system. Floodwaters also disrupt wastewater treatment facilities, resulting in the discharge of raw or improperly treated sewage. Periodically, water pollutants cause fish kills in Missouri streams, and excessive air pollutants associated with smog in large metropolitan areas create public health problems.

- In 1983, the town of Times Beach, located in St. Louis County, was evacuated due to dioxin contamination. Dioxin is chemical compound found to cause severe health effects when high levels of exposure occur. In the 1920s and 30s, the town was a summer resort but had since become a low-middle class town. Due to the dust problem from unpaved roads, a local waste hauler was hired to spray waste oil in and around the town on the dirt roads. The waste hauler had also been hired by a local company to dispose of toxic waste. The toxic waste came from a facility in western Missouri that had once produced Agent Orange during the Vietnam War. The hauler was unaware of the dioxin content and mixed it with the oil being sprayed. A problem first arose when 62 horses died after the mixture was sprayed in a stable to mitigate dust. On December 5, 1982, the Meramec River flooded causing an evacuation due to more than 95% of the town being under ten feet of water. On December 23, 1982, the EPA announced that dangerous levels of dioxin were found in the soil around Times Beach. By 1985, the Times Beach was evacuated and dis-incorporated. It was later found that the waste contained 2,000 times the amount of dioxin content of Agent Orange. It was the largest civilian exposure to dioxin in the county's history.

Air Pollution

Staff in the State of Missouri Air Quality Monitoring section operates a variety of instruments at 60 active locations around the State as part of a network to monitor air pollutants known to affect people's health (See **Figure 3.200**). In addition, staff conducts special air quality studies: http://dnr.mo.gov/env/esp/aqm/esp-aqm.htm.

Figure 3.200. Missouri Air Quality Monitoring Sites



Source: Missouri Department of Natural Resources, Division of Environmental Quality, Air Pollution Control Program, 05/03/2016; MSDIS

Water Pollution

The Missouri Department of Natural Resources also maintains the State's water quality management plan and has developed basin-by-basin assessments of Missouri's surface water resources. These basins may be divided into the following geographic categories: Upper Mississippi River tributaries, Missouri River tributaries north of the Missouri River, Missouri River tributaries south of the Missouri River, Lower Mississippi River tributaries, White River tributaries, and Arkansas River tributaries. For the most up to date information on water pollution go to https://dnr.mo.gov/env/wpp/.

According to the Missouri Division of Natural Resources 2016 Missouri Integrated Water Quality Report, Missouri has an area of 68,742 square miles and a population of 6.1 million people, according to the 2014 census estimate. About half of the population is concentrated on opposite sides of the State in the Kansas City and St. Louis metro areas, leaving most of the State and its waters rural in nature. Surface and groundwater in Missouri are quite varied in quantity and quality, corresponding closely with geology and land use. The 2016 Missouri Integrated Water Quality Report is available here: https://dnr.mo.gov/env/wpp/waterquality/303d/docs/2016-ir-305b-report.pdf

According to the 2016 Integrated Water Quality Report, state concerns include the following:

Managing agricultural and urban runoff is an ongoing challenge in Missouri; both sources have substantial influence on the condition of water quality.

- Wastewater treatment facilities and other point source dischargers have a significant impact on water quality. Point sources are subject to NPDES permit requirements; however, pollution incidents still happen occasionally. Failing treatment systems, bypasses, accidental spills, or illicit waste disposal are some types of violations that can occur.
- Current mining operations have caused significant changes to water quality. Heavy metals such as lead and zinc may enter streams from smelters, mills, mine water, and tailings ponds.
- Facilities that generate large amounts of animal waste and manure have the potential to cause serious water pollution problems. There are 528 Class I CAFOs located in Missouri.
- Mercury levels in fish continue to impair fish consumption in Missouri waters. For 2016, totals of 740 stream miles and 28,071 lake acres were listed as impaired for mercury in fish tissue.
- Missouri's water quality standards do not include statewide nutrient criteria, but site-specific criteria have been assigned to a limited set of lakes.
- Eutrophication of state waters, particularly the recreationally important large reservoirs, is an ongoing concern.
- Additional groundwater protection measures are needed.

Identifying Pollution Hazard Areas

Local emergency management officials should identify pollution hazard areas so that in case of a natural disaster, recovery steps will not be delayed. Pollution of public drinking water, for example, can cause severe problems with reentry and recovery. If alternate sources of safe drinking water can be identified, or relocation of water intakes can eliminate polluted drinking water, then recovery can be quicker, and local resources can be used to address other problems.

With the increases in motor vehicle registrations throughout the State, the levels of nitrocarbon emissions will naturally rise. Combinations of smog and carbon monoxide levels will also increase. In sufficient quantities, these pollutants can have deleterious effects on the health of thousands of Missourians.

Problem Statement:

Using population and major transportation corridors as key indicators, the data suggests that counties at most risk are St. Louis, Jackson, St. Charles, St. Louis City, Greene, Clay, Jefferson, Boone, Jasper and Franklin. Mitigation strategies and limited resources allocated in these counties first could prove most beneficial.

2018 risk assessment data and mapping is available through the Missouri Hazard Mitigation Viewer: http://bit.ly/MoHazardMitigationPlanViewer2018.

3.3.20. Special Events

Probability	Severity
<1%	Low to High

Description/Location

Special events present a unique set of challenges and security issues, including vulnerability to both man-made and natural hazards. Special events can include sporting events, concerts, political events, and events with religious significance, and can be handled at the local, state or federal level, depending on the size and scope of the event itself. Security for some special events can be handled with local- and state-level coordination, while some events rise to a level of national significance requiring a National Special Security Event designation and federal agency input and direction. Special events usually occur in larger cities, though this isn't always the case. When planning for special events, security officials should account for vulnerability to both natural and man-made hazards.

National Special Security Events

A number of factors are taken into consideration when designating an event as a national special security event (NSSE), including the following:

- **Anticipated attendance by dignitaries**—Events that are attended by officials of the United States government and/or foreign dignitaries may create an independent federal interest in ensuring that the event transpires without incident and that sufficient resources are brought to bear in the event of an incident.
- **Size of the event**—A large number of attendees and participants generally increases the security requirements. In addition, larger events are more likely to draw the attention of terrorists or other criminals, particularly those interested in employing weapons of mass destruction.
- **Significance of the event**—Some events have historical, political, and/or symbolic significance that may heighten concern about possible terrorist acts or other criminal activity.
- **Duration of the event** – State and local law enforcement and public safety agencies may possess the manpower and other resources to provide adequate security for a major event in their jurisdiction, but are unable to do so for events over several days or weeks and at the same time continue to meet the routine obligations of the greater community.
- **Availability of state and local resources** –State and local resources may lack the expertise, experience or manpower needed to ensure comprehensive protection.
- **Multiplicity of jurisdictions** – The event may require extensive coordination of law enforcement agencies between multiple jurisdictions.
- **Threat Assessment** – Terrorism, extensive illegal disobedience or other criminal activity is anticipated.

The Secretary of Homeland Security (DHS) is responsible for designating events as NSSEs. Homeland Security Presidential Directive (HSPD-5) grants the Secretary this authority. The Secretary is assisted in the NSSE designation process by **the NSSE Working Group**, comprised of interagency subject matter experts and co-chaired by the U.S. Secret Service (USSS), the Federal Bureau of Investigation, and the Federal Emergency Management Agency. The NSSE Working Group is responsible for conducting an assessment of each event being considered for NSSE designation. When the Secretary of Homeland Security designates an event as an NSSE, the Secret Service assumes its mandated role as the lead federal agency for the design and implementation of the operational security plan and coordinator for all federal resources deployed to maintain the level of security needed for the designated events. The Federal Bureau of Investigation (FBI) serves as the lead agency responsible for intelligence and law enforcement operations as well as statutory federal criminal investigations. The goal of such an operation is to prevent terrorist attacks and criminal acts.

Once an event is designated as an NSSE, the Secret Service employs existing partnerships with federal, state, and local law enforcement and public safety officials to coordinate provision of a safe and secure environment for the event and those in attendance.

Resources used as part of past NSSE operational security plans that could be deployed for upcoming NSSE designated events include physical infrastructure security fencing and barricades, special access accreditation badges, K-9 teams, and other security technologies.

The Emergency Preparedness and Response division within the U.S. Department of Homeland Security could preposition some combination of the following assets: the Domestic Emergency Support Team, Urban Search and Rescue teams, national Emergency Response Teams, the Nuclear Incident Response Team, the Strategic National Stockpile and Mobile Emergency Response System. The specific package will be tailored for each individual event based on coordination with other federal agencies, state and local jurisdictions, available local resources, mutual aid agreements, and other event-specific requirements.

Special Events Assessment Rating

Coordinated by the Department of Homeland Security/Office of Operations Coordination and Planning (OPS), the Special Events Working Group (SEWG) is the core of an interagency process that involves over 50 Departments, agencies and components of the federal government. Federal input and recommendations concerning special events are provided based on their respective authorities, responsibilities, and fields of expertise. The SEWG is the single forum that ensures comprehensive and coordinated Federal interagency awareness of and support to designated Special Events.

The Department of Homeland Security (DHS) Special Events Program utilizes the annual Data Call conducted in conjunction with the State, Local, Territorial and Tribal (S/L/T/T) Homeland Security Advisors. The Program provides an objective, calendared framework through which Federal, State and local entities can identify special events occurring within their jurisdictions.

The Special Events Assessment Rating (SEAR) is the single federal interagency resource used for assessing and categorizing domestic events that do not rise to the level of a National Security Special Event (NSSE). Using a risk-based approach to weigh vulnerabilities and consequences against threats, the SEWG develops the SEAR levels based primarily on event information submitted by S/L/T/T officials in the annual Data Call.

- **SEAR-I**: Events of significant national and/or international importance that may require extensive Federal interagency security and incident management preparedness. Pre-deployment of Federal assets as well as consultation, technical advice and support to specific functional areas in which the State and local agencies may lack expertise or key resources may also be warranted.
- **SEAR II:** Significant events with national and/or international importance that may require direct national level Federal support and situational awareness. The magnitude and significance of these events calls for close coordination between Federal, state, and local authorities and may warrant limited pre-deployment of USG assets as well as consultation, technical advice and support to specific functional areas in which the State and local agencies may lack expertise or key resources.
- **SEAR-III**: Events of national and/or international importance that require only limited direct Federal support to augment local capabilities. Generally, state and local authorities adequately support these events; however, the significance of these events generally warrants national situational awareness and, depending on the jurisdiction, may require limited direct support from specific Federal agencies.

- **SEAR-IV**: Events with limited national importance that are generally handled at the State and local level. Unusual circumstances may sometimes necessitate the employment of specific Federal resources to address unique needs of a particular event. Existing Federal assistance programs are available to state and local jurisdictions hosting the event for training, exercise, and/or tailored program support.
- **SEAR-V**: Events that may be nationally recognized but generally have local or state importance. Federal departments and agencies will receive notice of these events for situational awareness purposes, but in most cases minimal, if any, Federal assets or resources will be expended to assist with management of these events. Federal officials will not normally actively monitor or coordinate support for these events unless specifically requested.

Description/Location

Significant special events may include any type of event where large groups of people are gathered together, regardless of the cause or purpose of the event, where expanded security and other resources are required above and beyond the resources typically available to local and/or state government. In such instances, event sponsors, in conjunction with local and state authorities, are responsible for coordinating the event and requesting federal assistance, if necessary.

Special events may be motivated by political, economic or social causes, as in the case of inaugurations, state of the union addresses, and summit conferences, or by recreational causes, as with the Olympics and other major sporting events (Super Bowl, World Series, etc.). Special events may also include large holiday events such as the annual Fair St. Louis 4th of July Celebration, where large numbers of people crowd onto the Mississippi Riverfront in St. Louis.

The perception of inherent dangers and threats facing the country and Missouri has changed significantly since the terrorist attacks of September 11, 2001, and subsequent attacks on mass gatherings since the 2001 attack have reinforced the need for planning and security for these types of events. Anytime a large number of people are congregated in one area, an incident resulting from just about any of the hazards could have devastating impacts. For example, consider the impact a sudden, severe hailstorm could have on the population visiting the Fair St. Louis, which well over one million people usually attend each year. A severe hailstorm struck the north St. Louis County area in April 2001, causing thousands of dollars of damage to residences and vehicles. This storm produced baseball-size (and larger) hailstones, which killed many pets and nearly all the waterfowl residing at local park ponds. An incident such as this could have devastating impacts if it were to suddenly strike the fairgrounds with over one million people in attendance and without shelter (not to mention the potential impact a terrorist attack incident could impose at such an event). Medical services would likely be overwhelmed with the number of injuries.

Extent

Special events are vulnerable to both man-made and natural hazards, and each of these hazards presents its own set of parameters on the extent of impacts. A special event itself generally presents a large group of people condensed into a limited space, which can exacerbate the impacts from hazards by offering additional opportunity for injuries and fatalities.

The severity of incidents occurring in conjunction with designated special events could range from low to high, depending on many factors. The severity of these incidents will be a function of the number of people attending these events and the type and impacts of the specific hazards that affect the events. Considerations of severity could range from a hoax bomb scare or terrorist threat where no one is physically injured and without any property damage to a full-scale natural disaster affecting a large number of people gathered at one time with mass injuries and property damage by natural, accidental, terrorist, or criminal causes.

Previous Occurrences

Atlanta, Georgia, Centennial Olympic Park Bombing

On Saturday July 27, 1996, Georgia Bureau of Investigation (GBI) agents in Atlanta were dispatched to the Centennial Olympic Park for what seemed like a routine public disturbance call on the ninth day of the 1996 Summer Olympics. Apparently, some rowdy partygoers had been creating a scene at the event.

By the time GBI agents arrived, the partiers were gone. However, a security guard pointed out another problem: a green knapsack left unattended under a nearby bench. Because of the suspicious nature of the situation, a bomb diagnostic team was called as officers attempted to keep people away from the area without creating a panic. They were unaware that a warning call had been made to 911 emergency dispatchers.

About 20 minutes later, as agents were assessing the situation and continuing to attempt to steer people away from the abandoned bag, it blew up with a powerful explosion. The blast killed one visitor and injured more than 100. All of the law officers at the scene were injured except for one. A Turkish cameraman died of a heart attack while covering the explosion.

FBI said of this incident, "The fatal bombing in Atlanta was a terrorist attack aimed at thousands of innocent persons gathered at the Olympic Park." This blast was the worst attack on an Olympic Games since 11 Israeli athletes were killed by Palestinian guerrillas at the 1972 games in Munich, Germany.

St. Louis, Missouri, Papal Visit

Pope John Paul II visited St. Louis, Missouri, on January 26 and 27, 1999. This pastoral visit included 30 hours of speeches, parades, prayer services, and a papal mass for about 104,000 people at the St. Louis America's Center, which filled every available seat in the center, including the Edward Jones Dome and adjoining convention exhibit hall. This mass is billed as the largest U.S. indoors gathering ever and was designated a National Special Security Event.

This two-day series of events also included a welcome address by President Bill Clinton and ceremonial farewell meeting with Vice-President Al Gore and was attended by many state officials, including Missouri Governor Mel Carnahan. Event activities were spread throughout the St. Louis metropolitan area, from the Lambert–St. Louis International Airport to the downtown area and the grounds of the Gateway Arch on the Mississippi Riverfront.

This was undoubtedly one of the largest single special event to occur in Missouri, with security concerns reaching to national and international levels. Close coordination between local, state, and federal law enforcement agencies is required to provide adequate security measures for events like this. The potential for hazards from mass transportation accidents was also elevated for this event, as one quote said, "Seemingly every school bus in the region was enlisted to transport people from suburban pickup points down into St. Louis America's Center for the papal mass." Fortunately, this event was conducted without any major incidents.

St. Louis, Missouri, World Agricultural Forum Conference

The Hyatt Regency Hotel at Union Station in St. Louis hosted the World Congress meeting of the World Agricultural Forum May 18 to 20, 2003. The forum brought together agriculture industry leaders and world leaders to discuss the future of global agriculture. Mindful of Seattle's experience with violent protestors who disrupted the World Trade Organization (WTO) meeting there in December 1999, St. Louis police were braced for any possible problems that could arise from hundreds or even thousands of protestors descending on St. Louis for this event.

Four Seattle police officers were invited to St. Louis to talk about what happened at the 1999 WTO event (50,000 demonstrators overwhelmed 400 Seattle officers and protestors smashed windows and vandalized cars as police fought back with rubber bullets and tear gas). Washington, DC, police were also invited to St. Louis to share their experiences with riots during protests of major global conferences in their city.

Although St. Louis police were not anticipating the same level or intensity of violence as in Seattle, they did have intelligence reports that some visitors would be in St. Louis who were involved in the Seattle protests and other demonstrations. Another conference, called Biodevastation 7, was scheduled immediately prior to the World Agricultural Forum (May 16 to 18, 2003) in St. Louis, which involved a gathering of opponents to genetic engineering. An organizer with the group had indicated that 200 to 800 people were expected to attend the Biodevastation 7 conference and that there would be 200 to 2,000 protestors at the World Agricultural Forum.

During this time period, in nearby Creve Coeur, Missouri, extra police were also on hand at the Monsanto property for the annual Creve Coeur Days. Monsanto, an agriculture industry leader, is a host of the annual celebration, which includes carnival rides and game booths on its property. Creve Coeur police coordinated a plan with St. Louis police to gather information about possible protests at this event.

A local international security consulting firm was in charge of security for the World Agricultural Forum conference. They worked with St. Louis police and other law enforcement agencies to prepare for possible protests at the event. Close coordination between these agencies helped to ensure that St. Louis was prepared to provide adequate security for the event and the international visitors to the city. Other than a couple of minor incidents between police and activists in the days leading up to the conference, no incidents were reported. A protest outside the conference on May 18 drew only a few hundred demonstrators, all peaceful, and only a handful of demonstrators were present during the event's two days.

Indiana State Fair Stage Collapse

On August 13, 2011, a strong wind gust from an approaching severe thunderstorm hit the temporary roof structure of a stage during a country music concert at the Indiana State Fair in Indianapolis, Indiana. The roof structure collapsed, injuring 58 people and killing seven. Forecasts throughout the day of the show had called for severe weather in the evening, and discussions had been held whether to still hold the show. Despite recommendations to cancel due to incoming inclement weather, the show went on as scheduled.

Boston Marathon Bombing

On April 15, 2013, thousands of runners competed in the 117th annual Boston Marathon. The Marathon is held in Boston Massachusetts on Patriot's Day, and is the world's oldest annual marathon. The event attracts an average of 30,000 registered athletes and 500,000 spectators each year. A little before 3 PM, two bombs detonated near the finish line of the race, killing three and injuring several hundred other runners and spectators. The incident highlighted the vulnerability of large groups of people to an explosive device, and spawned a citywide manhunt that resulted in the death of one suspect and capture of another.

Between September 1998 and January 2017, 51 separate events were considered National Special Security Events (NSSEs) nationwide. These events included Super Bowl 50, Presidential Inaugurations and Addresses, world summits and National Conventions for the two major American political parties. None of these events occurred in Missouri.

Probability of Future Hazard Events

Missouri will undoubtedly host future special events that will require significant security and other emergency planning considerations. The overall probability that a disastrous incident from any cause would occur in conjunction with a designated special event or special security event is considered moderate, depending on the event in question. The probability for an incident to occur during any particular special event is really a function of the hazards previously detailed in this hazard analysis and the probability of the independent occurrences of these hazards. However, special events will unfortunately continue to be likely targets for protests, rioting, and terrorist attacks in the United States. Refer to the measure of probability and severity discussions on the other hazards for more specific considerations.

Changing Future Conditions Considerations

As Missouri continues to attract special events with local, state and/or national level awareness, the potential for vulnerabilities increases. Proper planning for large scale events plays a significant role in mitigating potential impacts. As weather hazards potentially strengthen due to a changing climate, special events will see increased vulnerability due to intensified weather incidents.

State Vulnerability Overview

Significant special events where large groups of people are gathered and expanded security and other resources are required above and beyond the resources typically available to local or state government are potential targets for attacks such as terrorist attacks and civil disorder. Regardless of the purpose for the event, special events will place a large number of people in one area at one time. Anytime people are crowded together in one place, an incident resulting from just about any of the hazards detailed in this risk assessment could have compounded and devastating impacts.

It is not possible to calculate a specific vulnerability across Missouri. However, because of the desire for publicity following terrorist-type attacks at special event venues, it is more likely that counties with greater population densities would be the target of such attacks. Sparsely populated rural counties are less desirable targets for publicity-seeking terrorists, though this doesn’t make them immune from attacks. It is expected that the likelihood of attack is directly related to population density or more likely to an event that is occurring or to a specific location of importance to the attacker. For example, a large venue event, such as a sporting event attended by tens of thousands of people might be considered a desirable target. Most large public venues occur in densely populated areas since those areas are able to provide the infrastructure support (hotels, eateries, etc) for large numbers of people.

Vulnerability is also not limited to terrorist attack. Tornadoes, lightning, hail and other severe weather can cause damages, injuries and death to crowds exposed to the elements at special events that are held outdoors.

State Estimates of Potential Losses

Potential losses for this hazard include all infrastructure, critical facilities, humans and animals. 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, spread of disease, increased morbidity and mortality among the local and distant populations and public panic.

As discussed previously, it is difficult to describe vulnerability in terms of the jurisdictions, since the nature of special events varies widely. A well attended one-time event could be subject to as much loss as a less well attended annual event. For the purposes of this plan, this loss estimate will take into account a hypothetical scenario in order to calculate potential dollar losses. Please note that this hypothetical scenario is included to provide one methodology for local jurisdictions to estimate potential losses. The hypothetical scenario is an IED attack. Analysis of vulnerable populations is aided by a program developed by Johns Hopkins University in 2006 called Electronic Mass Casualty Assessment and Planning Scenarios (EMCAPS) which utilizes scenarios put together by the Department of Homeland Security.

****THE FOLLOWING HYPOTHETICAL SCENARIO IS FOR INSTRUCTIONAL AND ILLUSTRATIVE PURPOSES ONLY****

Scenario Overview: An Improvised Explosive Device (IED) utilizing an ammonium nitrate/fuel oil (ANFO) mixture is carried in a panel van to a parking area during a time when stadium patrons are leaving their cars and entering the stadium and detonated. Potential losses with this type of scenario include both human and structural assets.

Assumptions: (1) The population density in the parking lot during the beginning and ending of the games is high, at least 1 person /50 square feet. (2) The quantity of ANFO used is 4,000 lbs, similar to that used by Timothy McVeigh in the Oklahoma City bombing. (3) The Lethal Air Blast Range for such a vehicle is 200 feet according to the Bureau of Alcohol, Tobacco, Firearms and Explosives (BATF) Standards. (4) The Falling Glass Hazard distance is 2,750 feet according to BATF Explosive Standards.

Table 3.153. Described Losses:

Total Dead	695 persons
Total Traumatic Injuries	1,218 persons
Total Urgent Care Injuries	5,967 persons
Injuries not Requiring Hospitalization	2,233 persons
Structures and Other Physical Assets (Damages would certainly occur to vehicles and depending on the proximity of other structures, damages would occur to the stadium complex itself. The exact amount of these damages is difficult to predict because of the large numbers of factors, including the type of structures nearby and the amount of insurance held by vehicle owners).	Vehicles – Replacement cost for approximately 100 vehicles @ $15,000 per vehicle inside the 200 ft BATF described Lethal Air Blast range = $ 150,000 Repair / repainting cost for approximately 500 vehicles @ $ 4,000 per vehicle inside the BATF described Falling Glass Hazard = $2,000,000

Hazard Impact on Future Growth and Development

As Missouri plays host to more national events and large scale venues the potential for losses increases. Proper planning for large scale events plays a significant role in mitigating future losses.

Table 3.154. EMAP Impact Analysis: Special Events

Subject	Detrimental Impacts
Public	May be severe for unprotected personnel and moderate to light for protected personnel in incident area.
Responders	Adverse impact expected to be severe for unprotected personnel and moderate to light for trained, equipped, and protected personnel.
Continuity of Operations including continued delivery of services	Danger to personnel in the area of the incident may require relocation of operations and lines of succession execution; localized disruption of roads and/or utilities caused by incident may postpone delivery of some services.
Property, Facilities, and Infrastructure	Facilities and infrastructure in the area of the incident may be denied until incident resolved.

Subject	Detrimental Impacts
Environment	Localized adverse impact depending on the nature of the incident.
Economic and Financial Condition	Localized adverse impact depending on the nature of the incident.
Public's Confidence in the Jurisdiction's Governance	Ability to respond and recover may be questioned and challenged if planning, response, and recovery not timely and effective.

Risk Summary

Significant special events are any type of event where large groups of people are gathered and expanded security and other resources are required above and beyond the resources typically available to local or state government. Special events may be motivated by political, economic, religious or social causes, as in the case of inaugurations, state of the union addresses, and summit conferences, or they may be motivated by recreational causes as with major sporting events or designated holiday events. With major sporting events and arenas, major league and collegiate sports teams, concerts and festivals, Missouri sees a significant number of events per year that can and do require special planning for the safety and security of attendees.

Regardless of the purpose or cause, special events will place a large number of people in one area at one time. Anytime people are crowded together in one place, an incident resulting from just about any of the hazards presented in this plan could have devastating impacts, compounded by the sheer number of people located in a condensed area.

In such instances, event sponsors, in conjunction with local and state authorities, are responsible for coordinating the event and requesting assistance at the federal level, if necessary. Local and state authorities are responsible for coordinating requirements from the organization sponsoring an event and determining resource shortfalls and submitting resource requests, through the existing structures and mechanisms, to the national level for consideration. Event sponsors are responsible for developing concepts for conducting the event, identifying resource requirements necessary to support the event, and submitting resource requests to local and state governments for consideration.

Problem Statement:

Using population and major transportation corridors as key indicators, the data suggests that counties at most risk are St. Louis, Jackson, St. Charles, St. Louis City, Greene, Clay, Jefferson, Boone, Jasper and Franklin. Mitigation strategies and limited resources allocated in these counties first could prove most beneficial.

2018 risk assessment data and mapping is available through the Missouri Hazard Mitigation Viewer: http://bit.ly/MoHazardMitigationPlanViewer2018.

3.3.21. Terrorism

Probability	Severity
<1%	Low to High

Description/Location

Terrorism, as defined by the Federal Bureau of Investigation (FBI), is "the unlawful use of force or violence against persons or property to intimidate or coerce a government, the civilian population, or any segment thereof, in furtherance of political or social objectives." The effects of terrorism can vary significantly, including loss of life, injuries to people and properties, and disruptions in services (e.g., water supplies, public transportation, and communications).

According to the FBI, there are two primary types of terrorism:

- **Domestic Terrorism** involves groups or individuals whose terrorist activities are directed at elements of our government or populations without foreign direction.
- **International Terrorism** involves terrorist activity committed by groups or individuals who are foreign-based and/or directed by countries or groups outside the United States or whose activities transcend national boundaries.

Forms of Terrorism

Terrorism can take place in various forms, depending on the technological means available to the terrorist group, the nature of the issue motivating the attack, and the points of weakness of their target. Potential terrorist actions include the following:

- **Bombings**—Bombings have long been used in terrorist attacks and probably represent the most "traditional" form of terrorism. These types of incidents range from small-scale letter bombs to large-scale attacks on specific buildings. Other bomb-related incidents frequently involve "suicide bombers," who sacrifice themselves for their cause.
- **Airline Attacks**—In the past, terrorist acts involving aircraft were generally restricted to hijackings and bombings. However, the attacks on the World Trade Center buildings in New York City in 2001 brought a new avenue to light—the use of commercial aircrafts to attack infrastructure targets. Surface-to-air missile attacks also present a threat to U.S. aircrafts.
- **Weapons of Mass Destruction (WMD) Attacks**—WMD attacks usually involve nuclear weapons or biological or chemical agents. Chemical and biological agents are infectious microbes or toxins used to produce illness or death. They can be dispersed as aerosols or airborne particles directly onto a population, producing an immediate effect (a few seconds to a few minutes) or a delayed effect (several hours to several days). Severity of injuries depends on the type and amount of the agent used and duration of exposure. Because some biological agents take time to grow and cause disease, an attack using this type of agent may go unnoticed for several days.
- **Infrastructure Attacks**—These types of attacks can impact various potential targets, including water distribution systems and treatment plants, utility companies and services, emergency services, gas and oil production facilities, telecommunications centers, transportation terminals, media facilities, government buildings, and religious institutions.
- **Cyberterrorism**—Cyberterrorism pertains to attacks on computer-based systems that are designed to spread disinformation and propaganda, deny service to legitimate computer users, spread electronic viruses to corrupt vital data, or cause critical infrastructure outages. Political conflicts that have led to attacks on cyber systems include clashes between India and Pakistan, Israel and the Palestinians, the

North Atlantic Treaty Organization, and Serbia. Cyber Disruptions are covered separately in Section 3.3.14

- **Agroterrorism**—Agroterrorism involves intentional contamination of commercial produce or meat supplies. Because the United States supplies approximately 16 percent of the world's meat, 40 percent of its soybeans, and 41 percent of its corn, a deadly fungus or bacteria could be devastating. Of the 222 possible bioterrorism attacks that have occurred worldwide in the twentieth century, only 17 of these targeted commercial livestock or plants, according to the Institute for National Strategic Studies.
- **Arson**—Intentional fires have caused extensive damage during terrorist-related incidents in the past. These types of incidents may also be associated with bombings and usually target specific structures, such as churches. Although deliberately set fires have been reported at 15 churches in Missouri, none have been determined to be hate crime-related or terrorist-related incidents.
- **Kidnappings/Assassinations**—Kidnappings and assassinations may also be terrorist-related incidents, but because these events generally involve few individuals, their effect on emergency management operations may be minimal in terms of response.

Domestic Terrorism

According to the FBI, domestic terrorist groups represent interests that span the full spectrum of political and economic viewpoints, as well as social issues and concerns. The current domestic terrorist threat comes primarily from white supremacists, black separatists, animal rights/environmental terrorists, anarchists, antiabortion extremists, and self-styled militia.

- **White Supremacists or Right-Wing Terrorists**—Right-wing terrorist groups often adhere to the principles of racial supremacy and embrace antigovernment, antiregulatory beliefs. Generally, extremist right-wing groups engage in activities that are protected by constitutional guarantees of free speech and assembly. Examples of this type of group include Aryan Nations, the Order, and Posse Comitatus. Missouri has seen some activity from these groups in the past few years. According to the Southern Poverty Law Center, Missouri has two extremist groups operating within its borders. Although a state statute against paramilitary training exists, one of these groups is also known to have such a facility in Missouri. In addition, several special gatherings of extremist groups have taken place within the State in recent years.
- **Black Separatists**—United States-based black separatist groups follow radical variants of Islam and in some cases express solidarity with al-Qa'ida and other international terrorist groups.
- **Animal Rights and Environmental Terrorists**—Operating under the umbrella of the Animal Liberation Front and Earth Liberation Front, these terrorists use a variety of tactics against their targets, including arson, sabotage/vandalism, theft of research animals, and the occasional use of explosive devises
- **Anarchists**—The potential for violence by anarchists and other emerging revolutionary groups, such as the Anarchist Black Cross Federation (ABCF), will continue to be an issue for law enforcement. The stated goals of the ABCF are "the abolishment of prisons, the system of laws, and the capitalist state." The ABCF believes in armed resistance to achieve a stateless and classless society. The ABCF has continued to organize, recruit, and train anarchists in the use of firearms.
- **Anti-Abortion Extremists**—The FBI investigates anti-abortion groups. Potential violent anti-abortion extremists linked to terrorism ideologies or groups pose a current threat.
- The Southern Poverty Law Center tracks hate groups, which it classifies as "any group with beliefs or practices that attack or malign an entire class of people – particularly when the characteristics being maligned are immutable." **Figure 3.201** shows SPLC-identified hate groups in Missouri.

Figure 3.201. Identifed Hate Groups in Missouri

American Guard
Missouri (statewide)
GENERAL HATE

Firm 22
Missouri (statewide)
RACIST SKINHEAD

The Daily Stormer
Missouri (statewide)
NEO-NAZI

Aryan Nations Sadistic Souls MC
Grovespring, Missouri
NEO-NAZI
ARYAN NATIONS

HEADQUARTERS
Council of Conservative Citizens
Potosi, Missouri
WHITE NATIONALIST
COUNCIL OF CONSERVATIVE CITIZENS

HEADQUARTERS
Conservative Citizens Foundation, Inc.
St Charles, Missouri
WHITE NATIONALIST
COUNCIL OF CONSERVATIVE CITIZENS

HEADQUARTERS
Church of Israel
Schell City, Missouri
CHRISTIAN IDENTITY

Nation of Islam
St. Louis, Missouri
BLACK NATIONALIST
NATION OF ISLAM

New Black Panther Party for Self Defense
Saint Louis, Missouri
BLACK NATIONALIST

ACT for America
St. Louis, Missouri
ANTI-MUSLIM
ACT FOR AMERICA

Israel United In Christ
St. Louis, Missouri
BLACK NATIONALIST

Israelite School of Universal Practical Knowledge
St. Louis, Missouri
BLACK NATIONALIST

Mass Resistance
St. Louis, Missouri
ANTI-LGBT

HEADQUARTERS
Vanguard News Network
Kirksville, Missouri
NEO-NAZI

Nation of Islam
Kansas City, Missouri
BLACK NATIONALIST
NATION OF ISLAM

ACT for America
Kansas City, Missouri
ANTI-MUSLIM
ACT FOR AMERICA

Israelite School of Universal Practical Knowledge
Kansas City, Missouri
BLACK NATIONALIST

Confederate White Knights of the Ku Klux Klan
Sikeston, Missouri
KU KLUX KLAN

Source: Southern Poverty Law Center

International Terrorism

The United States continues to face a formidable challenge from international terrorism. In general terms, the international terrorist threat can be divided into three categories: loosely affiliated extremists operating under the radical jihad movement, formal terrorist organizations, and state sponsors of terrorism. Each of these categories, which represent threats to U.S. citizens and interests both abroad and at home, are described below:

- **Loosely Affiliated Extremists**—These are motivated by political or religious beliefs, and pose the most urgent threat to the United States.
- **Formal Terrorist Organizations**—These organizations are typically autonomous and have their own infrastructures, personnel, financial arrangements, and training facilities.
- **State Sponsors of Terrorism**—This category includes countries known to sponsor terrorism and to view it as a tool of foreign policy. Currently, the U.S. Department of state recognizes seven countries in this category: Iran, Iraq, Sudan, Libya, Syria, Cuba, and North Korea.

Foreign Terrorist Organizations (FTOs) are foreign organizations that are designated by the secretary of state in accordance with Section 219 of the Immigration and Nationality Act, as amended by the Antiterrorism and Effective Death Penalty Act of 1996. A list is compiled every two years. As of November 2016, the current list of FTOs designates the following organizations (see **Table 3.155**):

Table 3.155. Designated Foreign Terrorist Organizations

Date Designated	Name
10/8/1997	Abu Nidal Organization (ANO)
10/8/1997	Abu Sayyaf Group (ASG)
10/8/1997	Aum Shinrikyo (AUM)
10/8/1997	Basque Fatherland and Liberty (ETA)
10/8/1997	Gama'a al-Islamiyya (Islamic Group) (IG)
10/8/1997	HAMAS
10/8/1997	Harakat ul-Mujahidin (HUM)
10/8/1997	Hizballah
10/8/1997	Kahane Chai (Kach)
10/8/1997	Kurdistan Workers Party (PKK) (Kongra-Gel)
10/8/1997	Liberation Tigers of Tamil Eelam (LTTE)
10/8/1997	National Liberation Army (ELN)
10/8/1997	Palestine Liberation Front (PLF)
10/8/1997	Palestinian Islamic Jihad (PIJ)
10/8/1997	Popular Front for the Liberation of Palestine (PFLF)
10/8/1997	PFLP-General Command (PFLP-GC)
10/8/1997	Revolutionary Armed Forces of Colombia (FARC)
10/8/1997	Revolutionary People's Liberation Party/Front (DHKP/C)
10/8/1997	Shining Path (SL)
10/8/1999	al-Qa'ida (AQ
9/25/2000	Islamic Movement of Uzbekistan (IMU)
5/16/2001	Real Irish Republican Army (RIRA)
12/26/2001	Jaish-e-Mohammed (JEM)
12/26/2001	Lashkar-e Tayyiba (LeT)
3/27/2002	Al-Aqsa Martyrs Brigade (AAMB)
3/27/2002	Asbat al-Ansar (AAA)
3/27/2002	al-Qaida in the Islamic Maghreb (AQIM)
8/9/2002	Communist Party of the Philippines/New People's Army (CPP/NPA)
10/23/2002	Jemaah Islamiya (JI)

Date Designated	Name
1/30/2003	Lashkar i Jhangvi (LJ)
3/22/2004	Ansar al-Islam (AAI)
7/13/2004	Continuity Irish Republican Army (CIRA)
12/17/2004	Islamic State of Iraq and the Levant (formerly al-Qa'ida in Iraq)
6/17/2005	Islamic Jihad Union (IJU)
3/5/2008	Harakat ul-Jihad-i-Islami/Bangladesh (HUJI-B)
3/18/2008	al-Shabaab
5/18/2009	Revolutionary Struggle (RS)
7/2/2009	Kata'ib Hizballah (KH)
1/19/2010	al-Qa'ida in the Arabian Peninsula (AQAP)
8/6/2010	Harakat ul-Jihad-i-Islami (HUJI)
9/1/2010	Tehrik-e Taliban Pakistan (TTP)
11/4/2010	Jundallah
5/23/2011	Army of Islam (AOI
9/19/2011	Indian Mujahedeen (IM)
3/13/2012	Jemaah Anshorut Tauhid (JAT)
5/30/2012	Abdallah Azzam Brigades (AAB)
9/19/2012	Haqqani Network (HQN)
3/22/2013	Ansar al-Dine (AAD)
11/14/2013	Boko Haram
11/14/2013	Ansaru
12/19/2013	al-Mulathamun Battalion
1/13/2014	Ansar al-Shari'a in Benghazi
1/13/2014	Ansar al-Shari'a in Darnah
1/13/2014	Ansar al-Shari'a in Tunisia
4/10/2014	ISIL Sinai Province (formally Ansar Bayt al-Maqdis)
5/15/2014	al-Nusrah Front
8/20/2014	Mujahidin Shura Council in the Environs of Jerusalem (MSC)
9/30/2015	Jaysh Rijal al-Tariq al Naqshabandi (JRTN)
1/14/2016	ISIL-Khorasan (ISIL-K)
5/20/2016	Islamic State of Iraq and the Levant's Branch in Libya (ISIL-Libya)

Source: U.S. Department of State, http://www.state.gov/j/ct/rls/other/des/123085.htm

Government Authority

After the attacks on September 11, 2001, parts of 22 domestic agencies were consolidated into one department, the U.S. Department of Homeland Security (DHS), to protect the nation against future terrorist threats. Roles of those agencies include analyzing threats and intelligence, guarding national borders and airports, protecting critical infrastructure, and coordinating response efforts for future emergencies.

The FBI is the lead federal agency for investigating terrorism. The FBI is authorized to open an investigation whenever "facts or circumstances reasonably indicate that two or more persons are engaged in an enterprise for the purpose of furthering political or social goals wholly or in part through activities that involve force or violence and a violation of the criminal laws of the United States." In any given year, the FBI engages in approximately 24 full-scale domestic terrorism investigations. The FBI maintains a state-of-the-art computer database known as the Terrorist Information System, which contains information on known or suspected terrorist groups and individuals. The system contains information on over 200,000 individuals and over 3,000 organizations.

An essential weapon in the battle against terrorists is the Joint Terrorism Task Force (JTTF). A national JTTF, located at FBI Headquarters, includes representatives from the U.S. Department of Defense, U.S. Department of Energy, FEMA, Central Intelligence Agency, Customs Service, Secret Service, and the Immigration and

Naturalization Service. Additionally, there are 66 local JTTFs where representatives from federal agencies, state and local law enforcement personnel, and first responders work together to track down terrorists and prevent acts of terrorism in the United States. There are two JTTFs in Missouri, one in Kansas City and one in St. Louis.

After terrorist-related events, communities may receive assistance from state and federal agencies operating within the existing Integrated Emergency Management System. FEMA is the lead federal agency for supporting state and local response to the consequences of terrorist attacks.

National Terrorism Advisory System (NTAS)

Because of the potential for future terrorist-related incidents, a national security alert system in place to disseminate information regarding the risk of terrorist acts to federal, state, and local governments and to the American people. The National Terrorism Advisory System (NTAS) consists of two types of advisories – Bulletins and Alerts. Bulletins communicate current developments or general trends regarding threats of terrorism. NTAS Bulletins permit the Secretary of Homeland Security to communicate critical terrorism information that, while not necessarily indicative of a specific threat against the United States, can reach homeland security partners or the public quickly, thereby allowing recipients to implement necessary protective measures. Because DHS may issue NTAS Bulletins in circumstances not warranting a more specific warning, NTAS Bulletins provide the Secretary with greater flexibility to provide timely information to stakeholders and members of the public.

When there is specific, credible information about a terrorist threat against the United States, DHS will share an NTAS Alert with the American public when circumstances warrant doing so. The Alert may include specific information, if available, about the nature of the threat, including the geographic region, mode of transportation, or critical infrastructure potentially affected by the threat, as well as steps that individuals and communities can take to protect themselves and help prevent, mitigate or respond to the threat. The Alert may take one of two forms: Elevated, if there is credible threat information, but only general information about timing and target such that it is reasonable to recommend implementation of protective measures to thwart or mitigate against an attack, or Imminent, if DHS believes the threat is credible, specific, and impending in the very near term.

Threat conditions are assigned by the secretary of Homeland Security in consultation with the attorney general and other appropriate federal agency heads, including other members of the Homeland Security Council. Threat conditions may be set for the entire nation or a particular geographic area or industrial sector. The assigned threat conditions are reviewed at regular intervals to determine whether adjustments are warranted.

Missouri's Homeland Security Program

The Missouri Office of Homeland Security (OHS) is a part of the Department of Public Safety, and directly under the Director of the Department of Public Safety (DPS).

Figure 3.202. Missouri Department of Public Safety – Organizational Chart

	Office of the Director	
Division of Fire Safety	Missouri Capitol Police	Missouri Adjutant General
Missouri State Highway Patrol	Missouri Homeland Security	State Emergency Management Agency
Division of Alcohol & Tobacco Control	Missouri Veterans Commission	Missouri Gaming Commission

Source: Missouri Department of Public Safety, http://dps.mo.gov/dir/programs/ohs/documents/OHSOverview05-17-13.pdf

Office of Homeland Security

The homeland security coordinator, who works directly for the director of the Department of Public Safety, manages the Office of Homeland Security and is tasked with implementing Missouri's Homeland Security Strategy. The coordinator is responsible for the overall Homeland Security program in Missouri, and works with the Homeland Security Advisory Council, the Regional Homeland Security Oversight Committees, and the various initiatives to ensure that Missouri's program is focused on an all threats, all hazards approach. Two "special assistants" support the different OHS initiatives. The Office of Homeland Security serves as Missouri's State Administrative Agency (SAA) and handles the administration and fiscal aspects of the Homeland Security Grant Program, Emergency Management Grant Program and the Juvenile Justice Program.

Governor's Homeland Security Advisory Council

The Governor's Homeland Security Advisory Council (HSAC) was established through Executive Order 05-20. The HSAC currently consists of 20 members. The chairman of the HSAC is the director of the Department of Public Safety. The vice chairman is the homeland security coordinator, who also heads the Missouri Office of Homeland Security.

Regional Homeland Security Oversight Committees

Local communities are focused and engaged in Missouri's homeland security program through the establishment of regional advisory groups, called Regional Homeland Security Oversight Committees (RHSOCs). RHSOCs fall under the governance structure of the Homeland Security Advisory Council.

Missouri's "Homeland Security Regionalization" program is focused on establishing a common sense, logical governance structure and process to facilitate local, community level engagement in not only grant funding priorities and strategies, but other homeland security related decisions consistently across the state. Sixteen core disciplines at the county/local level have been identified as minimum voting participants in these regional committees.

While only one individual from each discipline in a specific region will hold a voting seat on the committee, it is mandated that they represent all segments of their core discipline members in their region, including both county and local interest. They accomplish this through establishment of working groups within each discipline. The RHSOCs meet quarterly (January, April, July, and October), with additional meetings called as needed to discuss special topics.

Figure 3.203. Homeland Security Regions

Source: Missouri Department of Public Safety, http://dps.mo.gov/dir/programs/ohs/documents/OHSOverview05-17-13.pdf

Extent

Extent is reliant on the type of attack and other parameters. Terrorism is usually attempted to kill or injure persons, destroy property or impact critical functions, and affect public confidence and instill fear.

Previous Occurrences

The following section highlights noteworthy terrorist-related threats and actual attacks that have occurred in the United States since 1970. The French Revolution provided the first uses of the words “Terrorist” and “Terrorism.” Use of the word “terrorism” began in 1795 in reference to the Reign of Terror initiated by the Revolutionary government. The agents of the Committee of Public Safety and the National Convention that enforced the policies of “The Terror” were referred to as “Terrorists.” The French Revolution provided an example to future states in oppressing their populations. It also inspired a reaction by royalists and other opponents of the Revolution who employed terrorist tactics such as assassination and intimidation in resistance to the Revolutionary agents. The Parisian mobs played a critical role at key points before, during, and after the Revolution. The following section highlights noteworthy terrorist-related threats and actual attacks that have occurred in the United States since 1970.

In 1972, members of a U.S. fascist group called Order of the Rising Sun were found in possession of 30 to 40 kilograms of typhoid bacteria cultures, which they planned to use to contaminate water supplies in Chicago, St. Louis, and other large Midwestern cities.

In 1984, two members of an Oregon cult headed by Bhagwan Shree Rajneesh cultivated Salmonella bacteria and used it to contaminate restaurant salad bars in an attempt to affect the outcome of a local election. Although approximately 751 people became ill and 45 were hospitalized, there were no fatalities.

In February 1993, an improvised bomb exploded in a rental van parked on the second level of the World Trade Center's parking basement. The bomb contained approximately 1,200 to 1,500 pounds of a homemade fertilizer-based explosive, urea nitrate. The blast produced a crater 150 feet in diameter and five floors deep. Although the motive for the attack was never confirmed, it is believed that the suspect who masterminded the bombing was either backed by a loose network of militant Muslims or directed by Iraq. The incident, which killed 6 people and injured more than 1,000, was the most significant international terrorist act that had ever been committed on U.S. soil at that time.

In April 1995, a massive bomb exploded inside a rental truck parked near the Murrah Federal Building in Oklahoma City, destroying half the nine-story building and killing 168 people. The incident was traced to Timothy McVeigh, who was convicted of the bombing and executed by lethal injection in June 2001. He was the first federal prisoner to be executed in 38 years. McVeigh was a survivalist who believed individual rights (e.g., gun control) were being deprived by government agencies. Consequently, he was convinced he acted to defend the Constitution and saw himself as a crusader and hero. This was the worst terrorist event, either domestic or international in origin that had ever occurred in the United States at that time.

In March 1995, four members of the Minnesota Patriots Council, a right-wing militia organization advocating the violent overthrow of the U.S. government, were convicted of conspiracy charges under the Biological Weapons Anti-Terrorism Act of 1989 for planning to use ricin, a lethal biological toxin. The four men allegedly conspired to assassinate federal agents who served papers on one of them for tax violations.

In May 1995, a member of the neo-Nazi organization Aryan Nations was arrested in Ohio on charges of mail fraud. He allegedly misrepresented himself when ordering three vials of freeze-dried Yersinia Pestis, the bacteria that causes bubonic plague, from a Maryland biological laboratory.

In October 1995, the Amtrak Sunset Limited passenger train derailed near Hyder, Arizona. It was determined that the train track had been sabotaged, causing the train to derail and topple 30 feet from a bridge. A letter signed by the Sons of Gestapo was left at the scene. One person was killed and 83 others were injured in this incident.

In November 1995, members of the Tri-States Militia (a group composed of militia from at least 30 states) were arrested after being linked to five would-be terrorists whose bomb plots were thwarted by federal and state law enforcement agencies. The plots involved blowing up the Southern Poverty Law Center, offices of the Anti-Defamation League, federal buildings, abortion clinics, and gay community locations.

In December 1995, an Arkansas man was charged with possession of ricin in violation of the Biological Weapons Anti-Terrorism Act. The man was arrested and subsequently hanged himself in his jail cell the next day.

In July 1996, a pipe bomb exploded in Atlanta's Centennial Olympic Park as the city was hosting the summer Olympic Games. One person was killed and dozens were wounded. It was later determined that the bomb had been planted by Eric Robert Rudolph, who was also suspected of being responsible for a double bombing at the Sandy Springs Professional Building in Atlanta in January 1997 and a double bombing at the Otherside Lounge in Atlanta in February 1997. Rudolph was arrested in May 2003 after five years on the run. He is a former soldier and survivalist with extreme right-wing views and is also reported to have ties to white supremacist groups.

On September 11, 2001 there were a series of coordinated terrorist suicide attacks by Islamic extremists upon the United States of America. Nineteen terrorists affiliated with al-Qaeda hijacked four commercial passenger jet airliners. Each team of hijackers included a trained pilot. The hijackers intentionally crashed two of the airliners (United Airlines Flight 175 and American Airlines Flight 11) into the World Trade Center in New York City, one plane into each tower (1 WTC and 2 WTC), resulting in the collapse of both buildings soon afterward and extensive damage to nearby buildings. The hijackers crashed a third airliner (American Airlines Flight 77) into the Pentagon in Arlington County, Virginia, near Washington, D.C. Passengers and members of the flight crew on the fourth aircraft (United Airlines Flight 93) attempted to retake control of their plane from the hijackers; that plane crashed into a field near the town of Shanksville in rural Somerset County, Pennsylvania. In addition to the 19 hijackers, 2,974 people died as an immediate result of the attacks, and the death of at least one person from lung disease was ruled by a medical examiner to be a result of exposure to WTC dust. Another 24 people are missing and presumed dead. The victims were predominantly civilians. The New York City Fire Department lost 341 New York City Fire Department firefighters and 2 paramedics, while 23 New York Police Department, 37 Port Authority Police Department officers, and 8 private ambulance personnel were killed. There were 125 victims in the Pentagon. The dead included 8 children. The youngest victim was a 2 year-old child on Flight 175, the oldest an 82 year-old passenger on Flight 11. According to the Associated Press, the city identified over 1,600 bodies but was unable to identify the rest (about 1,100 people). They report that the city has "about 10,000 unidentified bone and tissue fragments that cannot be matched to the list of the dead." Bone fragments were still being found in 2006 as workers prepared the damaged Deutsche Bank Building for demolition. The average age of all the dead in New York City was 40.

The attacks created widespread confusion across the United States. All international civilian air traffic was banned from landing on US soil for three days; aircraft already in flight were either turned back or redirected to airports in Canada or Mexico. Unconfirmed and often contradictory reports were aired and published throughout the day. One of the most prevalent of these reported that a car bomb had been detonated at the U.S. State Department's headquarters, the Truman Building in Foggy Bottom, Washington, D.C.

Between early October and early December 2001, five people died from anthrax infection, and at least 13 others contracted the disease in Washington, DC; New York City; Trenton, New Jersey; and Boca Raton, Florida. Anthrax spores were found in a number of government buildings and postal facilities in these and other areas. Most of the confirmed anthrax cases were tied to contaminated letters mailed to media personalities and U.S. senators. Thousands of people were potentially exposed to the spores and took preventive antibiotics. Numerous mail facilities and government buildings were shut down for investigation and decontamination.

In the wake of these incidents, federal, state, and local emergency response agencies across the United States responded to thousands of calls to investigate suspicious packages, unknown powders, and other suspected exposures. Almost all of the incidents turned out to involve no actual biohazard. Nevertheless, emergency responders typically treated each call as a potentially serious health and safety risk. During this tense time, in Missouri, the Department of Health and Senior Services (DHSS) issued numerous health alert advisories to local officials and the public, providing guidance on how to handle anthrax or suspicious letters and packages during a time of extremely heightened tensions. DHSS also instituted a surveillance system, contacting health providers to obtain public health information twice weekly, while also working to improve the public health infrastructure, information sharing, health communication networks, and hospital surge capabilities.

In October 2002, a month-long sniper spree terrorized the entire Washington DC area as a sniper duo gunned down ten people at random. The shooters were later arrested while sleeping in their modified vehicle.

In 2005, the FBI arrested 11 people in relation to 17 attacks that included $12 million in arson damage to Vail Ski Resort in Vail, Colorado.

In March 2008, a homemade bomb damaged an Armed Forces Recruiting Office in Times Square in New York City. No suspect was caught.

In April 2013, two explosions occurred at the finish line of the Boston Marathon, killing three people and injuring more than 180. The attack resulted in a three-day manhunt for two suspects, one of which was apprehended and the other killed by police. A "shelter in place" order was given for residents in the Boston area as the search weaved in and out of area neighborhoods.

In December 2013, a 58 year old avionics technician in Wichita, Kansas was arrested for attempting a suicide bombing at Wichita Mid-Continental Airport. The perpetrator became radicalized after reading propaganda on the Internet. He was arrested while driving a vehicle into the airport with what he believed to be an active explosive device.

In June 2015, a mass shooting took place at an Episcopal church in Charleston, South Carolina, one of the oldest black churches in the country and a site for community organization around civil rights. Nine people were killed, and a tenth victim was shot but survived. The perpetrator was later arrested, and confessed that he was trying to initiate a race war.

In June 2016, a lone gunman opened fire at a gay nightclub in Orlando, FL. Almost 50 people were killed and 53 were injured in what is currently the deadliest mass shooting in modern American history.

Probability of Future Hazard Events

Probability

The threat of terrorism in the United States remains a concern. Over the past few years, the level of acts committed in the United States has increased steadily with attacks ranging from mass shootings to improvised explosive devices to cyber attacks.

Although several different extremist groups have been identified in Missouri, there have been no indications of any specific recent terrorist activities. The potential does remain, however, for new extremist and/or terrorist groups to move into the State at any time.

An open society such as ours, which depends on technology for its continued smooth operation, remains a potential target for terrorists. Large cities with a variety of news media outlets probably represent the most likely locations for terrorist acts because terrorists generally want their acts to reverberate in the news media and reach the largest audience possible. Since Missouri does not have large media markets compared to some states, it is not as likely a target for terrorist activity as those other states. However, the Oklahoma City bombing debunked the idea that rural America is completely safe from terrorists. With this in mind, it appears that a terrorist attack could occur in Missouri; the probability of such an attack is low, and noted as <1-percent.

Severity

Should Missouri experience a terrorist attack, the severity of such an attack could range from high to low depending on the attack. For instance, if a building was blown up and no lives were lost, the severity of the attack would be low. However, if a terrorist group decided to contaminate a large urban area's water supply with a poisonous chemical, the severity of the attack could be very high due to the number of people directly affected by the poisoned water, as well as damage to that community's sense of well-being. An attack of this nature could easily result in mass hysteria and insecurity concerning the government's ability to protect its citizens.

Local communities are focused and engage in Missouri's Homeland Security Program through the establishment of regional advisory groups, called Regional Homeland Security Oversight Committees (RHSOCs). RHSOCs fall under the governance structure of the Homeland Security Advisory Council. Missouri's program is focused on establishing a common sense, logical governance structure and process to facilitate homeland security related decisions consistently across the State. There are currently several initiatives underway.

Changing Future Conditions Considerations

Changing future conditions in terms of climate and weather patterns are not expected to have a direct impact on the probability or severity of potential terrorism events. However, there are extreme environmental groups that may resort to forms of terrorism in their protests.

State Vulnerability Overview

Terrorist acts could easily undermine the confidence that people have in their own security and in their government's ability to protect them from harm. Because bombs can be made so easily, the threat of a bomb should not be taken lightly. The threat of a bomb can disrupt a community almost as effectively as an actual bomb, while creating far fewer risks for the persons making the threat. Therefore, no matter how large or small the incident, a terrorist act can have a major impact on a community.

A strategic biological, or chemical attack on the United States could have the most devastating and far-reaching consequences. The potential for traditional war-related attacks, using conventional weapons, is a scenario that is more likely to occur, based on currently available information, however even attacks of that variety are rare. Attackers are likely to have either very specific targets such as Women's clinics, or desire large publicity from the attacks.

State Estimates of Potential Losses

It is not possible to calculate a specific vulnerability for each county in Missouri. However, because of the desire for publicity following attacks, it is more likely that counties with greater population densities would be the target of attacks. Sparsely populated rural counties are less desirable targets for publicity-seeking terrorists. It is expected that the likelihood of attack is directly related to population density or more likely to an event that is occurring or to a specific location of importance to the attacker. For example, a large venue event, such as a sporting event attended by tens of thousands of people might be considered a desirable target. Most large public venues occur in densely populated areas since those areas are able to provide the infrastructure support (hotels, eateries, etc) for large numbers of people. A description of population density is contained in this plan in Section 3.1.1 and a map **Figure 3.3** showing the population density of each Missouri county is found in **Table 3.6**.

Potential losses for this hazard include all infrastructure, critical facilities, humans and animals. The degree of impact would be directly related to the type of terrorist 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, spread of disease, increased morbidity and mortality among the local and distant populations and public panic. Terrorist events are rare occurrences and specific amounts of estimated losses for previous occurrence are not available due to the complexity and multiple variables associated with these types of hazards.

As discussed previously, it is difficult to describe vulnerability in terms of the jurisdictions most threatened by terrorist attack events due to the many variables and human element that come in to play. Therefore, for the purposes of this plan, the loss estimates will take into account a hypothetical scenario. Please note that this hypothetical scenario is included to provide one methodology for local jurisdictions to estimate potential losses. The hypothetical scenario is a chemical attack. The hypothetical venue is a stadium situated on less than one square mile and has a seating capacity of over 45,000 persons. Surface area and parking structures are located adjacent to the stadium.

Analysis of vulnerable populations is aided by a program developed by Johns Hopkins University in 2006 called Electronic Mass Casualty Assessment and `Planning Scenarios (EMCAPS) which utilizes scenarios put together by the Department of Homeland Security.

****THE FOLLOWING HYPOTHETICAL SCENARIOS ARE FOR INSTRUCTIONAL AND ILLUSTRATIVE PURPOSES ONLY****

Chemical Attack – Mustard Gas

Scenario Overview: Mustard gas is released from a light aircraft onto a stadium during a sporting event. The agent directly contaminates the stadium and the immediate surrounding area. This particular type of attack would cause harm to humans and could render portions of the stadium unusable for a short time period in order to allow for a costly clean-up. There might also be a fear by the public of long-term contamination of the stadium and subsequent boycott of games resulting in a loss of revenue and tourism dollars.

Assumptions: (1) The population density at the stadium on game day is high – approximately 75 percent of the seats, 31,000, are filled. (2) Sulphur mustards are extremely toxic and may damage eyes, skin and respiratory tract. Death sometimes results from secondary respiratory infections. (3) The rate of “worried well” is equal to 9 times the number of infected cases.

<u>Described Losses:</u>

Severe Eye Injuries (1-2 hours)	23,250 persons
Severe Airway Injuries (1-2 hours)	23,250 persons
Severe Skin Injuries (2 hrs to days)	27,900 persons
Total “Worried Well” Cases (9 times the number of affected cases)	251,000 persons
Deaths	620 persons

Notes: Victims will require decontamination and both long and short term treatment. Services may need to be suspended at the area until all investigations are conducted.

Hazard Impact on Future Growth and Development

As more and more large public events are held in Missouri, and as the population increases, more potential exists for these venues to become targets of a terrorist attack.

EMAP Consequence Analysis

As stated above, terrorist acts could easily undermine the confidence that people have in their own security and in their government’s ability to protect them from harm. For example, instructions to make bombs are readily accessible to potential terrorists (including via the Internet), and the materials for their construction are readily available. Because bombs can be made so easily, the threat of a bomb should not be taken lightly. The threat of a bomb can disrupt a community almost as effectively as an actual bomb, while creating far fewer risks for the persons making the threat. Therefore, no matter how large or small the incident, a terrorist act can have a major impact on a community.

The information in **Table 3.156** is from the Impact Analysis of Potential for Detrimental Impacts of Hazards done for the Emergency Management Accreditation Program.

Table 3.156. EMAP Impact Analysis: Terrorism

Subject	Detrimental Impacts
Public	Adverse impact expected to be severe for unprotected personnel and moderate to light for protected personnel
Responders	Adverse impact expected to be severe for unprotected personnel and moderate to light for trained and protected personnel.
Continuity of Operations including continued delivery of services	Damage to facilities/personnel in the area of the incident may require relocation of operations and lines of succession execution; Disruption of lines of communication and destruction of facilities may extensively postpone delivery of services.
Property, Facilities, and Infrastructure	Facilities and infrastructure in the area of the incident may be extensive for explosion, moderate to light for HazMat.
Environment	May cause extensive damage, creating denial or delays in the use of some areas. Remediation needed.
Economic Condition of Jurisdiction	Local economy and finances adversely affected, possibly for an extended period of time, depending on damage and length of investigation.
Public Confidence in the Jurisdiction's Governance	Ability to respond and recover may be questioned and challenged if planning, response, and recovery not timely and effective.

Risk Summary

A terrorist can attack a society in many ways. Since the September 11, 2001 attacks renewed terrorism into the public consciousness, the Nation has seen dozens of attacks qualified as terrorism across the country, including shootings, stabbings, cyber attacks, bombings and biological agents. The relatively open society Americans take pride in unfortunately offers an ever-present (though low) risk of a terrorist attack occurring where citizens live and work. Fortunately, the combined efforts of local, state and federal law enforcement and concerned citizens have thwarted a majority of these attacks.

Problem Statement:

Using population and major transportation corridors as key indicators, the data suggests that counties at most risk are St. Louis, Jackson, St. Charles, St. Louis City, Greene, Clay, Jefferson, Boone, Jasper and Franklin. Mitigation strategies and limited resources allocated in these counties first could prove most beneficial.

2018 risk assessment data and mapping is available through the Missouri Hazard Mitigation Viewer: http://bit.ly/MoHazardMitigationPlanViewer2018.

3.3.22. Utilities (Interruptions and System Failures)

Probability	Severity
100%	Low

Description/Location

Utility Interruptions and failures may involve electrical power, internet/telecommunications systems, natural gas, and public water and wastewater systems. These systems or combinations of these utility systems exist virtually throughout the State. Many utilities are localized and serve only one community, while other utilities serve a regional area.

Disruption of any of these services could result from many of the natural or human-caused / technological hazards described in this plan. In addition to a secondary or cascading impact from another primary hazard, utilities and infrastructure can fail because of geomagnetic storms, faulty equipment, lack of maintenance, degradation over time, or accidental damage such as damage to buried lines or pipes during excavation.

Geomagnetic storms can cripple communications that rely on the ionosphere. Many communications systems use the ionosphere to reflect radio signals over long distances. While TV and commercial radio stations are not typically affected by solar activity, ground-to-air, ship-to-shore, shortwave broadcast and amateur radio (mostly the bands below 30 MHz) are frequently disrupted. Users of these bandwidths include some military detention early warning systems, submarine detection systems, and aircraft. Solar disturbances also damage communications satellites. Increased solar ultraviolet emissions heat the earth's upper atmosphere causing it to expand. The heated air rises and the density at the orbit of the satellites increases. This creates increased drag on the satellite which in turn causes the satellite to slow and change orbit slightly. Also, during a storm, the number and energy of electrons and ions increases. As a satellite travels through this environment, charge accumulates and can harm the satellite's electrical systems. Damage to communications satellites can disrupt non-terrestrial telephone service, television, radio, and internet service.

Electric Power

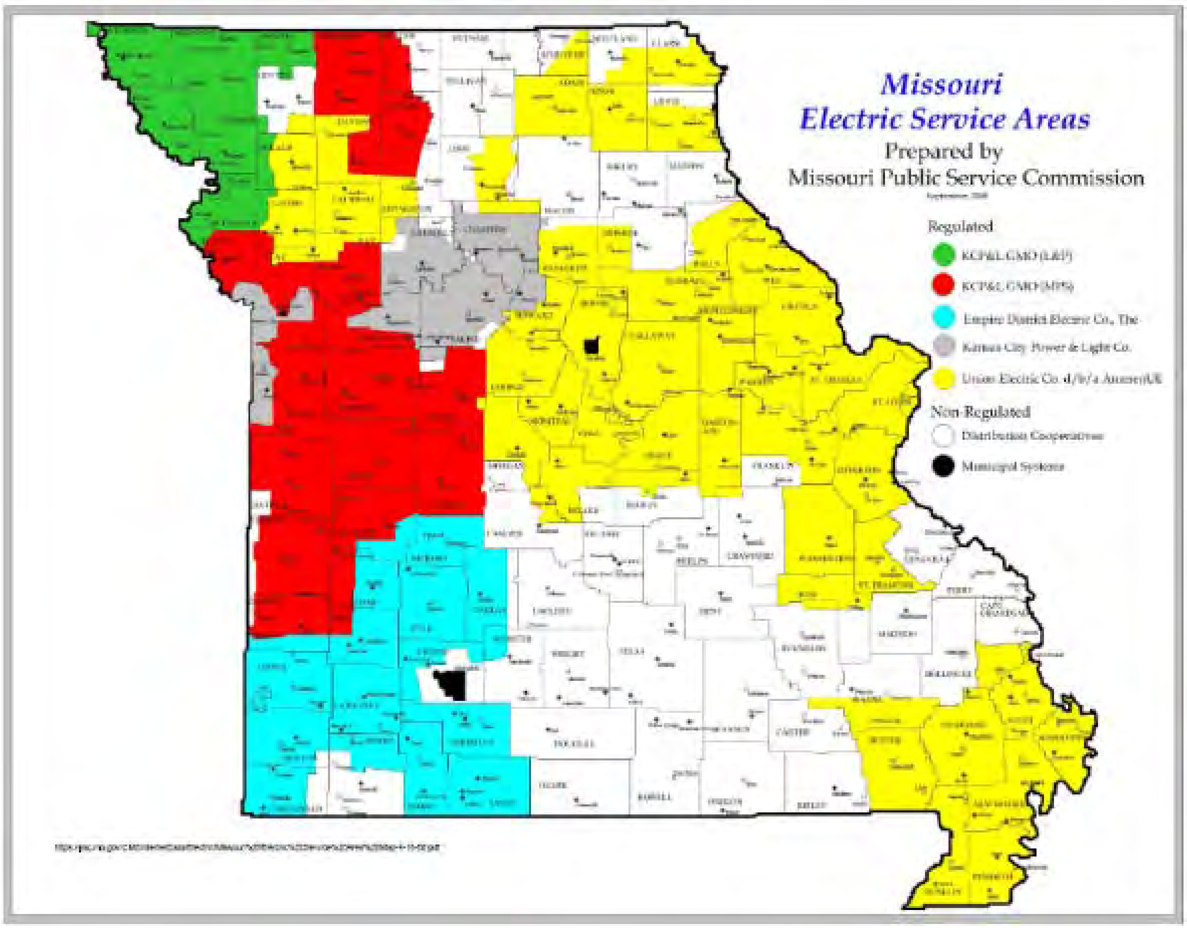
Disruption of electric power supply can be a cascading impact of several other hazards profiled in this plan including: flood, tornado, windstorm, and wither weather. These hazards can cause damage to power infrastructure. To a lesser extent, extreme temperatures, dam failure, levee failure, lightning, and terrorism could cause power disruption as well. Extreme heat can disrupt power supply when air conditioning use spikes during heat waves which can cause brownouts. Like flood, dam and levee failure can impact power infrastructure. Lightning strikes can damage substations and transformers, but is usually isolated to small areas of outage. Many forms of terrorism could impact power supply either by direct damage to infrastructure our through cyber-terrorism targeting power supply networks. Geomagnetic storms, faulty equipment, lack of maintenance, degradation over time, or accidental damage such as damage to buried power cables can also cause disruption to electric power. Electrical utilities in Missouri prepare for disasters and power outages by developing written plans to 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 lines are free of potential limbs that could fall on power lines and cause interruptions of power if knocked down. In addition, ongoing reviews of emergency plans and training for such events have been implemented. Many utilities also use emergency batteries or generators to provide back-up power for high priority equipment. After the 2002 ice storm that struck western and northern Missouri, an automated outage reporting system was created. The Public Service Commission also advised utility companies to provide feedback to customers that their outage report was recorded.

Electric service is provided in Missouri by the following providers:

- Kansas City Power & Light
- Empire District Electric Company
- Union Electric Company d/b/a Ameren UE
- Distribution Cooperatives (electric cooperatives)
- Municipal Systems

Figure 3.204 provides Missouri Electric Service Areas.

Figure 3.204. Missouri Electric Service Areas



Source: Missouri Public Service Commission, https://psc.mo.gov/CMSInternetData/Electric/Missouri%20Electric%20Service%20Area%20Map-9-18-08.pdf

Missouri's electric cooperatives are non-profit power suppliers owned by their members. Each is governed by a board of directors elected from among the membership. There are 40 distribution cooperatives which provide electricity to individual homes, farms, and businesses. Some of these co-ops are quite large while others may serve just one county. Missouri's smallest electric cooperative has just over 2,000 member-owners while the largest has more than 40,000 members. In addition to the 40 distribution cooperatives, there are six transmission cooperatives and Associated Electric Cooperative, the wholesale power provider to the distribution and transmission cooperatives. These cooperatives contribute to a comprehensive hazard mitigation plan which contains information pertaining to all 47 of the state's electric cooperatives. Due to sensitive data relating to the power grid in the State, this plan is not available to the public.

Regardless of size, each electric cooperative operates in similar fashion. Each member-owner has one vote at an annual membership meeting at which bylaws are approved and board members are elected. The board members, each a member of the cooperative, set policy for the co-op to direct day to day operations. Missouri's electric distribution cooperatives buy wholesale power from Associated Electric Cooperative, headquartered in Springfield, Missouri. Like the local electric cooperatives, Associated Electric Cooperative operates on a not-for-profit basis and is owned by those who use the services it provides—in this case, Missouri's distribution and transmission cooperatives. Missouri's six transmission cooperatives deliver wholesale electricity from Associated to local distribution cooperatives over high-voltage transmission lines. For more information about specific cooperatives, visit the Association of Missouri Electric Cooperatives at http://www.amec.org.

Internet / Telecommunications

Internet and telecommunications infrastructure and service can be impacted by the same hazards that can impact electric power supply. Land line telephone lines often utilize the same poles as electric lines. So, when weather events such as windstorm or winter weather cause lines to break, both electricity and telephone services experience outages. With the increasing utilization of cellular telephones, hazard events such as tornado that can damage cellular repeaters can cause outages. In addition, during any hazard event, internet and telecommunications systems can become overwhelmed due to the surge in call usage/volume.

Vulnerability of buried telecommunications cables has always been a problem. Cables may be subject to accidental or intentional cuts. However, legislation and mitigation procedures have been taken to prevent such events. Missouri law provided for the creation of the "One Call" call center to locate and mark buried utilities when requested prior to any digging/excavating. Most Local Exchange Carriers have their facilities on record with One Call. Missouri Revised Statute Chapter 319, "underground Facility Safety and Damage Prevention Act" is the legislation governing requirements to have utilities identified prior to digging or excavation. Additional steps to prevent cutting of buried telecommunications cables include clearly marking cable routes with above ground pedestals and poles, as well as patrolling the routes by vehicle and air. In addition to these precautions, most companies have constructed fiber rings for the fiber optic routes to provide for continuity of service in the event of an accidental cut.

Since floods pose a threat to telephone service, most companies with buried cables in floodplains are replacing conventional telephone pedestals with flood resistant telephone pedestals, which protect the cables during floods of short duration.

In 1990, the Missouri Public Service Commission requested that all Local Exchange Carriers submit plans for disaster recovery. Every LEC in the state submitted a plan detailing practices and procedures for service restoration in the event of a disaster. Additionally, to mitigate damage of earthquakes or other disasters, the Local Exchange Carriers added bracing to their central offices for their switching equipment and batteries. Many companies have also obtained on-site generators or made contingency arrangements to acquire them in response to an outage.

Natural Gas

Primary hazards that can impact natural gas pipelines are earthquake, land subsidence, human error/digging accidents, infrastructure degradation, and acts of terrorism/vandalism. All natural gas system operators in the State operate under the jurisdiction of the Missouri Public Service Commission. These operators must comply with the commission's pipeline safety regulations which include emergency response procedures to pipeline emergencies and natural disasters. Natural gas operators have plans on file with the Missouri Public Service Commission. These include indexes of utilities and their locations in the State.

In 1989, Missouri House Bill 938 provided the commission with additional legal power to enforce the Pipeline Safety Regulations. In 1990, due in part to the Iben Browning earthquake projection, all utilities were mandated by the commission to develop natural disaster plans (to include potential impacts of earthquakes) and file the plans with the commission. The commission also developed its own plan to respond to a disaster causing an interruption or failure of a utility service. The Iben Browning earthquake projection created a new awareness for the necessity for such disaster response and recovery plans. Several natural gas companies have since stored emergency equipment and survival rations in protected locations. This also resulted in a new demand for excess flow and motion sensing valves on natural gas service lines. Operators also reviewed, updated or increased their mutual aid agreements with other utilities and contractors.

According to the Pipeline and Hazardous Materials Administration, in 2015, there were 50,771 miles of natural gas pipelines in Missouri as shown in the following table:

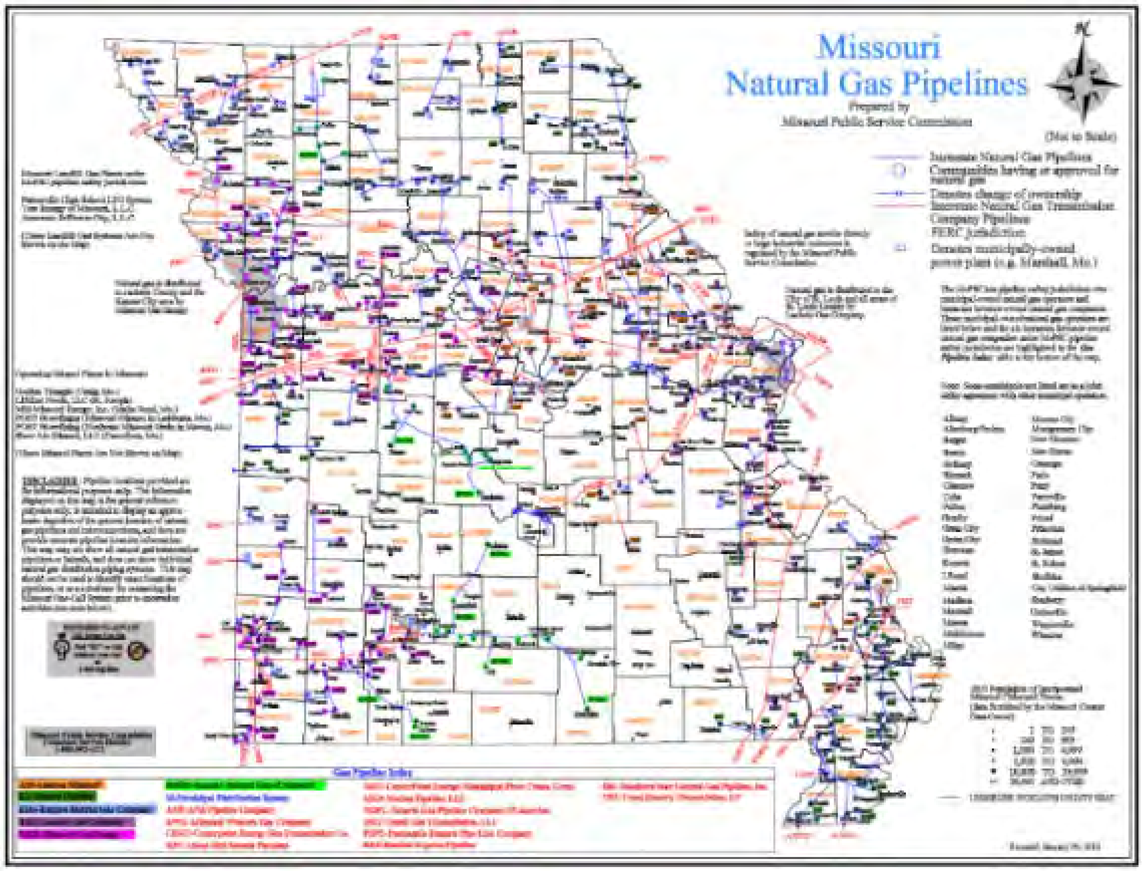
Table 3.157. Natural Gas Pipeline Miles by System Type

Type	Miles
Gas Distribution Mail Miles	27,348
Gas Distribution Service Miles	18,811
Gas Transmission	4,612
Gas Gathering	0
Total	**50,771**

Source: Pipeline and Hazardous Materials Administration, https://hip.phmsa.dot.gov/analyticsSOAP/saw.dll?Portalpages

The distribution pipelines are operated by 50 different companies. Over 3,600 miles of Interstate transmission lines are operated by 12 companies and over 1,000 miles of intrastate transmission lines are operated by 13 companies. Missouri's natural gas pipelines are shown in the figure below:

Figure 3.205. Missouri Natural Gas Pipelines



Source: Missouri Public Service Commission, https://psc.mo.gov/CMSInternetData/NaturalGas/Missouri%20Natural%20Gas%20Pipeline%20Map.pdf

As discussed previously, Missouri law requires all owners and operators of underground pipeline facilities to participate in the One Call notification center. This participation provides for the location of underground pipelines after notification by the excavator and before any excavation begins.

Public Water and Wastewater Systems

The primary hazards that can impact water supply systems are: drought, flood, hazardous materials, and terrorism and any hazard impacting power supply. The primary hazard that impacts waster systems is flood and other hazards impacting power supply. As with other infrastructure, these systems can also be impacted by accidental damage, lack of maintenance/degradation over time, and human error. **Table 3.158** below provides the number of Public Water Intakes and Wastewater Treatment Facilities by county in Missouri.

Table 3.158. Public Water Intakes/Wells and Wastewater Treatment Facilities by County

County	Number of Public Water Intakes/Wells	Number of Wastewater Treatment Facilities
Adair	2	2
Andrew	1	4
Atchison	0	5
Audrain	0	6
Barry	0	13
Barton	1	3

County	Number of Public Water Intakes/Wells	Number of Wastewater Treatment Facilities
Bates	13	9
Benton	0	6
Bollinger	0	1
Boone	0	22
Buchanan	2	2
Butler	1	7

County	Number of Public Water Intakes/Wells	Number of Wastewater Treatment Facilities
Caldwell	2	11
Callaway	0	21
Camden	0	153
Cape Girardeau	1	36
Carroll	0	4
Carter	0	3
Cass	11	12
Cedar	0	5
Chariton	1	9
Christian	0	11
Clark	2	6
Clay	3	14
Clinton	1	8
Cole	1	21
Cooper	1	6
Crawford	0	3
Dade	1	5
Dallas	0	2
Daviess	3	9
DeKalb	5	9
Dent	0	3
Douglas	0	1
Dunklin	0	8
Franklin	1	36
Gasconade	0	7
Gentry	3	3
Greene	4	5
Grundy	1	4
Harrison	7	7
Henry	3	8
Hickory	0	3
Holt	0	11
Howard	3	6
Howell	0	1
Iron	1	5
Jackson	2	13
Jasper	0	11
Jefferson	3	37
Johnson	1	15
Knox	4	4
Laclede	0	7
Lafayette	5	16
Lawrence	0	5
Lewis	4	7
Lincoln	0	23
Linn	6	11
Livingston	0	6
Macon	4	3
Madison	4	6
Maries	0	1
Marion	2	6
McDonald	0	6

County	Number of Public Water Intakes/Wells	Number of Wastewater Treatment Facilities
Mercer	1	3
Miller	0	21
Mississippi	0	5
Moniteau	0	6
Monroe	2	5
Montgomery	4	5
Morgan	0	25
New Madrid	0	6
Newton	2	6
Nodaway	3	22
Oregon	0	4
Osage	0	8
Ozark	0	2
Pemiscot	0	6
Perry	1	5
Pettis	1	18
Phelps	0	17
Pike	5	10
Platte	2	7
Polk	0	9
Pulaski	1	12
Putnam	2	4
Ralls	1	9
Randolph	3	10
Ray	1	8
Reynolds	1	4
Ripley	0	1
Saline	0	8
Schuyler	4	2
Scotland	2	1
Scott	0	11
Shannon	0	6
Shelby	4	4
St. Charles	1	21
St. Claire	0	5
St. Francis	0	12
St. Louis	7	19
St. Louis City	1	1
Ste. Genevieve	0	6
Stoddard	0	16
Stone	0	31
Sullivan	6	5
Taney	3	12
Texas	0	6
Vernon	0	5
Warren	0	14
Washington	1	10
Wayne	3	7
Webster	0	10
Worth	0	2
Wright	0	4
Totals	**172**	**1169**

Source: Missouri Department of Natural Resources

Extent

In many cases, utility interruptions are small, isolated events that are within the capabilities of the local utility to address. Therefore, the degree of severity of the day-to-day events may be considered low. Due to long-range planning, regulation, and diligence of the utility operators, major interruptions resulting in a high degree of severity are few and far between. In some instances, utility outages and interruptions can impact a larger area and be for a prolonged period. Utility outages can also often be a cascading impact of a primary hazard such as flooding, severe thunderstorm, severe winter weather, and cyber disruptions.

Previous Occurrences

Because utilities exist everywhere in the State, damage to utilities may occur frequently. Causes of damage can range from a backhoe cutting a buried line, an accident involving a motor vehicle, a flood, a geomagnetic storm, or another hazard event. Many of these interruptions or failures go unreported and no comprehensive system is in place to capture historical outages. Therefore, limited information is available to develop statistical analysis of previous events for all utility types. For electric utility interruptions, Inside Energy has compiled a database of 15 years of power outages compiled from annual data available from the Department of Energy. **Table 3.159** provides the outages that included the State of Missouri.

Table 3.159. Power Outages in Missouri (2000-2014)

Event Description	Date Event Began	Time Event Began	Date of Restoration	Time of Restoration	Respondent	Geographic Areas	Number of Customers Affected	Tags
Severe Weather - Snow/Ice	2/20/2014	4:40 pm	2/21/2014	11:59 PM	Ameren Missouri	Missouri, Illinois	66,000	severe weather, winter storm
Physical Attack - Vandalism	1/21/2014	12:14 pm	1/21/2014	12:39 PM	Ameren Missouri	Missouri	Unknown	vandalism, physical
Severe Weather - Tornadoes	11/17/2013	12:35 pm	11/20/2013	11:00 AM	Ameren Missouri	Central Missouri, Central Illinois	200,000	severe weather, tornado
Physical Attack; Vandalism	8/29/2013	9:50 am	8/29/2013	9:50 AM	Empire District Electric Co	Joplin, Missouri	Unknown	vandalism, physical
Severe Weather - Thunderstorms	5/31/2013	7:30 pm	6/1/2013	8:00 PM	Ameren Missouri	St. Louis Metro Area Missouri	100,000	severe weather, thunderstorm
Severe Weather - Winter Storm Nemo	2/26/2013	1:00 pm	3/1/2013	10:00 AM	Associated Electric Coop, Inc	Northern Missouri	56,444	severe weather, winter storm
Severe Thunderstorms	6/27/2011	12:00 am	6/29/2011	1:00 AM	AMEREN	Illinois; Missouri	80,000	severe weather, thunderstorm
Severe Weather	5/23/2011	12:30 pm	5/25/2011	12:30 PM	Ameren	St. Louis County	70,000	severe weather
Severe Weather	5/22/2011	5:09 pm	5/31/2011	12:01 PM	Empire District Electric	Joplin, Sarcoxie, and Wentworth,	20,000	severe weather
Severe Weather	4/22/2011	9:00 pm	4/22/2011	11:00 PM	Ameren	Metro St. Louis area, Missouri	55,000	severe weather
Severe Thunderstorm	5/8/2009	7:30 am	5/8/2009	9:00 a.m.	Empire District Electric Company	SW Missouri	83,000	severe weather, thunderstorm
Winter Storm	1/28/2009	12:10 am	1/30/2009	9:20 p.m.	Midwest ISO	East Central Missouri	1	severe weather, winter storm
Winter Storm	1/27/2009	11:00 am	1/30/2009	6:00 p.m.	Associated Electric Coop, Inc.	South Central and Southeast	62,500	severe weather, winter storm
Fire/Load Shedding	12/2/2008	4:30 am	12/2/2008	7:00 a.m.	Midwest ISO	St. Louis, Missouri	53,000	wild fire, load shedding
Hurricane Ike	9/14/2008	7:30 am	9/18/2008	3:00 p.m.	Ameren Corporation	Missouri and Illinois	107,000	severe weather, hurricane/tropical storm
Severe Thunderstorm	8/13/2007	1:30 am	8/14/2007	12:00 a.m.	Ameren Corporation	State of Missouri	63,000	severe weather, thunderstorm
Ice Storm	1/13/2007	5:00 am	1/19/2007	12:00 p.m.	Ameren Corporation	Missouri and Illinois	225,000	severe weather, winter storm
Ice Storm	11/30/2006	9:00 pm	12/9/2006	6:00 p.m.	Ameren Corporation	Missouri and Illinois	550,000	severe weather, winter storm
Severe Storms (3) (Many experienced multiple outages.)	7/19/2006	6:00 pm	7/31/2006	8:00 a.m.	Ameren Corporation	Greater St. Louis Metropolitan area (MO and IL)	700,000(peak) 2,500,000 (actual)	severe weather, storm
Ice Storm	1/30/2002	4:00 pm	2/10/2002	9:00 AM	Missouri Public Service	Missouri	95,000	severe weather, winter storm

Source: Inside Energy, http://insideenergy.org/2014/08/18/data-explore-15-years-of-power-outages/ , compiled from Annual reports from the Department of Energy

Narratives of additional notable previous occurrences of various utility interruptions/failures are provided below:

- On March 13, 1989, a geomagnetic storm caused the Hydro-Québec power grid to fail. On March 10, an explosion on the sun released a billion-ton cloud of gas that headed towards earth at a million miles per hour. The solar flare that followed the explosion caused short-wave radio interference immediately. The magnetic disturbance was so intense that it created electrical currents in the ground beneath North America. These currents found a weakness in the Québec power grid and millions of people were without power for 12 hours. The power outage closed schools and businesses, Dorval Airport and the Montreal Metro during morning rush hour. U.S. electrical utilities were also affected. There were 96 electrical utilities in New England interrupted while other reserves of electrical power were brought online. Across the United States, over 200 power grid problems were reported within minutes of the storm but none cased a blackout (NASA, 2009).
- During the flood of 1993, telecommunications companies proved their adaptability by using cellular service to replace wire line service in areas where service could not be restored I a timely manner. One local exchange company used a trailer with cellular pay phones where the land lines were interrupted. Another company temporarily replaced analog subscriber carrier service with site-based cellular service. Short-haul portable microwave was also used to replace copper lines lost during the flood.
- On January 30, 2002, a severe ice storm struck portions of western and northern Missouri leaving devastation and darkened homes and businesses. Many news articles referred to this ice storm as the worst in Missouri's history. During the ice storm, ice accumulated on any object that was at or below freezing, and the weight of the ice broke utility poles, conductors, tree limbs, and other objects that could not withstand the weight of the ice. Ice accumulations over an inch were reported in many areas. Many tree branches could not withstand the added weight of the ice and fell to the ground, striking whatever was in their path. Cars, homes, streets, properties, and electric power facilities were recipients of the falling trees and limbs. When the ice began to melt, the falling ice caused additional outages. Some electric customers experienced outages more than once during that period, as power was restored but interrupted again by falling limbs. At the peak of outages, over 400,000 customers were without power. Within three days, most of these customers were returned to service, but many customers in more heavily damaged areas were without power for over a week. Utilities affected by the ice storm quickly mobilized all their available crews and sought outside assistance. Work crews from 16 different states came to western Missouri to rapidly restore power to as many customers as possible.
- On July 19-20, 2006, severe storms with high winds and possible tornado activity struck St. Louis and the counties of St. Louis, Dent, Iron, Jefferson, Oregon, St. Charles, and Washington. Because of the storms, approximately 500,000 AmerenUE customers were without electrical power. Over 3,600 utility workers from AmerenUE and outlying utility companies were involved in restoration efforts, the largest in company history. High priority projects included restoring power to 14 nursing homes, cooling stations, hospitals, city services, and utility and fuel terminals. Compounding the power outage problems, a heat advisory with heat index values as high as 104 degrees Fahrenheit plagued recovery efforts for several weeks.
- In January 2009, over two-and one-half inches of snow covered most of the southeast portion of the state. Heavy ice accumulations caused over 3,800 AmerenUE transmission and distribution poles to break. Similar breakages were experienced by municipal and electric cooperative systems and transmission operators. Because of the extent of damage, some locations were without power for up to three weeks.

- In January 2011, record amounts of snow that caused blizzard conditions across the state resulted in widespread power outages.
- Sunday, May 22, 2011, a devastating weather event struck Joplin, Missouri, continuing through the cities of Duquesne, Diamond, Granby, Sarcoxie and Wentworth. The National Weather Service identified the event as an EF-5 tornado with winds more than 200 miles per hour. The tornado took a direct route through the heart of Joplin's residential and retail district, resulting in hundreds of injuries, deaths and the loss of thousands of homes and businesses. In addition, the storm also affected electrical power, natural gas, water and communications services.
- July 13, 2016, Major power outages occurred across the St. Louis metro area due to powerful storms. At the height of the storm, winds were clocked as high as 7miles per hour. As a result, approximately 128,000 Missouri AmerenUE customers were without power.
- The City of St. Louis Water Division routinely lists water mains that are out of service on their website. On March 31, 2017, there were five mains out of service. Information on estimated population impacted was not available
(source: http://www.stlwater.com/wateroos.php).
- Like St. Louis, KC Water also provides water service issues and outages on their website (https://local.nixle.com/kcwater/). For the one month period for March 2017, there were 26 alerts posted regarding water pressure reductions and boil orders.

Probability of Future Hazard Events

Because utilities exist throughout the State and are vulnerable to interruptions or failures and because of multiple primary, secondary/cascading hazards, there is a very high probability that utility failures can occur at any time or location throughout the state. In most cases, these are small isolated events well within the capabilities of the local utility to address. But, occasionally, utility interruptions/failures are widespread, relying on coordinated response efforts to restore function. As previously noted, Inside Energy compiled a list of 20 power outage events within Missouri over a 15-year period which calculates to a 100% probability.

Changing Future Conditions Considerations

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.

Existing stormwater systems were designed based on past conditions that are now changing; many systems may quickly become inadequate if storms continue to become more frequent and/or intense. Communities should prepare for even greater stress on infrastructure systems that may already be outdated. Although declining infrastructure is a serious problem, it also presents an opportunity to improve and integrate existing systems so that they serve communities better and more efficiently.

State Vulnerability Overview

Utilities and infrastructure 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 and telephone lines are the most vulnerable infrastructure asset; but water supply, wastewater facilities and communications towers are also vulnerable. Typically, the events that cause the most damages are flood, lightning, winter storm, tornado, and wind storm. 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 (http://www.moga.mo.gov/mostatutes/chapters/chapText319.html) 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.

State Estimates of Potential Losses

This hazard includes all utility infrastructure and facilities that could be impacted by one or more hazard events. Electrical blackouts and power surges can damage high tech equipment but generally do not cause structural damage. Descriptions of utility/infrastructure assets that could be impacted are discussed above under the "Description/Location" section.

Potential losses would include the cost of repair or replacement of damaged facilities and lost economic opportunities for businesses. Secondary effects of infrastructure failure could include burst water pipes in homes without electricity during winter storms and damage to equipment due to power surges in the electrical grid during blackouts. Public safety hazards include risk of electrocution from downed power lines and hazard events that affect the normal functioning of wastewater facilities. Loss of use estimates can be calculated using FEMA's BCA Reference Guide Loss of Use Estimates (see **Table 3.160**). These figures represent the loss of service only and do not consider physical damages to utility equipment and infrastructure.

Table 3.160. FEMA Standard Values for Loss of Service for Utilities

Loss of Electric Power	**Cost of Complete Loss of Service**
Total Economic Impact	$126 per person per day
Loss of Potable Water Service	**Cost of Complete Loss of Service**
Total Economic Impact	$93 per person per day
Loss of Wastewater Service	**Cost of Complete Loss of Service**
Total Economic Impact	$41 per person per day

Source: FEMA BCA Reference Guide, June 2009, Appendix C

The July 2016 power outages due to windstorms knocked out power to more than 128,000 St. Louis metro area residents. Some residents were without power for two days. Based on FEMA's loss of use estimates above, the cost of one full day without power for 128,000 residents, would exceed $16 Million.

Table 3.161 provides loss of service estimates, in relation to the populations served, in Missouri by county. The loss of use for each utility is provided in the heading as the loss of use cost per person per day of loss. The estimated loss of use provided for each county in Missouri represents the loss of service of the indicated utility for one day for 10 percent of the population. In rural areas, the typical loss of use may be for a larger percentage of the population for a longer time during weather extremes. This loss estimation does not consider the portion of the population that does not utilize public utilities such as rural areas that use well water and home-site septic systems.

Table 3.161. Potential Loss Estimates for Utility Failure

County	2015 ACS Population	Potentially Affected Population (10%)	Electric ($126)	Drinking Water ($93)	Wastewater Treatment ($41)
Adair	25,378	2,538	$319,763	$236,015	$104,050
Andrew	17,296	1,730	$217,930	$160,853	$70,914
Atchison	5,306	531	$66,856	$49,346	$21,755

County	2015 ACS Population	Potentially Affected Population (10%)	Electric ($126)	Drinking Water ($93)	Wastewater Treatment ($41)
Audrain	26,096	2,610	$328,810	$242,693	$106,994
Barry	35,829	3,583	$451,445	$333,210	$146,899
Barton	11,880	1,188	$149,688	$110,484	$48,708
Bates	16,446	1,645	$207,220	$152,948	$67,429
Benton	18,670	1,867	$235,242	$173,631	$76,547
Bollinger	12,182	1,218	$153,493	$113,293	$49,946
Boone	174,974	17,497	$2,204,672	$1,627,258	$717,393
Buchanan	89,100	8,910	$1,122,660	$828,630	$365,310
Butler	42,951	4,295	$541,183	$399,444	$176,099
Caldwell	9,014	901	$113,576	$83,830	$36,957
Callaway	44,834	4,483	$564,908	$416,956	$183,819
Camden	44,237	4,424	$557,386	$411,404	$181,372
Cape Girardeau	78,572	7,857	$990,007	$730,720	$322,145
Carroll	8,992	899	$113,299	$83,626	$36,867
Carter	6,263	626	$78,914	$58,246	$25,678
Cass	101,603	10,160	$1,280,198	$944,908	$416,572
Cedar	13,934	1,393	$175,568	$129,586	$57,129
Chariton	7,589	759	$95,621	$70,578	$31,115
Christian	83,279	8,328	$1,049,315	$774,495	$341,444
Clark	6,801	680	$85,693	$63,249	$27,884
Clay	235,637	23,564	$2,969,026	$2,191,424	$966,112
Clinton	20,609	2,061	$259,673	$191,664	$84,497
Cole	76,720	7,672	$966,672	$713,496	$314,552
Cooper	17,642	1,764	$222,289	$164,071	$72,332
Crawford	24,526	2,453	$309,028	$228,092	$100,557
Dade	7,595	760	$95,697	$70,634	$31,140
Dallas	16,393	1,639	$206,552	$152,455	$67,211
Daviess	8,253	825	$103,988	$76,753	$33,837
DeKalb	12,687	1,269	$159,856	$117,989	$52,017
Dent	15,593	1,559	$196,472	$145,015	$63,931
Douglas	13,373	1,337	$168,500	$124,369	$54,829
Dunklin	30,895	3,090	$389,277	$287,324	$126,670
Franklin	102,426	10,243	$1,290,568	$952,562	$419,947
Gasconade	14,858	1,486	$187,211	$138,179	$60,918
Gentry	6,692	669	$84,319	$62,236	$27,437
Greene	288,072	28,807	$3,629,707	$2,679,070	$1,181,095
Grundy	10,097	1,010	$127,222	$93,902	$41,398
Harrison	8,615	862	$108,549	$80,120	$35,322
Henry	21,737	2,174	$273,886	$202,154	$89,122
Hickory	9,201	920	$115,933	$85,569	$37,724
Holt	4,484	448	$56,498	$41,701	$18,384
Howard	10,139	1,014	$127,751	$94,293	$41,570
Howell	40,117	4,012	$505,474	$373,088	$164,480
Iron	10,125	1,013	$127,575	$94,163	$41,513
Jackson	687,623	68,762	$8,664,050	$6,394,894	$2,819,254
Jasper	118,596	11,860	$1,494,310	$1,102,943	$486,244
Jefferson	224,124	22,412	$2,823,962	$2,084,353	$918,908
Johnson	53,951	5,395	$679,783	$501,744	$221,199
Knox	3,910	391	$49,266	$36,363	$16,031
Laclede	35,473	3,547	$446,960	$329,899	$145,439
Lafayette	32,701	3,270	$412,033	$304,119	$134,074
Lawrence	38,180	3,818	$481,068	$355,074	$156,538
Lewis	10,207	1,021	$128,608	$94,925	$41,849
Lincoln	54,696	5,470	$689,170	$508,673	$224,254
Linn	12,308	1,231	$155,081	$114,464	$50,463
Livingston	15,028	1,503	$189,353	$139,760	$61,615
Macon	15,335	1,534	$193,221	$142,616	$62,874
Madison	12,408	1,241	$156,341	$115,394	$50,873

County	2015 ACS Population	Potentially Affected Population (10%)	Electric ($126)	Drinking Water ($93)	Wastewater Treatment ($41)
Maries	8,963	896	$112,934	$83,356	$36,748
Marion	28,880	2,888	$363,888	$268,584	$118,408
McDonald	22,643	2,264	$285,302	$210,580	$92,836
Mercer	3,694	369	$46,544	$34,354	$15,145
Miller	25,113	2,511	$316,424	$233,551	$102,963
Mississippi	14,036	1,404	$176,854	$130,535	$57,548
Moniteau	15,963	1,596	$201,134	$148,456	$65,448
Monroe	8,583	858	$108,146	$79,822	$35,190
Montgomery	11,703	1,170	$147,458	$108,838	$47,982
Morgan	20,171	2,017	$254,155	$187,590	$82,701
New Madrid	18,208	1,821	$229,421	$169,334	$74,653
Newton	58,615	5,862	$738,549	$545,120	$240,322
Nodaway	22,810	2,281	$287,406	$212,133	$93,521
Oregon	10,953	1,095	$138,008	$101,863	$44,907
Osage	13,628	1,363	$171,713	$126,740	$55,875
Ozark	9,409	941	$118,553	$87,504	$38,577
Pemiscot	17,482	1,748	$220,273	$162,583	$71,676
Perry	19,183	1,918	$241,706	$178,402	$78,650
Pettis	42,255	4,226	$532,413	$392,972	$173,246
Phelps	44,794	4,479	$564,404	$416,584	$183,655
Pike	18,348	1,835	$231,185	$170,636	$75,227
Platte	96,096	9,610	$1,210,810	$893,693	$393,994
Polk	31,229	3,123	$393,485	$290,430	$128,039
Pulaski	53,221	5,322	$670,585	$494,955	$218,206
Putnam	4,858	486	$61,211	$45,179	$19,918
Ralls	10,196	1,020	$128,470	$94,823	$41,804
Randolph	25,104	2,510	$316,310	$233,467	$102,926
Ray	22,810	2,281	$287,406	$212,133	$93,521
Reynolds	6,432	643	$81,043	$59,818	$26,371
Ripley	13,802	1,380	$173,905	$128,359	$56,588
Saline	23,258	2,326	$293,051	$216,299	$95,358
Schuyler	4,436	444	$55,894	$41,255	$18,188
Scotland	4,854	485	$61,160	$45,142	$19,901
Scott	39,008	3,901	$491,501	$362,774	$159,933
Shannon	8,258	826	$104,051	$76,799	$33,858
Shelby	6,128	613	$77,213	$56,990	$25,125
St. Charles	385,590	38,559	$4,858,434	$3,585,987	$1,580,919
St. Clair	9,440	944	$118,944	$87,792	$38,704
St. Francois	66,520	6,652	$838,152	$618,636	$272,732
St. Louis	1,003,362	100,336	$12,642,361	$9,331,267	$4,113,784
St. Louis city	315,685	31,569	$3,977,631	$2,935,871	$1,294,309
Ste. Genevieve	17,919	1,792	$225,779	$166,647	$73,468
Stoddard	29,862	2,986	$376,261	$277,717	$122,434
Stone	30,943	3,094	$389,882	$287,770	$126,866
Sullivan	6,353	635	$80,048	$59,083	$26,047
Taney	54,592	5,459	$687,859	$507,706	$223,827
Texas	25,690	2,569	$323,694	$238,917	$105,329
Vernon	20,826	2,083	$262,408	$193,682	$85,387
Warren	33,513	3,351	$422,264	$311,671	$137,403
Washington	24,788	2,479	$312,329	$230,528	$101,631
Wayne	13,405	1,341	$168,903	$124,667	$54,961
Webster	37,483	3,748	$472,286	$348,592	$153,680
Worth	2,057	206	$25,918	$19,130	$8,434
Wright	18,268	1,827	$230,177	$169,892	$74,899

Source: FEMA BCA Reference Guide, June 2009, Appendix C; U.S. Census Bureau 5-year American Community Survey, 2015

Hazard Impact on Future Growth and Development

Future development can increase vulnerability to this hazard by placing additional strains on existing infrastructure and by increasing the size and thus the exposure of infrastructure networks. In addition, utility and infrastructure development and expansion should be minimized or mitigated in known hazard areas to ensure the vulnerability to this hazard is not increased as a secondary impact to other hazard events.

EMAP Consequence Analysis

The information in **Table 3.162** provides the Impact Analysis of Potential for Detrimental Impacts of Hazards completed for the Emergency Management Accreditation Program.

Table 3.162. EMAP Impact Analysis: Utilities (Interruptions and System Failures)

Subject	Detrimental Impacts
Public	Localized impact expected to be moderate to severe for special needs population and moderate to light for others.
Responders	Nature of hazard expected to minimize any serious damage to properly equipped and trained personnel.
Continuity of Operations including continued delivery of services	Unlikely to necessitate execution of the Continuity of Operations Plan, although some temporary relocation may be needed. Disruption of utilities may postpone delivery of some services and require repairs to resume services. Regulatory waivers may be needed locally. Fulfillment of some contracts may be difficult. Impact may temporarily reduce deliveries.
Property, Facilities, and Infrastructure	Impact on facilities and infrastructure dependent upon the nature of the incident (i.e., electric, water, natural gas, communication disruptions).
Environment	Localized adverse impact depending on the nature of the incident.
Economic Condition of Jurisdiction	Local economy and finances may be adversely affected, depending on damage.
Public Confidence in the Jurisdiction's Governance	Ability to respond and recover may be questioned and challenged if planning, response, and recovery not timely and effective.

Risk Summary

Utility companies are generally well prepared to deal with day-to-day outages. The earthquake threat to statewide and multi-state utilities is the greatest concern to the integrity and operability of Missouri's utilities. Severe weather causes more frequent local, and occasionally widespread, utility outages. Manmade incidents, accidental or intentional, could significantly impact utility service. Geomagnetic storms could disrupt communications and affect utility services. Planning, regulation, mitigation, and mutual aid are all just a few tools available to reduce, speed recovery from, and prevent utility interruptions and failures.

Utilities are often dispersed over a wide area, and many have facilities located throughout their service area. For example, many electric companies have multiple generating facilities which can redistribute power via transmission lines as they are connected to load stations. Therefore, power can be redistributed, if needed, so that power is lost to as limited an area as possible. Many water companies have some type of back-up systems such as water impoundments, other deep wells, or hook-up arrangements with other water companies. Similar switching and rerouting capabilities may exist with communications and natural gas utilities.

Although there are capabilities in place to minimize disruptions and restore outages as quickly as possible, risk remains for extended outages. As societies' reliance on power and communications continues to escalate, the extent of disruptions escalates as well.

Problem Statement:

Using the Potentially Affected Population from Table 3.161 as the key indicator for Utility Disruptions, the most at-risk counties are St. Louis, Jackson, St. Charles, St. Louis City, Greene, Clay, Jefferson, Boone, Jasper, Franklin and Cass Counties. Mitigation efforts and dollars focused on these counties first would be beneficial.

2018 risk assessment data and mapping is available through the Missouri Hazard Mitigation Viewer: http://bit.ly/MoHazardMitigationPlanViewer2018.

3.4. Integration of Local Plans: Vulnerability and Loss Estimates

Requirements §201.4(c)(2)(ii) and §201.4(c)(2)(iii): [The state risk assessment shall include] An overview and analysis of the State's vulnerability to the hazards described in this paragraph (c)(2), based on estimates provided in local risk assessments as well as the State risk assessment. The State shall describe vulnerability in terms of the jurisdictions most threatened by the identified hazards, and most vulnerable to damage and loss associated with hazard events.

Requirement §201.4(c)(2)(iii): [The state risk assessment shall include] An overview and analysis of potential losses to the identified vulnerable structures, based on estimates provided in local risk assessments as well as the State risk assessment.

3.4.1. Overview and Analysis of Local Plan Vulnerability Assessments

As of December 2016, there were 105 FEMA-approved local hazard mitigation plans in Missouri, representing 103 county level plans; two regional plans representing a total of 10 counties; one multi-jurisdictional plan representing two counties, and one plan for the Missouri electric cooperatives. This gave the State the opportunity to review the local risk assessments to help the State better understand its vulnerability in terms of the jurisdictions most threatened by hazards.

In its analysis, the State was interested in how the local governments ranked the hazards in their jurisdictions and the potential losses (i.e., people, buildings, and dollar values) associated with the hazards of greatest concern. This analysis revealed that the county-level plans did not include manmade hazards in their analysis, but rather focused on the natural hazards. Within the natural hazards analysis sections only a limited number of local plans discussed levee failure (19) as a hazard separate from flood; lightning (14) as a hazard separate from thunderstorms; and land subsidence/sinkholes (33). To better determine areas of the state that are potentially impacted by both manmade and natural hazards, see the State Profile and Vulnerability sections for the man-made hazards listed in Section 3.2.2; and for natural hazards see Sections 3.3.7, 3.3.8, and 3.3.9 of the State Profile and Vulnerability Analysis for levee failure, lightning, and land subsidence/sinkholes, respectively.

Where available, the State extracted the "Overall Summary of Hazard Vulnerability by Jurisdiction" information. This ranking was primarily described in terms of high, moderate, or low. In some instances, the overall ranking was done on a five-step scale ranging from high to moderate-high to moderate to low-moderate to low. For these five-step scales, high and mod-high rankings were summarized as high; moderate as moderate; and low and low-mod as low. In cases where overall ranking information was not available, rankings were determined from the individual hazard probability and severity rankings.

Based on the analysis of all approved local plans, **Figure 3.206, Figure 3.207,** and **Figure 3.208** that follow indicate the hazard rankings (High, Moderate, and Low) for each county for each of the 12 natural hazards considered in local plans. For those hazards indicating N/A, that hazard was not separately profiled in the local plan.

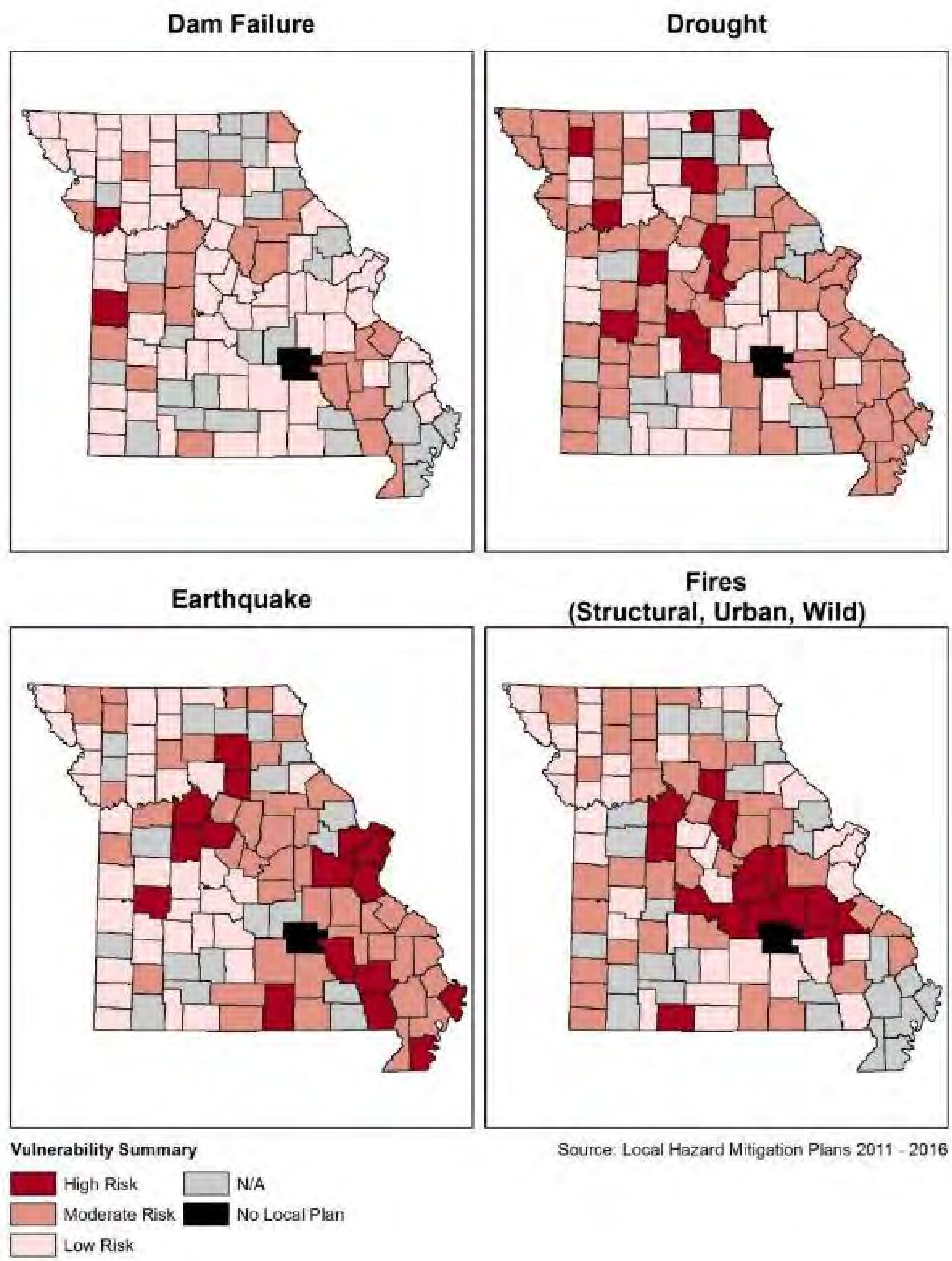
The local risk assessment summary allowed for an analysis to determine which hazards are of high concern to particular counties. **Table 3.163** lists all hazards and the number of counties that ranked them at each of the scale levels: High, Moderate, and Low. The data suggests that the top ranked hazards statewide in order are: Thunderstorms, tornadoes, flooding (riverine and flash), and severe winter weather. Local plans have ranked thunderstorms and tornadoes higher in priority than flooding events, since the 2013 State Plan.

Table 3.163. Local Risk Assessment Hazards Ranking Summary (Ranked by Number of Highs)

Hazard	High	Moderate	Low	N/A
Thunderstorms	67	17	1	29
Tornadoes	66	29	3	16
Flooding (Riverine and Flash)	57	26	8	23
Severe Winter Weather	52	40	6	16
Extreme Temperatures	23	57	19	15
Earthquakes	17	42	36	19
Fires (Urban/Structural and Wild)	15	35	39	25
Drought	11	60	27	16
Lightning	5	3	6	100
Levee Failure	3	9	7	95
Dam Failure	2	23	62	27
Land Subsidence/Sinkholes	1	4	28	81

Table 3.164 shows the rankings each county assigned these hazards. The county highlighted in blue did not have an approved plan at the time this report was developed. The county names highlighted in yellow denote counties that had either new or updated plans since the 2013 State Mitigation Plan update.

Figure 3.206. Local Plans Risk Summary for Dam Failure, Drought, Earthquake, and Fires (Structural, Urban, Wild)



3 Risk Assessment

Figure 3.207. Local Plans Risk Summary for Extreme Temperatures, Land Subsidence/Sinkholes, Flooding (Riverine and Flash), and Levee Failure

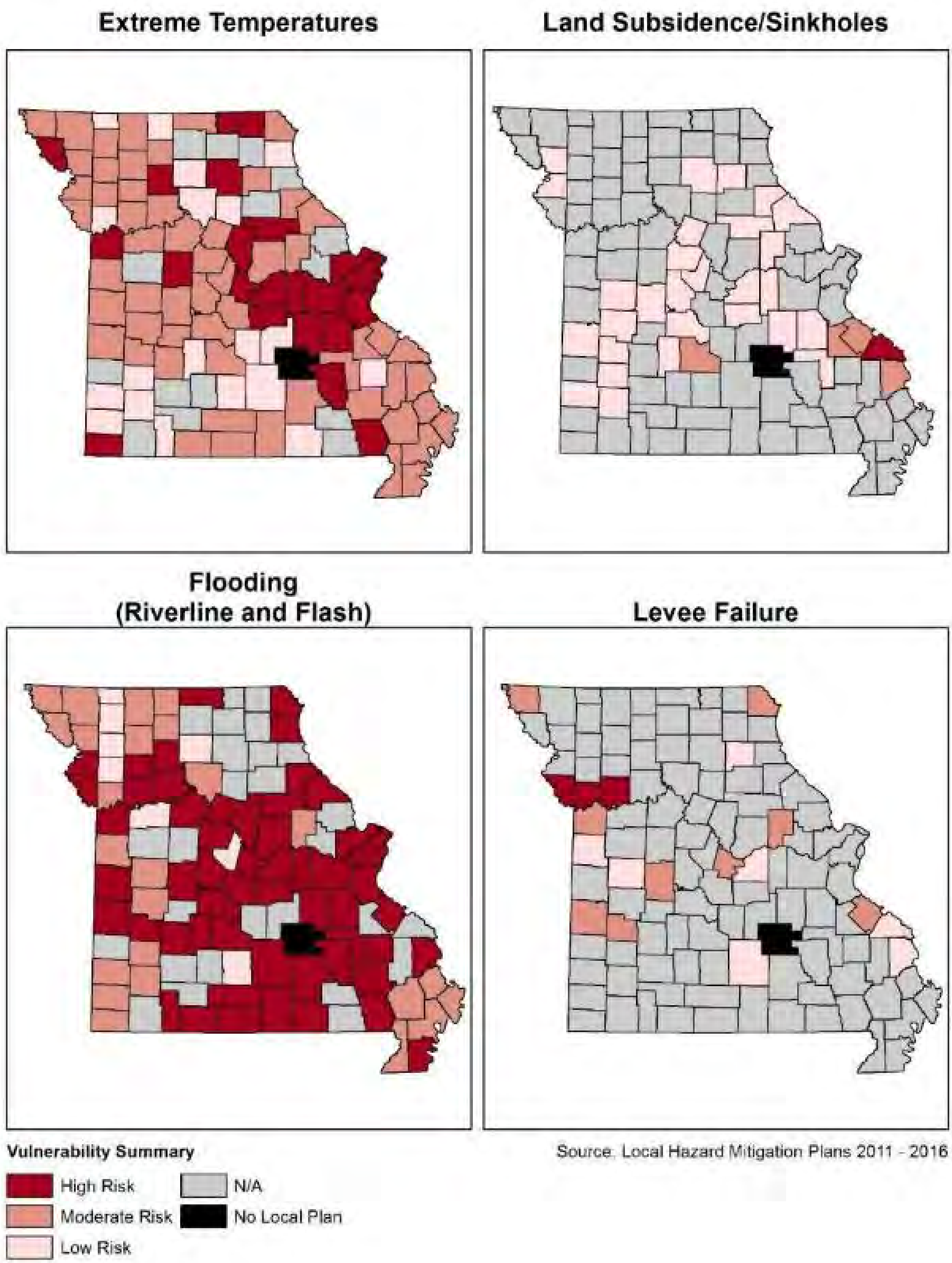


Figure 3.208. Local Plans Risk Summary for Severe Winter Weather, Severe Thunderstorms, Tornadoes, and Lightning

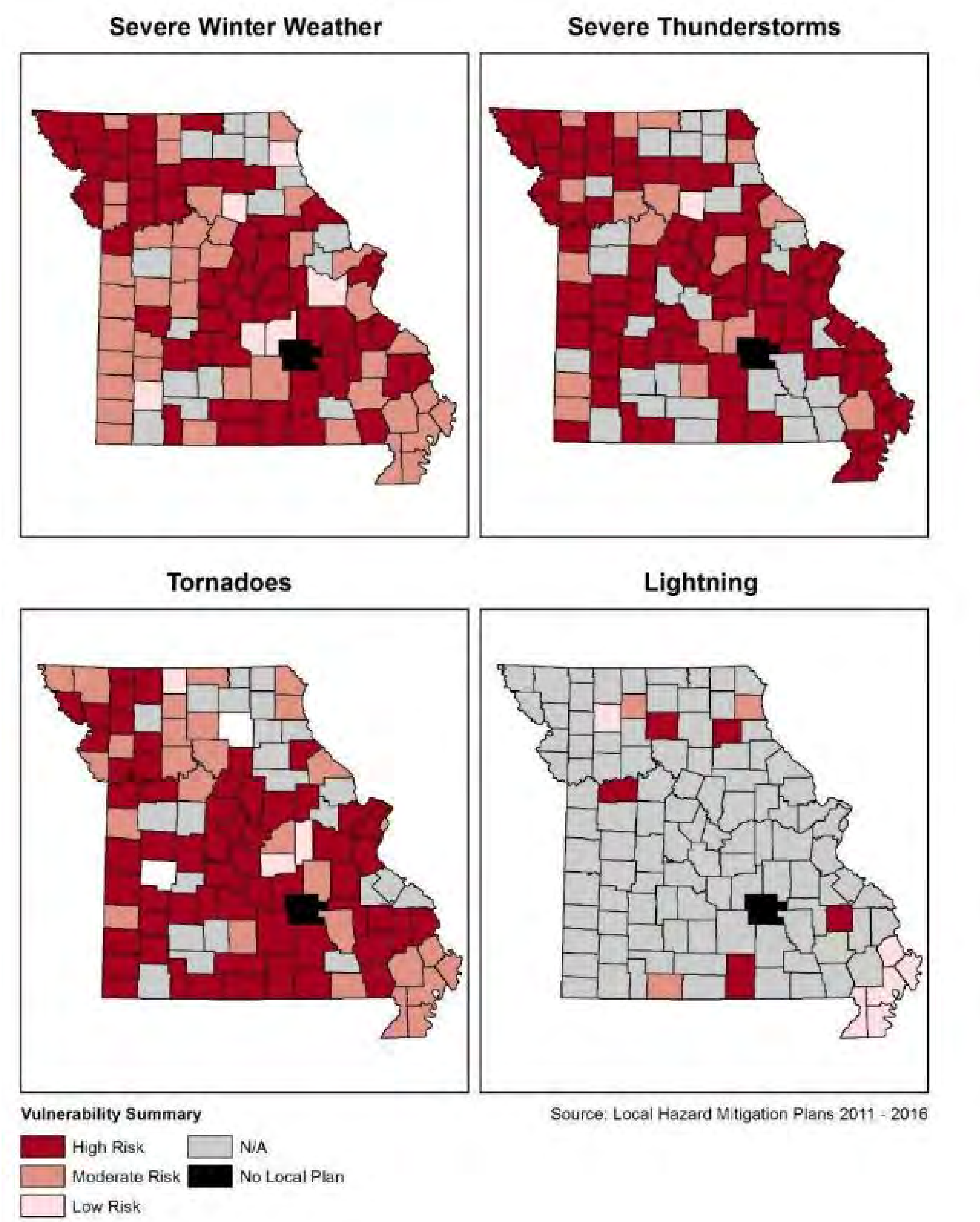


Table 3.164. Hazard Rankings by County

County[1]	Dam Failure	Drought	Earthquake	Fires (structural, urban and wild)	Heat Wave	Landslide/Land Subsidence	Riverine Flooding (Major and Flash)	Severe Winter Weather	Thunderstorms	Tornadoes	Lightning
Adair	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Andrew	low	mod	low	low	mod	low	mod	n/a	high	high	high
Atchison	low	mod	low	low	mod	n/a	mod	mod	high	high	mod
Audrain	mod	mod	mod	mod	high	low	high	n/a	high	high	high
Barry	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Barton	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	mod	n/a	mod
Bates	high	low	low	mod	mod	n/a	high	n/a	mod	high	high
Benton	mod	mod	low	mod	mod	low	high	mod	mod	high	high
Bollinger	n/a	mod	mod	n/a	mod	n/a	n/a	n/a	high	high	high
Boone	mod	high	mod	high	high	n/a	high	n/a	high	high	high
Buchanan	low	mod	low	low	mod	low	high	n/a	high	high	high
Butler	mod	mod	high	low	high	n/a	high	n/a	high	n/a	high
Caldwell	low	mod	low	low	mod	n/a	high	n/a	high	n/a	high
Callaway	mod	mod	mod	mod	mod	n/a	high	n/a	high	mod	high
Camden	low	high	low	high	mod	low	high	n/a	high	high	high
Cape Girardeau	low	mod	mod	mod	mod	mod	high	low	high	high	high
Carroll	low	low	low	mod	mod	n/a	high	n/a	high	mod	mod
Carter	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Cass	low	low	mod	low	mod	n/a	mod	low	mod	mod	mod
Cedar	low	mod	low	low	mod	low	high	mod	mod	high	high
Chariton	low	low	low	mod	low	n/a	mod	n/a	mod	mod	mod

County[1]	Dam Failure	Drought	Earthquake	Fires (structural, urban and wild)	Heat Wave	Landslide/Land Subsidence	Riverine Flooding (Major and Flash)	Severe Winter Weather	Thunderstorms	Tornadoes	Lightning
Christian	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Clark	mod	high	low	low	mod	n/a	high	mod	mod	high	mod
Clay	high	mod	mod	low	low	n/a	mod	high	mod	high	high
Clinton	n/a	low	n/a	mod	mod	n/a	low	n/a	mod	mod	mod
Cole	low	high	mod	mod	high	n/a	high	mod	high	high	high
Cooper	low	low	high	low	mod	low	high	n/a	mod	high	high
Crawford	low	low	mod	high	high	low	high	n/a	high	high	mod
Dade	mod	mod	low	mod	low	low	mod	n/a	mod	high	high
Dallas	low	low	low	low	low	low	high	n/a	high	high	high
Daviess	mod	mod	low	mod	mod	n/a	mod	n/a	high	high	mod
DeKalb	low	low	n/a	low	mod	n/a	low	n/a	high	high	high
Dent	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Douglas	n/a	low	mod	low	mod	n/a	high	n/a	high	n/a	high
Dunklin	mod	mod	mod	n/a	mod	n/a	mod	n/a	mod	high	mod
Franklin	low	mod	high	mod	high	n/a	high	n/a	low	high	high
Gasconade	low	low	mod	high	high	low	high	n/a	high	high	low
Gentry	low	high	mod	low	mod	n/a	low	n/a	high	high	high
Greene	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Grundy	low	mod	low	mod	mod	n/a	mod	n/a	mod	high	mod
Harrison	low	mod	low	mod	mod	n/a	mod	n/a	high	high	high
Henry	mod	mod	low	mod	mod	low	mod	low	mod	high	high
Hickory	n/a	mod	low	n/a	mod	n/a	n/a	n/a	n/a	n/a	n/a

County[1]	Dam Failure	Drought	Earthquake	Fires (structural, urban and wild)	Heat Wave	Landslide/Land Subsidence	Riverine Flooding (Major and Flash)	Severe Winter Weather	Thunderstorms	Tornadoes	Lightning
Holt	low	mod	low	low	high	n/a	mod	n/a	high	high	high
Howard	low	mod	mod	mod	mod	low	high	n/a	mod	high	high
Howell	low	mod	high	mod	mod	n/a	high	n/a	high	high	high
Iron	mod	mod	mod	high	mod	low	high	n/a	high	high	high
Jackson	low	mod	low	low	high	n/a	high	mod	high	high	high
Jasper	low	mod	low	mod	low	low	mod	n/a	mod	mod	high
Jefferson	low	mod	high	low	high	n/a	high	n/a	mod	high	high
Johnson	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Knox	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Laclede	low	high	low	mod	mod	mod	high	n/a	high	high	high
Lafayette	low	mod	mod	n/a	mod	n/a	low	n/a	mod	n/a	high
Lawrence	low	mod	mod	n/a	low	low	mod	n/a	low	high	high
Lewis	low	low	mod	low	low	n/a	high	n/a	low	mod	mod
Lincoln	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Linn	mod	low	mod	low	low	n/a	low	n/a	high	high	mod
Livingston	low	low	mod	mod	high	n/a	high	n/a	high	high	mod
Macon	mod	high	high	mod	high	low	n/a	n/a	high	high	high
Madison	low	low	mod	low	low	n/a	high	n/a	mod	high	high
Maries	low	low	mod	high	high	low	high	n/a	high	high	low
Marion	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
McDonald	low	mod	low	mod	high	n/a	mod	n/a	mod	high	high
Mercer	low	low	low	mod	low	n/a	mod	n/a	mod	mod	low

County[1]	Dam Failure	Drought	Earthquake	Fires (structural, urban and wild)	Heat Wave	Landslide/Land Subsidence	Riverine Flooding (Major and Flash)	Severe Winter Weather	Thunderstorms	Tornadoes	Lightning
Miller	low	mod	low	low	mod	n/a	high	n/a	high	n/a	high
Mississippi	n/a	mod	high	n/a	mod	n/a	mod	n/a	mod	high	mod
Moniteau	low	mod	mod	low	mod	low	low	n/a	high	high	high
Monroe	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Montgomery	low	mod	mod	mod	mod	low	mod	mod	mod	high	high
Morgan	low	mod	low	mod	mod	low	high	n/a	high	n/a	high
New Madrid	n/a	mod	mod	n/a	mod	n/a	mod	n/a	mod	high	mod
Newton	low	mod	low	mod	low	n/a	mod	n/a	mod	mod	high
Nodaway	low	mod	mod	mod	mod	n/a	mod	n/a	high	high	mod
Oregon	low	mod	mod	mod	low	n/a	high	n/a	high	high	high
Osage	low	low	mod	high	high	low	high	low	high	high	mod
Ozark	low	low	mod	low	mod	n/a	high	n/a	high	n/a	high
Pemiscot	n/a	mod	high	n/a	mod	n/a	high	n/a	mod	high	mod
Perry	low	mod	mod	mod	mod	high	high	low	mod	high	high
Pettis	mod	high	high	high	high	n/a	high	n/a	mod	high	high
Phelps	n/a	low	n/a	high	low	n/a	n/a	n/a	low	mod	high
Pike	low	mod	mod	low	mod	low	high	n/a	high	mod	mod
Platte	mod	mod	low	low	mod	n/a	high	high	high	high	mod
Polk	low	mod	low	mod	mod	n/a	high	n/a	high	high	high
Pulaski	n/a	low	n/a	high	low	n/a	n/a	n/a	low	mod	high
Putnam	low	low	low	mod	mod	n/a	high	n/a	high	mod	mod
Ralls	mod	mod	low	low	mod	low	high	n/a	mod	high	high

County[1]	Dam Failure	Drought	Earthquake	Fires (structural, urban and wild)	Heat Wave	Landslide/Land Subsidence	Riverine Flooding (Major and Flash)	Severe Winter Weather	Thunderstorms	Tornadoes	Lightning
Randolph	low	mod	high	high	low	n/a	n/a	n/a	low	low	high
Ray	low	high	low	low	mod	n/a	high	high	high	high	high
Reynolds	mod	mod	high	low	high	n/a	high	n/a	high	n/a	mod
Ripley	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	mod	n/a	mod
Saline	mod	mod	high	high	mod	n/a	high	n/a	mod	mod	mod
Schuyler	n/a	high	mod	low	high	n/a	n/a	n/a	n/a	n/a	n/a
Scotland	n/a	n/a	mod	low	high	n/a	n/a	n/a	n/a	n/a	n/a
Scott	low	mod	mod	n/a	mod	n/a	mod	n/a	mod	high	mod
Shannon	low	low	mod	low	mod	n/a	high	n/a	high	n/a	high
Shelby	low	mod	mod	mod	mod	low	mod	low	high	high	high
St. Charles	low	mod	high	low	high	n/a	high	n/a	mod	high	high
St. Clair	low	high	high	low	mod	low	mod	n/a	high	high	high
St. Francois	mod	mod	mod	high	mod	mod	mod	n/a	high	n/a	high
St. Louis	low	mod	high	low	high	n/a	high	n/a	high	high	high
St. Louis City*	low	mod	high	low	high	n/a	high	n/a	high	high	mod
Ste. Genevieve	mod	mod	mod	mod	mod	mod	high	mod	high	high	high
Stoddard	n/a	mod	mod	n/a	mod	n/a	mod	n/a	mod	mod	mod
Stone	low	low	low	low	low	n/a	high	n/a	high	high	high
Sullivan	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Taney	mod	low	low	high	mod	n/a	high	n/a	mod	high	high
Texas	low	mod	mod	low	low	n/a	high	low	mod	high	high
Vernon	mod	mod	low	mod	mod	low	high	mod	mod	high	high

County[1]	Dam Failure	Drought	Earthquake	Fires (structural, urban and wild)	Heat Wave	Landslide/Land Subsidence	Riverine Flooding (Major and Flash)	Severe Winter Weather	Thunderstorms	Tornadoes	Lightning
Warren	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Washington	low	low	mod	high	high	low	high	n/a	high	high	high
Wayne	mod	mod	high	mod	mod	n/a	high	n/a	mod	n/a	high
Webster	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Worth	low	mod	mod	low	low	n/a	low	n/a	mod	mod	high
Wright	low	low	low	low	low	n/a	low	n/a	mod	mod	mod

[1] The county name highlighted in blue did not have an approved plan at the time this report was developed. The county names highlighted in yellow denote counties that had either new or updated plans since the 2013 State Mitigation Plan update.

3.4.2. Overview and Analysis of Local Plan Potential Loss Estimates

To assess potential losses, the State extracted data from local plans' vulnerability assessments for the hazards the jurisdictions had ranked either High or Moderate. A general statement in many of the plans reads "loss estimates were calculated using a combination of information from the community profiles, historical loss data in the hazard profiles, parcel information, and general knowledge of the jurisdiction. Rough economic estimates were also included. For assessments reflecting 100 percent of the county's total resources, the planning area should be assumed to be evenly at risk to that respective hazard." Thus, for many hazards that could have an impact anywhere in the county, such as severe winter weather or tornadoes, it was difficult to refine the loss estimate further.

After extensive review of the loss-estimate data, the State determined that it was not suitable for county to county comparisons of loss, due largely to the different methods used by the counties to estimate, or interpret, potential loss. Reasons for largely excluding this data include:

- Accurate loss ratios were not possible as total exposure was rarely identified within the local plans. Many plans instead identified total vulnerability or the sum of the potential losses for all hazards, which would mean losing property many times over.
- Hazard scenarios were not consistent and therefore not comparable against each other.
- There was no consistently applied definition of "undeveloped." Some counties considered it unincorporated land, others considered it potential future development, some considered it rural, and others did not specify. This added to the complexity of the data capture process.

The exception to the above issues were flood, earthquake, and tornado where many of the plans were able to summarize the population and buildings at risk within the hazard area. **Table 3.165, Table 3.166, and Table 3.167** provide flood, earthquake, and tornado loss estimate summary data for each county and the City of St. Louis. Loss ratios were calculated based upon the approximate value affected, as presented in the local plans, and the total building exposure value, as obtained from FEMA's HAZUS loss estimation software. Again, the county highlighted in blue did not have an approved plan available for review and the counties highlighted in yellow had new or updated plans since the 2013 State Mitigation Plan.

Figures 3.209 through **Figure 3.217** provide this summary data in thematic maps for persons impacted, buildings impacted, and potential dollar loss, respectively.

Table 3.165. Local Plans Flood Loss Estimate Summary

County[1]	Population Impacted[2]	No. of Buildings Impacted	Approximate Value Affected	Flood Loss Ratio (based on exposure)
Adair	n/a[3]	n/a	$3,594,000	0.00138
Andrew	n/a	n/a	$11,090,000	0.00643
Atchison	1,406	726	$98,029,800	0.12151
Audrain	n/a	n/a	$20,112,080	0.00748
Barry	n/a	4,312	$15,650,495	0.00419
Barton	12,531	7,126	$51,401,000	0.03633
Bates	1,194	674	$12,419,750	0.00753
Benton	n/a	n/a	n/a	n/a
Bollinger	23	9	$43,501	0.00004
Boone	n/a	n/a	n/a	n/a
Buchanan	1,339	402	$94,573,000	0.00894

3 Risk Assessment

County[1]	Population Impacted[2]	No. of Buildings Impacted	Approximate Value Affected	Flood Loss Ratio (based on exposure)
Butler	n/a	19	$1,270,000	0.00031
Caldwell	n/a	56	$781,000	0.00079
Callaway	n/a	n/a	n/a	n/a
Camden	n/a	n/a	$148,624,992	0.01785
Cape Girardeau	360	151	$5,971,668.00	0.00068
Carroll	n/a	n/a	n/a	n/a
Carter	n/a	n/a	$35,989,000	0.06931
Cass	n/a	n/a	n/a	n/a
Cedar	2,875	937	$22,986,124	0.01758
Chariton	301	35	$6,720,000	0.00716
Christian	n/a	3,097	$13,747,200	0.00177
Clark	1,123	356	$17,210,900	0.02424
Clay	n/a	n/a	n/a	n/a
Clinton	n/a	n/a	$14,734,977	0.00645
Cole	n/a	n/a	n/a	n/a
Cooper	n/a	n/a	n/a	n/a
Crawford	n/a	n/a	$50,611,000	0.02118
Dade	n/a	101	$11,088,125	0.01501
Dallas	n/a	180	$11,619,470	0.00855
Daviess	100	3	$15,431,000	0.01610
DeKalb	n/a	n/a	$5,712,000	0.00524
Dent	n/a	n/a	n/a	n/a
Douglas	n/a	90	$5,812,246	0.00555
Dunklin	11626	3,340	$80,617,405	0.02709
Franklin	n/a	n/a	n/a	n/a
Gasconade	n/a	343	$18,595,000	0.00985
Gentry	1,013	808	$63,633,450	0.09229
Greene	n/a	n/a	$38,269,906	0.00119
Grundy	n/a	n/a	n/a	n/a
Harrison	n/a	n/a	n/a	n/a
Henry	n/a	n/a	n/a	n/a
Hickory	n/a	n/a	n/a	n/a
Holt	2,418	984	$53,054,092	0.08519
Howard	n/a	n/a	n/a	n/a
Howell	154	284	$589,039,448	0.16588
Iron	21	8	$91,818	0.00009
Jackson	n/a	n/a	n/a	n/a
Jasper	n/a	n/a	$161,197,000	0.01335
Jefferson	n/a	n/a	n/a	n/a
Johnson	n/a	n/a	n/a	n/a
Knox	n/a	n/a	n/a	n/a
Laclede	n/a	n/a	n/a	n/a
Lafayette	2,424	1,953	$241,278,000	0.06281
Lawrence	n/a	92	$236,033,000.00	0.06752
Lewis	4,057	410	$21,995,900	0.02209
Lincoln	n/a	n/a	n/a	n/a

County[1]	Population Impacted[2]	No. of Buildings Impacted	Approximate Value Affected	Flood Loss Ratio (based on exposure)
Linn	n/a	n/a	n/a	n/a
Livingston	n/a	n/a	n/a	n/a
Macon	n/a	n/a	n/a	n/a
Madison	1,923	684	$35,844,502	0.03156
Maries	n/a	3,711	$6,798,000	0.00711
Marion	n/a	n/a	$58,138,404	0.01803
McDonald	7,288	2,173	$127,313,096	0.07562
Mercer	n/a	n/a	n/a	n/a
Miller	n/a	n/a	n/a	n/a
Mississippi	2541	1,401	$78,212,475	0.07018
Moniteau	n/a	n/a	n/a	n/a
Monroe	5,540	572	$59,382	0.00006
Montgomery	n/a	n/a	n/a	n/a
Morgan	n/a	n/a	n/a	n/a
New Madrid	4,218	1,327	$225,319,912	0.12764
Newton	n/a	n/a	n/a	n/a
Nodaway	1,718	1,617	$17,228,704	0.00704
Oregon	1,314	49	$10,124,690	0.01136
Osage	n/a	n/a	n/a	n/a
Ozark	n/a	190	$8,202,222	0.00885
Pemiscot	5243	1,383	$20,351,425	0.01239
Perry	42	17	$172,769	0.00008
Pettis	n/a	n/a	$15,474,000	0.00346
Phelps	n/a	n/a	$74,357,447	0.01568
Pike	2,827	925	$157,300,000	0.08450
Platte	n/a	n/a	n/a	n/a
Polk	n/a	n/a	n/a	n/a
Pulaski	n/a	n/a	$82,740,936	0.01551
Putnam	n/a	n/a	$2,290,000	0.00430
Ralls	1,503	588	$75,000,000	0.06490
Randolph	n/a	n/a	$4,883,000	0.00201
Ray	n/a	n/a	n/a	n/a
Reynolds	24,728	7,917	$171,361,564	0.25590
Ripley	n/a	n/a	n/a	n/a
Saline	3,563	1,530	$64,676,191	0.02653
Schuyler	n/a	n/a	$1,409,000	0.00351
Scotland	1,308	375	$14,014,800	0.02588
Scott	7754	2,634	$74,340,410	0.01842
Shannon	n/a	n/a	n/a	n/a
Shelby	637	509	$52,986,870	0.06736
St. Charles	n/a	n/a	n/a	n/a
St. Clair	n/a	n/a	n/a	n/a
St. Francois	8	3	$18,322	0.000003
St. Louis	n/a	n/a	n/a	n/a
St. Louis City*	n/a	n/a	n/a	n/a
Ste. Genevieve	42	18	$292,171	0.00014

County[1]	Population Impacted[2]	No. of Buildings Impacted	Approximate Value Affected	Flood Loss Ratio (based on exposure)
Stoddard	5,666	3,165	$141,769,567	0.04743
Stone	n/a	22	$22,914,984	0.00582
Sullivan	n/a	n/a	$3,583,000	0.00574
Taney	n/a	216	$30,786,027	0.00503
Texas	n/a	403	$1,719,092	0.00075
Vernon	n/a	n/a	n/a	n/a
Warren	n/a	n/a	n/a	n/a
Washington	n/a	9,493	$1,038,000	0.00060
Wayne	34,663	9,874	$110,973,597	0.08831
Webster	n/a	1,973	$6,984,587	0.00251
Worth	238	190	$12,200,000	0.04526
Wright	1,975	968	$48,211,560	0.03009

[1] The county name highlighted in blue did not have an approved plan at the time this report was developed. The county names highlighted in yellow denote counties that had either new or updated plans since the 2013 State Mitigation Plan update.
[2] Population impacted was obtained directly from the existing local plans. Computations of total population from displaced households were not performed.
[3] Data not available from the existing local plan.

Table 3.166. Local Plans Earthquake Loss Estimate Summary

County[1]	Population Impacted[2]	Buildings Impacted	Approximate Value Affected	Earthquake Loss Ratio (based on exposure)
Adair	n/a[3]	n/a	n/a	n/a
Andrew	n/a	n/a	n/a	n/a
Atchison	1,876	972	$125,570,770	0.15565
Audrain	n/a	n/a	$103,170	0.00004
Barry	n/a	n/a	$9,893,264	0.00265
Barton	n/a	n/a	$19,814	0.00001
Bates	3980	2250	n/a	n/a
Benton	n/a	n/a	n/a	n/a
Bollinger	6182	2672	$12,356,549	0.01194
Boone	n/a	n/a	n/a	n/a
Buchanan	range 0-500	n/a	$69,000	0.00001
Butler	n/a	n/a	$908,027	0.00022
Caldwell	n/a	56	$361,000	0.00037
Callaway	n/a	n/a	n/a	n/a
Camden	n/a	n/a	$369,000	0.00004
Cape Girardeau	38,516	17833	$689,342,250	0.07840
Carroll	n/a	n/a	n/a	n/a
Carter	n/a	n/a	$193,000	0.00037
Cass	n/a	99,000	120,000	0.00001
Cedar	2,892	1259	$23,864,106	0.01825
Chariton	n/a	n/a	n/a	n/a
Christian	n/a	n/a	$12,803,456	0.00165
Clark	2,027	519	$9,520,300	0.01341
Clay	n/a	208,000	261,000	0.00001
Clinton	n/a	n/a	$15,000	0.00001
Cole	n/a	n/a	n/a	n/a
Cooper	n/a	n/a	n/a	n/a
Crawford	n/a	n/a	n/a	n/a

County[1]	Population Impacted[2]	Buildings Impacted	Approximate Value Affected	Earthquake Loss Ratio (based on exposure)
Dade	n/a	n/a	$2,109,922	0.00286
Dallas	n/a	7801	$5,106,934	0.00376
Daviess	n/a	n/a	n/a	n/a
DeKalb	n/a	n/a	$5,000	0.00000
Dent	n/a	n/a	n/a	n/a
Douglas	n/a	2015	$13,273,120	0.01267
Dunklin	21129	7072	$228,609,835	0.07682
Franklin	n/a	n/a	$1,659,000	0.00015
Gasconade	n/a	n/a	n/a	n/a
Gentry	1,353	1,038	$665,747,000	0.96555
Greene	n/a	n/a	$1,913,495	0.00006
Grundy	n/a	n/a	n/a	n/a
Harrison	n/a	n/a	n/a	n/a
Henry	n/a	n/a	n/a	n/a
Hickory	n/a	n/a	n/a	n/a
Holt	2,729	679	$35,695,250	0.05732
Howard	n/a	n/a	$27,000	0.00002
Howell	406	19,509	$29,862,380	0.00841
Iron	5315	2356	$21,062,023	0.02152
Jackson	n/a	776,000	995,000	0.00001
Jasper	n/a	n/a	$275,000	0.00002
Jefferson	n/a	n/a	$44,442,000	0.00200
Johnson	n/a	n/a	n/a	n/a
Knox	n/a	n/a	n/a	n/a
Laclede	n/a	n/a	n/a	n/a
Lafayette	2,879	1,427	$241,030,000	0.06275
Lawrence	n/a	8744	$58,189,900	0.01665
Lewis	1,250	525	$9,682,814	0.00972
Lincoln	n/a	n/a	n/a	n/a
Linn	n/a	n/a	n/a	n/a
Livingston	n/a	n/a	n/a	n/a
Macon	1,557	961	$169,313	0.00010
Madison	1,098	323	$17,239,787	0.01518
Maries	n/a	4861	$53,620,000	0.05610
Marion	n/a	n/a	n/a	n/a
McDonald	473	137	$16,095,775	0.00956
Mercer	n/a	n/a	n/a	n/a
Miller	n/a	n/a	n/a	n/a
Mississippi	7633	4162	$237,809,328	0.21337
Moniteau	n/a	n/a	$53,000	0.00004
Monroe	8840	571.6	$59,382	0.00006
Montgomery	n/a	n/a	n/a	n/a
Morgan	n/a	n/a	n/a	n/a
New Madrid	12641	3998	$695,048,426	0.39373
Newton	n/a	n/a	n/a	n/a
Nodaway	7095	805	$12,470,375	0.00509
Oregon	6,135	2,325	$125,545,509	0.14090
Osage	n/a	n/a	n/a	n/a
Ozark	n/a	1,642	$2,247,905	0.00243
Pemiscot	15163	4013	$77,566,127	0.04723
Perry	9,486	4279	$44,220,746	0.01980
Pettis	n/a	n/a	$127,000	0.00003

County[1]	Population Impacted[2]	Buildings Impacted	Approximate Value Affected	Earthquake Loss Ratio (based on exposure)
Phelps	n/a	n/a	$456,868	0.00010
Pike	3,772	1,235	$213,000,000	0.11442
Platte		78,000	96,000	0.00001
Polk	n/a	n/a	$10,356,473	0.00382
Pulaski	n/a	n/a	$277,440	0.00005
Putnam	n/a	n/a	n/a	n/a
Ralls	2,005	793	$100,000,000	0.08653
Randolph	n/a	n/a	$65,000	0.00003
Ray	n/a	20,000	24,000	0.00001
Reynolds	19,776	6,324	$137,089,246	0.20472
Ripley	n/a	n/a	$348,826,000	0.30833
Saline	2,901	1,303	$219,233,200	0.08994
Schuyler	4170	736	$6,839,300	0.01702
Scotland	n/a	n/a	$17,568,800	0.03245
Scott	22258	6486	$661,857,204	0.16398
Shannon	n/a	2480	$3,040,568	0.00448
Shelby	637	509	$52,986,870	0.06736
St. Charles	n/a	n/a	$4,667,000	0.00011
St. Clair	n/a	n/a	n/a	n/a
St. Francois	27821	12205	$67,825,461	0.01097
St. Louis	n/a	n/a	$26,419,000	0.00019
St. Louis City*	n/a	n/a	$12,279,000	0.00026
Ste. Genevieve	9073	4227	$61,367,627	0.02837
Stoddard	16,899	9,481	$425,308,708	0.14229
Stone	n/a	17086	$21,335,066	0.00542
Sullivan	n/a	n/a	n/a	n/a
Taney	n/a	14991	$20,514,425	0.00335
Texas	n/a	18,692	$8,147,507	0.00355
Vernon	n/a	n/a	n/a	n/a
Warren	n/a	n/a	n/a	n/a
Washington	n/a	n/a	n/a	n/a
Wayne	27,724	7,895	$88,778,876	0.07065
Webster	n/a	n/a	n/a	n/a
Worth	543	985	$30,477,750	0.11308
Wright	8,608	2,629	$167,112,931	0.10429

[1] The county name highlighted in blue did not have an approved plan at the time this report was developed. The county names highlighted in yellow denote counties that had either new or updated plans since the 2013 State Mitigation Plan update.
[2] Population impacted was obtained directly from the existing local plans. Computations of total population from displaced households were not performed.
[3] Data not available from the existing local plan

Table 3.167. Local Plans Tornado Loss Estimate Summary

County[1]	Population Impacted[2]	Buildings Impacted	Approximate Value Affected	Tornado Loss Ratio (based on exposure)
Adair	n/a[3]	n/a	n/a	n/a
Andrew	n/a	n/a	$51,008,088	0.02957
Atchison	1,876	972	$125,570,770	0.15565
Audrain	n/a	n/a	$25,792,770	0.00959
Barry	n/a	n/a	$19,786,529	0.00530
Barton	n/a	n/a	n/a	n/a
Bates	n/a	n/a	n/a	n/a

County[1]	Population Impacted[2]	Buildings Impacted	Approximate Value Affected	Tornado Loss Ratio (based on exposure)
Benton	n/a	n/a	n/a	n/a
Bollinger	618	268	$1,235,655	0.00119
Boone	n/a	n/a	n/a	n/a
Buchanan	range 0-500	n/a	$772,217,289	0.07299
Butler	n/a	1,104	$107,569,600	0.02596
Caldwell	n/a	279	$9,180,000	0.00933
Callaway	n/a	n/a	n/a	n/a
Camden	n/a	n/a	n/a	n/a
Cape Girardeau	3,852	1783	$68,934,225	0.00784
Carroll	n/a	n/a	n/a	n/a
Carter	n/a	n/a	n/a	n/a
Cass	101,000	n/a	$5,400,904,000	0.49445
Cedar	n/a	n/a	n/a	n/a
Chariton	n/a	n/a	n/a	n/a
Christian	n/a	n/a	$25,606,906	0.00331
Clark	2,857	799	$36,020,100	0.05073
Clay	234,000	n/a	$14,958,612,000	0.54219
Clinton	n/a	1423	$210,928,924	0.09240
Cole	n/a	n/a	n/a	n/a
Cooper	n/a	n/a	n/a	n/a
Crawford	n/a	741	n/a	n/a
Dade	n/a	n/a	$210,992,019	0.28565
Dallas	n/a	7801	$51,069,335	0.03759
Daviess	n/a	n/a	$91,352	0.00010
DeKalb	n/a	722	$76,054,500	0.06977
Dent	n/a	n/a	n/a	n/a
Douglas	n/a	2015	$26,546,241	0.02533
Dunklin	11234	4628	$114,720,406	0.03855
Franklin	n/a	n/a	n/a	n/a
Gasconade	n/a	1,222	n/a	n/a
Gentry	1,353	1,038	$665,747,000	0.96555
Greene	n/a	n/a	$31,890,588	0.00099
Grundy	n/a	n/a	n/a	n/a
Harrison	n/a	n/a	n/a	n/a
Henry	n/a	n/a	n/a	n/a
Hickory	n/a	n/a	n/a	n/a
Holt	1,561	390	$20,217,286	0.03246
Howard	n/a	n/a	$3,031,177	0.00279
Howell	1,006	19,520	$202,575,533	0.05705
Iron	532	235	$2,106,202	0.00215
Jackson	683,000	n/a	$76,612,247,000	0.85782
Jasper	n/a	n/a	n/a	n/a
Jefferson	n/a	n/a	n/a	n/a
Johnson	n/a	n/a	n/a	n/a
Knox	n/a	n/a	n/a	n/a
Laclede	n/a	n/a	n/a	n/a
Lafayette	3,915	2,053	$360,850,000	0.09394
Lawrence	n/a	8744	$116,379,800	0.03329
Lewis	2,620	981	$50,381,000	0.05059
Lincoln	n/a	n/a	n/a	n/a
Linn	n/a	n/a	n/a	n/a
Livingston	n/a	n/a	n/a	n/a

County[1]	Population Impacted[2]	Buildings Impacted	Approximate Value Affected	Tornado Loss Ratio (based on exposure)
Macon	1,557	961	$169,313	0.00010
Madison	1,098	323	$17,239,787	0.01518
Maries	n/a	36	n/a	n/a
Marion	n/a	n/a	n/a	n/a
McDonald	17,015	5,077	$523,289,005	0.31081
Mercer	n/a	n/a	n/a	n/a
Miller	n/a	n/a	n/a	n/a
Mississippi	3640	1996	$111,733,110	0.10025
Moniteau	n/a	n/a	$3,653,460	0.00242
Monroe	8,840	571.6	$59,382	0.00006
Montgomery	n/a	n/a	n/a	n/a
Morgan	n/a	n/a	n/a	n/a
New Madrid	6032	1889	$330,245,447	0.18708
Newton	n/a	n/a	n/a	n/a
Nodaway	7095	6262	$62,145,595	0.02539
Oregon	2,778	1,175	$57,322,494	0.06433
Osage	n/a	n/a	n/a	n/a
Ozark	n/a	4642	$11,095,811	0.01198
Pemiscot	7000	1873	$27,447,906	0.01671
Perry	n/a	n/a	n/a	n/a
Pettis	8,448	4,155	$708,520,000	0.15857
Phelps	n/a	n/a	$1,876,552	0.00040
Pike	1,886	616	$106,900,000	0.05742
Platte	95,000	n/a	$7,907,587,000	0.69608
Polk	n/a	n/a	$103,564,737	0.03823
Pulaski	n/a	n/a	n/a	n/a
Putnam	n/a	n/a	n/a	n/a
Ralls	1,001	400	$49,000,000	0.04240
Randolph	n/a	n/a	n/a	n/a
Ray	23,000	n/a	$935,840,000	0.36887
Reynolds	12,363	3,954	$85,680,784	0.12795
Ripley	n/a	n/a	n/a	n/a
Saline	4,927	2,580	$425,160,000	0.17441
Schuyler	4,170	736	$6,839,300	0.01702
Scotland	n/a	n/a	$99,223,522	0.18324
Scott	10308	3731	$118,352,003	0.02932
Shannon	2480	n/a	$6,081,137	0.00896
Shelby	637	509	$52,986,870	0.06736
St. Charles	n/a	n/a	n/a	n/a
St. Clair	n/a	n/a	n/a	n/a
St. Francois	2782	1221	$6,788,546	0.00110
St. Louis	n/a	n/a	n/a	n/a
St. Louis City*	n/a	n/a	n/a	n/a
Ste. Genevieve	907	423	$6,136,762	0.00284
Stoddard	8,096	4,519	$202,254,954	0.06766
Stone		17086	$213,349,358	0.05420
Sullivan	n/a	n/a	n/a	n/a
Taney	n/a	14991	$205,144,245	0.03352
Texas	n/a	18,692	$16,295,014	0.00711
Vernon	n/a	n/a	n/a	n/a
Warren	n/a	n/a	n/a	n/a
Washington	n/a	2383	n/a	n/a

County[1]	Population Impacted[2]	Buildings Impacted	Approximate Value Affected	Tornado Loss Ratio (based on exposure)
Wayne	17,331	4,937	$55,486,799	0.04416
Webster	n/a	n/a	$10,583,858	0.00380
Worth	434	381	$2,440,000	0.00905
Wright	4,239	1,142	$80,232,143	0.05007

[1] The county name highlighted in blue did not have an approved plan at the time this report was developed. The county names highlighted in yellow denote counties that had either new or updated plans since the 2013 State Mitigation Plan update.
[2] Population impacted was obtained directly from the existing local plans. Computations of total population from displaced households were not performed.
[3] Data not available from the existing local plan.

Figure 3.209. Local Plans Flood Risk Summary: Persons Impacted

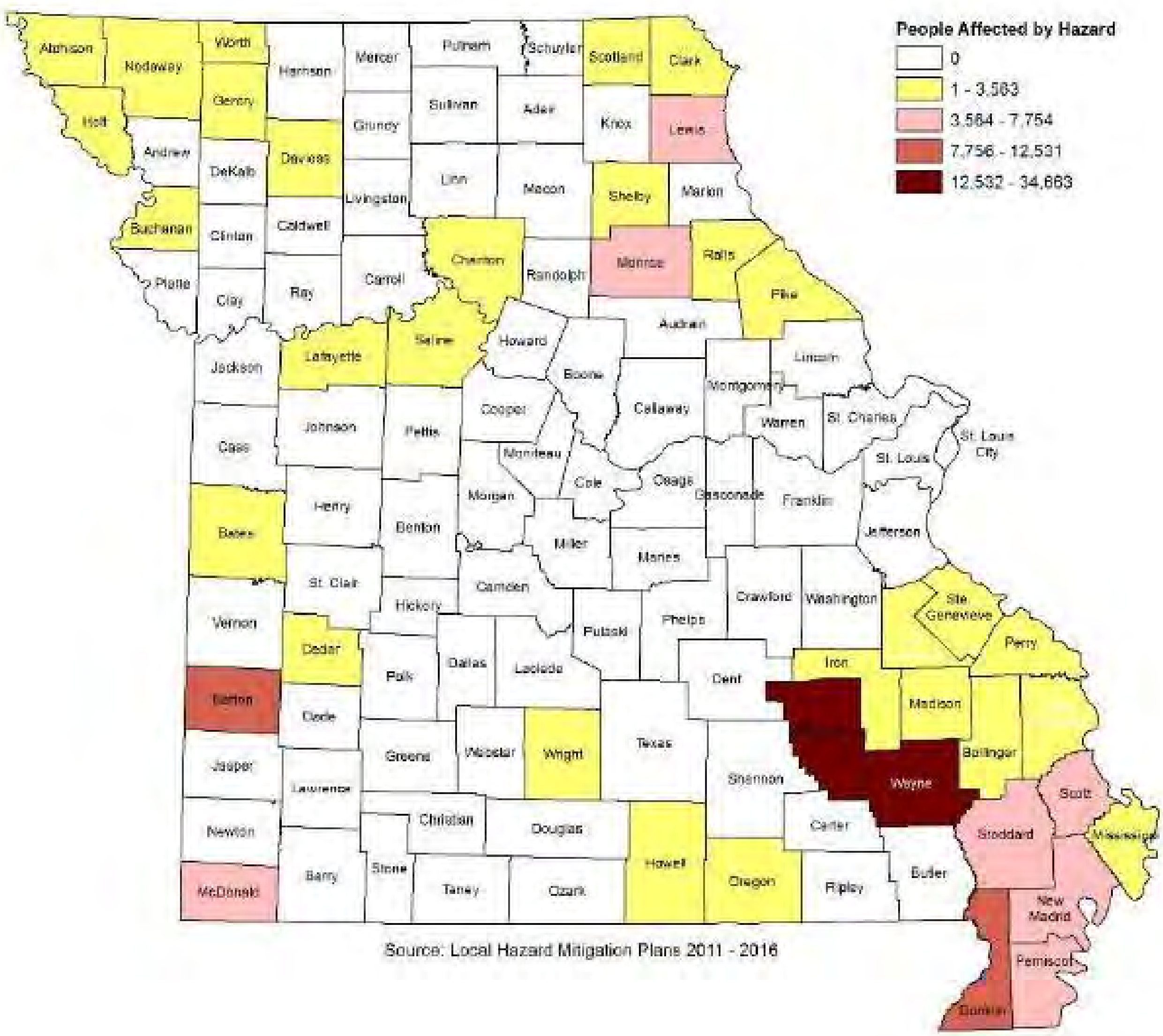


Figure 3.210. Local Plans Flood Risk Summary: Buildings Impacted

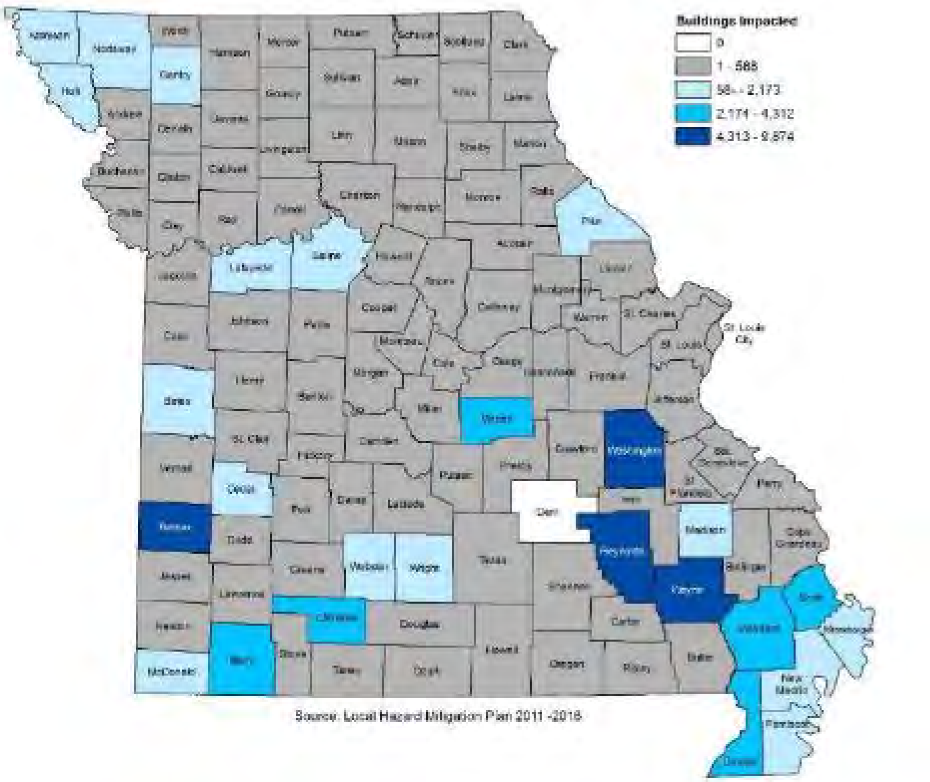


Figure 3.211. Local Plans Flood Risk Summary: Estimated Dollar Loss

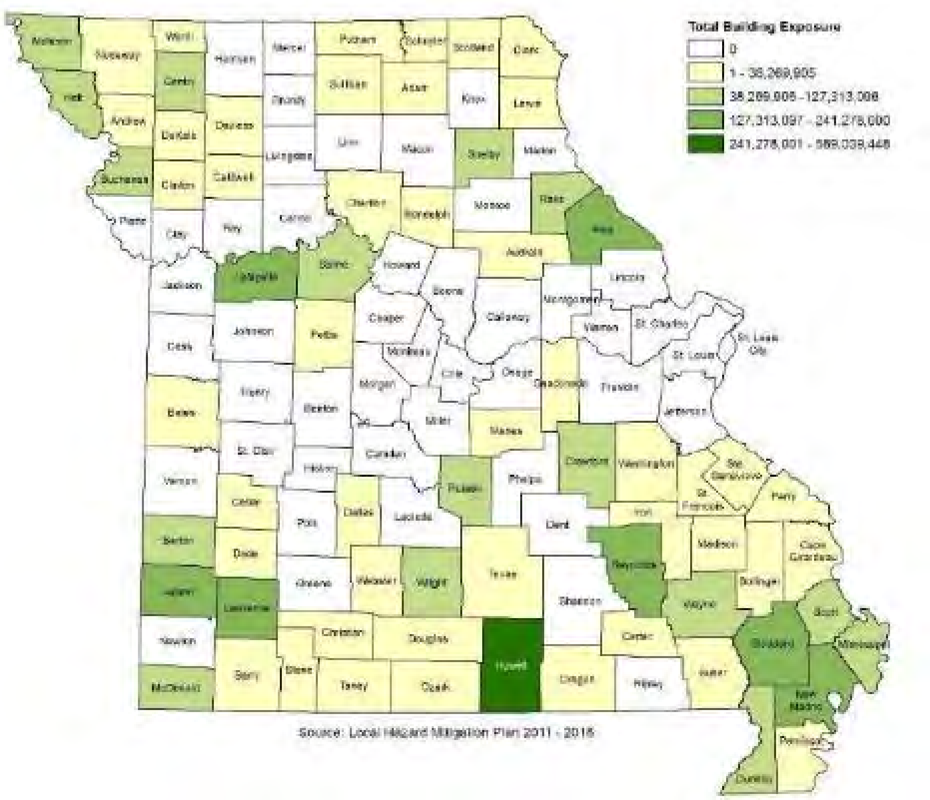


Figure 3.212. Local Plans Earthquake Risk Summary: Persons Impacted

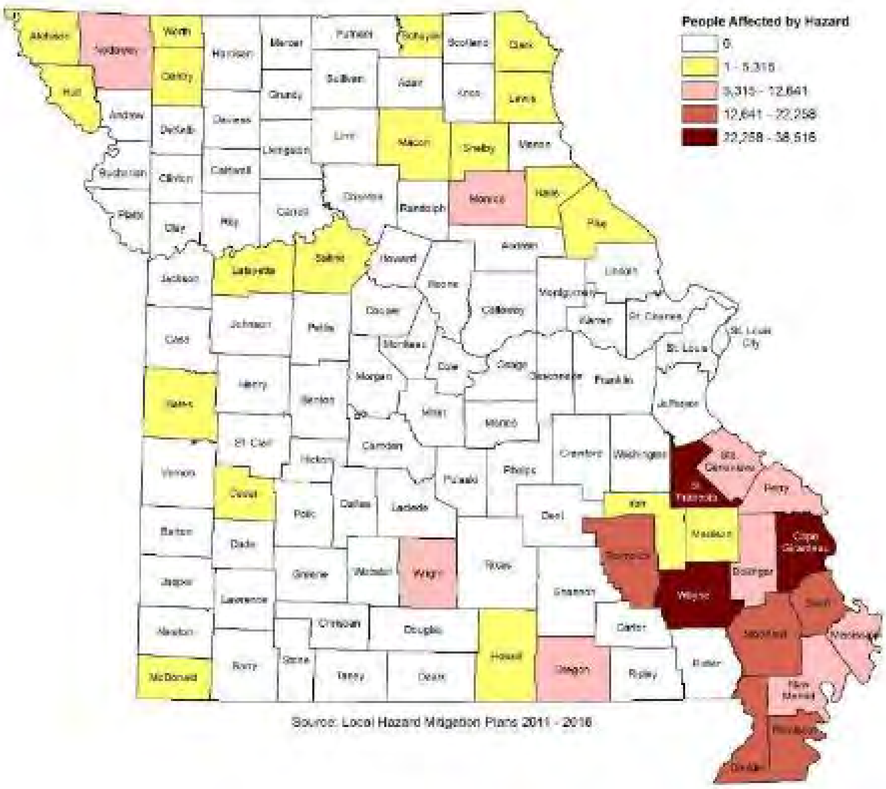


Figure 3.213. Local Plans Earthquake Risk Summary: Buildings Impacted

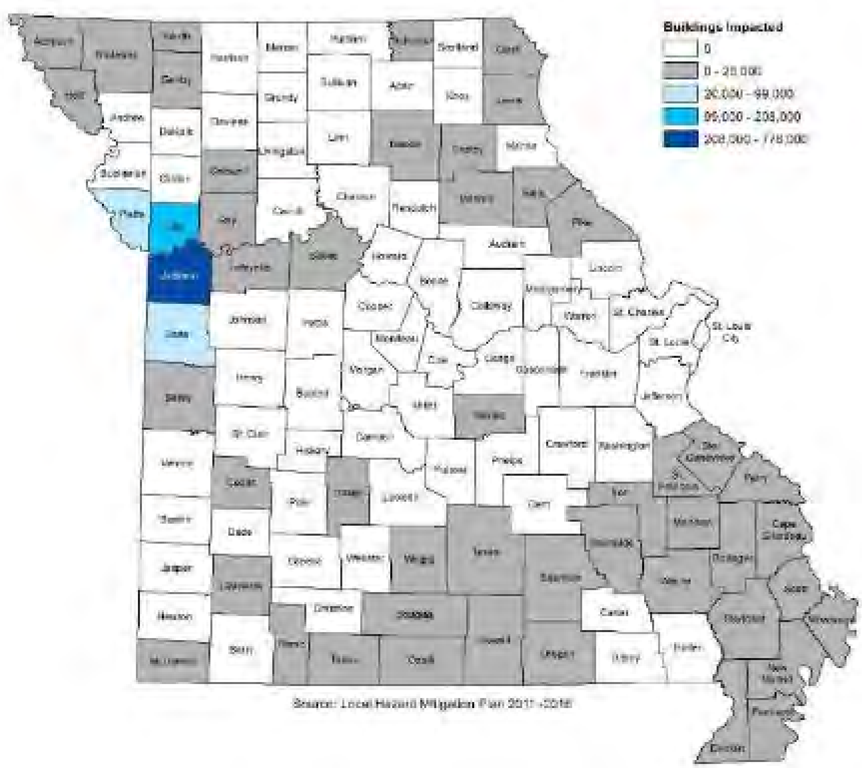


Figure 3.214. Local Plans Earthquake Risk Summary: Estimated Dollar Loss

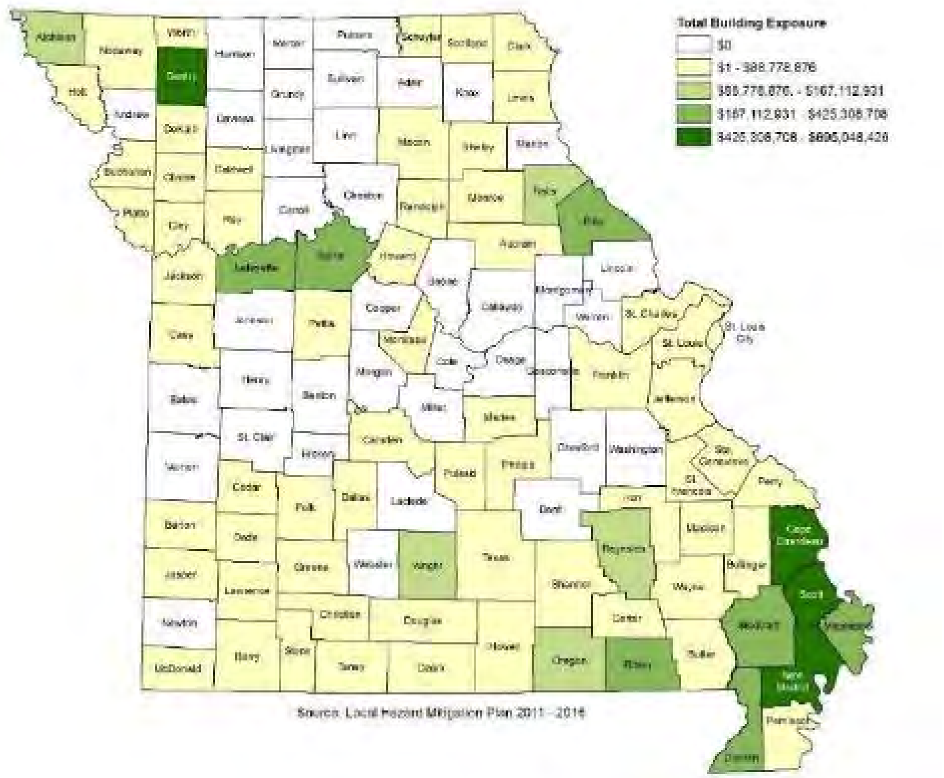


Figure 3.215. Local Plans Tornado Risk Summary: Persons Impacted

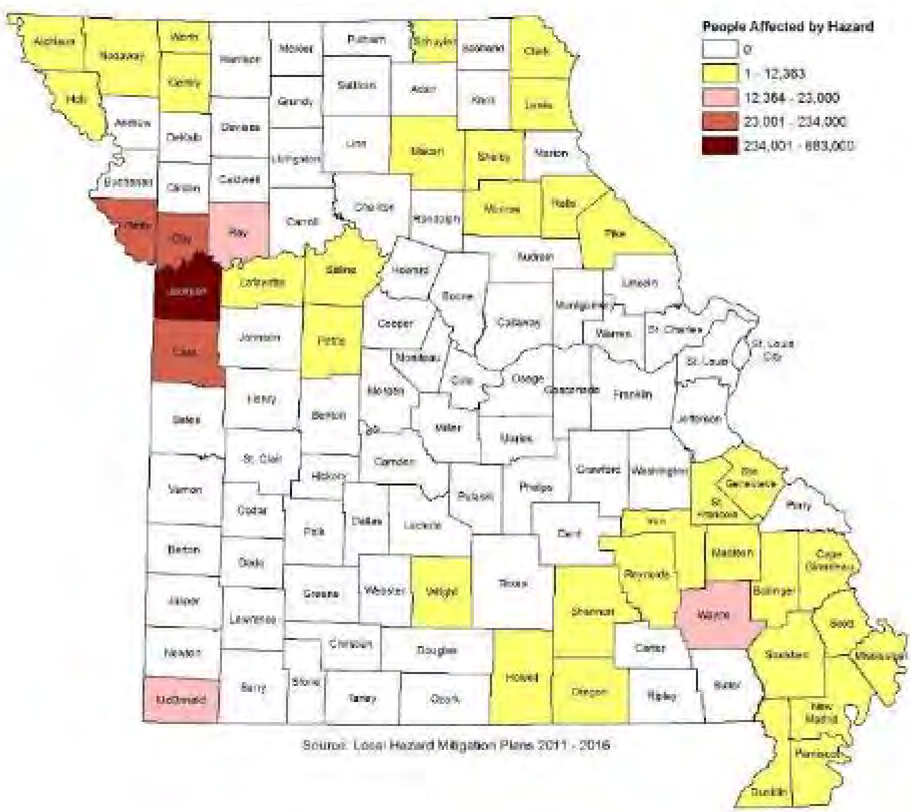


Figure 3.216. Local Plans Tornado Risk Summary: Buildings Impacted

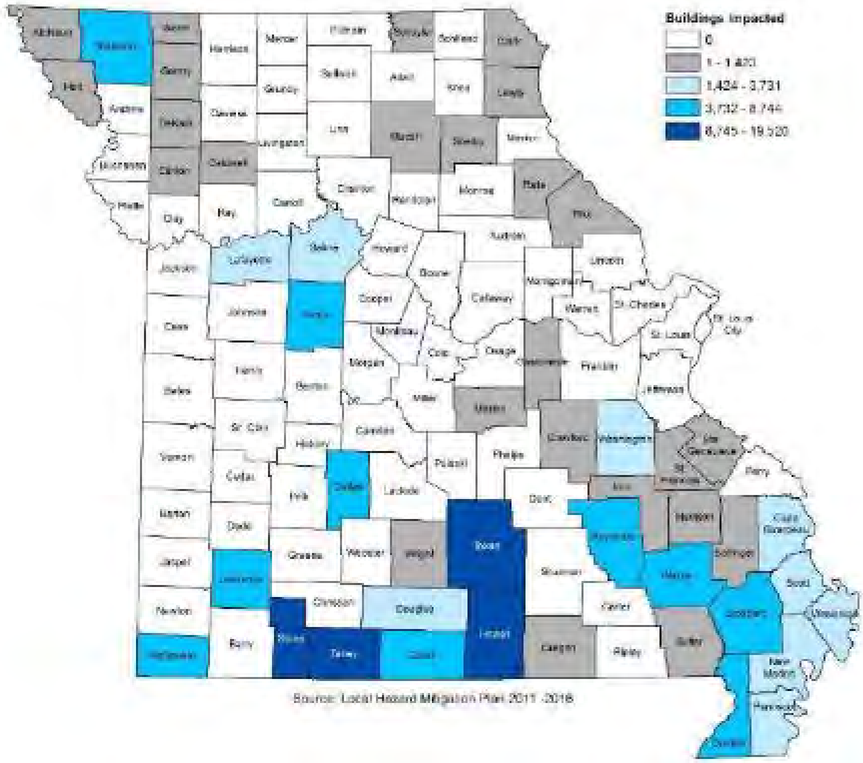
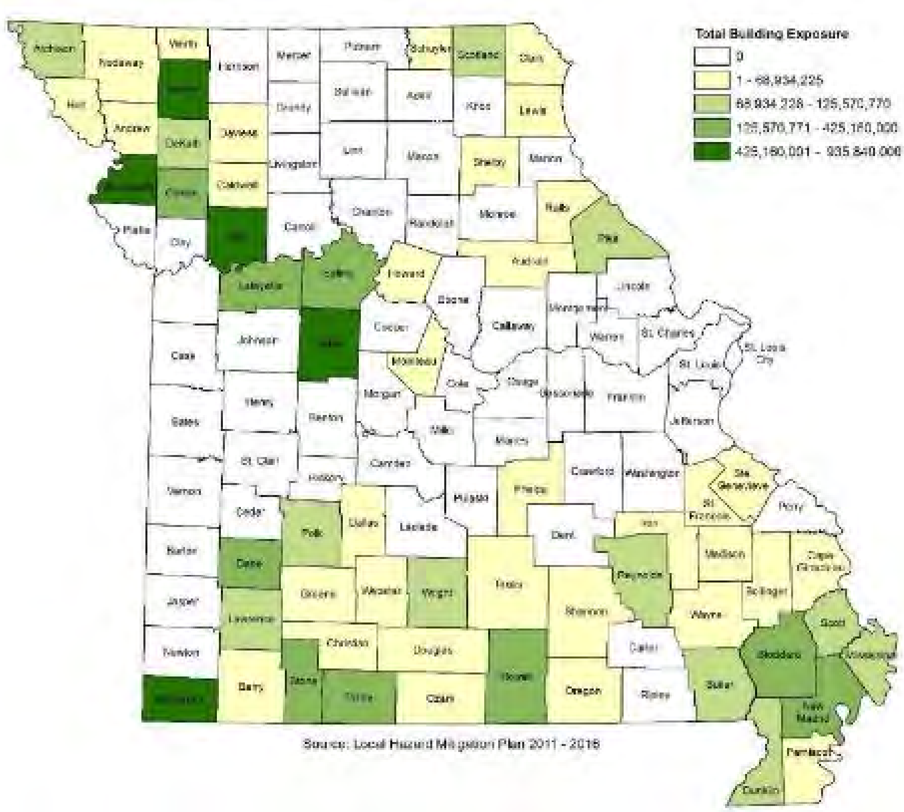


Figure 3.217. Local Plans Tornado Risk Summary: Estimated Dollar Loss



3.5. State Owned and Operated Facilities: Vulnerability and Loss Estimates

Requirements §201.4(c)(2)(ii) and §201.4(c)(2)(iii): [The state risk assessment shall include an overview and analysis of the state's vulnerability to the hazards described in this paragraph (c)(2), based on estimates provided in] the state risk assessment. <u>State owned critical or operated facilities located in the identified hazard areas shall also be addressed.</u>

[The State risk assessment shall include an] overview and analysis of potential losses to the identified vulnerable structures, based on estimates provided in local risk assessments as well as the State risk assessment. <u>The State shall estimate the potential dollar losses to State owned or operated buildings, infrastructure, and critical facilities located in the identified hazard areas.</u>

As Missouri remains vulnerable to natural hazards, state-owned or operated facilities are at risk to incur damage from hazard events. The state's resources, both monetary and fixed assets, depend heavily upon these facilities and their continuity. This section assesses vulnerability and potential losses to state-owned or operated facilities. According to the regulatory requirements of the Disaster Mitigation Act, the State must provide an overview vulnerability analysis and loss estimates for state-owned or operated buildings, infrastructure, and critical facilities located in the identified hazard areas. To perform this analysis, identified hazard areas exist for the following hazards: dam failure, earthquake, flood, and levee failure. During the 2017-2018 update, new data allowed for the analysis of vulnerability to sinkholes, wildfire, and hazardous materials fixed facility incidents. Therefore, for those hazards, a more comprehensive analysis was completed, including loss estimates. For the remaining hazards, clearly identified hazard areas are not established due to the random nature of the hazard (as with severe thunderstorms or tornadoes). For these hazards, where appropriate, the State has utilized the statewide vulnerability analysis to identify state-owned facilities within counties indicated to have increased vulnerability. For some of the hazards addressed, a narrative is provided to discuss vulnerability of state- owned facilities. Where data is available, vulnerability and loss estimation are described in more detail by hazard in this section. **Table 3.168** summarizes the updates in this section for each hazard profiled.

Table 3.168. Summary of Vulnerability Analysis/Loss Estimation Update Methods

Natural Hazards	2007	2010	2013	2018
Riverine Flooding (Major and Flash)	HAZUS-MH	GIS locations of available State-owned facilities compared with HAZUS-generated floodplain (with integrated DFIRM depth grids where available) to determine number and exposure value of state-owned facilities in the 100-year floodplain.	GIS locations of updated State-owned facilities compared with HAZUS-generated floodplain (with integrated DFIRM depth grids where available) to determine number and exposure value of state-owned facilities in the 100-year floodplain.	GIS locations of updated State Owned and Leased facilities compared with NFHL and HAZUS-generated floodplains to determine counts and values at risk in the 100-year floodplain.
Levee Failure	None	Analysis of DFIRM data to determine locations of state-owned facilities in proximity to DFIRM levees (limited by available data)	Analysis of MLI and NLD data to determine locations of state-owned facilities in proximity to all levees known to provide protection against 100-year flood.	GIS location analysis using the updated National Flood Hazard Layer which includes the levee certification in conjunction with the National Levee Inventory Database provided by the US Corps of Engineers.

Natural Hazards	2007	2010	2013	2018
Dam Failure	None	Identified facilities (with GIS data) within floodplain and 5-mile downstream radius of state-regulated Class I or Class II dams.	Identified critical facilities (using GIS data) within MoDNR high risk dam inundation zones.	Identified State Owned and Leased Facilities (using GIS data) within available State-regulated dam inundation areas from Missouri Department of Natural Resources (MoDNR) and available USACE dam inundation areas from USACE.
Earthquakes	HAZUS-MH	HAZUS-MH ground shaking data utilized to indicate vulnerable state-owned facilities (with GIS data)	HAZUS 2.1 USGS ground shaking data utilized to indicate vulnerable state-owned facilities (with GIS data).	GIS location analysis to identify State Owned and Leased Facilities based on the resulting Modified Mercalli Intensity and the corresponding Peak-Ground Acceleration (PGA) data.
Extreme Temperatures	None	Narrative	Narrative	Updated Narrative
Land Subsidence /Sinkholes	None	Utilized results of statewide vulnerability analysis to identify state-owned facilities within counties indicated to have increased vulnerability.	Utilized results of updated statewide vulnerability analysis to identify state-owned facilities within counties indicated to have increased vulnerability.	GIS location analysis of updated State Owned and Leased facilities compared to Sinkhole GIS layer supplied by MoDNR, Missouri Geological Survey (MGS), Geological Survey Program (GSP), Environmental Geology Section (EGS).
Drought	None	Narrative	Updated narrative.	Updated narrative.
Extreme Temperatures	None	Narrative	Narrative	Updated Narrative
Severe Thunderstorms	None	Utilized results of statewide vulnerability analysis to identify state-owned facilities within counties indicated to have increased vulnerability.	Utilized results of statewide vulnerability analysis to identify state-owned facilities within counties indicated to have increased vulnerability.	Utilized results of statewide vulnerability analysis to identify State Owned and Leased facilities within counties indicated to have increased vulnerability.
Severe Winter Weather	None	GIS locations of available State-owned facilities compared with HAZUS-generated floodplain (with integrated DFIRM depth grids where available) to determine number and exposure value of state-owned facilities in the 100-year floodplain.	Utilized results of statewide vulnerability analysis to identify state-owned facilities within counties indicated to have increased vulnerability	Utilized results of statewide vulnerability analysis to identify State Owned and Leased facilities within counties indicated to have increased vulnerability.
Tornadoes	Statistical analysis of NCEI data	Analysis of DFIRM data to determine locations of state-owned facilities in proximity to DFIRM levees (limited by available data)	Utilized results of statewide vulnerability analysis to identify state-owned facilities within counties indicated to have increased vulnerability.	Utilized results of statewide vulnerability analysis to identify State Owned and Leased facilities within counties indicated to have increased vulnerability.
Fires: Structural & Urban Wild	None	Utilized results of statewide vulnerability analysis to identify state-owned facilities within counties indicated to have increased vulnerability.	Utilized updated results of statewide vulnerability analysis to identify state-owned facilities within counties indicated to have increased vulnerability.	Identified State Owned and Leased Facilities in Wildland Urban High Interface and Wildland Urban Intermix areas based on GIS layers from the University of Wisconsin SILVIS lab.

Manmade and Other Hazards	2007	2010	2013	2018
Attack (Nuclear, Conventional, Chemical, and Biological)	None	Narrative	Narrative	Narrative
Civil Disorder	None	Narrative	Narrative	Narrative
Cyber Disruption	None	None	Narrative	Narrative
Hazardous Materials Release: Fixed facility accidents Transportation accidents	None	Summary of state-owned facilities that may contain hazardous materials (based on asset use)	Summary of updated state-owned facilities database that may contain hazardous materials (based on asset use).	Identified State Owned and Leased facilities within 0.5 mile radius of Tier II Facilities.
Mass Transportation Accidents	None	Narrative	Narrative	Narrative
Nuclear Power Plants (Emergencies and Accidents)	None	Identified state-owned facilities in counties within 50 mile radius of nuclear power plants or in county with University Research Reactor	Narrative	Identified State Owned and Leased facilities within 10 mile radius of nuclear power plants.
Public Health Emergencies/Environmental Issues	None	Narrative	Narrative	Narrative
Special Events	None	Narrative	Narrative	Updated Narrative
Terrorism	None	Narrative	Narrative	Narrative
Utilities (Interruptions and System Failures)	None	Narrative	Narrative	Narrative

State-owned Facilities

As part of the 2018 update, major improvements to available facility and bridge data resulted in a greatly improved data set to base the vulnerability assessments and loss estimations from. The State Office of Administration facility inventory databases for owned and leased facilities was geo-referenced with available information (latitude longitude or address). In addition, the State obtained inventories from other state departments that are not captured in the Office of Administration inventory, including MODOT, DHE, and MDC**. Table 3.169** summarizes state-owned facilities data obtained for this 2018 plan update.

Table 3.169. State Facilities Inventories

Source/Inventory	2010 # of Facilities Geolocated	2013 # of Facilities Geolocated	2018 # of Facilities Geolocated
Office of Administration/State Facilities—includes the following: • Department of Agriculture (DOA) • Department of Corrections (DOC) • Department of Economic Development (DED) • Department of Elementary and Secondary Education (DESE) • Department of Labor and Industrial Relations (DLIR) Department of Mental Health (DMH) • Department of Natural Resources (MoDNR) • Department of Revenue (DOR) • Department of Social Services (DOSS) • Department of Public Safety (DPS)	3,477 (Owned) 0 (Leased)	3,437 (Owned) 959 (Leased)	7,229 (Owned) 954 (Leased)

Source/Inventory	2010 # of Facilities Geolocated	2013 # of Facilities Geolocated	2018 # of Facilities Geolocated
• Missouri Department of Transportation (MoDOT)-facilities • Bridges	0 7,124	175 10,361	295 10,400
Department of Higher Education (DHE) /Public Colleges and Universities	143	89	455
Missouri Department of Conservation (MDC)	688	0	1,511

State-owned Bridges

In addition to inventories compiled for facilities, the inventory of State-owned bridges was obtained. This inventory consists of information on 10,400 state-owned bridges in Missouri. This inventory does include GIS information that allowed for GIS-based analysis.

State-leased Facilities

The State, through the Office of Administration, also currently leases space in 954 facilities. **Figure 3.219** provides the number of leased facilities in each county.

Figure 3.218. State-owned Facilities in Missouri

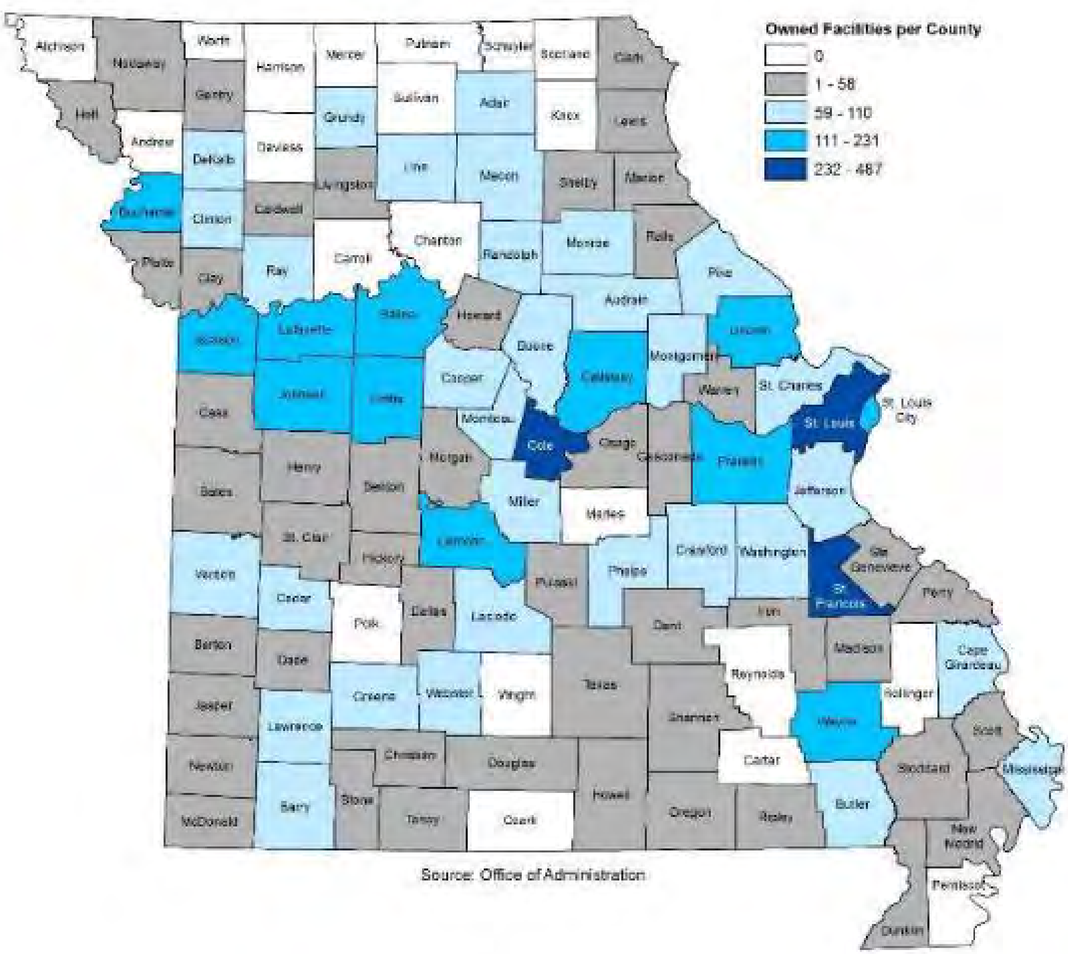
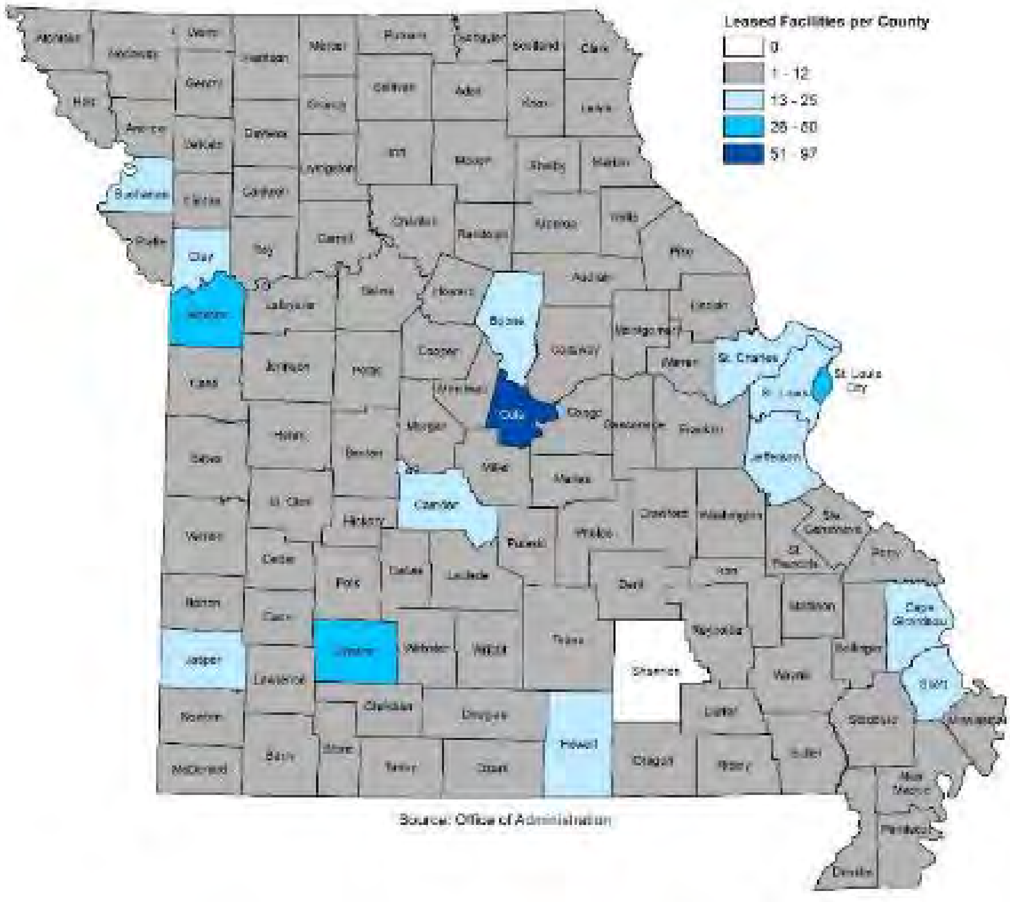


Figure 3.219. **State-leased Facilities in Missouri**

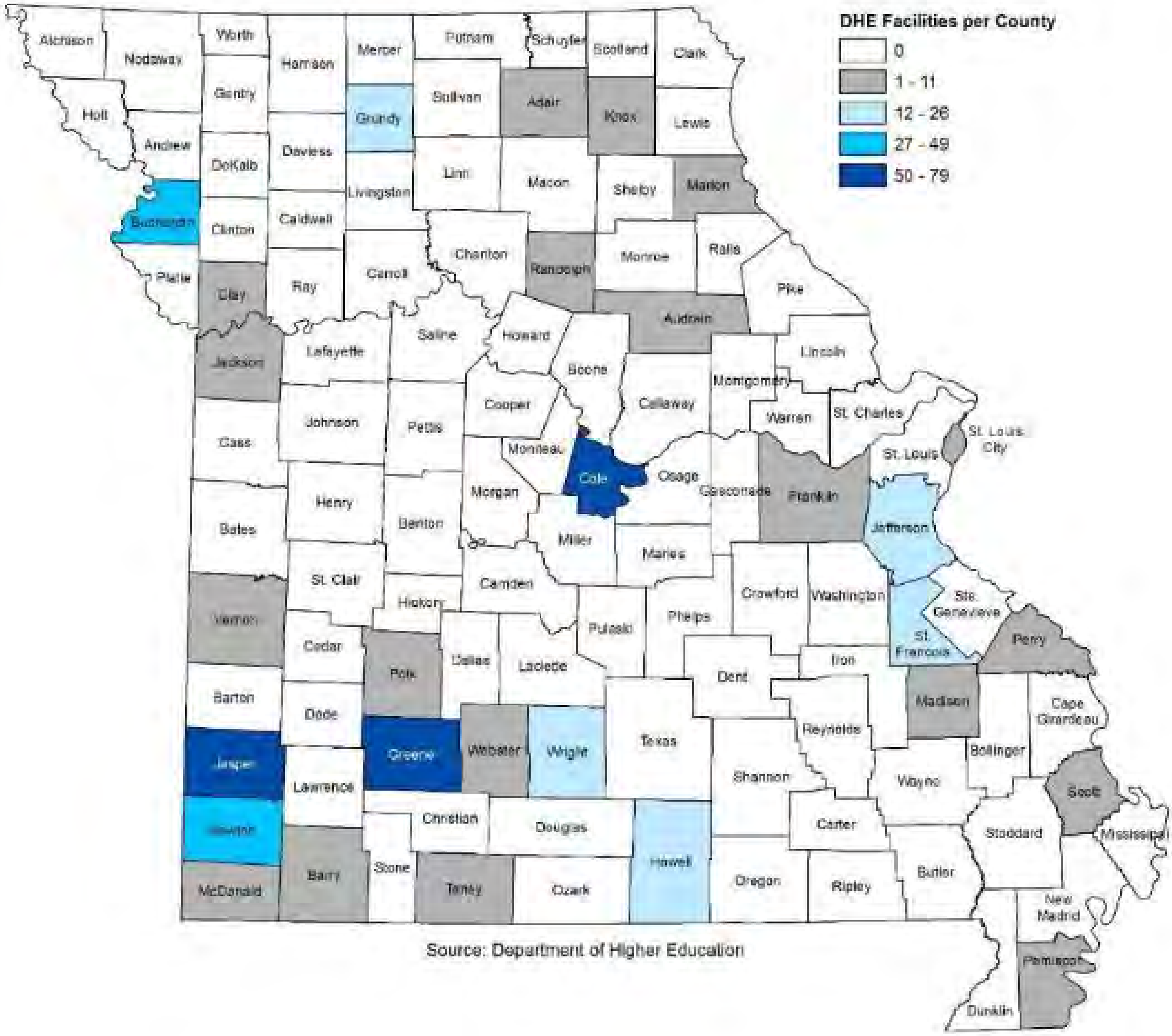


Critical Facility Determination

One of the first steps in providing for a meaningful analysis was the determination of critical facilities from the inventories available. FEMA's HAZUS-MH loss estimation software uses the following three categories of critical assets. 'Essential facilities' are those that if damaged would have devastating impacts on disaster response and/or recovery. 'High potential loss facilities' are those that would have a high loss or impact on the community. Transportation and lifeline facilities are third category of critical assets. For the facilities provided by the Office of Administration, Missouri Department of Transportation (MoDOT), and Missouri Department of Conservation (MDC) the State applied FEMA's guidelines for determining critical facilities to the asset use/facility types. For the MoDOT State Bridge Inventory, all were considered critical as were the education facilities provided by the Department of Higher Education (DHE). Not including the State bridge inventory, of the total 8,119 facilities in the remaining inventory, 1,950 were determined to be critical facilities.

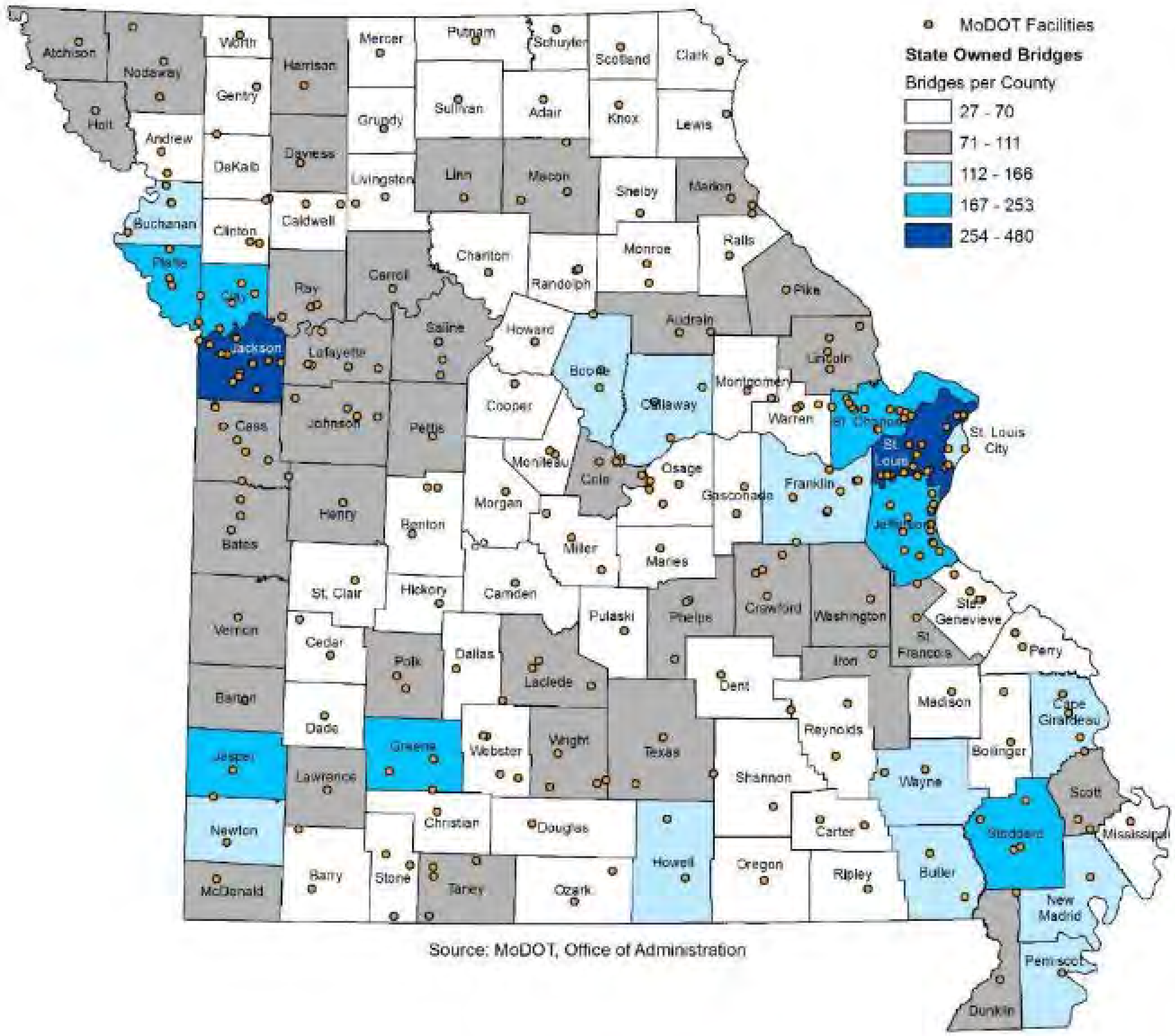
Figure 3.220 provides the locations of the education facilities provided by the Department of Higher Education. **Figure 3.221** provides the locations of the MoDOT State Bridge Inventory.

Figure 3.220. Department of Higher Education Facilities



Source: Department of Higher Education

Figure 3.221. MoDOT Facilities and State-owned Bridges



Source: MoDOT, Office of Administration

Table 3.170 lists the number of total facilities, the number of determined critical facilities, and the combined reported replacement cost summarized by state departments and divisions. The Departments of Corrections and Higher Education contain some of the largest building exposure in terms of numbers and value of facilities. Another table that follows contains similar details for state leased facilities, including annual rent instead of replacement value.

Table 3.170. State-owned Facilities and Critical Facilities by Department

State Department/division	Replacement Cost	# of Facilities	# of Critical Facilities
DED - Tourism	$1,043,520	4	1
DED - Workforce Development	$10,394,484	13	0
DESE - Special Education	$193,367,693	266	70
DHE - Higher Education	$1,996,235,560	455	455
DHM - Developmental Disabilities	$290,073,609	383	89
DLIR - Employment Security	$57,436,106	23	2
DMH - Department Of Behavioral Health	$442,196,636	274	85
DOA - State Fairgrounds	$128,989,919	159	23
DOC - Adult Institutions	$1,761,448,428	1,154	566
DOC - Probation & Parole	$56,574,632	72	26
DOR - Lottery	$11,891,287	4	0
DPS - Adjutant General	$482,757,600	846	205
DPS - Highway Patrol	$116,134,345	255	129
DPS - Veteran's Commission	$222,539,415	211	53
DSS - Youth Services	$102,265,141	334	97
MDC - Conservation	$80,401,830	1,511	175
MoDNR – Missouri Geological Survey	$9,799,955	21	4
MoDNR - Parks & Historic Preservation	$371,349,649	2,953	709
MoDOT (Bridges)	$3,141,822,000	10,400	10,400
MoDOT (Facilities)	-	295	181
OA - Facilities Management, Design, & Construction	$802,347,862	257	31
Total	$10,279,069,672	19,890	13,301

Source: Missouri OA 2017

Table 3.171. State Leased Facilities and Critical Facilities by Department

State Department/division	Total Annual Rent	# of Facilities	# of Critical Facilities
Agriculture-Leasing	$200,050	8	4
Agriculture-Operating	$624	1	1
Attorney General-Leasing	$608,529	10	4
Corrections-Leasing	$4,429,350	112	99
DIFP-Leasing	$62,037	6	2
Economic Development-Leasing	$1,765,158	30	23
Elem & Sec Education-Leasing	$1,878,125	40	35
Health & Senior Services-Leasing	$2,696,574	98	92
Judiciary-Leasing	$1,971,838	7	5

State Department/division	Total Annual Rent	# of Facilities	# of Critical Facilities
Labor & Industrial Rel-Leasing	$263,968	17	13
Labor & Industrial Rel-Operating	$519	1	1
Legislature-Leasing	$6,003	2	0
Mental Health-Leasing	$1,499,366	15	11
Natural Resources-Leasing	$1,367,336	23	9
Office Administration-Leasing	$549,014	25	16
Public Safety-Leasing	$2,376,174	220	129
Public Safety-Operating	$5,805	2	1
Revenue-Leasing	$623,313	17	8
Secretary Of State-Leasing	$468,713	7	2
Social Services-Leasing	$10,820,589	312	268
State Auditor-Leasing	$3,181	1	0
Total	$31,596,265	954	723

Source: Office of Administration

Table 3.172 provides the total number of state-owned facilities and state-leased facilities for each county in Missouri compiled from all inventories obtained. The number of determined critical facilities is also provided for both state-owned and state-leased facilities. For owned facilities, the replacement value is summarized within each county and for the leased facilities, the total annual rent is summarized.

Table 3.172. State-owned and Leased Facilities in Missouri Counties

County	Total # of State-Owned Facilities	State Owned # of Critical Facilities	State-Owned Facility Replacement Values	Total # of State-leased Facilities	State-leased # of Critical Facilities	Total Annual Rent
Adair	81	16	$13,177,493	8	7	$180,875
Andrew	0	0	$0	2	2	$10,200
Atchison	0	0	$0	6	4	$49,439
Audrain	71	28	$107,274,565	5	4	$51,702
Barry	96	24	$22,558,621	7	5	$143,847
Barton	44	11	$4,339,965	4	3	$53,179
Bates	28	10	$2,851,569	7	5	$95,523
Benton	37	13	$7,098,829	5	5	$43,435
Bollinger	0	0	$0	4	4	$27,000
Boone	81	23	$14,497,551	21	17	$1,354,916
Buchanan	213	83	$208,466,189	15	2	$233,592
Butler	90	30	$37,553,880	11	10	$374,699
Caldwell	1	0	$18,235	5	5	$29,144
Callaway	219	75	$485,063,438	6	3	$130,457
Camden	231	38	$19,694,707	13	9	$234,144
Cape Girardeau	110	33	$44,876,132	25	22	$1,233,394

County	Total # of State-Owned Facilities	State Owned # of Critical Facilities	State-Owned Facility Replacement Values	Total # of State-leased Facilities	State-leased # of Critical Facilities	Total Annual Rent
Carroll	0	0	$0	3	3	$34,324
Carter	0	0	$0	1	1	$0
Cass	23	5	$5,474,979	7	7	$278,349
Cedar	62	11	$4,293,100	6	6	$49,600
Chariton	24	10	$1,959,240	3	3	$22,355
Christian	0	0	$0	8	7	$119,040
Clark	36	9	$3,272,588	4	3	$48,994
Clay	37	15	$14,216,671	14	12	$562,504
Clinton	61	13	$27,090,330	5	4	$38,358
Cole	487	129	$811,416,599	97	50	$7,345,200
Cooper	104	44	$73,065,784	5	4	$45,321
Crawford	77	19	$7,326,526	7	6	$63,885
Dade	7	5	$3,264,999	4	4	$6,000
Dallas	34	5	$5,985,002	4	4	$38,684
Daviess	0	0	$0	3	3	$27,409
DeKalb	102	58	$179,026,433	12	10	$139,489
Dent	44	7	$7,387,872	4	4	$102,275
Douglas	1	0	$158,486	3	3	$41,467
Dunklin	8	2	$3,562,838	9	9	$246,205
Franklin	136	42	$70,254,661	7	6	$286,047
Gasconade	15	5	$2,046,438	3	2	$17,111
Gentry	15	5	$6,735,297	1	1	$0
Greene	97	24	$82,806,908	38	17	$1,933,428
Grundy	65	13	$7,158,608	6	5	$91,763
Harrison	0	0	$0	7	5	$44,939
Henry	45	13	$11,052,291	7	7	$99,969
Hickory	58	13	$6,387,591	3	3	$34,209
Holt	39	12	$3,356,020	5	3	$26,543
Howard	11	1	$1,724,780	3	3	$37,425
Howell	19	9	$6,104,187	13	13	$346,437
Iron	56	14	$3,820,396	5	3	$62,846
Jackson	221	50	$195,404,391	50	29	$2,592,150
Jasper	52	15	$25,231,348	15	14	$636,641
Jefferson	98	32	$28,784,400	15	12	$665,826
Johnson	141	34	$38,989,781	9	6	$232,505
Knox	0	0	$0	2	2	$3,660

County	Total # of State-Owned Facilities	State Owned # of Critical Facilities	State-Owned Facility Replacement Values	Total # of State-leased Facilities	State-leased # of Critical Facilities	Total Annual Rent
Laclede	71	22	$19,342,129	12	10	$186,750
Lafayette	133	38	$68,627,839	6	5	$94,892
Lawrence	65	15	$45,709,279	6	5	$108,080
Lewis	31	9	$4,204,480	4	3	$38,027
Lincoln	152	29	$22,911,729	7	5	$132,642
Linn	84	26	$4,402,703	4	4	$48,763
Livingston	34	17	$82,400,374	11	9	$108,219
Macon	96	20	$17,806,539	9	8	$294,826
Madison	9	3	$2,857,722	5	4	$61,014
Maries	0	0	$0	2	2	$12,124
Marion	52	13	$17,017,964	6	4	$104,483
McDonald	20	7	$3,035,411	5	5	$65,463
Mercer	0	0	$0	3	3	$15,846
Miller	72	41	$13,173,795	7	6	$120,672
Mississippi	66	29	$79,455,479	5	4	$140,264
Moniteau	63	33	$60,055,174	2	2	$5,561
Monroe	65	19	$8,132,201	3	2	$42,974
Montgomery	76	21	$14,138,490	4	4	$34,800
Morgan	5	3	$2,705,212	4	4	$44,606
New Madrid	45	15	$7,058,356	6	6	$100,555
Newton	13	0	$7,528,989	7	7	$200,033
Nodaway	42	20	$30,275,033	8	8	$68,103
Oregon	16	2	$197,431	6	4	$60,731
Osage	3	2	$124,962	2	2	$17,860
Ozark	0	0	$0	3	2	$53,931
Pemiscot	0	0	$0	7	7	$220,078
Perry	13	4	$3,097,425	5	4	$30,933
Pettis	195	34	$145,088,100	9	8	$255,679
Phelps	86	26	$47,987,671	9	8	$257,678
Pike	62	30	$109,934,698	4	4	$49,300
Platte	37	9	$3,012,535	6	5	$100,014
Polk	0	0	$0	7	7	$60,379
Pulaski	25	4	$1,711,824	9	7	$131,128
Putnam	0	0	$0	3	3	$15,483
Ralls	1	0	$14,297	3	3	$9,263
Randolph	106	42	$104,366,938	8	8	$135,571

County	Total # of State-Owned Facilities	State Owned # of Critical Facilities	State-Owned Facility Replacement Values	Total # of State-leased Facilities	State-leased # of Critical Facilities	Total Annual Rent
Ray	71	8	$15,001,798	4	4	$51,462
Reynolds	0	0	$0	3	2	$43,693
Ripley	14	5	$4,276,708	2	1	$13,911
Saline	186	34	$128,741,325	6	6	$703,522
Schuyler	0	0	$0	2	2	$5,940
Scotland	0	0	$0	4	4	$72,856
Scott	45	10	$16,436,082	13	13	$334,510
Shannon	28	4	$0	0	0	$0
Shelby	7	7	$895,668	3	3	$26,079
St. Charles	69	24	$44,753,953	20	18	$950,358
St. Clair	3	0	$6,924	3	2	$9,646
St. Francois	380	130	$361,871,369	9	9	$345,996
St. Louis	457	103	$316,494,648	25	16	$850,224
St. Louis City	167	42	$357,182,129	44	11	$2,486,345
Ste. Genevieve	50	15	$4,707,902	5	4	$22,200
Stoddard	28	10	$8,910,696	7	6	$175,215
Stone	6	3	$746,066	6	5	$80,741
Sullivan	0	0	$0	4	3	$33,683
Taney	28	11	$4,104,001	11	9	$231,994
Texas	48	25	$87,333,775	5	5	$101,928
Vernon	105	23	$22,423,176	12	11	$647,428
Warren	10	3	$3,225,690	6	5	$98,370
Washington	87	29	$81,204,479	5	5	$110,242
Wayne	133	31	$28,082,791	2	2	$2,658
Webster	92	42	$43,006,607	6	6	$63,770
Worth	0	0	$0	2	2	$9,300
Wright	0	0	$0	6	6	$130,966
Totals	7,229	2,090	$5,060,610,282	954	723	$31,596,265

3.5.1. Riverine Flooding (Major and Flash)

State Facilities in the 100-year Floodplain

To determine which state facilities are in the 100-year floodplain, the available GIS data was compared against the FEMA NFHL and HAZUS generated floodplains (in areas lacking FEMA maps). **Table 3.173** provides the summary results of the analysis. **Table 3.174** shows the counts of the facilities by county.

Table 3.173. All State Facilities – Flood Hazard Analysis Summary

Facility Type	Total Facilities	Critical Facilities	Value of Structures/ Leased Amount
State-leased	41	36	$1,116,776
State-owned	478	90	$466,567,614
Dept Higher Education	8	8	$21,051,050
MDC Facilities	296	11	$7,920,359
MoDOT Facilities	15	10	-
Total	838	155	$496,655,798

At a conservative loss estimate of 25 percent, damages to state-owned facilities as a result of the 100-year flood could be $124M.

Table 3.174 provides the counties with state-owned facilities in the 100-year floodplain. For each county, the total number of state-owned facilities is provided along with the number of critical state-owned facilities and the total replacement cost for all state-owned facilities in the 100-year floodplain.

Table 3.174. State-owned Facilities in the 100-year Floodplain by County

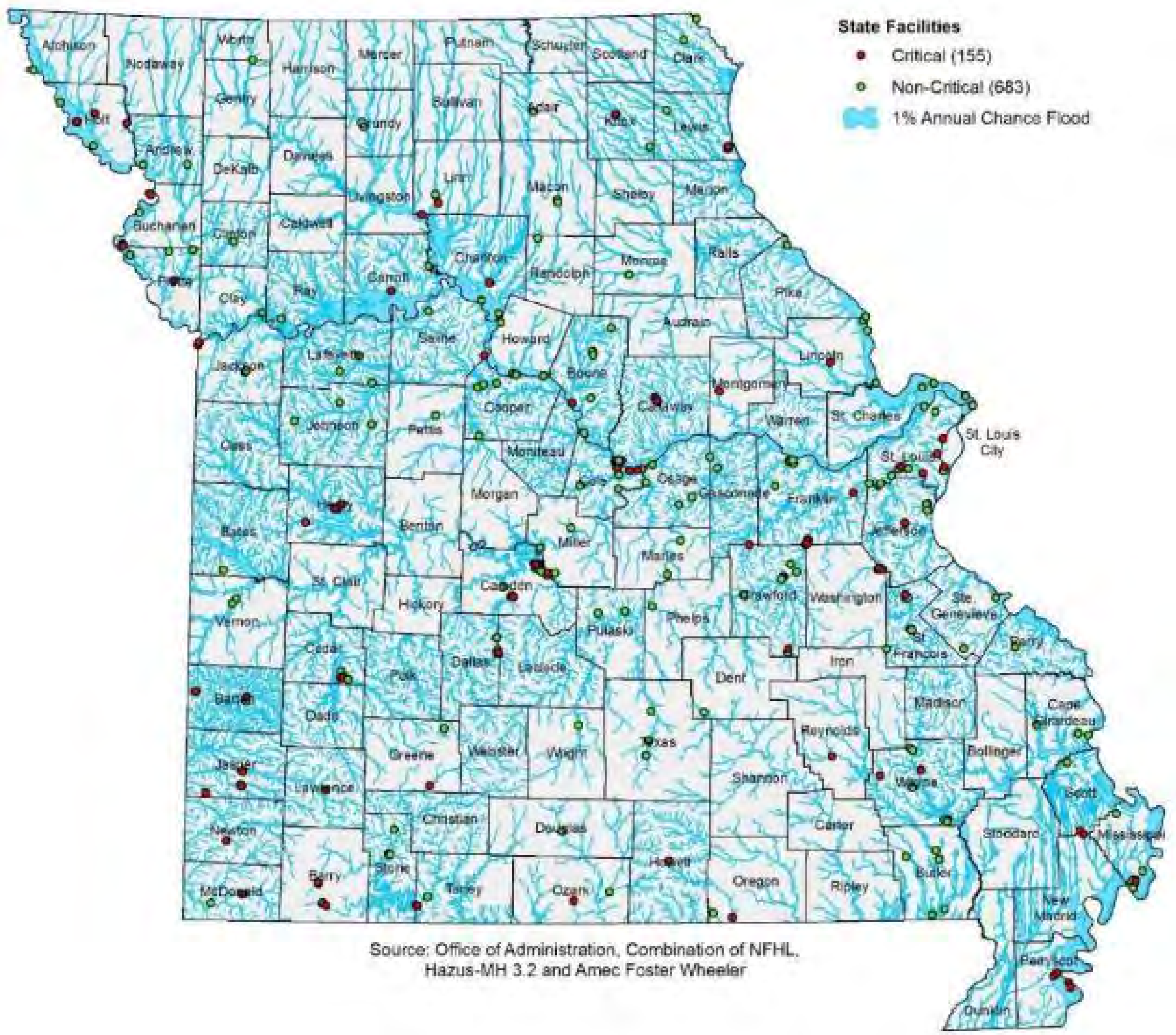
County	# of State-Owned Facilities	# of Critical State-Owned Facilities	Value of Structures
Adair	2	0	$29,839
Barry	15	3	$1,059,336
Barton	13	2	$2,890,529
Boone	8	0	$342,396
Buchanan	31	11	$20,891,874
Butler	2	0	$3,599,370
Callaway	48	15	$248,306,877
Camden	54	5	$4,446,326
Cape Girardeau	3	0	$651,161
Cedar	12	2	$656,383
Clark	1	0	$0
Cole	21	4	$131,557,914
Crawford	24	5	$714,897
Dallas	13	0	$2,411,776
Franklin	26	2	$2,345,436

County	# of State-Owned Facilities	# of Critical State-Owned Facilities	Value of Structures
Greene	1	1	$12,550
Grundy	1	0	$284,450
Henry	11	2	$3,692,167
Holt	4	2	$103,128
Howard	6	0	$1,471,049
Jackson	17	4	$26,522,204
Jasper	10	6	$2,271,904
Jefferson	12	1	$448,566
Johnson	1	0	$12,825
Laclede	4	0	$443,938
Lewis	9	1	$292,381
Lincoln	2	1	$78,048
Linn	3	1	$176,102
Macon	2	0	$38,844
McDonald	5	3	$283,370
Miller	1	0	$13,433
Mississippi	16	2	$1,558,346
Monroe	2	0	$120,027
Montgomery	1	1	$4,267
New Madrid	6	3	$788,280
Oregon	11	2	$126,733
Pettis	1	0	$9,465
Saline	6	1	$143,410
Scott	10	3	$340,465
St. Charles	6	0	$363,317
St. Francois	20	4	$740,784
St. Louis	10	1	$4,064,493
Ste. Genevieve	3	0	$391,785
Taney	4	1	$147,813
Washington	8	1	$837,579
Wayne	12	0	$881,778
Total	**478**	**90**	**$466,567,614**

Table 3.175. State-leased Facilities in the 100-year Floodplain by County

County	# of State-leased Facilities	# of Critical State-leased Facilities
Barry	4	4
Callaway	1	0
Cole	1	0
Crawford	1	1
Greene	1	0
Henry	1	1
Holt	1	1
Howell	9	9
Jasper	1	1
Newton	1	1
Ozark	2	2
Pemiscot	6	6
St. Charles	1	0
St. Louis	7	6
Stone	3	3
Wayne	1	1
Total	41	36

Figure 3.222. State Facilities in the 100-year Floodplain



Facilities from DHE, MoDOT, and MDC were also analyzed for flood risk. The results are shown in the following tables. While DHE facility count is low, there is a high value exposure in Cole County. MDC has 296 facilities in floodplains across the state worth approximately $7.9M, but only 11 are designated as critical.

Table 3.176. DHE Facilities in the 100-year Floodplain by County

County	# of Facilities	# of Critical Facilities	Value of Structures
Cole	6	6	$19,152,918
Knox	1	1	$1,368,564
Pemiscot	1	1	$529,568
Total	**8**	**8**	**$21,051,050**

Table 3.177. MoDOT Facilities in the 100-year Floodplain by County

County	# of Facilities	# of Critical Facilities	Value of Structures
Callaway	1	0	-
Carroll	1	1	-
Henry	1	1	-
Holt	1	1	-
Jackson	1	1	-
Jefferson	1	0	-
Lawrence	1	1	-
Pemiscot	1	1	-
Platte	1	0	-
Ray	1	0	-
Reynolds	1	1	-
St. Louis	3	2	-
Wayne	1	1	-
Total	15	10	-

Table 3.178. MDC Facilities in the 100-year Floodplain by County

County	# of Facilities	# of Critical Facilities	Value of Structures
Andrew	2	0	$17,750
Atchison	1	0	$2,700
Bates	3	0	$26,451
Boone	13	1	$1,904,426
Buchanan	1	0	$7,500
Butler	5	0	$176,025
Callaway	1	0	$623,300
Camden	4	0	$54,750
Cape Girardeau	4	0	$131,000
Carroll	1	0	$7,500
Cedar	1	0	$350
Chariton	5	2	$14,500
Clark	5	0	$66,330
Clay	3	0	$18,000
Clinton	1	0	$11,595
Cole	8	0	$119,861
Cooper	12	0	$55,250
Crawford	3	0	$21,250
Dallas	7	0	$60,000
Dent	6	0	$307,138

County	# of Facilities	# of Critical Facilities	Value of Structures
Douglas	2	0	$9,500
Franklin	6	0	$77,507
Gasconade	2	0	$45,500
Henry	9	2	$88,319
Holt	23	1	$1,698,125
Howard	2	0	$55,000
Jackson	6	0	$106,700
Jefferson	1	0	$7,000
Johnson	4	0	$56,380
Knox	15	0	$41,232
Laclede	8	1	$873,267
Lafayette	10	0	$132,214
Lincoln	3	0	$26,400
Livingston	39	2	$474,017
Maries	3	0	$28,640
McDonald	1	0	$12,000
Miller	3	0	$47,300
Mississippi	2	0	$0
Osage	3	0	$35,000
Ozark	4	0	$31,700
Perry	6	0	$67,600
Phelps	1	0	$0
Pike	5	0	$27,040
Platte	15	2	$97,962
Pulaski	2	0	$11,820
Randolph	10	0	$106,831
Scott	4	0	$30,500
St. Charles	3	0	$3,880
St. Francois	1	0	$25,250
St. Louis	4	0	$26,500
Stone	3	0	$0
Taney	3	0	$12,680
Texas	3	0	$28,500
Vernon	2	0	$4,200
Worth	1	0	$3,800
Wright	1	0	$2,320
Total	**296**	**11**	**$7,920,359**

3.5.2. Levee Failure

A GIS location analysis was conducted to identify state facilities within areas of reduced flood risk due to levees. Two GIS data sets were used for levee protected areas. The National Flood Hazard Layer includes levee protected areas that are certified for 1% annual chance flood protection. A National Levee Inventory Database provided by the US Corps of Engineers shows other levee protected areas that may not be certified and includes a much larger area. The value field in the tables below present the value of assets exposed as a general indication of potential loss. Loss would vary depending on the extent and depth of flooding at a particular location. The total value of structures is provided.

Table 3.179. State Facilities in Levee Protected Areas – FEMA National Flood Hazard Layer

County	# of Facilities	# of Critical Facilities	Value of Structures
Owned			
Scott	5	1	$5,319,278
Ste. Genevieve	10	1	$1,282,693
Subtotal	15	**2**	**$6,601,970**
Leased			
Clay	1	1	---
Scott	13	13	---
Subtotal	**14**	**14**	---

Table 3.180. State Facilities in Levee Protected Areas – Corp National Levee Inventory Hazard Layer

County	# of Facilities	# of Critical Facilities	Value of Structures
Owned			
Buchanan	38	16	$21,819,403
Butler	1	0	$3,595,931
Callaway	17	2	$10,167,485
Dunklin	7	2	$3,543,810
Holt	27	7	$1,650,361
Howard	6	0	$1,471,049
Jackson	17	4	$26,522,204
Lewis	30	9	$4,126,168
Mississippi	65	29	$79,314,255
New Madrid	45	15	$7,058,356
Ray	2	1	$741,650
Scott	11	3	$4,288,662
St. Charles	5	0	$280,457
Ste. Genevieve	11	1	$1,302,679
Stoddard	14	4	$5,066,551
Subtotal	**296**	**93**	**$170,949,021**
Leased			
Callaway	1	0	---
Clay	1	1	---

County	# of Facilities	# of Critical Facilities	Value of Structures
Dunklin	9	9	$246,205
Mississippi	5	4	$140,264
New Madrid	6	6	$100,555
Pemiscot	7	7	$220,078
St. Charles	1	0	$0
Ste. Genevieve	1	1	$900
Subtotal	**31**	**28**	**$769,387**

Table 3.181. DHE and MODOT Facilities in Levee Protected Areas – FEMA National Flood Hazard Layer

County	# of Facilities	# of Critical Facilities	Value of Structures
DHE Facilities			
Jackson	1	1	$0
Scott	1	1	$419,783
DHE Total	2	2	$419,783
MODOT Facilities			
Scott	2	2	-
St. Charles	1	0	-
St. Louis City	1	1	-
Total	4	3	-

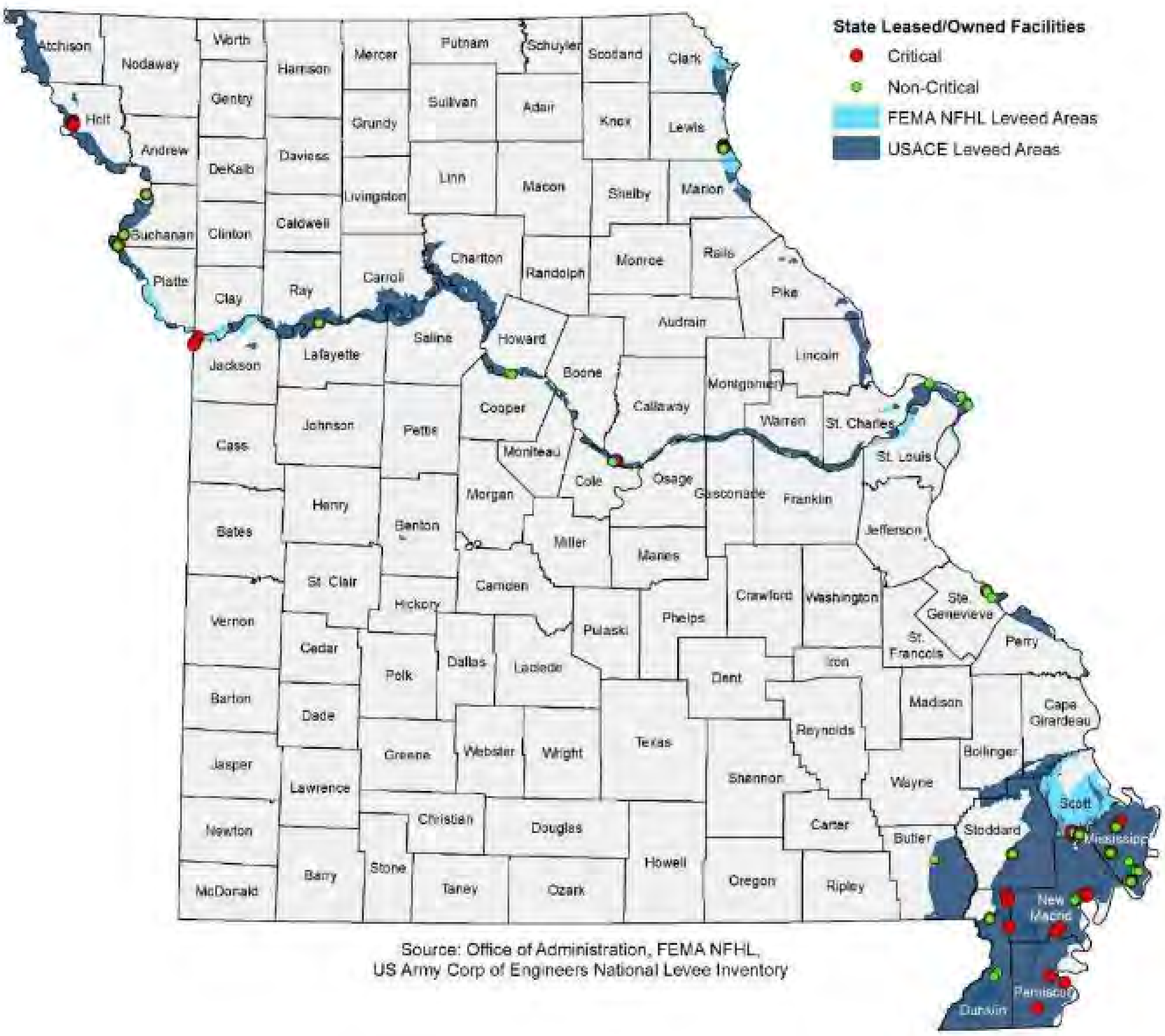
Table 3.182. DHE and MODOT Facilities in Levee Protected Areas – Corp National Levee Inventory Hazard Layer

County	# of Facilities	# of Critical Facilities	Value of Structures
DHE Facilities			
Jackson	1	1	$0
Pemiscot	1	1	$529,568
St. Louis City	1	1	$808,172
Subtotal	3	3	$1,337,740
MODOT Facilities			
Butler	1	1	-
Callaway	1	0	-
Carroll	1	1	-
Dunklin	2	2	-
Jackson	1	1	-
Mississippi	1	1	-
New Madrid	1	1	-
Pemiscot	1	1	-
Scott	2	2	-
St. Charles	1	0	-
St. Louis City	1	1	-
Subtotal	13	11	-

Table 3.183. MDC Facilities in Levee Protected Areas – Corp National Levee Inventory Hazard Layer

County	# of Facilities	# of Critical Facilities	Value of Structures
Bollinger	38	3	$285,660
Boone	12	1	$1,871,426
Butler	3	0	$62,400
Callaway	1	0	$623,300
Dunklin	1	0	$18,000
Holt	5	0	$639,300
Howard	1	0	$45,000
Lincoln	1	0	$11,000
Mississippi	14	1	$12,000
New Madrid	4	2	$25,788
Pemiscot	8	2	$179,750
Platte	3	0	$9,200
Saline	7	0	$1,471,330
St. Charles	2	0	$3,880
St. Louis	12	2	$2,065,215
Total	**112**	**11**	**$7,323,249**

Figure 3.223. State Owned and Leased Facilities in Areas Protected by Levee



Source: Office of Administration, FEMA NFHL,
US Army Corp of Engineers National Levee Inventory

Figure 3.224. DHE, MODOT and MDC Facilities in Areas Protected by Levee

3.5.3. Dam Failure

State facilities potentially vulnerable to dam failure were identified by their location within available State-regulated dam inundation areas from MoDNR and USACE dam inundation areas. This refined analysis resulted in 505 total state-owned facilities in potential inundation zones, and 42 leased facilities. No DHE education facilities or MoDOT facilities intersected the inundation zones. A total of 255 MDC facilities (13 designated as critical) worth $14M intersected the inundation zones. **Table 3.184, Table 3.186** provide additional details regarding state facilities and total replacement value summarized by county and **Figure 3.225** shows the locations.

Table 3.184. State-owned Facilities in Inundation Zones of USACE dams by County

County	# of State-Owned Facilities	# of Critical State-Owned Facilities	Value of Structures
Adair	2	0	$29,839
Benton	4	3	$0
Boone	8	0	$54,017
Buchanan	41	16	$24,026,781
Butler	15	4	$10,113,058
Callaway	65	18	$237,581,716

County	# of State-Owned Facilities	# of Critical State-Owned Facilities	Value of Structures
Camden	71	6	$5,711,501
Clark	6	1	$490,081
Clay	1	0	$273,130
Cole	142	35	$422,751,516
Cooper	5	3	$286,630
Franklin	7	0	$1,905,432
Gasconade	8	3	$1,587,967
Holt	39	12	$3,356,020
Howard	7	0	$1,497,170
Jackson	21	5	$26,804,475
Lewis	11	3	$537,657
Macon	1	1	$153
Miller	1	0	$13,433
Platte	19	5	$1,917,386
Ray	2	1	$741,650
Saline	12	1	$282,083
St. Charles	6	0	$363,317
St. Louis	5	3	$59,450
Taney	6	3	$2,382,743
Total	**505**	**123**	**$742,767,204**

Table 3.185. Leased Facilities in Inundation Zones of USACE dams by County

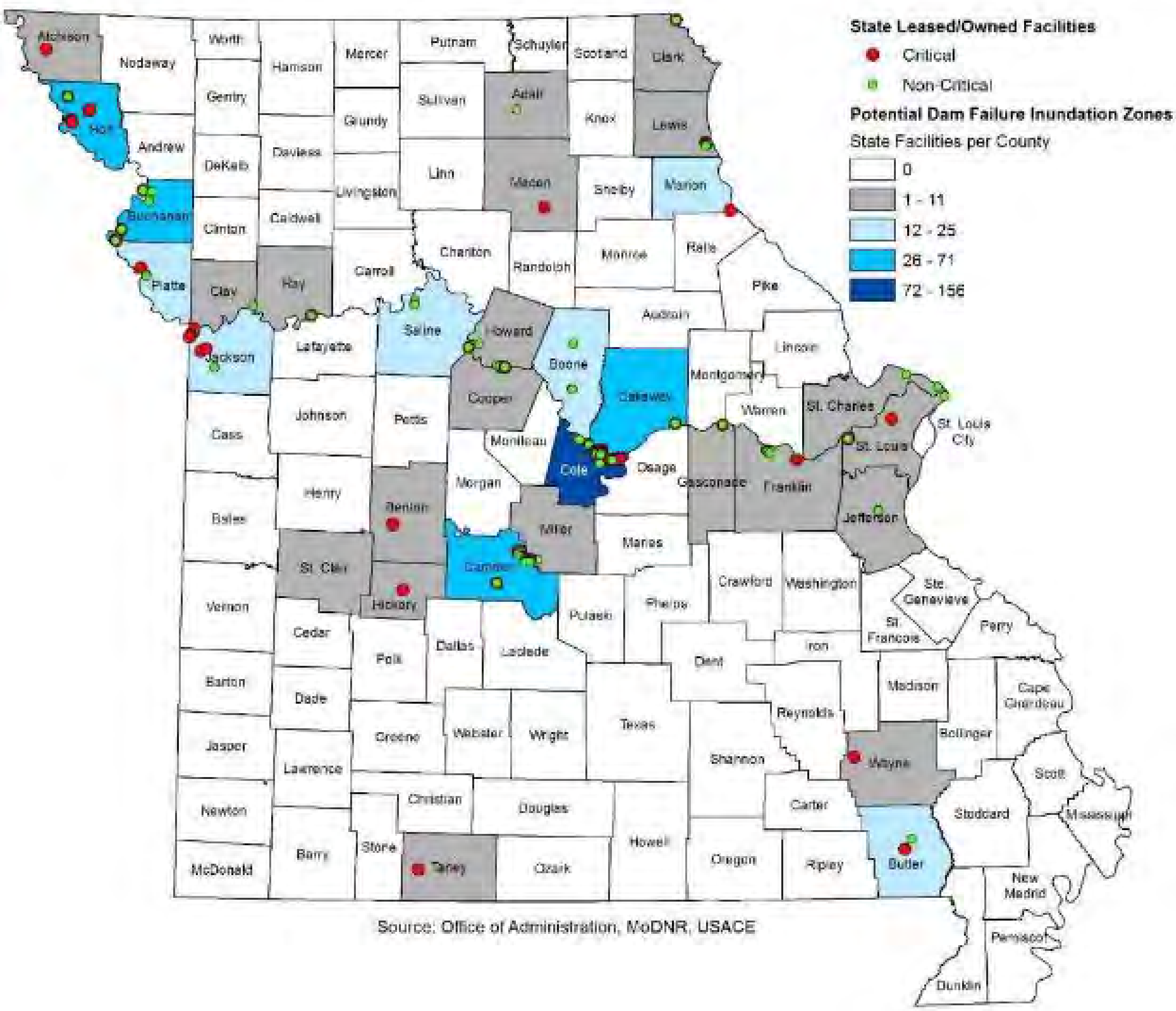
County	# of State-Leased Facilities	# of Critical State-Leased Facilities
Atchison	2	2
Benton	2	2
Buchanan	1	0
Callaway	1	0
Clay	1	1
Cole	14	1
Cooper	4	3
Franklin	2	2
Hickory	3	3
Holt	3	3
Jackson	4	3
St. Charles	1	0
St. Louis	1	1
Taney	2	0
Wayne	1	1
Total	**42**	**22**

Table 3.186. State-owned Facilities Within Inundation Areas of State Regulated Dams

County	# of State-Owned Facilities	# of Critical State-Owned Facilities	Value of Structures
Adair	2	0	$29,839
Boone	6	0	$164,667
Jefferson	4	0	$50,601
Marion	13	5	$4,202,126
Total	**25**	**5**	**$4,447,233**

A precise loss estimate based on depth-damage information for state-owned facilities in potential dam inundation areas was not possible due to data limitations. However, the exposure of state facilities as an estimate of potential losses from dam failure is high.

Figure 3.225. State Facilities in Potential Dam Failure Inundation Zones



3.5.4. Earthquakes

Potential for Damage to State-owned Facilities Resulting from Earthquake

This analysis was limited to the facilities with available GIS data from the Office of Administration, and MoDOT bridges. Based on the resulting Modified Mercalli Intensity and the corresponding Peak-Ground Acceleration (PGA), perceived shaking and potential damage classifications were determined. **Table 3.187** provides the perceived shaking and potential damage classifications for the Modified Mercalli Intensity and approximate corresponding PGA.

Table 3.187. Ground Shaking and Potential Damage Classifications

Modified Mercalli Intensity	Acceleration (%g) (PGA)	2% Map Contour Range (%g) (PGA)	Perceived Shaking	Potential Damage
I	<0.17	0-2	Not felt	None
II	0.17 – 1.4	0-2	Weak	None
III	0.17 – 1.4	0-2	Weak	None
IV	1.4 – 3.9	2-4	Light	None
V	3.9 – 9.2	4-10	Moderate	Very Light
VI	9.2 – 18	10-18	Strong	Light
VII	18 – 34	18-30	Very Strong	Moderate
VIII	34 – 65	30-60	Severe	Moderate to Heavy
IX	65 – 124	60-120	Violent	Heavy
X	>124	120-160	Extreme	Very Heavy
XI	>124	160- 200	Extreme	Very Heavy
XII	>124	200	Extreme	Very Heavy

Facilities

To determine the State owned facilities at risk to earthquake and loss estimates, the USGS ground shaking grid contour map with a 2% probability of exceedance in the next 50 years was compared against the locations of State-owned and leased facilities provided in GIS format from the Office of Administration and Department of Higher Education. GIS analysis enabled the potential peak ground acceleration (PGA) (as expressed as % of gravity) with a 2% probability of exceedance in the next 50 years event to be assigned to each facility. Based on the PGA for each state-facility, the perceived shaking and potential damage classifications were applied. To generate potential loss estimates, a percent loss was applied to the potential damage classifications in the following manner: Very Light-10 percent, Light-20 percent, Moderate-30 percent, Moderate to Heavy-40 percent, Heavy-50 percent, and Very Heavy-60 percent. By applying the percent loss to the replacement values of the State-owned facilities, this analysis resulted in approximately estimated $802,063,414,900M in damages as a result of the earthquake scenario with a 2% probability of exceedance in the next 50 years. It should be noted that only the structure replacement value was considered in this loss estimate as contents value was not available. If contents value had been included, the loss estimate would be much higher. **Table 3.188** provides the summary results of this analysis. Site-specific information resulting from this analysis is available to authorized users at the following link: state-owned facilities earthquake analysis (password protected).

Table 3.188. State-owned Facilities and Earthquake Potential Damage

Potential Damage Classification	# of Facilities	# of Critical Facilities	Total Replacement Value	Estimated Damage
Very Heavy	156	54	$102,949,917	$61,769,950
Heavy	121	32	$70,312,515	$35,156,257
Moderate to Heavy	685	201	$289,957,280	$115,982,912
Moderate	1,213	338	$1,040,184,668	$312,055,401
Light	623	204	$254,335,112	$50,867,022
Very Light	4,295	1,216	$3,259,975,130	$325,997,513
None	136	45	$42,895,659	$0
Total	7,229	2,090	$5,060,610,282	$901,829,056

Table 3.189. State-leased Facilities and Earthquake Potential Damage

Potential Damage Classification	# of Facilities	# of Critical Facilities
Very Heavy	40	39
Heavy	40	36
Moderate to Heavy	42	35
Moderate	118	69
Light	112	97
Very Light	561	413
None	41	34
Total	**954**	**723**

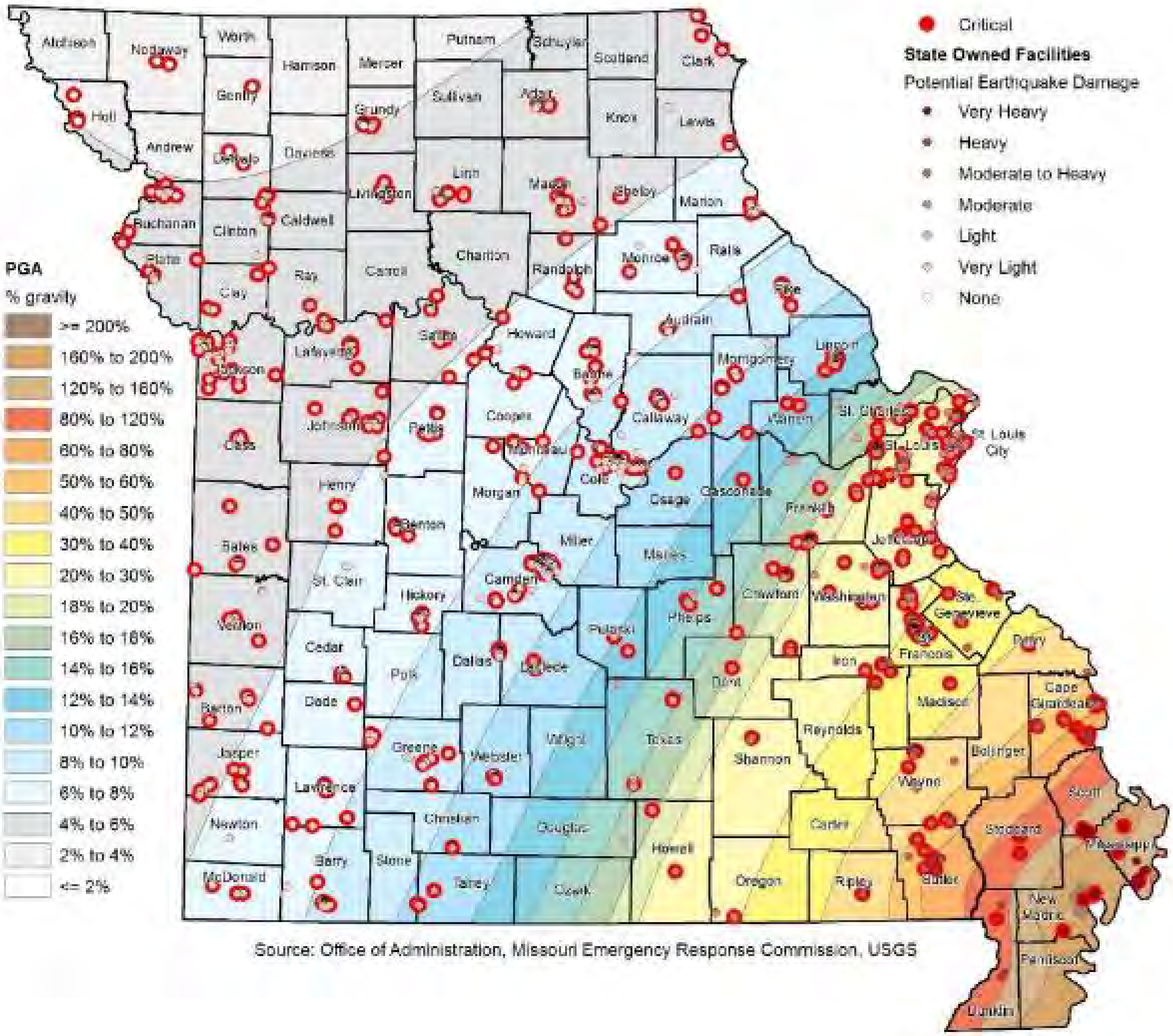
Table 3.190 provides a summary of the State-owned facilities in 25 counties that could receive moderate, moderate to heavy, heavy, or very heavy damages. For each county, the total number of state-owned facilities in these categories is provided along with the number of critical state-owned facilities in each category. **Figure 3.226** details the location of these facilities.

Table 3.190. State-owned Facilities With Resulting Earthquake Potential Damages of Moderate and Higher Reported by County

County	Total Moderate and Higher	Very Heavy		Heavy		Moderate to Heavy		Moderate	
		Total	Critical	Total	Critical	Total	Critical	Total	Critical
Butler	90	-	-	41	9	49	21	-	-
Cape Girardeau	110	-	-	44	11	66	22	-	-
Crawford	65	-	-	-	-	-	-	65	15
Dent	44	-	-	-	-	-	-	44	7
Dunklin	8	-	-	8	2	-	-	-	-
Franklin	106	-	-	-	-	-	-	106	36
Howell	8	-	-	-	-	-	-	8	3
Iron	56	-	-	-	-	50	12	6	2

County	Total Moderate and Higher	Very Heavy		Heavy		Moderate to Heavy		Moderate	
Jefferson	98	-	-	-	-	-	-	98	32
Madison	9	-	-	-	-	9	3	-	-
Mississippi	66	66	29	-	-	-	-	-	-
New Madrid	45	45	15	-	-	-	-	-	-
Oregon	16	-	-	-	-	-	-	16	2
Perry	13	-	-	-	-	13	4	-	-
Ripley	14	-	-	-	-	14	5	-	-
Scott	45	45	10	-	-	-	-	-	-
Shannon	28	-	-	-	-	-	-	28	4
St. Charles	52	-	-	-	-	-	-	52	21
St. Francois	380	-	-	-	-	301	88	79	42
St. Louis	457	-	-	-	-	-	-	457	103
St. Louis City	167	-	-	-	-	-	-	167	42
Ste. Genevieve	50	-	-	-	-	50	15	-	-
Stoddard	28	-	-	28	10	-	-	-	-
Washington	87	-	-	-	-	-	-	87	29
Wayne	133	-	-	-	-	133	31	-	-
Totals	**2,175**	**156**	**54**	**121**	**32**	**685**	**201**	**1,213**	**338**
Butler	90	-	-	41	9	49	21	-	-
Cape Girardeau	110	-	-	44	11	66	22	-	-

Figure 3.226. State-owned Facilities with Potential Earthquake Damages Moderate and Above based on Ground Shaking with a 2% Probability of Exceedance in 50 years



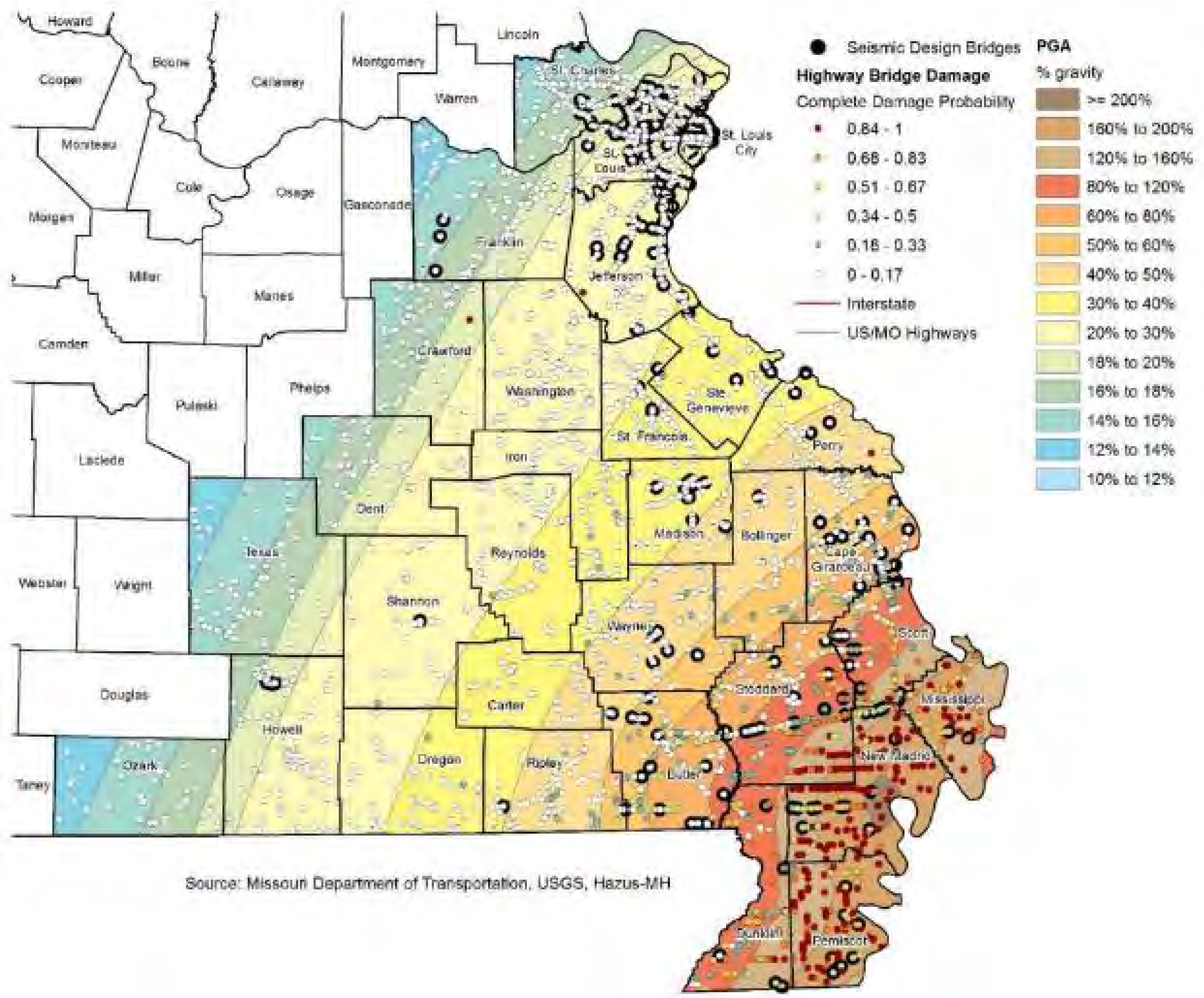
During the 2017-18 update an enhanced analysis was performed for bridges, hazardous materials facilities and essential facilities (schools, fire and medical facilities to further refine the vulnerability assessment to identify areas that may warrant further analysis or targeted mitigation. Default Hazus inventories for bridges were replaced with data supplied by MoDOT. The results are detailed in Appendix C. In addition to the analysis of facilities from the Office of Administration and the Department of Higher Education that were available in GIS format, the State analyzed information provided by the Missouri Department of Transportation regarding state-owned bridges. It should be noted that MoDOT considers risk to seismic activity in the design and construction of all new bridges in Missouri. In addition, as older bridges are retrofitted, MoDOT considers incorporation of seismic design standards. This analysis does not differentiate those bridges that have been seismically retrofitted or built to modern design standards.

Table 3.191 provides the counts of state-owned bridges by PGA range according to the seismic event with a 2% probability of exceedance in 50 years. The table below summarizes the average damage probability for bridges by county for high risk counties. Counties where over 50% of the bridges are likely to be completely damaged are highlighted in the table. This includes Dunklin, New Madrid, Mississippi, and Pemiscot counties. **Figure 3.227** provides the locations of the bridges in critical counties with sorted in PGA Ranges.

Table 3.191. State-owned Bridges Earthquake Potential Damages 2% in 50 Years Scenario

Counties	Average for Damage State					
	Bridge Counts	None	Slight	Moderate	Extensive	Complete
Bollinger	65	0.56	0.17	0.09	0.1	0.08
Butler	136	0.39	0.16	0.13	0.14	0.18
Cape Girardeau	147	0.5	0.17	0.11	0.12	0.11
Carter	43	0.71	0.13	0.07	0.05	0.04
Crawford	86	0.88	0.06	0.03	0.01	0.02
Dent	60	0.83	0.09	0.04	0.03	0.01
Dunklin	110	0.11	0.09	0.1	0.18	0.52
Franklin	134	0.86	0.07	0.04	0.02	0.01
Howell	123	0.87	0.07	0.03	0.02	0.01
Iron	80	0.76	0.12	0.05	0.04	0.03
Jefferson	189	0.78	0.09	0.06	0.04	0.03
Madison	67	0.68	0.15	0.07	0.06	0.04
Mississippi	61	0.04	0.06	0.06	0.15	0.7
New Madrid	148	0.03	0.04	0.04	0.11	0.77
Oregon	58	0.72	0.14	0.06	0.05	0.03
Ozark	46	0.82	0.09	0.04	0.03	0.02
Pemiscot	135	0.02	0.04	0.05	0.12	0.76
Perry	51	0.62	0.14	0.1	0.07	0.07
Reynolds	64	0.75	0.12	0.06	0.04	0.03
Ripley	70	0.61	0.14	0.08	0.09	0.08
Scott	99	0.19	0.13	0.13	0.17	0.38
Shannon	43	0.72	0.12	0.07	0.05	0.03
St. Charles	199	0.88	0.06	0.04	0.01	0.01
St. Francois	87	0.75	0.12	0.07	0.04	0.03
St. Louis	165	0.86	0.07	0.04	0.02	0.02
St. Louis City	468	0.85	0.07	0.04	0.02	0.01
Ste. Genevieve	64	0.71	0.12	0.08	0.06	0.04
Stoddard	188	0.19	0.14	0.1	0.17	0.41
Texas	85	0.86	0.07	0.04	0.02	0.01
Washington	95	0.85	0.07	0.04	0.02	0.01
Wayne	121	0.64	0.16	0.08	0.07	0.05

Figure 3.227. MoDOT State-Owned Bridges Damage Probability based on Ground Shaking with a 2% Probability of Exceedance in 50 years



3.5.5. Land Subsidence/Sinkholes

During the 2018 Plan update GIS data was available for sinkholes to determine proximity of State-owned facilities. State Owned and Leased facilities were compared to the sinkhole GIS layer supplied by Missouri Department of Natural Resources (MoDNR), Missouri Geological Survey (MGS), Geological Survey Program (GSP), Environmental Geology Section (EGS). Six facilities, one critical, were located in potential sinkhole hazard areas as summarized in the following table. No state leased, MDC, or MoDOT facilities were identified as potentially vulnerable.

Table 3.192. State Owned Facilities Potentially Vulnerable to Sinkholes

County	# of Facilities	# of Critical Facilities	Value of Structures
Laclede	3	1	$3,599,035
Oregon	3	0	$101,944
Total	6	1	$3,700,979

3.5.6. Drought

Structures that are part of the State-owned facility inventory are not directly vulnerable to losses as a result of drought. However, the shrink-swell cycle that occurs as soils swell during wet periods and shrink during drought periods can cause damage to MoDOT roads and bridges as well as other concrete components, and structure foundations. In Missouri, the majority of impacts associated with drought are to the agricultural sector, not facilities. However, the conservation areas owned and operated by the Missouri Department of Conservation would be impacted as streams, lakes, and ponds can shrink in size or completely dry up causing death to fish and other wildlife and loss of recreation-based revenue. Another potential vulnerability could be state-owned fish hatcheries.

3.5.7. Extreme Temperatures

The vulnerability of state-owned or leased buildings or facilities to extreme temperatures is difficult to quantify. Extreme cold can sometimes result in burst water pipes if mitigative measures are not taken, which can result in water damage. Extreme does not typically impact buildings but does place additional stress on HVAC components. Asphalt parking lots and roads are routinely damaged during periods of extreme heat as the hot asphalt becomes less rigid and can be displaced by heavy equipment or automobiles.

3.5.8. Severe Thunderstorms (includes damaging winds, hail and lightning)

The counties in **Table 3.193** below are those counties that received a High or Medium-High vulnerability rating for Severe Thunderstorms. The table provides the total number of state-owned facilities in these counties as well as the number of facilities determined to be critical and the total replacement value. Potential annualized damages were determined utilizing the annualized loss ratios for high wind, hail, and lightning as developed in **Section 3.3.8**. Information is also provided for the number of state-leased facilities in these counties and the number of leased facilities determined to be critical.

Table 3.193. State-owned and Leased Facilities in Counties with High and Medium-High Vulnerability to Severe Thunderstorms

Thunderstorm	County	Total Owned Facilities	Owned Critical Facilities	Value of Structures	Potential Annualized Damages	Total Leased Facilities	Critical Leased Facilities
Medium High	Barry	96	24	$22,558,621	$1,888.16	7	5
Medium High	Boone	81	23	$14,497,551	$25.81	21	17
Medium High	Cape Girardeau	110	33	$44,876,132	$1,892.43	25	22
Medium High	Christian	24	10	$1,959,240	$137.38	8	7
Medium High	Douglas	1	0	$158,486	$45.57	3	3
High	Greene	97	24	$82,806,908	$2,316.94	38	17
Medium High	Howell	19	9	$6,104,187	$343.48	13	13
High	Jackson	221	50	$195,404,391	$2,407.38	50	29
High	Jasper	52	15	$25,231,348	$713.04	15	14
Medium High	Jefferson	98	32	$28,784,400	$14.10	15	12
Medium High	Laclede	71	22	$19,342,129	$734.61	12	10

Thunderstorm	County	Total Owned Facilities	Owned Critical Facilities	Value of Structures	Potential Annualized Damages	Total Leased Facilities	Critical Leased Facilities
Medium High	Newton	13	0	$7,528,989	$282.86	7	7
Medium High	Ozark				$0.00	3	2
High	St. Charles	69	24	$44,753,953	$10,542.69	20	18
High	St. Louis	457	103	$316,494,648	$92,653.81	25	16
Medium High	St. Louis City	167	42	$357,182,129	$585.78	44	11
Medium High	Stone	6	3	$746,066	$42.49	6	5
Medium High	Taney	28	11	$4,104,001	$84.95	11	9
	Total	**1,610**	**425**	**$1,172,533,181**	**$114,711**	**323**	**217**

MoDOT has 92 (44 critical) facilities within the High or Medium-High vulnerability rated counties; MDC has 405 (50 critical) facilities worth $43M, and DHE has 243 facilities worth $1.5B exposed in counties most vulnerable to thunderstorms.

3.5.9. Severe Winter Weather

The counties in **Table 3.194** below are those counties that received a High or Medium-High vulnerability rating for Severe Winter Weather. The table provides the total number of state-owned facilities in these counties as well as the number of facilities determined to be critical and the total replacement value. Information is also provided for the number of state-leased facilities in these counties and the number of leased facilities determined to be critical.

Table 3.194. State-owned and Leased Facilities in Counties with High Vulnerability to Severe Winter Weather

County	Total Owned Facilities	Owned Critical Facilities	Value of Structures	Total Leased Facilities	Critical Leased Facilities
Butler	90	30	$37,553,880	11	10
Camden	231	38	$19,694,707	13	9
Cape Girardeau	110	33	$44,876,132	25	22
Clay	37	15	$14,216,671	14	12
Dunklin	8	2	$3,562,838	9	9
Franklin	136	42	$70,254,661	7	6
Greene	97	24	$82,806,908	38	17
Jackson	221	50	$195,404,391	50	29
Mississippi	66	29	$79,455,479	5	4
New Madrid	45	15	$7,058,356	6	6
Pemiscot	0	0	$0	7	7
Ripley	14	5	$4,276,708	2	1
Scott	45	10	$16,436,082	13	13
St. Charles	69	24	$44,753,953	20	18
St. Louis	457	103	$316,494,648	25	16

County	Total Owned Facilities	Owned Critical Facilities	Value of Structures	Total Leased Facilities	Critical Leased Facilities
St. Louis City	167	42	$357,182,129	44	11
Stoddard	28	10	$8,910,696	7	6
Wayne	133	31	$28,082,791	2	2
Total	**1,954**	**503**	**$1,331,021,030**	**298**	**198**

3.5.10. Tornadoes

The counties in **Table 3.195** below are those counties that received a High vulnerability rating for Tornadoes. The table provides the total number of state-owned facilities in these counties as well as the number of facilities determined to be critical and the total replacement value. Information is also provided for the number of state-leased facilities in these counties and the number of leased facilities determined to be critical.

Table 3.195. State-owned and Leased Facilities in Counties with High Vulnerability to Tornadoes

County	Total Owned Facilities	Owned Critical Facilities	Value of Structures	Total Leased Facilities	Critical Leased Facilities
Barry	96	24	$22,558,621	7	5
Butler	90	30	$37,553,880	11	10
Clay	37	15	$14,216,671	14	12
Greene	97	24	$82,806,908	38	17
Howell	19	9	$6,104,187	13	13
Jackson	221	50	$195,404,391	50	29
Jasper	52	15	$25,231,348	15	14
Newton	13	0	$7,528,989	7	7
St. Charles	69	24	$44,753,953	20	18
St. Louis	457	103	$316,494,648	25	16
St. Louis City	167	42	$357,182,129	44	11
Total	**1,318**	**336**	**$1,109,835,725**	**244**	**152**

3.5.11. Wildfires

During the 2018 Plan update an analysis was performed to identify state facilities within a high interface or high intermix wildland fire zone based on the SILVIS hazard data. These are summarized in the table that follows. There were not any DHE or MODOT facilities identified in a high wildland fire hazard zone.

Table 3.196. Facilities Within a High Wildfire Hazard Zone

SILVIS Fire Hazard	County	# of Facilities	# of Critical Facilities	Value of Structures
Owned Facilities				
High_Interface	Adair	6	1	$3,550,230
High_Interface	Camden	4	1	$654,646
High_Interface	Gasconade	7	3	$1,005,139
High_Interface	Grundy	19	6	$1,429,854
High_Interface	Jefferson	6	5	$3,223,570
High_Interface	Johnson	18	5	$3,594,784
High_Interface	Platte	12	5	$1,733,154
High_Interface	St. Francois	8	5	$5,184,437
	SubTotal	80	31	$20,375,816
Leased Facilities				
High_Interface	Adair	1	1	---
High_Interface	Buchanan	11	0	---
High_Interface	Crawford	1	1	---
High_Interface	Franklin	1	1	---
High_Interface	Wayne	1	1	---
	SubTotal	15	4	---
MDC Facilities				
High_Interface	Texas	2	1	---
	SubTotal	2	1	---

Source: Wood E&IS 2017

3.5.12. Scour Critical Bridges

The State analyzed information provided by the Missouri Department of Transportation regarding scour critical state-owned bridges. Scour critical bridges are those bridges that are vulnerable to scour during a flood. Bridge scour is the removal of sediment such as sand and rocks from around bridge abutments or piers. Scour is caused by swiftly moving water and can scoop out scour holes, compromising the integrity of the bridge. The National Bridge Inventory uses a classification system of 0-3 to indicate the potential for scour. Bridges in the 0-1 categories are those that are at or near failure due to scour; those in the 2-3 categories are vulnerable to scour and determined to be unstable. There are a total of 221 scour critical bridges that are a category 3 out of the inventory of 10,400 total state-owned bridges. There are no category 0-2 bridges in the inventory. **Table 3.197** provides the counts of state-owned bridges with the scour rating of 3. **Figure 3.228** provides the locations of these bridges across the State.

Table 3.197. Count of State-owned Scour Critical Bridges

Scour Class	# of Bridges	Value of Bridges
3	221	$519,625,000

Figure 3.228. MoDOT State-Owned Flood Scour Critical Bridges

3.5.13. Attack (Nuclear, Conventional Chemical, and Biological)

Data is not available to quantify vulnerability or estimated losses as a result of attack incidents that might impact state-owned facilities

3.5.14. Civil Disorder

Civil disorder can occur at random times and locations. As a result, it is difficult to specify state-owned or operated facilities that may be impacted by this hazard. Incarcerated populations can be more prone to civil disorder as a concentrated group of high-risk individuals. Therefore, the State-owned correctional facilities with incarcerated populations could be considered to be at higher risk to civil disorder than other state-owned facilities. There are 189 state-owned facilities that were identified as areas where groups of incarcerated individuals are located at times. There were no state-leased facilities with incarcerated populations at the site. The state-owned facilities with incarcerated populations are located in the following Missouri counties in **Table 3.198**.

Table 3.198. State-owned Facilities with Incarcerated Populations

County	# of Facilities w/ Incarcerated Persons
Audrain	6
Buchanan	4
Callaway	12
Clark	13
Cole	34
DeKalb	21
Dunklin	12
Franklin	14
Gentry	6
Howard	13
Laclede	9
Livingston	6
Marion	1
Mississippi	7
Nodaway	1
Randolph	5
St. Francois	14
St. Louis	4
St. Louis City	1
Webster	6
Worth	1
Total	**190**

3.5.15. Cyber Disruptions

Data is not available to quantify vulnerability or estimated losses as a result of cyber disruption incidents that might impact state-owned facilities. Any state-owned/operated facility that uses computers to provide services/conduct business is at risk to cyber disruption incidents, whether intentional or accidental. In Missouri, the Information Technology Services Division (ITSD), which is part of the Office of Administration (OA), provides direct IT support to nearly all the state government agencies that are under the umbrella of Missouri's 14 IT-consolidated departments. During the 2016 legislative session, ITSD received additional ongoing funding for cyber security from Governor Nixon and the General Assembly. These funds are being used by ITSD's team of cyber security professionals as they enhance the state's cyber security systems and train state employees in cyber security best practices. Within ITSD, the Office of Cyber Security (OCS) is responsible for managing all cyber security related events within the enterprise and ensuring proper administrative and technical controls are implemented to safeguard the State of Missouri's information system (State of Information Technology in Missouri, 2015, https://oa.mo.gov/information-technology-itsd).

According to the 2015 State of Information Technology in Missouri report published by ITSD, during an average month, the state's intrusion prevention system blocks over two million attacks. In early 2015, the OCS developed a threat intelligence (intel) sharing portal for internal state staff and associated business partners with the state. The portal enables OCS to share threat intel to others quickly and effectively. The portal is meant to raise awareness throughout the state community about the adversaries the state faces and to provide meaningful and actionable intel so others can quickly protect themselves from similar attacks. Since the launch of this portal, OCS has shared over 1,200 pieces of intelligence.

Cyber impacts on State and national infrastructure organizations such as utility companies which provide critical services could cause widespread impacts. It is reported that the deregulated energy market may be most susceptible to cyber impacts. Power supply impacts have been noted in a variety of national studies and were common in news reports in the past number of years. It should be noted that many utilities are working to increase infrastructure security to reduce these risks.

3.5.16. Hazardous Materials Release (Fixed Facility Accidents)

Risk to state facilities was modeled by a GIS buffer analysis to determine state facilities within 0.5 miles of a Tier II hazardous materials facility.

Table 3.199 summarizes the State-owned facilities within 0.5 miles of Tier II hazardous materials facilities, followed by a table summarizing state-leased facilities. The analysis shows that a large number of facilities are in the buffer zone, 4,892 total. An additional 402 DHE, 176 MDC and 205 MoDOT facilities are within the buffer zone.

Table 3.199. State-owned facilities within 0.5 miles of Tier II hazardous Materials Facilities

County	Total Owned Facilities	Owned Critical Facilities	Value of Structures
Adair	48	14	$10,610,263
Audrain	54	23	$84,782,561
Barry	22	4	$3,554,473
Barton	14	3	$987,051
Bates	10	1	$1,853,514
Benton	12	5	$1,060,508
Boone	31	8	$2,768,076
Buchanan	183	74	$203,642,188
Butler	52	20	$19,286,922
Callaway	185	68	$472,305,256
Camden	64	11	$4,689,499
Cape Girardeau	56	17	$18,219,088
Cass	18	4	$4,753,538
Cedar	11	3	$677,944
Clinton	9	5	$1,696,999

County	Total Owned Facilities	Owned Critical Facilities	Value of Structures
Cole	413	103	$735,525,005
Cooper	102	43	$69,215,308
Crawford	43	10	$5,226,347
Dade	7	5	$3,264,999
Dallas	14	2	$2,123,800
DeKalb	56	28	$103,954,366
Dent	44	7	$7,387,872
Dunklin	7	2	$3,543,810
Franklin	70	28	$62,065,032
Gasconade	12	3	$1,922,234
Gentry	15	5	$6,735,297
Greene	61	17	$52,133,584
Grundy	38	11	$5,547,390
Henry	29	9	$7,070,867
Hickory	3	1	$193,754
Holt	12	5	$1,705,659
Howard	6	1	$1,606,089
Howell	8	3	$2,792,817
Iron	3	1	$167,340
Jackson	165	39	$179,197,790
Jasper	33	7	$17,394,593
Jefferson	48	17	$17,895,990
Johnson	70	19	$34,865,518
Laclede	53	17	$15,339,489
Lafayette	113	34	$65,280,268
Lawrence	33	8	$35,001,450
Lewis	9	3	$492,316
Lincoln	34	11	$8,379,084
Linn	10	5	$1,198,456
Livingston	15	6	$4,954,969
Macon	41	10	$11,083,303
Madison	9	3	$2,857,722
Marion	46	12	$12,692,049
McDonald	3	2	$0
Miller	52	31	$9,484,958
Mississippi	45	27	$77,807,944

County	Total Owned Facilities	Owned Critical Facilities	Value of Structures
Moniteau	56	29	$59,409,733
Monroe	18	6	$2,071,457
Montgomery	52	12	$13,206,958
New Madrid	17	6	$2,900,153
Newton	13	0	$7,528,989
Nodaway	33	16	$26,180,831
Oregon	8	2	$63,602
Pettis	150	25	$119,859,744
Phelps	85	26	$46,929,061
Pike	61	29	$109,934,698
Platte	17	6	$1,988,091
Randolph	13	4	$5,172,172
Ray	69	7	$14,260,148
Ripley	14	5	$4,276,708
Saline	143	29	$123,538,648
Scott	25	6	$9,915,512
St. Charles	23	8	$27,425,274
St. Francois	174	80	$229,114,193
St. Louis	192	45	$158,763,114
St. Louis City	143	36	$301,089,087
Ste. Genevieve	29	9	$3,532,534
Stoddard	9	5	$3,116,859
Stone	6	3	$746,066
Taney	28	11	$4,104,001
Texas	46	25	$87,127,100
Vernon	92	17	$18,856,360
Warren	6	1	$3,105,322
Washington	25	13	$61,424,915
Webster	54	22	$32,046,968
Total	**4,092**	**1,278**	**$3,874,683,649**

Table 3.200. State –leased Facilities within 0.5 miles of Tier II hazardous Materials Facilities

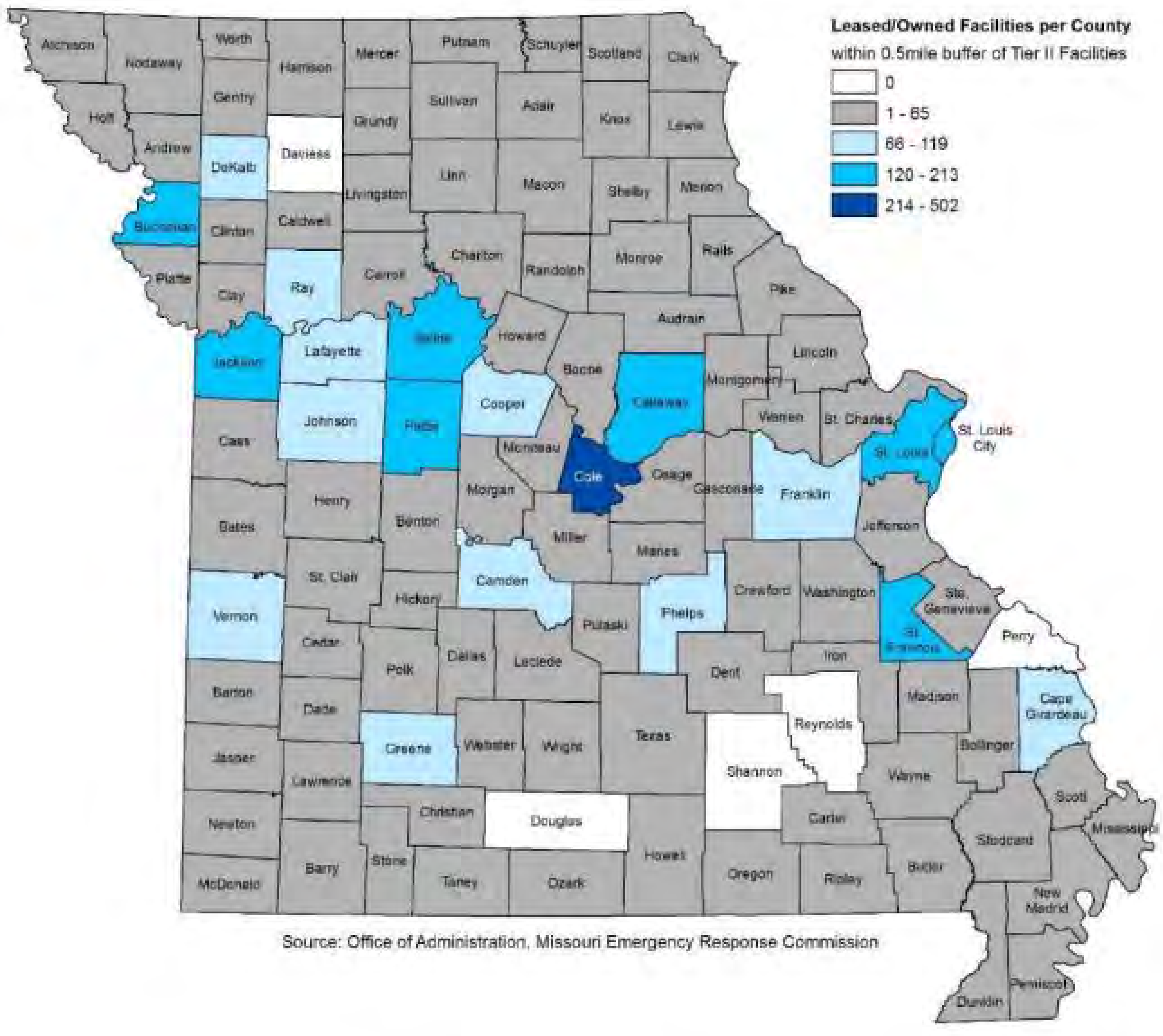
County	Total Owned Facilities	Owned Critical Facilities	Value of Structures
Adair	5	5	$126,162
Andrew	2	2	$10,200

County	Total Owned Facilities	Owned Critical Facilities	Value of Structures
Atchison	6	4	$49,439
Audrain	4	4	$51,700
Barry	5	4	$83,847
Barton	4	3	$53,179
Bates	6	5	$91,923
Benton	5	5	$43,435
Bollinger	4	4	$27,000
Boone	18	17	$1,324,219
Buchanan	14	2	$221,072
Butler	11	10	$374,699
Caldwell	5	5	$29,144
Callaway	6	3	$130,457
Camden	13	9	$234,144
Cape Girardeau	20	18	$1,136,398
Carroll	3	3	$34,324
Carter	1	1	$0
Cass	6	6	$183,069
Cedar	4	4	$42,000
Chariton	3	3	$22,355
Christian	6	5	$88,094
Clark	4	3	$48,994
Clay	12	11	$544,680
Clinton	1	1	$0
Cole	89	44	$6,274,229
Cooper	5	4	$45,321
Crawford	5	5	$61,342
Dade	4	4	$6,000
DeKalb	12	10	$139,489
Dent	4	4	$102,275
Dunklin	8	8	$231,055
Franklin	5	5	$271,544
Gasconade	2	2	$15,479
Gentry	1	1	$0
Greene	34	16	$1,802,146
Grundy	6	5	$91,763
Harrison	7	5	$44,939

County	Total Owned Facilities	Owned Critical Facilities	Value of Structures
Henry	7	7	$99,969
Hickory	3	3	$34,209
Holt	3	3	$10,545
Howard	3	3	$37,425
Howell	3	3	$52,790
Iron	3	3	$33,806
Jackson	45	25	$2,174,440
Jasper	14	14	$635,441
Jefferson	8	8	$306,408
Johnson	9	6	$232,505
Knox	2	2	$3,660
Laclede	11	9	$186,250
Lafayette	6	5	$94,892
Lawrence	6	5	$108,080
Lewis	3	3	$24,023
Lincoln	5	5	$131,980
Linn	4	4	$48,763
Livingston	10	9	$94,308
Macon	9	8	$294,826
Madison	4	4	$45,712
Maries	2	2	$12,124
Marion	6	4	$104,483
McDonald	5	5	$65,463
Mercer	3	3	$15,846
Miller	6	5	$115,872
Mississippi	4	3	$104,514
Moniteau	2	2	$5,561
Monroe	2	2	$28,970
Montgomery	3	3	$34,200
Morgan	2	2	$10,336
New Madrid	6	6	$100,555
Newton	6	6	$200,032
Nodaway	3	3	$21,937
Oregon	4	3	$48,131
Osage	2	2	$17,860
Ozark	3	2	$53,931

County	Total Owned Facilities	Owned Critical Facilities	Value of Structures
Pemiscot	7	7	$220,078
Pettis	9	8	$255,679
Phelps	8	8	$256,656
Pike	4	4	$49,300
Platte	5	5	$100,013
Polk	7	7	$60,379
Pulaski	8	7	$114,435
Putnam	3	3	$15,483
Ralls	3	3	$9,263
Randolph	6	6	$127,188
Ray	4	4	$51,462
Ripley	2	1	$13,911
Saline	5	5	$449,281
Schuyler	2	2	$5,940
Scotland	4	4	$72,856
Scott	13	13	$334,510
Shelby	3	3	$26,079
St. Charles	16	16	$836,556
St. Clair	3	2	$9,646
St. Francois	7	7	$291,996
St. Louis	21	13	$790,674
St. Louis City	43	10	$2,440,775
Ste. Genevieve	4	4	$21,300
Stoddard	5	4	$116,819
Sullivan	3	3	$23,843
Taney	3	1	$19,280
Texas	1	1	$500
Vernon	11	11	$559,393
Warren	3	3	$60,270
Washington	5	5	$110,242
Wayne	1	1	$2,658
Webster	6	6	$63,770
Worth	2	2	$9,300
Wright	6	6	$130,966
Total	**800**	**617**	**$27,276,460**

Figure 3.229. State Facilities Within 0.5 Miles of a Tier II Facility



3.5.17. Mass Transportation Accidents

Transportation accidents do not impact state-owned facility building structures, however they can impact state-owned roads and bridges. Roads are not typically damaged by transportation accidents. But, bridge railings and other structures can sustain damages. Data is not available to estimate future damages.

3.5.18. Nuclear Power Plants (Emergencies and Accidents)

Table 3.201 below lists the facilities within a 10-mile radius of the two nuclear power plants (Callaway and Cooper) that could impact Missouri in the event of an emergency or accident. This table provides counts and values of state-owned facilities as well as counts of state-leased facilities.

Table 3.201. State-owned and Leased Facilities in Counties within 10-mile Radius of Nuclear Power Plants

County	Total State-owned Facilities	Critical State-owned Facilities	Total State-leased facilities	State-leased Critical Facilities	Value of Structures
Atchison	0	0	4	3	---
Callaway	91	41	NA	NA	$116,186,784
Montgomery	3	2	0	0	$124,962

3.5.19. Public Health Emergencies/Environmental Issues

State-owned facilities are not directly impacted by this hazard. However, the Missouri Department of Health and Senior Services would be heavily involved in response to a pandemic incident. A research review was conducted to determine if there was additional non-quantifiable data that could add information or provide a better understanding of vulnerability of facilities. This information is provided for review purposes only and has not been incorporated into the mitigation analysis. The review showed that while state-owned facilities are not directly impacted by this hazard, the citizens and communities in which these facilities reside could be directly and indirectly impacted. The information determined to be of significance is provided below.

First, a public health or environmental incident could provide a primary impact; the most common and most recent experience would be that of a severe or pandemic influenza event. A severe event could have an impact to a widespread segment of the population and could remain a threat for a long period of time. The Missouri Department of Health and Senior Services would be heavily involved in response to a pandemic incident. Many State agencies and programs exist to help citizens and businesses prepare for and reduce transmission risks. Medical information is available, particularly during flu season and at all times citizens are encouraged to create family plans, and to keep informed on current events that may impact them and their homes. Other incidents that would have a public health and environmental impact would be terrorist attacks using nuclear, biological or chemical materials. The results from even minor incidents of these types would have large impacts on the surrounding environment and could indirectly impact state facilities.

Secondly, a review of available information does show that a public health or environmental emergency could emerge as the result of another incident or event. For example, poor sanitary conditions and the lack of sanitation in the aftermath of a weather related event such as a hurricane or tornado could lead to an increase in waterborne illness or more serious impacts. Critical to the recovery process is ensuring that public health issues are immediately addressed to reduce the risk of such incidents occurring.

3.5.20. Special Events

Data is not available to quantify vulnerability or estimated losses as a result of incidents at special events. However, special events do occur at state-owned facilities on an ongoingbasis. The State of Missouri is home to thirteen public universities. In addition, there are thirty-nine private four-year institutions in the state. These universities host special events regularly throughout the year. These include athletic events, visits from high-profile individuals and large gatherings like graduations. These occurrences are generally open to the public, and thus can expose a large number of people to a potential event.

In addition to the universities within the state, Missouri is home to multiple professional sports teams. While the teams are privately owned, many of the stadiums in which they play receive public funds. These teams generally draw crowds in the tens of thousands. These large crowds are drawn into public areas, and can expose the attendees to a variety of hazards. The Scottrade Center (Home to the St. Louis Blues) is an enclosed arena, and can help protect attendees from weather-related events like thunderstorms, winter storms, etc. Busch Stadium (home to the St. Louis Cardinals) is an open-air stadium; this leaves attendees exposed to the potential weather hazards like thunderstorms, excessive heat and high wind events.

Regardless of the venue, or the time of year, large public gatherings will leave attendees susceptible to a variety of hazards. Attendees can be susceptible while traveling to and from these events. Special events present a strain to community and state resources by their very nature. The addition of a weather-related or other hazard can serve to exacerbate the situation.

3.5.21. Terrorism

Data is not available to quantify vulnerability or estimated losses as a result of terrorism incidents that might impact state-owned facilities. However, a research investigation was conducted to determine if there was additional non-quantifiable data that could add information or provide a better understanding of vulnerability of facilities. This information is provided for review purposes only and has not been incorporated into the mitigation analysis. The information determined to be of significance is provided below.

The 2012 Threat and Hazard Identification and Risk Assessment (THIRA) identifies major threats for the State of Missouri as well as the implications for the state should an event occur. Chemical Terrorist Attack (Non-Food) is listed as one of the hazards applicable for the State of Missouri. The report quantifies the potential for impact as the entire state of Missouri consisting of 114 Counties, 961 cities, 9 regions, 69,704 sq/mi and 6,010,688 people (Missouri Office of Homeland Security, 2012). A terrorist attack could impact any portion of the land, population, or any state facility, depending on the scale of the event.

Missouri is home to a wealth of organizations that focus on homeland security and counterterrorism. The state has three fusion centers that gather, analyze, and share intelligence information, and has more than one Joint Terrorism Task Force (JTTF). Two centers, the St. Louis Terrorism Early Warning Group fusion center and the Kansas City Regional TEW Interagency Analysis Center keep inventories of the critical infrastructure and key resources in each region. The critical infrastructure information is protected in order to safeguard the facilities from terrorist attacks. A protective security advisor from the Department of Homeland Security (DHS) is stationed in St. Louis in order to assist the region in protecting critical infrastructure. One of the important functions of the DHS advisor is to conduct building or property security assessments with owners of infrastructure. The state implemented Regional Homeland Security Oversight Committees (RHSOC) that covers the same nine regions as the Highway Patrol Troop. The FBI has field offices in both St. Louis and Kansas City, but also have remote offices scattered throughout the rest of the state (Priest and Arkin, 2013).

Missouri's State Emergency Management Agency (SEMA) has organized a Homeland Security Regional Response System (HSRRS) to improve emergency response to various hazards and build capabilities, including terrorist neutralization as a region. An initiative called Project Homeland has started in Missouri and three other pilot states to collect intelligence and GIS data from various agencies to assist in protecting critical infrastructure in Missouri (Missouri Office of Homeland Security, 2013).

Though state facilities in Missouri are still vulnerable to terrorist attack, the planning mechanisms, organizations, agencies, and resources that are organized within the state help to reduce the overall risk as well as mitigate the impact should an event occur.

3.5.22. Utilities (Interruptions and System Failures)

The primary impact to state-owned facilities as a result of the loss of utilities is the inability to provide continuous state government services. The Office of Administration Facilities Management, Design & Construction (FMDC) manages many of the state owned facilities in Missouri. The State uses physical and environmental security controls in order to protect their systems from data loss due to utility interruption. State agencies are instructed to maintain battery backup power onsite in addition to a 24 hour fuel supply for power generators if they are present at facilities (MOA, 2007). Another guideline suggests that state facilities should consider providing an uninterruptible power source (UPS) to maintain operations during events (MSU, 2012).

Utility interruptions can occur in any part of the state at any time of year. Harsh weather conditions such as lightning strikes, high winds, heavy rain, and ice storms can cause trees to fall and damage electric power lines and equipment or gas lines. The National Weather Service produces an Ice Impact Index to estimate the potential utility interruptions based on the weather conditions prior to an ice storm. The index ranges from 1 to 5 and increases in severity as it increases in number, estimating that the potential for longer outages increases as the conditions worsen. Though the vulnerability of state- owned facilities has not yet been quantified, it could be estimated for discrete events by using this index (NWS, 2012). Earthquakes are another natural hazard that can lead to utility service interruption. The same state facilities vulnerable to earthquakes are also vulnerable to utility interruption or failure. See Section 3.7.4 for Earthquake Facility Vulnerability.

In Macon, Missouri, part of their combined heat and power system (CHP) can be used to disconnect from the local grid if there is an outage in order to continue running an ethanol plant. The system is owned and operated by the City, and has kept the plant running during recent outages (USCHPA, 2010).

SEMA has emergency generators that they can loan out to critical state or private facilities as needed during events. This reduces the overall vulnerability of facilities when they can rely on back-up power sources until the main systems are restored (SEMA, 2013).

3.6. References

References and data sources are provided below, as well as, in Appendix A2, *Vulnerability Analysis Data Sources*.

General

- Missouri State Highway Patrol Statistical Analysis Center, http://www.mshp.dps.missouri.gov/MSHPWeb/SAC/Compendium/TrafficCompendium.html
- Missouri Commercial Motor Vehicles Involved Crashes by Annual Percentage
- 2015 Crashes Involving Commercial Motor Vehicles by Crash Severity and Personal Injury Severity
- Missouri Department of Public Safety, Organizational Chart. http://dps.mo.gov/dir/programs/ohs/documents/OHSOverview05-17-13.pdf
- Southern Poverty Law Center, Identified Hate Groups in Missouri.
- U.S. Department of State, Foreign Terrorist Organizations. http://www.state.gov/j/ct/rls/other/des/123085.htm
- Electronic Mass Casualty Assessment and Planning Scenarios (EMCAPS), Johns Hopkins University.
- Federal Aviation Administration
- Passenger Boarding (Enplanement) and All-Cargo Data for U.S. Airports, https://www.faa.gov/airports/planning_capacity/passenger_allcargo_stats/passenger/
- Primary and Non-Primary Commercial Service Airports, https://www.faa.gov/airports/central/about_airports/ce_airports/missouri/
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Flooding

- "The Response, Recovery and Lessons Learned from the Missouri Floods of 1993 and 1994." SEMA
- "After Action Report. The 1995 Missouri Flood." SEMA
- Preliminary Damage Assessment Reports, multiple events. FEMA
- 1Romero-Lankao, Patricia, et al., et al. Summary for Policy Makers. In: Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part B: Regional Aspects. Contribution of Working Group II to the Fifth

Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge: Cambridge University Press, 2014. pp. 1439-1498.

- Environmental Protection Agency: What Climate Change Means for Missouri, August 2016, EPA 430-F-16-027, https://www.epa.gov/sites/production/files/2016-09/documents/climate-change-mo.pdf
- The Bootheel Regional Planning and Economic Development Commission "The Historic Flood of 2011"
- SEMA. "The Response, Recovery and Lessons Learned from the Missouri Floods of 1993 and 1994."
- SEMA. "After Action Report. The 1995 Missouri Flood."

Levee Failure

- U.S. Army Corps of Engineers, National Levee Database; http://nld.usace.army.mil/egis/f?p=471:58:994716546449901::NO
- FEMA, National Flood Hazard Layer
- FEMA, Levee Accreditation Status
- National Weather Service, Flood Response Levels/Activities; and http://www.nwrfc.noaa.gov/floods/papers/oh_2/great.htm
- Preliminary Report of the Scientific Assessment and Strategy Team, 1994

Dam Failure

- USACE National Inventory of Dams as reported to the Homeland Security Infrastructure Program Freedom Database, version 2015
- Missouri Department of Natural Resources State-regulated dam inventory as reported to the Missouri Spatial Data Inventory System, supplemented with additional state hazard class information from the Dam Safety Program
- U.S. Army Corps of Engineers, Available inundation Areas of USACE dams impacting Missouri+
- U.S. Army Corps of Engineers, Available Risk Evaluation Summaries
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4 COMPREHENSIVE STATE HAZARD MITIGATION PROGRAM

Contents

4. Comprehensive State Hazard Mitigation Program

This chapter describes the State's Comprehensive State Hazard Mitigation Program including the hazard mitigation goals and objectives that frame and focus the mitigation strategy, mitigation actions and strategy for reducing repetitive flood losses, funding sources, the State capability assessment to implement the mitigation strategy, and the local capability assessment.

4.1. Hazard Mitigation Goals and Objectives

Requirement §201.4(c)(3)(i): [The state mitigation strategy shall include a] description of state goals to guide the selection of activities to mitigate and reduce potential losses.

Plan Update Requirement §201.4(d): [The] plan must be reviewed and revised to reflect changes in development, progress in statewide mitigation efforts and changes in priorities.

The purpose of this section is to describe the goals and objectives of the state mitigation program. In order to be effective, these goals and objectives must be achievable and they must complement both state and local mitigation strategies. They also play a role in the State's overall mitigation strategy through a balanced review and prioritization of proposed mitigation projects.

The results of these mitigation efforts are important to state and local governments, public-private partnerships, and the general public. By establishing reasonable goals and objectives, those involved in the planning process can see their efforts realized which can make a difference in other mitigation efforts.

Section 4.1.1 identifies the primary goals and objectives for the State's hazard mitigation program in prioritized order. The goals and objectives reflect the mature nature of SEMA's established statewide hazard mitigation program and have evolved over several years of state mitigation planning efforts. SEMA encourages its partners to consider these mitigation goals when developing local mitigation plans and other plans.

4.1.1. State of Missouri Mitigation Goals and Objectives

<u>Goal 1: Implement mitigation actions that improve the protection of human life, health, and safety from the adverse effects of disasters</u>

1.1. Maintain a robust mitigation program that addresses ways to mitigate the loss of life from disaster events. (This includes supporting the development and funding of mitigation plans and sensible mitigation projects to reduce the effects of natural hazards, future flooding, eliminate repetitive flood losses, improve safety and reduce losses during severe weather events, mitigate losses due to earthquakes, minimize losses due to terrorism, and reduce risk and losses due to high wind, tornadoes, winter storms, drought, high heat, and fire.)

1.2. Strengthen cooperation with SEMA's mitigation partners and help educate them about mitigation.

1.3. Support the development of sensible enabling legislation, programs, and capabilities of federal, state, and local governments and public-private partnerships engaged in mitigation activities.

1.4. Increase public awareness of disaster risks and effective mitigation measures that protect human life.

1.5. Maintain a high level of mitigation proficiency among SEMA staff.

Goal 2: Implement mitigation actions that improve the continuity of government and essential services from the adverse effects of disasters

2.1. Support the development of sensible mitigation projects to protect key and essential facilities and services.

2.2. Continue to educate federal, state, and local public officials; educational institutions; private associations; and private business entities that provide essential services about hazards and how mitigation can reduce losses and help maintain continuity.

2.3. Educate state and local officials concerning the need to use sensible mitigation techniques for new facility construction.

2.4. Encourage maximum participation in maintaining effective state and local mitigation plans, disaster plans, and business continuity plans.

2.5. Encourage federal, state, and local officials; educational institutions; private associations; and private business entities that provide essential services to incorporate mitigation into other plans.

Goal 3: Implement mitigation actions that improve the protection of public and private property from the adverse effects of disasters

3.1. Maintain an effective mitigation program that addresses ways to mitigate the loss of property from disaster events. (This includes supporting the development and funding of mitigation plans and sensible mitigation projects to reduce the effects of natural hazards, future flooding, eliminate repetitive flood losses, improve safety and reduce losses during severe weather events, mitigate losses due to earthquakes, minimize losses due to terrorism, and reduce risk and losses due to high wind, tornadoes, winter storms, drought, high heat, and fire.)

3.2. Strengthen cooperation with SEMA's mitigation partners and help educate them about mitigating the loss of property.

3.3. Support organizations that work to help mitigate the adverse effects of disasters.

3.4. Increase public awareness of disaster risks and effective mitigation measures that protect property.

3.5. Support the National Flood Insurance Program, Community Rating System (CRS), earthquake insurance, and other programs that serve to reduce the impacts of disasters on properties.

Goal 4: Implement mitigation actions that improve the protection of community tranquility from the adverse effects of disasters

4.1. Develop, implement, and complete mitigation projects as expeditiously, effectively, efficiently, and unobtrusively as possible.

4.2. Consider sustainability issues (ecologically sound, economically viable, socially just, and humane) when developing or reviewing mitigation projects and plans.

4.3. Lead and support the work of mitigation partners to educate the general public about how mitigation can help protect communities and promote community tranquility.

4.4. Develop and provide periodic reports and success stories to federal, state, and local public officials, educational institutions, private associations, private business entities, and the public on the progress of hazard mitigation activities.

4.5. Encourage citizens and citizen organizations to support and use mitigation in plans, projects, and public outreach to increase a sense of community security and safety.

4.1.2. Process for Identifying, Reviewing, and Updating State Goals and Objectives

Missouri's SRMT developed the goals and objectives to guide the state mitigation program and the selection of actions to mitigate potential losses from hazard events. The goals and objectives represent a long-term vision for hazard reduction and enhancement of mitigation capabilities and have evolved over years of mitigation planning in Missouri.

During the 2018 update process, the goals and objectives from the 2013 plan were reviewed to determine if they still address current conditions and anticipated future needs. This was accomplished during the fourth planning meeting. The SRMT assessed the goals and objectives based on the process outlined in Section 6.2.4 Monitoring Progress for Mitigation Goals, Objectives, and Activities. In addition to that process, the review was based on:

- The 2018 updated statewide risk assessment, which includes changes in growth and development, recent disasters, enhanced vulnerability assessments, and analysis of local risk assessments. The key issues identified in the statewide risk assessment and the analysis of local risk assessments can be found in Section 3 Risk Assessment.
- Assessment of changes and challenges in state and local capabilities since the 2013 plan. Information on the changes in state and local mitigation capabilities is summarized in Sections 4.5 State Capability Assessment and 4.6 Local Capability Assessment.
- Analysis of the similarities and/or differences of the state mitigation plan goals with local mitigation plan goals and objectives. Section 4.1.3 describes how the local mitigation plan goals and objectives were reviewed and considered during the 2018 update.
- Identification of achieved mitigation objectives from the 2013 plan. Section 4.2 Mitigation Actions includes detailed and updated mitigation measures designed to meet the designated goals and objectives and progress on these objectives is evaluated in Sections 4.2 and Section 7.5 Effective Use of Available Mitigation Funding.

The SRMT concluded that the goals and objectives from the 2013 plan remain valid for the 2018 plan update and continue to guide the State's mitigation philosophy.

4.1.3. Review of Local Goals

SEMA analyzed the goals and objectives of 114 Missouri local community hazard mitigation plans to assess their consistency with state goals and objectives. The analysis involved calculating the percentage of local plans that had goals similar to a goal in the 2018 Missouri State Hazard Mitigation Plan Update.

The results in **Table 4.1** show that most local plans have similar goals to State Goal #1 to improve protection of life, health, and safety (96 percent) and State Goal #3 to improve protection of public and private property (89 percent). More than half of local plans have a goal similar to State Goal #4 to improve protection of community tranquility. Approximately 30-percent of local plans specifically address continuity of government and essential services. SEMA also assessed local goals that address a specific hazard and found that 26 percent of local plans have a goal related to reducing the impacts of flooding.

Table 4.1. Percentage of Local Plans with Similar Goals to State Plan

Missouri State Hazard Mitigation Plan Goals	Local Plans with Similar Goal
Goal 1: Improve Protection of Life, Health, and Safety	96%
Goal 2: Improve Protection of Continuity of Government and Essential Services	33%
Goal 3: Improve Protection of Public and Private Property	89%
Goal 4: Improve Protection of Community Tranquility	70%

SEMA also analyzed the local goals that differed from state goals. **Table 4.2** lists common general goals among the local plans and the percent of plans that contained a similar goal. The third column in the table lists the percentage of local plans that had a similar objective. Because the local plans were developed by Missouri's Regional Planning Commissions, many plans in the same region had very similar goals and objectives. The SRMT concluded that the additional goals and objectives identified by the local plans, while not worded exactly the same, tended to align with State Goal #4 to improve protection of community tranquility or were similar to the State plan's objectives. While many of the local plans identified promoting public education and awareness as a goal, the SRMT views this as an objective, which is currently listed under each of this plan's goals.

Table 4.2. Other Common Goals and Objectives in Local Plans

Common Goals in Local Plans	Local Plans with Similar Goal	Local Plans with Similar Objective
Promote Public Information, Education, and Awareness about Hazards and Risk	53%	30%
Improve Structures and Infrastructure to Reduce Hazard Impacts	30%	34%
Manage Growth and Development in Hazard Areas	25%	22%
Establish Long-Term Risk Reduction Priorities	29%	32%
Strengthen Communication, Cooperation, and Partnerships	25%	23%
Maintain Local Economy	18%	3%
Secure Resources for Investment in Hazard Mitigation	32%	2%
Reduce Risk to Most Vulnerable Populations	22%	4%
Protect and Restore Natural Systems	17%	28%
Improve Warning and Emergency Systems	15%	72%
Design Policies to Limit Hazard Impacts	21%	2%

4.2. Mitigation Actions

Requirement §201.4(c)(3)(iii): [State plans shall include an] identification, evaluation, and prioritization of cost-effective, environmentally sound, and technically feasible mitigation actions and activities the State is considering and an explanation of how each activity contributes to the overall mitigation strategy. This section should be linked to local plans, where specific local actions and projects are identified.

Plan Update Requirement §201.4(d): Plans must be reviewed and revised to reflect changes in development, progress in statewide mitigation efforts and changes in priorities.

This section introduces the mitigation action categories considered by the State to meet the goals and objectives of this plan. Each category is listed, followed by background on how they were identified and prioritized. This section also describes how the action categories were reviewed during the 2018 update to reflect changes in risk, progress in statewide mitigation efforts, and changes in priorities. It further describes the progress of implementation for those mitigation actions and concludes with an analysis of local mitigation actions summarized from the available local mitigation plans including the challenges associated with implementing them.

4.2.1. Categories of Mitigation Actions in Missouri

There are 14 action categories that SEMA and the SRMT have identified to fulfill this plan's goals and objectives. These action categories must comply with all federal and state requirements for mitigation funding, which means they must be cost-effective, environmentally sound, and technically feasible. The action categories listed below are the primary ones the State supports for addressing the hazards analyzed in this plan (which is not an all-inclusive list). This is followed by a brief description of the types of projects associated with each action category.

- M1—State and Local Hazard Mitigation Plans
  (required to qualify for mitigation funding)
- M2—National Flood Insurance Program Floodplain Management and
  Community Rating System
- M3—Risk Communication
- M4—Voluntary Property Acquisitions (Flood Buyout)
- M5—Voluntary Elevation, Relocation, Floodproofing
- M6—Tornado Safe Rooms
- M7—Earthquake/High Wind Structural Mitigation Projects
- M8—Earthquake/High Wind Nonstructural Mitigation Projects
- M9—Structural/Infrastructure Mitigation Projects
  (including Public Assistance projects)
- M10— Response and Recovery Facility Mitigation Projects
- M11— State Owned/Operated Facility Mitigation Projects
- M12—Buried Electric Service Lines
- M13—State 5% Initiative Projects
- M14—Technical Assistance

Mitigation Action Categories With Project Descriptions

M1—State and Local Hazard Mitigation Plans

This includes activities related to mitigation planning at the State and local level and includes completing remaining local mitigation plans and updating existing plans, developing or revising guidance (as appropriate), and providing training.

M2—National Flood Insurance Program Floodplain Management and Community Rating System

This category includes promotion of participation in the National Flood Insurance Program (NFIP) and the wise use of floodplains. Activities can include floodplain management workshops, flood insurance promotion, community assistance visits, floodplain map modernization activities, streambank stabilization, and minor flood control. Communities willing to exceed the minimum NFIP regulations, particularly those with large policy bases, are encouraged to join the Community Rating System. SEMA's Recovery Division, Floodplain Management Section provides information on the NFIP on the following website: https://sema.dps.mo.gov/programs/floodplain/

M3—Risk Communication

Added during the 2018 State Plan Update, this category includes activities related to the communication of information to the communities and citizens of Missouri who are at risk of exposure to hazards. Risk communication activities build risk awareness and understanding at the local level and can include preventative measures addressing development within dam and/or levee inundation areas; outreach measures such as publication and distribution of risk assessment mapping; and coordination efforts with other state, federal or local agencies to exchange hazard and risk information.

M4—Voluntary Property Acquisitions

These projects entail partnering with local entities to buy out properties at risk to flooding. This is SEMA's most important mitigation action, and usually most cost-effective, because the people and property are totally and permanently removed from the path of flooding and danger. SEMA supports acquisitions of residential property and gives priority for funding to residential over commercial property at this time. SEMA's top priorities for acquisition are repetitive flood loss properties and severe repetitive loss properties.

M5—Voluntary Elevation, Relocation, Floodproofing

These projects, in partnership with local entities and property owners, are additional ways to reduce the impacts of flooding. Elevation of flood-prone properties may be used if it is proven to be cost-effective and desirable over the long term (e.g., when the cost of the land is so high that a buyout is impractical). Relocation may be used if it is more practical/cost-effective or when the threat is so severe or has the potential to be repetitive that it is more advantageous to relocate a structure or structures, up to and including entire communities, entirely out of harm's way. Floodproofing may be more feasible in areas of limited danger, particularly for commercial properties (the NFIP does not recognize dry floodproofing for residential structures).

M6—Tornado Safe Rooms

These are projects that protect people from tornadoes and high winds and must also comply with FEMA Publications 320 and 361, which prescribe shelter and safe room construction standards. Projects can range from rooms in non-profit organization (Habitat for Humanity) sponsored homes that protect individual families to large-scale community safe rooms in public buildings and schools. These projects can often meet multiple community objectives, such as a combination school gymnasium/safe room. Safe rooms can also be standalone buildings or internal buildings that are intended to provide protection during a short-term high-wind event, like a tornado. Safe rooms have proven to be successful during these events.

M7—Earthquake/High Wind Structural Mitigation Projects

These projects reinforce structural components of a building to resist seismic and/or high wind loads. There is an emphasis on critical facilities or facilities that would impact life safety if they were to fail due to the hazard.

M8—Earthquake/High Wind Nonstructural Mitigation Projects

These projects reduce life safety impacts and, in some cases, can limit damage to nonstructural building elements, such as building utility and lighting systems. Examples include window film and strapping and bracing appliances and fixtures, such as water heaters, shelves, etc.

M9—Structural/Infrastructure Mitigation Projects (including Public Assistance projects)

These projects develop structures to redirect or modify the impact of a hazard, such as a floodwall or stormwater collection system. Public Assistance refers to FEMA's post-disaster program that funds repair or replacement of damaged infrastructure and can sometimes be used for mitigation, depending on the type of damage. An example would be replacing a washed-out culvert with one designed to convey higher flood flows or replacing a cylindrical corrugated pipe with a box culvert. Bridges and low water crossings are other examples that have been funded.

M10—Response and Recovery Facility Mitigation Projects

Added during the 2018 State Plan Update, this category of projects reduces hazard impacts to existing state and local buildings that have been identified as necessary for post-disaster response and recovery operations. Mitigation actions may address flood, wind, earthquake, or other hazard events and include such projects as structural reinforcement or relocation.

M11—State Owned/Operated Facility Mitigation Projects

Through the 2018 State Mitigation planning process and improved data capabilities, detailed risk assessments were performed on state owned/operated facilities at risk to dam failure, levee failure, flood, earthquake, sinkholes, wildfire, and hazardous materials. Projects within this category reduce the newly defined hazard impacts to existing state owned and operated facilities.

M12—Buried Electric Service Lines

These projects mitigate utility outages and repair costs from severe weather events such as ice storms, high winds, and tornadoes.

M13—State 5% Initiative Projects

These projects are those that are worthwhile but difficult to prove cost-effective and refer to the five percent of Hazard Mitigation Grant Program funds that, following a disaster, can be set aside for projects such as development of community outreach programs and materials, increasing weather radio coverage, hazard studies, warning sirens, generators, etc.

M14—Technical Assistance

This category applies to various efforts from multiple state agencies to provide technical assistance, including training, in the identification and mitigation of hazards. The technical assistance can be for local governments or to update state policies and legislation. SEMA also makes a considerable effort to educate the public, local officials, government officials, schools, private associations, and businesses about the value and importance of mitigation programs. SEMA offers mitigation workshops, participates in public forums, provides one-on-one counseling, presents at conferences, provides written materials, develops guidebooks and manuals, publishes success stories, sends out press releases, offers information on the Internet, and provides training materials to local emergency managers, earthquake program partners, floodplain managers, and businesses.

Table 4.3 shows how these 14 action categories meet the objectives and goals identified in Section 4.1 Hazard Mitigation Goals and Objectives and thus contribute to the overall mitigation strategy. Some of these action categories have already proven successful, as demonstrated in Section 7.5 Effective Use of Available Mitigation Funding.

Table 4.3. Mitigation Action Categories and Goals Crosswalk

Objectives	M1	M2	M3	M4	M5	M6	M7	M8	M9	M10	M11	M12	M13	M14
Goal 1: Improve the Protection of Human Life, Health, and Safety														
Objective 1	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Objective 2	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Objective 3	✓	✓	✓			✓	✓	✓		✓	✓		✓	✓
Objective 4	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Objective 5	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Goal 2: Improve the Protection of Continuity of Government and Essential Services														
Objective 1	✓	✓	✓			✓	✓	✓	✓	✓	✓	✓	✓	✓
Objective 2	✓	✓	✓			✓	✓	✓	✓	✓	✓	✓	✓	✓
Objective 3	✓	✓	✓			✓	✓	✓	✓	✓	✓	✓	✓	✓
Objective 4	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Objective 5	✓	✓	✓			✓	✓	✓	✓	✓	✓	✓	✓	✓
Goal 3: Improve the Protection of Public and Private Property														
Objective 1	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

Objectives	M1	M2	M3	M4	M5	M6	M7	M8	M9	M10	M11	M12	M13	M14
Objective 2	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Objective 3	✓	✓	✓			✓	✓	✓		✓	✓		✓	✓
Objective 4	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Objective 5	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Goal 4: Improve the Protection of Community Tranquility														
Objective 1	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Objective 2	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Objective 3	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Objective 4	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Objective 5	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

4.2.2. Process for Identifying, Evaluating, Prioritizing, and Updating Mitigation Actions

Mitigation actions in this plan were identified over years of mitigation planning in Missouri by the SRMT and its predecessors (e.g., the State Hazard Mitigation Planning Team (SHMPT) and the Hazard Mitigation Project Coordinating Group). The nature of recent disasters has often dictated the action types and hazards addressed. In the 1990s, widespread flooding emphasized the importance, and benefits of, removing properties from the floodplain. Missouri's drought and tornado events in more recent years have shifted the local interest and focus from flood projects to tornado safe rooms. Identification of specific local mitigation actions typically comes from communities impacted by a disaster, or in more recent years, from proactive communities with local mitigation plans applying for pre-disaster grant funding.

During the 2018 plan update, SEMA and the SRMT assessed existing mitigation actions and developed new actions for consideration based on:

- Review of the updated state risk assessment and information from local risk assessments
- Review of goals and objectives
- Review and assessment of existing state actions, including priorities
- Review of state and local capabilities
- Review of a summary of commonly used actions identified in local plans

Ongoing, revised, and new actions and how they fit with the M categories are summarized in Section 4.2.5 Review and Progress of Mitigation Actions.

All of the identified mitigation actions have proven to be effective based on past experience with some proving more effective than others. Effectiveness is measured in general terms based on how well the project meets multiple objectives:

- **High**—mitigates impacts to life safety and property
- **Moderate**—mitigates impacts to life safety only or property only

For example, flood buyout projects not only remove property from the floodplain, but they remove the risk to lives in the floodplain as well and eliminate the need to put first responders' lives in jeopardy during flood events. A tornado safe room may reduce deaths and injuries, but they may not necessarily reduce property damage. Effectiveness of specific projects is measured using FEMA's benefit-cost software modules, which is described in more detail in Section 7.2.4 Pre-Project Determination of Cost-Effectiveness of Mitigation Measures.

SEMA has chosen to utilize a modified version of the STAPLEE (social, technical, administrative, political, legal, economic, and environmental) criteria for prioritizing mitigation actions. In addition to the seven basic elements, SEMA is also prioritizing mitigation actions based upon impact to historical structures, timeframe for implementation, and mitigation effectiveness. Additionally, mitigation action priorities may be adjusted based upon the current situations and threats. For example:

- Flood mitigation projects (repetitive loss properties high priority)
- Tornadoes and high wind mitigation projects
- Earthquake mitigation projects
- Other, not direct life safety

During the 2018 update, the SRMT measured each of the 19 mitigation actions against the modified STAPLEE criteria and completed a STAPLEE survey (see **Table 4.4** and **Table 4.5**). The total STAPLEE score for each mitigation action is presented in Table 4.4.3a, along with prioritization by action category.

Table 4.4. Modified STAPLEE Survey

Table 4.5. Modified STAPLEE Survey (continued)

Missouri 2018 State Hazard Mitigation Plan Update
MITIGATION ACTION PRIORITIZATION

Mitigation Action #1

#1 - Track local community hazard mitigation plans to ensure completion of new plans and updates to exist

STAPLEE Critera

	Definitely YES	Maybe YES	Probably NO	Definitely NO	N/A - I do not feel qualified to rate this question
Is it SOCIALLY acceptable?	○	○	○	○	○
Is it TECHNICALLY feasible and potentially successful?	○	○	○	○	○
Does the responsible state agency/department have the ADMINISTRATIVE capacity to execute this action?	○	○	○	○	○
Is it POLITICALLY acceptable?	○	○	○	○	○
Is there LEGAL authority to implement?	○	○	○	○	○
Is it ECONOMICALLY beneficial?	○	○	○	○	○
Will the project have either a neutral or positive impact on the ENVIRONMENT? (3=positive: 2=neutral)	○	○	○	○	○
Will HISTORIC structures be saved or protected?	○	○	○	○	○
Could it be IMPLEMENTED quickly?	○	○	○	○	○

Effectiveness Criteria

	Least Likely		Likely		Highest Likelihood
Will the implemented action likely result in LIVES SAVED?	○	○	○	○	○
Will the implemented action likely result in a REDUCTION of DISASTER DAMAGE?	○	○	○	○	○

4.2.3. 2018 Updated Mitigation Actions

Table 4.6 details actions that the State is considering to further the implementation of mitigation actions in Missouri. The actions recommended are a result of the 2018 plan review and update and can be accomplished with state effort and/or resources. The table also includes the Action Category M1 - M11, the action title, the lead agency, and supporting agencies. The overall STAPLEE score is listed with the status of the action for this 2018 plan update and potential funding sources for the actions turning into projects. There are no new sources of funding identified in the table below.

Table 4.7 details the actions and how they relate to the different hazards.

Table 4.6. Summary of Mitigation Actions for 2018 Updated Plan

Action #	Action Category	Action Title	Lead Agency	Support Agencies	STAPLEE Score	Priority	Status	Status Report	Funding Source
1.	M1	Track local community hazard mitigation plans to ensure completion of new plans and updates to existing plans as their 5-year cycle expires.	SEMA	COG's RPC's	34	High	Ongoing for 2018	This will continue with the 2018 update.	HMGP, PDM, SEMA Operating Budget
2.	M1	Provide technical assistance, planning assistance, and available funding to RPCs to develop new and updated local community plans, using the latest FEMA guidance materials, the SEMA-developed plan outline, and SEMA-led workshops which emphasized the use of NFIP risk assessment products to identify local mitigation projects.	SEMA	COG's RPC's	37	High	Revised for 2018	The revision updates assistance to include "planning" and identifies SEMA developed local mitigation plan outline and associated workshops.	HMGP, PDM, SEMA Operating Budget
3.	M1	Use RPCs and SEMA staff to encourage and track implementation of actions in local plans.	SEMA	COG's RPC's	37	High	Revised for 2018	The revision incorporates tracking of actions.	SEMA Operating Budget
4.	M1	Continue to refine and enhance vulnerability assessments for natural hazards, for example incorporation of changing future conditions data.	SEMA	Other agencies with pertinent data.	38	High	Revised for 2018	With the 2018 Update, vulnerability assessments were completed for all 22 hazards. New data will continue to enhance the vulnerability section as future updates are completed.	HMGP, PDM, SEMA Operating Budget
5.	M2	Continue to encourage new participation in the NFIP and CRS programs with a special focus on communities within PIR (Paper Inventory Reduction) Counties which have not previously been mapped but are now being updated and encourage existing participants to promote and enforce their floodplain management programs.	SEMA	FEMA	38	High	Revised for 2018	NFIP and CRS will continue to be encouraged and promoted in Missouri with an updated focus on communities within PIR counties.	FMA, CAP, HMGP, PDM, SEMA Operating Budget

Action #	Action Category	Action Title	Lead Agency	Support Agencies	STAPLEE Score	Priority	Status	Status Report	Funding Source
6.	M3	Publish all statewide vulnerability assessment results, including HAZUS-MH results to RPCs and local governments for mitigation planning purposes and to promote consistency in the updates to local plan risk assessments.	SEMA	COG's RPC's	37	High	Revised for 2018	The 2018 Plan Update included the development of a website to publish vulnerability assessment results.	SEMA Operating Budget
7.	M3	Support and provide technical assistance for FEMA Risk MAP Products to communicate risk and promote mitigation actions.	SEMA	FEMA	37	High	Revised for 2018	This will continue in 2018 and incorporate the use of SEMA developed RiskMAP User Guide and associated workshops.	PDM, SEMA Operating Budget
8.	M4	Employ the Loss Avoidance Tool, developed as part of the 2018 Plan Update, for acquisition and safe room locations following Disaster Declarations to track avoided losses associated with each event.	SEMA	FEMA	37	High	Revised for 2018	A loss avoidance tool has been updated with this 2018 Enhanced Plan Update.	FMA, HMGP, PDM, SEMA Operating Budget
9.	M5	Continue to pursue mitigation of flood-prone properties through implementation of the Repetitive Loss Strategy and development/implementation of a Statewide Buyout Strategy.	SEMA	CDBG	39	High	Revised for 2018	Severe Repetitive Loss Properties & Repetitive Loss Properties continue to be a top priority for property buyouts in Missouri with additional focus on the developed strategy. Through the Silver Jackets program, SEMA will begin the development of a statewide buyout strategy in 2018.	FMA, HMGP, CDBG, PDM
10.	M6	Support the construction of tornado safe rooms in local communities' public buildings, public schools, and eligible private non-profit facilities to FEMA standards.	SEMA	COG's RPC's DESE, DHE, non-profit organizations	39	High	Ongoing for 2018	This is a priority, following flood buyout properties, for grant funds in Missouri & continues to be updated in the 2018 Plan Update.	HMGP, CDBG, PDM

Action #	Action Category	Action Title	Lead Agency	Support Agencies	STAPLEE Score	Priority	Status	Status Report	Funding Source
11.	M7	Support the Missouri Statute "Earthquakes - Seismic Building and Construction Ordinances," to require public buildings in the State of Missouri to be designed in accordance with building codes based upon the latest version of the National Earthquake Hazards Reduction Program (NEHRP) provisions for the design of new buildings.	SEMA	MoDNR COG's RPC's	38	Medium	Ongoing for 2018	This is a priority in Missouri & and continues to be supported through SEMA efforts.	SEMA Operating Budget
12.	M8	Support the distribution of Public Education materials regarding Earthquake/High Wind nonstructural mitigation measures	SEMA	MoDNR COG's RPC's	38	Medium	Ongoing for 2018	These are recognized as significant hazards in Missouri & are supported through SEMA and continue to be updated in the 2018 Plan Update. Action was further described to note distribution of educational materials.	SEMA Operating Budget
13.	M9	Maximize the use of PA mitigation funds in Missouri	SEMA	FEMA Local Communities	37	Medium	Updated for 2018	SEMA will seek to maximize the use of PA mitigation funds in Missouri following disaster declarations.	PA mitigation funds
14.	M10	Support development of a comprehensive plan to identify and mitigate the risks posed to response and recovery facilities throughout Missouri.	SEMA	FEMA Local Communities	37	Medium	New for 2018	This is recognized as a good use for grant funds in Missouri and thus added in the 2018 Plan Update.	HMGP, CDBG, PDM
15.	M11	Pursue mitigation of state owned/operated facilities which have been identified through the refined risk assessments as at risk.	SEMA	MDC, DHE, MoDOT, OA	37	Medium	New for 2018	This is recognized as a good use for grant funds in Missouri and ongoing projects & thus updated in 2018 Plan Update.	HMGP, CDBG, PDM
16.	M12	Continue to pursue mitigation of municipal and public electric provider's services.	SEMA	Municipal and public electric providers	32	Low	Ongoing for 2018	This is recognized as a good use for grant funds in Missouri and ongoing projects & thus updated in 2018 Plan Update.	HMGP, CDBG, PDM

Action #	Action Category	Action Title	Lead Agency	Support Agencies	STAPLEE Score	Priority	Status	Status Report	Funding Source
17.	M13	Support projects that are consistent with the State goals & objectives, but difficult to quantify the benefits using the standard BCA (i.e. warning sirens, permanently installed generators, etc.)	SEMA	COG's RPC's	36	Low	Ongoing for 2018	This is a consideration for HMGP 5% set aside funds in Missouri & thus been updated in 2018 Plan Update.	HMGP
18.	M14	Support Missouri agencies that own, operate, and/or lease state facilities, continue to improve work to geolocate their facilities as data becomes available to further refine risk assessments using GIS.	SEMA	MDC, DHE, MoDOT, OA	32	Low	Ongoing for 2018	The revision includes all state agencies that own, operate, and/or lease state facilities. This list will continue to be incorporated when this plan is updated every 5 years or as required.	Missouri state funds
19.	M14	Encourage the creation of a State-level Levee Safety Program similar to MoDNR's Dam and Reservoir Safety program.	SEMA	MoDNR, COE Silver Jackets	36	Low	Revised for 2018	The National Committee on Levee Safety supports the creation of state-level levee safety programs. Mitigation action revised to note Silver Jackets as a supporting agency.	Missouri state funds, COE funds

Note: Supporting Agencies: COE (U.S. Corps of Engineers), COG (Council of Governments), MoDNR (Missouri Department of Natural Resources), FEMA (Federal Emergency Management Agency), MDC (Missouri Department of Conservation), DHE (Department of Higher Education), MoDOT (Missouri Department of Transportation), OA (Missouri's Office of Administration), RPC (Regional Planning Commissions) SEMA (State Emergency Management Agency)

Priority: High denotes action mitigates impacts to life safety and property, moderate denotes action mitigates impacts to life safety only or property only

Funding Sources: CDBG (Community Development Block Grant) HMGP (Hazard Mitigation Grant Program); PDM (Pre-Disaster Mitigation); FMA (Flood Mitigation Assistance); COE (US Corps of Engineers)

Table 4.7. How Actions Relate to the Different Hazards

Mitigation Action	Mitigation Category	Flooding	Levee Failure	Dam Failures	Earthquakes	Land Subsidence/Sinkholes	Drought	Extreme Temperatures	Severe Thunderstorms	Severe Winter Weather	Tornadoes	Wildfires	CBRNE	Civil Disorder	Cyber Disruption	Structural and Urban Fires	Hazardous Materials Release	Mass Transportation	Nuclear Power Plants	Public Health Emergencies	Special Events	Terrorism	Utilities	# of Hazards Addressed
1	M1	X	X	X	X	X	X	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X	21
2	M1	X	X	X	X	X	X	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X	21
3	M1	X	X	X	X	X	X	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X	21
4	M1	X	X	X	X	X	X	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X	21
5	M2	X	X	X					X															4
6	M3	X			X											X								3
7	M3	X	X	X																				3
8	M4	X	X	X					X															4
9	M5	X	X	X					X															4
10	M6								X		X													2
11	M7				X																			1
12	M8				X	X			X		X													4
13	M9	X	X	X	X	X	X	X	X	X	X		X	X		X				X		X		15
14	M10	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	22
15	M11	X	X	X	X	X						X					X							7
16	M12				X				X	X	X				X				X			X	X	8
17	M13	X	X	X	X	X	X	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X	21
18	M14	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	22
19	M14			X																				1
# of Actions Addressing		12	11	12	11	8	7	7	13	8	10	1	7	7	7	8	6	6	7	7	6	8	7	
Probability %		100	100	45	72	100	6-11	100	100	100	100	100	<1	<1	<1	100	100	100	<1	<1	<1	<1	100	
Severity		H	M	M	H	L	H	M	M	M	H	L to M	H	L to H	L to H	M	M	M	L to H	L to H	L to H	L to H	L	

4.2.4. Review and Progress of Mitigation Actions

During the 2018 update, the status of mitigation actions implemented over the past five years were evaluated to ensure that the State is making progress with its mitigation strategy. Progress is measured based on the following variables:

- The number of projects implemented over time
- The successful disbursement of mitigation grant funds over time
- The disaster losses avoided over time (given a post-disaster event)
- Plans, partnerships, and outreach developed over time

The number of projects that incorporate mitigation while meeting other community objectives, such as a floodplain buyout that becomes a community park and natural area, is another measure of success. These are the types of successful mitigation projects that gain community buy-in and demonstrate tangible benefits. Success stories and methods of reporting them are discussed in Chapter 7 Enhanced Plan.

Actions that the State has been involved with between 2002 and 2017 are summarized in **Table 4.8**. The number of actions and amount of Hazard Mitigation Assistance (HMA) funds dispersed through various grant programs indicate that Missouri is continuing to make progress with implementation of its mitigation strategy. The high number of tornado safe room projects (see **Figure 4.1**) reflects the numerous tornado disaster events and the momentum being built by the successful implementation of these projects across the State, especially in more rapidly developing areas where safe rooms are incorporated into the design of new structures (e.g., schools).

Figure 4.1. Construction of Tornado Safe Rooms in Missouri

Note: Photo on left from Holts Summit safe room construction, Photo on right from West Plains safe room construction, Source: SEMA files

Low water crossings are alternatives to bridges in Missouri; however, they are dangerous when drivers attempt to use them during floods. Projects to address these low-water crossing dangers entail replacing the crossings with bridges designed to accommodate flood flows. This mitigates impacts on life safety, as lives have been lost when drivers attempt to negotiate low water crossings during floods. More details on mitigation actions, including funding sources used, can be found in Section 7.5 Effective Use of Available Mitigation Funding and this link to Past Mitigation Projects. Note, mitigation action categories M3 Risk Communication, M10 Response and Recovery Facility Mitigation Projects, and M11

State Owned/Operated Facility Mitigation Projects were added with this 2018 plan update and therefore do not have corresponding historic project types at this time.

Table 4.8. Summary of Mitigation Actions Implemented and Estimated Funding Amounts, 2002–2012 and 2013-2017

Project Type	Action Category	2002-2012 Number of Projects	2002-2012 Estimated Funding Amount	2013-2017 Number of Projects	2013-2017 Estimated Funding Amount
State and Local Hazard Mitigation Plans	M1	258	$7,885,551	5	$1,096,856
Flood Buyouts	M4	67	$47,337,218	18	$8,458,688
Flood Elevations	M5	3	$488,573	---	
Tornado Safe Rooms	M6	133	$159,925,978	62	$68,575,060
Tornado Safe Rooms - Multipurpose	M6	1	$686,493	---	
Bridge Replacements	M9	1	$449,787	---	
Low Water Crossings	M9	8	$888,246	2	$432,896
Streambank Stabilizations	M9	2	$92,267	---	
Basin	M9	1	$1,333,333	---	
Culvert	M9	2	$553,625	---	
Water Supply Interconnects	M9	1	$66,701	---	
Buried Electric Lines	M12	10	$11,959,530	---	
State 5% Initiative Projects	M13	12	$1,753,866	10	$598,378

Details on the above projects, including funding sources and general timeframe are provided in Table 4.9, Table 4.10, and Table 4.11. These mitigation projects solidify the State's mitigation strategy by demonstrating that the State's goals, objectives, and actions are the basis for these projects.

This documentation indicates that Missouri is effectively using both pre- and post-disaster funding mechanisms and has been successful at securing annual allocations of mitigation funds in the nationally competitive Pre-Disaster Mitigation Grant Program. Since Missouri has an enhanced hazard mitigation plan, they receive 20 percent of post-disaster costs from the Hazard Mitigation Grant Program for mitigation purposes. Several project closeouts are also noted, indicating successful mitigation grant management. Section 6.2.1 Monitoring Implementation of Mitigation Measures and Project Closeouts provides details on individual project review and closeout procedures.

Table 4.9. HMGP Mitigation Project Summary Table 2002–2017

Year	Tornado Safe Rooms	Flood Buyouts	State 5% Initiative Projects	State and Local Hazard Mitigation Plans	Low Water Crossings	Buried Electric Lines	Culvert	Tornado Safe Rooms - Multipurpose	Water Supply Interconnects	Total	Total Completed[1]	Total Pending[2]
Action Category	M6	M4	M13	M1	M9	M12	M9	M6	M9			
2002	3	20	5			2				**30**	**30**	**0**
2003		3	1						1	**5**	**5**	**0**
2004	1									**1**	**1**	**0**
2006	11	1	1		5	1	1	1		**21**	**21**	**0**
2007	9	10	1			1				**21**	**21**	**0**
2008	3	5		2			1			**11**	**11**	**0**
2009	27	1	1	3		1				**33**	**33**	**0**
2010	2		1							**3**	**3**	**0**
2011	57	2	3	1						**63**	**63**	**0**
2012	41	1	1	1						**44**	**44**	**0**
2013	41	5	2	1						**49**	**47**	**2**
2014	6	1			1					**8**	**8**	**0**
2015	1				1					**2**	**2**	**0**
2016	7		4	2						**13**	**3**	**10**
2017	7		4	1						**12**	**4**	**8**
Total	**216**	**49**	**24**	**11**	**7**	**5**	**2**	**1**	**1**	**316**	**296**	**20**

[1] Number of projects completed are projects in which the final performance is complete as of December 1, 2017.
[2] Number of projects pending are projects that have not completed their scope of work as of December 1, 2017.
Source: State Emergency Management Agency

Table 4.10. FMA, RFC, and SRL Mitigation Project Summary Table 2004–2017

Project Type	Flood Buyouts	Flood Elevations	Total
Action Category	M4	M5	
RFC[1] 2008 - 2012	3	---	3
SRL[1] 2008-2012	1	---	1
FMA 2004-2012	3	2	5
FMA 2013	1	---	1
FMA 2014	1	---	1
FMA 2015	0	---	0
FMA 2016	1	---	1
FMA 2017	8	---	8
Total	18	2	20
Total Completed[2]	10	2	12
Total Pending[3]	8	0	8

[1] The RFC and SRL programs were eliminated in July 2013 with the Biggert Waters Flood Insurance Reform Act of 2012.
[2] Number of projects completed are projects in which the final performance is complete as of December 1, 2017.
[3] Number of projects pending are projects that have not completed their scope of work as of December 1, 2017.
Source: State Emergency Management Agency

Table 4.11. PDM Mitigation Project Summary Table 2004–2017

Year	Tornado Safe Rooms	Siren/ Generator	Low Water Crossings	Flood Buyouts	Buried Electric Lines	Bank Stabil-ization	Basin	Bridge Replace-ment	Total	Total Completed[1]	Total Pending[2]
Action Category	M6	M13	M9	M4	M12	M9	M9	M9			
2004	2								2	2	0
2005	14		2	2	1	2		1	22	22	0
2006	4				1				5	5	0
2007	12		1						13	13	0
2008	1	2					1		4	4	0
2009	1								1	1	0
2010	1	1							2	2	0
2011	1								1	1	0
2012	1								1	1	0
2013									0	---	---
2014									0	---	---
2015									0	---	---
2016	1								1	0	1
2017									0	---	---
Total	38	3	3	2	2	2	1	1	52	51	1

[1] Number of projects completed are projects in which the final performance is complete as of December 1, 2017.
[2] Number of projects pending are projects that have not completed their scope of work as of December 1, 2017.
Source: State Emergency Management Agency

Prior to 2002, Missouri used mitigation funding for buyouts, elevations, and relocations; however, the nature of hazards in Missouri and types of mitigation projects broadened. Flood mitigation remains a priority, but changes in threats required SEMA to broaden its perspective in mitigation projects. Since the last State plan update in 2013, the State has successfully completed and proposed flood buyout projects, tornado safe rooms, low water crossings, siren and generator projects, and mitigation planning projects, as listed in the tables above.

Progress in the remaining mitigation action categories, those not addressed in **Table 4.8** are summarized below. These action categories are more program- than project-related.

M2—National Flood Insurance Program Floodplain Management and Community Rating System: Participation in the NFIP has increased between the publication of the 2013 plan and September 2017 (see Table 4.24). There are an additional 17 communities in the program. As of September 2017, there were 669 NFIP participating jurisdictions, all participating in the regular program. All the participating communities have established local floodplain management ordinances to help them administer the program. Mitigation planning and the Pre-Disaster Mitigation grant program have had a positive impact on participation and interest in the NFIP. The program is expected to continue to grow. Many communities have had their current flood hazards mapped but have not yet joined the program.

Funds from a variety of programs have been used to develop flood maps for areas previously unmapped and to revise or update older existing maps. This initiative will enable more communities in the State to join the NFIP. The Paper Inventory Reduction (PIR) program will assist in getting paper-only floodplain maps updated to a digital format. There are 33 PIR counties in Missouri and 21 of these counties will be updated to digital format in FY17. SEMA is coordinating with these counties throughout the RiskMAP process and encouraging participation in the NFIP, as well as the CRS. Handouts covering the process to join the NFIP have been developed by SEMA to assist non-participating communities. The current status of the RiskMAP program across the state is provided in the flooding hazard discussion in Section 3.3.1.

M7—Earthquake/High Wind Structural Mitigation Projects: No new projects were implemented between 2013 and 2017 due in part to the lack of recent damaging earthquake events and the increased interest in tornado safe room projects because of recent tornado disaster events.

M8—Earthquake/High Wind Nonstructural Mitigation Projects: No new projects were implemented between 2013 and 2017 due in part to the lack of recent damaging earthquake events and the increased interest in tornado safe room projects because of recent tornado disaster events.

M14—Technical Assistance: SEMA mitigation staff schedule and conduct various trainings and workshops throughout the year to increase knowledge and understanding of mitigation and floodplain management. Training includes Local Hazard Mitigation Plan Development; Tools of Floodplain Management; Digital Flood Insurance Rate Map (DFIRM) Workshops and DFIRM Plus RiskMAP Workshops; and Certified Floodplain Manager (CFM) Training. Training is further defined in Section 4.5.1 State Agency Capability Assessment.

Sections 7.4 Assessment of Mitigation Actions and 7.5 Effective Use of Mitigation Funding provide additional examples of the progress and success of mitigation actions and programs.

4.2.5. Review and Integration with Local Actions

A roll-up and analysis of the mitigation actions contained in local plans was conducted to summarize the types of mitigation actions most commonly implemented, or desired to be implemented. This analysis included a summary of actions and the associated hazards, which give an indication of the priority hazards to be mitigated at the local level.

Methodology

The roll-up was conducted by reviewing and capturing key elements of the mitigation sections of each local plan into a master spreadsheet. Most local plans provided a summary table of their mitigation actions, which included a variety of information, such as action description, category of mitigation action, priority, responsible agency, potential funding sources, hazard addressed, and the action's relationship to the local plan's goals and objectives. Some local plans provided a limited amount of information that made it difficult to summarize their data.

The roll-up of the local mitigation actions focused on evaluating the types of local mitigation actions by determining the following:

- The number of actions for each mitigation category (i.e., prevention, emergency services, property protection, natural resource protection, structural protection, and public information);
- The total number of mitigation actions in each county.

Each mitigation action was reviewed and assigned to the appropriate FEMA-established mitigation categories included in FEMA state and local guidance.

Results

Table 4.12 summarizes the results of the roll-up of local mitigation actions using FEMA's mitigation categories. FEMA's publication Developing the Mitigation Plan emphasizes four categories of mitigation activities that are defined as follows:

- **Local Plans and Regulations:** Administrative or regulatory actions/processes that influence the way land and buildings are developed and built.
- **Structure and Infrastructure Projects**: Actions that involve modifying existing structures and infrastructure to protect them from a hazard or remove them from a hazard area. These projects include:
  - **Property Protection:** Actions include acquisition, elevation, relocation, structural retrofits, storm shutters, and shatter-resistant glass.
  - **Structural Projects:** Actions that involve the construction of manmade structures to reduce the impact of hazard.
- **Natural Systems Protection:** Actions that, in addition to minimizing hazard losses, also preserve or restore the functions of natural systems.
- **Public Education and Awareness:** Actions to inform and educate citizens, elected officials, and property owners about the hazards and potential ways to mitigation them.

Additionally, many local mitigation plans identified actions which could be categorized as emergency services. These actions protect people and property during and immediately after a disaster or hazard event and include warning systems or sirens, generators, weather radios, and emergency services communications.

Table 4.12. Breakdown of Local Actions by Mitigation Categories

Mitigation Category	Number of Mitigation Actions	Percent
Local Plans and Regulations	1,319	38.0%
Public Education and Awareness	915	26.3%
Emergency Services	528	15.2%
Property Protection	365	10.5%
Natural Systems Protection	162	4.7%
Structural Projects	186	5.4%

Based on this summary, a large portion of the actions seemed to be policy and/or regulatory in nature. This means they deal with influencing change on the front-end through community outreach efforts, policy changes, and developing and enforcing new regulations. Many of these fell into the emergency services, public information, and property protection categories showing that the full cycle of mitigation actions is needed at the local level. **Table 4.13** provides a summary the results of the roll-up of local mitigation actions by County.

Table 4.13. Breakdown of Local Actions by Mitigation Categories by County

County	Local Plans & Regulations	Public Education	Emergency Services	Property Protection	Natural Systems	Structural Projects	Total
Adair	5	3	1	2	1		12
Andrew	22	20	7	8	2	3	62
Atchison	12	4	3	1	1		21
Audrain	18	25	17	2	5	4	71
Barry	8	5	2	4	4	2	25
Barton	13	10	1	2	2	1	29
Bates	16	13	2	4		2	37
Benton	12	14	4	4			34
Bollinger	11	4	7	6	4	1	33
Boone	17	5	12	5	1	1	41
Buchanan	17	10	8	3	1	3	42
Butler	8	11	4	2	2	3	30
Caldwell	9	1	2	2		1	15
Callaway	9	2	7	2	1	3	24
Camden	11	5	5	1			22
Cape Girardeau	11	4	7	6	4	1	33
Carroll	5	3		3	2	2	15

County	Local Plans & Regulations	Public Education	Emergency Services	Property Protection	Natural Systems	Structural Projects	Total
Carter	8	8	4	2	1	2	25
Cass	8	2		1		1	12
Cedar	14	13	2	4	1		34
Chariton	2	6				2	10
Christian	12	10	3	5	2	1	33
Clark	33	29	4	8	2		76
Clay	8	2		1		1	12
Clinton	20	15	8	5	2	2	52
Cole	14	5	5	4	2	3	33
Cooper	9	2	6	2		7	26
Crawford	15	14	2	4	1	1	37
Dade	8	3	6	5	2	1	25
Dallas	5	3	2	4	1		15
Daviess	5	6		2	2	2	17
DeKalb	21	22	14	5	3	6	71
Douglas	6	7	9	1		1	24
Dunklin	11	4	2	1	1	1	20
Franklin	5	8	8	2	2	3	28
Gasconade	14	14	1	3		1	33
Gentry	14	4	3	5	1		27
Greene	4	6	3	2	1	2	18
Grundy	9	10		3	2	3	27
Harrison	11	5	1	2	1	1	21
Henry	16	13	3	4	1		37
Hickory	11	9	1	3	1	1	26
Holt	10	3	5	1	1	2	22
Howard	14	9	9	6	3	2	43
Howell	3	1	6	8		3	21
Iron	11	4	7	6	4	1	33
Jackson	8	2		1		1	12
Jasper	20	8	7	2		1	38
Jefferson	5	7	8	3	2	3	28
Johnson	15	3	5	4	3	2	32

County	Local Plans & Regulations	Public Education	Emergency Services	Property Protection	Natural Systems	Structural Projects	Total
Knox	5	3	1	2	1		12
Laclede	12	13		5		3	33
Lafayette	15	12	3	5	1		36
Lawrence	3	5	4	3	1		16
Lewis	20	15	2	6	1		44
Lincoln	22	3	3	4	6	1	39
Linn	11	6	2	3	1	3	26
Livingston	7	7		3	1	3	21
Macon	21	19	16	4	6	1	67
Madison	12	4	7	6	3	1	33
Maries	29	22	3	6	1	2	63
Marion	4	5	1	1	1	2	14
McDonald	15	10	1	1	1	1	29
Mercer	7	7		3	1	3	21
Miller	25	20	3	6		3	57
Mississippi	4					1	5
Moniteau	13	7	6	2	1	3	32
Monroe	15	17	19	1	5	3	60
Montgomery	18	4	7	4	2	1	36
Morgan	24	21	4	4		3	56
New Madrid	11	4	4	2	1		22
Newton	20	8	7	2		1	38
Nodaway	16	6	9	4	1	1	37
Oregon	2	1	7	6		3	19
Osage	13	19	3	3	1	1	40
Ozark	5	7	9	1		2	24
Pemiscot	12	8	2	2	2	2	28
Perry	11	4	7	6	4	1	33
Pettis	15	3	4	3	4	2	31
Phelps	21	20	6	5		2	54
Pike	7	6	6	5	2	1	27
Platte	8	2		1		1	12
Polk	6	5	4	3	1	1	20

County	Local Plans & Regulations	Public Education	Emergency Services	Property Protection	Natural Systems	Structural Projects	Total
Pulaski	28	17	8	5	1	3	62
Putnam	3	4		1	1	2	11
Ralls	5	3	4	1		1	14
Randolph	27	24	25	6	3	3	88
Ray	8	2		1		1	12
Reynolds	6	8	5	3	1	2	25
Ripley	8	5	1	5	2		21
Saline	7	2	1	1		1	12
Schuyler	5	3	1	2	1		12
Scotland	5	3	1	2	1		12
Scott	11	4	2	1	1	1	20
Shannon	8	7	9	1		2	27
Shelby	18	17	18	7	4	4	68
St. Charles	5	8	8	2	2	3	28
St. Clair	19	14	3	5		1	42
St. Francois	11	4	7	6	4	1	33
St. Louis	5	8	8	2	2	3	28
St. Louis City	5	8	8	2	2	3	28
Ste. Genevieve	11	4	7	6	4	1	33
Stoddard	14	8	8	2	2	2	36
Stone	14	10	3	3	1	1	32
Sullivan	4	5		2	1	2	14
Taney	11	9	2	2	1	1	26
Texas	2	1	2				5
Vernon	8	8	1	3			20
Warren	22	3	7	3	6	2	43
Washington	18	16	2	4		1	41
Wayne	7	8	4	2	1	2	24
Webster	9	10	2	4		1	26
Worth	10	2	1	1		2	16
Wright	3	1	7	2		4	17
Grand Total	**1319**	**915**	**528**	**365**	**162**	**186**	**3475**

4.2.6. Challenges in Implementation

In general, the State has been very successful in implementing mitigation projects. SEMA averages approximately $22 million dollars in federal grant funding each year. There has been an average of 24 disaster-related HMGP projects each year over the past four years (2013-2017). Non-disaster related funds continue to be utilized, with an increase in FMA funding for residential acquisitions in 2017. Available PDM funding has decreased over the years which has resulted in a reduction in potential projects.

Funding, or lack thereof, has been a major challenge in implementing mitigation projects in Missouri. Missouri has taken advantage of new grant programs, such as the Flood Mitigation Assistance program, which provides annual allocations to fund both plans and projects. Missouri experiences Presidential disasters frequently and as a result obtains significant Hazard Mitigation Grant Program funds. The fact that Missouri regularly experiences disasters presents its own special challenge, as SEMA mitigation staff are often involved in response and recovery operations in addition to mitigation program administration. Solutions to this challenge include developing innovative solutions for surge capacity backfill of SEMA mitigation staff. Currently this is accomplished through special contracts.

Additional information on project implementation is demonstrated in Section 7.2 Project Implementation Capability.

4.2.7. Mitigation Success

Mitigation successes are discussed in detail in Section 7.5 Effective Use of Available Mitigation Funding.

4.3. Repetitive Flood Loss Strategy

Requirement §201.4(c)(3)(v): A State may request the reduced cost share authorized under §79.4(c)(2) of this chapter for the FMA and SRL programs, if it has an approved State Mitigation Plan... that also identified specific actions the State has taken to reduce the number of repetitive loss properties (which must include severe repetitive loss properties), and specifies how the State intends to reduce the number of such repetitive loss properties.

In addition, the plan must describe the strategy the State has to ensure that local jurisdictions with severe repetitive loss properties take actions to reduce the number of these properties, including the development of local mitigation plans.

Note: The Biggert-Waters Flood Insurance Reform Act of 2012 consolidated the SRL grant program into the FMA grant program

4.3.1. Background on the NFIP and Repetitive Loss

Flooding is the most common natural hazard in the United States. More than 22,000 communities experience floods and this hazard accounts for more than 70 percent of all Presidential Disaster Declarations. Over 8 million residential and commercial structures in the US are currently built in areas subject to flooding. The costs of these disasters are spread among local, state and federal governments and the individual victims themselves.

The National Flood Insurance Program (NFIP) is continually faced with the challenge of balancing the financial soundness of the program with competing expectation of keeping flood insurance premiums affordable. According to the Congressional Research Services' (CRS) August 16th, 2016 Report on FEMA's National Flood Insurance Program, there are approximately 5.1 million flood insurance policies in force with annual premiums of $3.55 billion. One of the largest obstacles to achieving financial soundness of the NFIP is Repetitive Loss (RL) properties, properties with two or more claims of $1,000 paid against the NFIP.

Since the inception of the NFIP, almost 9 billion dollars have been paid out to RL properties, approximately one-fourth of all NFIP payments. Since 1978, the year that detailed record keeping started for RL properties, approximately 199,000 RL properties have been identified in the United States. While many communities have practiced sound floodplain management principals, and many of these structures have been mitigated, RL properties continue to be a drain on the National Flood Insurance Fund.

Currently RL properties only represent approximately 1.3% of all NFIP policies, but are expected to account for between 15 to 20 percent of all future losses. Therefore, the Federal Emergency Management Agency (FEMA) has placed greater emphasis on addressing this problem. To focus more resources on these high-risk properties, Congress defined a subset called "Severe Repetitive Loss Properties (defined later in this section)" when it passed the National Flood Insurance Reform Act of 2004.

An obstacle to achieving financial soundness of the NFIP is that FEMA has not historically been allowed to eliminate coverage for any policy holder including high-risk properties. FEMA has only been authorized by Congress to make incremental adjustments to increase premium rates and reduce overall coverage. Since repetitive flood claims must be paid, FEMA has had no choice but to spread these costs among all policy holders.

Because of past significant flood events and more recent ones (Hurricane Katrina in 2005 and Superstorm Sandy in 2012), the NFIP Fund is in debt to the US Treasury in the amount of $24.6 billion. It may not be realistic to recover this debt through premium increases for Pre-FIRM properties and by eliminating grandfathering of rates. Congress may need to take further action to protect the solvency of the NFIP.

The Congressional Research Service (CRS) conducted a report in February of 2013, which was a follow up to a report created in June of 2012, on *The National Flood Insurance Program: Status and Remaining Issues*, which provided detail of the impacts of Superstorm Sandy on the NFIP. Increased costs associated with flood events is evidenced in **Table 4.14** which lists the top 20 floods in terms of NFIP payouts. To be included on this list, the minimum threshold is at least 1,500 flood insurance claims. Please note that as of the date of this study all data for Superstorm Sandy was not available and the number of paid losses, amount paid and average paid loss may change.

Table 4.14. Top 20 Significant Flood Events Covered by the National Flood Insurance Program (1978 to February 6, 2013; $ nominal)

Rank	Event	Date	Number of Paid Losses	Amount Paid	Average Paid Loss
1	Hurricane Katrina	Aug. 2005	167,671	$16,264,168,476	$97,001
2	Superstorm Sandy	Oct. 2012	131,315	$8,599,564,123	$65,183
3	Hurricane Ike	Sept. 2008	46,412	$2,664,167,040	$57,391
4	Hurricane Ivan	Sept. 2004	27,658	$1,590,436,206	$57,504
5	Hurricane Irene	Aug. 2011	43,848	$1,302,111,631	$29,696
6	Tropical Storm Allison	June 2001	30,663	$1,103,877,235	$36,000
7	Louisiana Flood	May 1995	31,343	$585,071,593	$18,667
8	Hurricane Isabel	Sept. 2003	19,869	$493,453,308	$24,835
9	Hurricane Rita	Sept. 2005	9,517	$472,774,099	$49,667
10	Hurricane Floyd	Sept. 1999	20,437	$462,252,753	$22,618
11	Tropical Storm Lee	Sept. 2011	9,748	$452,229,918	$45,369
12	Hurricane Opal	Oct. 1995	10,343	$405,527,543	$39,208
13	Tropical Storm Isaac	Aug 2012	10,126	$407,251,178	$40,218
14	Hurricane Hugo	Sept. 1989	12,840	$376,433,739	$29,317
15	Hurricane Wilma	Oct. 2005	9,614	$365,030,822	$37,975
16	Nor'easter	Dec. 1992	25,142	$346,150,356	$13,768
17	Midwest Flood	June 1993	10,472	$272,819,515	$26,052
18	PA, NJ, NY Floods	June 2006	6,423	$228,743,070	$35,613
19	Torrential Rain - TN	Apr. 2010	4,108	$228,248,545	$55,562
20	Nor'easter	Apr. 2007	8,636	$225,657,504	$26,130

Source: U.S. Department of Homeland Security, Federal Emergency Management Agency.

While most Special Flood Hazard Area (SFHA) properties are charged the true actuarial rate based on the flood risk to that building, there is a subset of properties called Pre-FIRM (constructed or substantially improved prior to July 31st, 1974, or before the community adopted its first Flood Insurance Rate Map (FIRM), whichever is later) which were allowed by statute to have lower premiums than predicted to cover potential future claims.

The August 16th, 2016 Congressional Research Service report on FEMA's National Flood Insurance Program indicated that as of October 2015, there were 889,621 polices that received a Pre-FIRM subsidy which represented around 17% of all NFIP policies. Because of federal legislative changes to the NFIP through Section 100205 of the Biggert-Waters Flood Insurance Reform Act of 2012 (BW-12) and Sections 3 and 5 of the Homeowner Flood Insurance Affordability Act of 2014 (HFIAA), the Pre-FIRM subsidy will be progressively phased out (different pace of phase out based on the property type). Therefore, premiums for Pre-FIRM properties will reach sound actuarial rates which represents the true flood risk for that location.

Table 4.15 indicates that presently, the NFIP has nearly 5.1 million policies in force covering almost $1.2 trillion in property in around 22,000 participating communities. These 5.1 million policies generated $3.5 billion in premiums in 2016. Since 1978 when the NFIP started keep more accurate records, payouts of $1 billion to policy holders have happened nine times. The first of which was in 1995. The other years where payouts exceeded $1 billion were in 2001, 2004, 2005, 2008, 2011, 2012, 2015 and 2016. Five of those times were in a 10-year period from 2001 to 2011.

Table 4.15. NFIP Program Statistics (1978 to December 2016; $ nominal)

Calendar Year	Number of Policies in Force	Total Written Premium	Total Face Value of Coverage	Total Number of Claims Paid	Total Payments Made to Policyholders
1972-1977	NA	NA	NA	4,441	$18,035,658
1978	1,446,354	$111,250,585	$50,500,956,000	29,122	$147,719,253
1979	1,843,441	$141,535,832	$74,375,240,000	70,613	$483,281,219
1980	2,103,851	$159,009,583	$99,259,942,000	41,918	$230,414,295
1981	1,915,065	$256,798,488	$102,059,859,000	23,261	$127,118,031
1982	1,900,544	$354,842,356	$107,296,802,000	32,831	$198,295,820
1983	1,981,122	$384,225,425	$117,834,255,000	51,584	$439,454,937
1984	1,926,388	$420,530,032	$124,421,281,000	27,688	$254,642,874
1985	2,016,785	$452,466,332	$139,948,260,000	38,676	$368,238,794
1986	2,119,039	$518,226,957	$155,717,168,000	13,789	$126,384,695
1987	2,115,183	$566,391,536	$165,053,402,000	13,400	$105,432,378
1988	2,149,153	$589,453,163	$175,764,175,000	7,758	$51,022,523
1989	2,292,947	$632,204,396	$265,218,590,000	36,245	$661,658,285
1990	2,477,861	$672,791,834	$213,588,265,000	14,766	$167,896,816
1991	2,532,713	$737,078,033	$223,098,548,000	28,549	$353,681,702
1992	2,623,406	$800,973,357	$236,844,980,000	44,650	$710,225,154
1993	2,828,558	$890,425,274	$267,870,761,000	36,044	$659,059,461
1994	3,040,198	$1,003,850,875	$295,935,328,000	21,583	$411,075,128
1995	3,476,829	$1,140,808,119	$349,137,768,000	62,441	$1,295,578,117
1996	3,693,076	$1,275,176,752	$400,681,650,000	52,677	$828,036,508
1997	4,102,416	$1,509,787,517	$462,606,433,000	30,338	$519,537,378
1998	4,235,138	$1,668,246,681	$497,621,083,000	57,348	$886,327,133
1999	4,329,985	$1,719,652,696	$534,117,781,000	47,247	$754,970,800
2000	4,369,087	$1,723,824,570	$567,568,653,000	16,362	$251,720,536
2001	4,458,470	$1,740,331,079	$611,918,920,000	43,589	$1,277,002,489
2002	4,519,799	$1,802,277,937	$653,776,126,000	25,312	$433,644,094
2003	4,565,491	$1,897,687,479	$691,786,140,000	36,838	$780,492,440
2004	4,667,446	$2,040,828,486	$765,205,681,000	55,825	$2,232,042,331
2005	4,962,011	$2,241,264,140	$876,679,658,000	212,778	$17,713,105,660
2006	5,514,895	$2,604,844,133	$1,054,087,148,000	24,592	$640,623,771
2007	5,655,919	$2,843,422,049	$1,141,242,230,000	23,129	$612,351,594
2008	5,684,275	$3,066,729,200	$1,197,659,846,000	74,266	$3,450,249,017
2009	5,704,198	$3,202,267,224	$1,233,005,263,000	30,821	$772,390,723

Calendar Year	Number of Policies in Force	Total Written Premium	Total Face Value of Coverage	Total Number of Claims Paid	Total Payments Made to Policyholders
2010	5,559,313	$3,348,222,091	$1,227,932,424,400	27,165	$708,992,043
2011	5,585,797	$3,477,338,993	$1,264,043,634,800	65,315	$1,847,881,892
2012	5,620,017	$3,341,335,762	$1,291,764,167,000	151,849	$9,516,995,000
2013	5,568,642	$3,512,987,082	$1,300,834,626,000	18,118	$492,542,000
2014	5,406,725	$3,542,524,781	$1,291,437,810,000	12,907	$380,222,000
2015	5,205,904	$3,436,750,383	$1,267,394,338,000	25,798	$1,028,338,000
2016	5,081,470	$3,332,142,146	$1,254,564,168,000	59,332	$3,693,224,000

Source: U.S. Department of Homeland Security, Federal Emergency Management Agency.

Before the inception of the NFIP, flood hazards in the United States, whether from hurricanes and coastal storm surge or inland flooding on rivers, streams, and lakes, was largely deemed uninsurable from the private insurance industry. Hurricane Betsy in September of 1965, a Category 3 storm, was the first natural disaster in the U.S. to generate over a billion dollars in damage without an insurance program to help property owners recover and rebuild. In response, largely on a basis of the "general welfare" and "interstate commerce" clauses of the U.S. Constitution, Congress created the NFIP in 1968. The NFIP would regulate the nation's floodplains (Special Flood Hazard Areas – SFHA) with land use controls and building requirements that communities in the SFHA must adopt and enforce in order for property owners to be eligible for insurance.

Properties that experience repetitive flood losses—RL properties and Severe Repetitive Loss (SRL) properties—account for a disproportionate share of all flood insurance claims filed under the NFIP. About 1 in 10 homes that suffer repetitive flood damages have cumulative flood claims that exceed the value of the structure. It is estimated by FEMA that almost 90% of RL properties were built prior to December 31, 1974 or before the adoption of a FIRM and are subject to premium discounts.

4.3.2. Definition of Repetitive Loss and Severe Repetitive Loss

Repetitive Loss (RL) and Severe Repetitive Loss (SRL) properties create a drain on the National Flood Insurance Fund (NFIF). These properties increase the NFIP's annual losses and may cause increases for additional borrowing from the Treasury Department. More importantly, they take away resources needed to prepare for catastrophic events. There is more than one definition for repetitive loss; however, the State of Missouri uses the following definitions for RL and SRL properties:

Table 4.16. Total Repetitive Flood Loss Properties in the NFIP: 1978-2017 (As of June 30, 2017: $ nominal)

Building Payments	$13,388,582,162
Contents Payments	$3,505,575,874
Total payments	$16,894,158,477
Average payment	$28,325
Number of Losses	600,710
Number of Properties	199,875

Source: U.S. Department of Homeland Security, Federal Emergency Management Agency.

Table 4.17 shows the historical repetitive flood problem within the state of Missouri. Since 1978 when FEMA began keeping better records, Missouri accounts for 3.5% of total claims payments against the NFIP. The state of Missouri as of June 30, 2017, has 2.9% of the total number of repetitive loss properties in the US.

Table 4.17. Total Repetitive Flood Loss Properties in the State of Missouri: 1978-2017 (As of June 30, 2017: $ nominal)

Building Payments	$333,751,519
Contents Payments	$121,418,757
Total payments	$455,170,276
Average payment	$21,691
Number of Losses	20,984
Number of Properties	5,718

Source: U.S. Department of Homeland Security, Federal Emergency Management Agency.

One issue with trying to reduce the number of RL properties is enforcement of local flood damage prevention ordinances and the substantial damage requirement. Historically, there has been a reluctance to enforce and inconsistencies in enforcement of the substantial damage requirement (i.e., building damaged 50% or more of market value). Some communities have solved this problem by incorporating a Cumulative Substantial Damage requirement (improvements or damages counted cumulatively) in their ordinance.

4.3.3. Federal Requirements for a Repetitive Loss Strategy

To be eligible to receive an increased Federal cost share of up to 90 percent for project grants related to reducing losses to severe repetitive loss properties, mitigation plans must specifically address such projects. States may address the repetitive loss strategy through an amendment to their existing FEMA-approved State Mitigation Plans, or they may accomplish this as part of a cyclical update.

To be eligible for an increased Federal cost share of up to 90 percent under the SRL program, the FEMA-approved State or Tribal Standard Mitigation Plan must also meet all of the requirements described below:

Repetitive Loss: Any insurable building for which two or more claims of more than $1,000 were paid by the NFIP within any rolling 10-year period, since 1978. Two of the claims paid must be more than 10 days apart but, within 10 years of each other. A repetitive loss property may or may not be currently insured by the NFIP.

Severe Repetitive Loss: As defined by the Flood Insurance Reform Act of 2004, SRLs are 1-4 family residences that have had four or more claims of more than $5,000 or at least two claims that cumulatively exceed the building's value. The Act creates new funding mechanisms to help mitigate flood damage for these properties.

Per the National Flood Insurance Manual (April 2017 edition), approximately 11,900 policies out of the total 160,000 RL were classified as SRL. As these policies come up for renewal, they will be (if not already) transferred to the NFIP Servicing Agent's Special Direct Facility (SDF) away from being handled by any Write-Your-Own (WYO) company.

A Congressional Research Service report in June of 2012 indicates that new RLs are outpacing FEMA mitigation efforts by 10 to 1. FEMA, along with other agencies, placed a greater emphasis on mitigation after the 1993 Midwest floods where hundreds of millions were spent to remove frequently flooded structures from the floodplain.

From a national perspective, **Table 4.16** shows that over $16 billion in total payments have been paid to RL properties ($13 billion for structures and $3 billion for contents). FEMA has implemented many different methods over the years to deal with the RL property problem. During the last reform to the Flood Insurance Program in 2012, the Repetitive Flood Claims (RFC) and Severe Repetitive Loss (SRL) grant programs were eliminated and combined in the Flood Mitigation Assistance Program (FMA).

a) **Repetitive Loss Strategy** - *44 CFR 201.4(c)(3)(v): A State may request the reduced cost share authorized under Sec. 79.4(c)(2) of this chapter for the FMA and SRL programs, if it has an approved State Mitigation Plan meeting the requirements of this section that also identifies specific actions the State has taken to reduce the number of repetitive loss properties (which must include severe repetitive loss properties), and specifies how the State intends to reduce the number of such repetitive loss properties. This requirement supplements the risk assessment and mitigation strategy portions of the plan required under 201.4(c)(2) and (3) by specifically identifying goals, capabilities, and actions that will reduce the number of repetitive loss properties, including severe repetitive loss properties.*

The mitigation strategy is based on the State's Risk Assessment as required under 201.4(c)(3)(ii). Therefore, the State must address repetitive loss structures in its risk assessment, where applicable. For example, in its overview of Estimating Potential Losses by Jurisdiction under 201.4(c) (2)(iii), the State may analyze potential losses to identified repetitive loss properties based on estimates provided in local risk assessments. The Plan should refer generally to geographic areas where concentrations of repetitive loss properties are located for the purpose of identifying and prioritizing areas for mitigation projects, or the plan may list the number of repetitive loss properties with aggregate repetitive loss data.

The State Hazard Mitigation Goals under 201.4(c)(3)(i) must support the selection of activities to mitigate and reduce potential losses to structures susceptible to flood damage, including repetitive loss properties. In addition, the State and Local Capability Assessments required under 201.4(c)(3)(ii) must include an evaluation of policies, programs, and capabilities that allow the mitigation of repetitive losses from flood damage.

The State must describe specific actions that it has implemented to mitigate repetitive loss properties, and specifically actions taken to reduce the number of severe repetitive loss properties as a subset of all repetitive loss properties in the State. If the State cannot show that any action has ever been taken to reduce the number of such properties, this criterion cannot be met.

Based on the findings of the risk assessment, the State must identify actions in the statewide mitigation strategy that specifically address repetitive loss properties, including those that are severe repetitive loss properties. This supplements the mitigation actions requirement under 201.4(c)(3)(iii). Mitigation actions should be tied to goals and objectives and provide the means to achieve them. Actions should have been identified in the planning process, and local plans should be consistent with state-wide actions. As part of the mitigation strategy, the plan must also describe the current funding sources as well as potential sources that will be pursued to fund proposed mitigation actions for repetitive loss properties. This supplements the identification of funding requirement under 201.4(c)(3)(iv)

b) **Coordination with Repetitive Loss Jurisdictions** - *44 CFR 201.4(c)(3)(v): The plan must describe the strategy the State has to ensure that local jurisdictions with severe repetitive loss properties take actions to reduce the number of these properties, including the development of local mitigation plans.*

The State is required to identify strategies that encourage local communities to mitigate severe repetitive loss properties, including the development of local mitigation plans. This supplement the Coordination of Local Mitigation Planning portion of the plan under 201.4(c)(4). At a minimum, the State must include severe repetitive loss in the description of its process for providing funding and technical assistance to prepare mitigation plans 201.4(c)(4)(i)), and in its criteria for prioritizing communities that have such properties for planning and project grant assistance 201.4(c)(4)(iii)). Other strategies for encouraging local communities to mitigate severe repetitive loss properties should be demonstrated through specific actions identified in the Mitigation Strategy.

4.3.4. National Flood Insurance Reform Act of 2004

The Bunning-Bereuter-Blumenauer Flood Insurance Reform Act of 2004 was signed into law by President George W. Bush on June 30 of the same year. The Act (Public Law 108-264) revised the existing Flood Mitigation Assistance (FMA) Program by creating a Pilot Program at $40 million per year to mitigate severe repetitive loss properties. It reduced the non-federal match from 25% to 10% with an approved mitigation plan that specifies the state's strategy to reduce the number of severe repetitive loss properties. Missouri has developed this Repetitive Flood Loss Strategy in part to receive this share reduction.

The Federal Insurance Administration database shows claims paid that reflect either Repetitive Loss (RL) properties or Severe Repetitive Loss (SRL) properties. Residential SRL properties receive priority for mitigation under the NFIP Reform Act of 2004 (Public Law 108-264). The primary goal of the Program is to reduce excessive flood claim payments and reliance on the National Flood Insurance Fund for flood relief when mitigation is an option.

For the FMA program, FEMA may contribute funding to eligible projects as follows.

- Up to 100% federal cost share for SRL properties or the expected savings to the NFIP for acquisition or relocation activities. The Greatest Savings to the Fund (GSTF) value for property acquisition may be offered to the property owner if the project is not cost-effective using pre-event or current market value.
- Up to 90% federal cost share for RL properties.
- Up to 75% federal cost share for NFIP-insured properties. Cost share requirements are summarized in Table 4.18 below. Therefore, with the inclusion of the RL strategy in this plan, cost shares of up to 90%/10% and 100%/0% are available for eligible projects as noted below.

Table 4.18. FEMA HMA Cost Share Requirements

Programs	Mitigation Activity (Percent of Federal/Non-Federal Share)	Recipient Management Costs (Percent of Federal/Non-Federal Share)	Subrecipient Management Costs (Percent of Federal/Non-Federal Share)
HMGP	75/25	100/0	–/–(1)
PDM	75/25	75/25	75/25
PDM – subrecipient is small and impoverished community	90/10	75/25	90/10
PDM – Tribal Recipient/subrecipient is small and impoverished	90/10	90/10	90/10
FMA – insured properties and planning grants	75/25	75/25	75/25
FMA – repetitive loss property(2)	90/10	90/10	90/10
FMA – severe repetitive loss property(2)	100/0	100/0	100/0

(1) Subapplicants should consult their State Hazard Mitigation Officer (SHMO) for the amount or percentage of **HMGP** subrecipient management cost funding their State has determined to be passed through to subrecipients.

(2) To be eligible for an increased Federal cost share, a FEMA-approved State or Tribal (Standard or Enhanced) Mitigation Plan that addresses repetitive loss properties must be in effect at the time of award, and the property that is being submitted for consideration must be a repetitive loss property.

Source: FEMA Hazard Mitigation Assistance Guidance 2015

4.3.5. State Mitigation Goals that Support Reducing Repetitively Flooded Properties

This Repetitive Flood Loss Strategy is supported by the State Mitigation Goals (restated below) to reduce repetitively flooded properties. Goal 1 and Goal 3 both support the development and funding of sensible mitigation projects to eliminate repetitive flood losses. Goal 4 supports the Community Buyout Program by creating deed restricted open space areas. Properties that have no buildings means emergency services will not have to respond to either evacuate or rescue people. Additionally, since the property must be kept as open space for perpetuity, damage to the building has been eliminated and no new buildings can be constructed on site.

Goal 1: Implement mitigation actions that improve the protection of human life, health, and safety from the adverse effects of disasters.

Goal 2: Implement mitigation actions that improve the continuity of government and essential services from the adverse effects of disasters.

Goal 3: Implement mitigation actions that improve the protection of public and private property from the adverse effects of disasters.

Goal 4: Implement mitigation actions that improve the protection of community tranquility from the adverse effects of disasters.

4.3.6. State Mitigation Outreach Objectives to Reduce the Number of Repetitively Flooded Properties

This Repetitive Flood Loss Strategy is based on the State Risk Assessment and the State addressing repetitively flooded structures in its risk assessment. The mitigation of RL properties should occur through the coordination of local plans and through a mitigation strategy in this plan. SEMA provides guidance and outreach to all state communities through digital methods (via emails to mitigation contacts and through online website information) and workshops at the inception of each pre-disaster and post-disaster grant period. SEMA will inform local jurisdictions of the number of repetitive loss properties and indicate the prioritization of RL properties in its grant announcement to ensure communities with RL and SRL properties are fully aware that grant monies are available for acquisition, relocation and/or elevation projects. Follow-up with communities who are interested in elevation or buyout projects will be considered a high priority for staff members at SEMA. For FMA project funding opportunities, the State of Missouri considers RL and SRL properties to be the highest priority factor in making grant awards to local communities.

Therefore, the State of Missouri Mitigation Strategy consists of the following objectives:

- Local jurisdictions with RL and SRL properties will be encouraged to take actions to reduce the number of these properties by identifying those properties and working with them to explain the benefits of FEMA's HMA Grant Programs.
- Identify and describe RL and SRL properties for each community so that funding and technical assistance is available to prepare local mitigation plans that addresses the mitigation of these properties.
- Prioritize project grants for communities that have RL and SRL properties and who have targeted them for mitigation projects such as elevation or acquisition.

4.3.7. Status of Repetitive Loss in Missouri

As of June 30th, 2017, the State of Missouri had 196 properties designated as Severe Repetitive Loss with total payments to property owners (building and contents) of more than $35 million. These 196 SRL properties had 1,460 losses or an average of 7.4 losses for each SRL property.

There were 5,718 properties designated as Repetitive Loss Properties as of June 30th, 2017. Paid claims on these buildings totaled more than $455 million. There were 20,984 losses for these 5,718 properties which means each property had an average of 3.7 losses per property.

Table 4.19. Missouri Severe Repetitive Loss County Summary

County	Community Name	Number of SRL Properties	Number of Paid NFIP Claims	Total Paid Losses	Average Payment
Andrew	Andrew County	1	4	$134,320.56	$33,580.14
Boone	Boone County	1	10	$219,131.36	$21,913.14
Butler	Butler County	1	4	$83,777.01	$20,944.25
Cape Girardeau	Cape Girardeau Cnty	2	9	$115,860.40	$12,873.38
Cape Girardeau	Jackson	1	6	$143,434.26	$23,905.71
Carter	Carter County	2	8	$383,322.20	$47,915.29
Cass	Lee's Summit	2	12	$234,237.60	$19,519.80

County	Community Name	Number of SRL Properties	Number of Paid NFIP Claims	Total Paid Losses	Average Payment
Cass	Lake Annette	1	6	$127,099.71	$21,183.29
Christian	Christian County	1	5	$85,081.53	$17,016.31
Clay	Claycomo	1	4	$102,148.45	$25,537.11
Clay	Kansas City	3	29	$244,724.75	$8,438.78
Cole	Cole County	6	54	$1,177,147.25	$22,470.62
Franklin	Franklin County	4	20	$496,331.40	$24,816.57
Franklin	Pacific	3	12	$938,470.99	$78,205.92
Gasconade	Gasconade County	7	45	$1,011,177.83	$22,470.62
Gasconade	Hermann	1	7	$54,452.93	$8,350.42
Holt	Big Lake	8	24	$1,714,592.54	$71,441.36
Jackson	Jackson County	1	5	$64,465.73	$13,893.15
Jasper	Carthage	1	4	$65,904.30	$16,476.08
Jefferson	Arnold	1	6	$172,645.61	$28,774.27
Jefferson	Byrnes Mill	1	7	$398,465.53	$56,922.36
Jefferson	Herculaneum	1	6	$91,126.68	$15,187.78
Jefferson	Jefferson County	40	303	$7,135,143.43	$25,548.33
Lincoln	Chain of Rocks	1	5	$47,671.24	$9,534.25
Lincoln	Lincoln County	6	94	$829,766.48	$8,827.30
Maries	Maries County	1	4	$76,195.15	$19,047.79
McDonald	McDonald County	1	4	$291,069.00	$72,767.25
McDonald	Noel	1	4	$46,752.78	$11,688.20
Newton	Grand Falls Plaza	1	4	$125,930.20	$31,482.55
Newton	Neosho	1	5	$69,655.35	$13,931.07
Newton	Newton County	3	12	$594,371.61	$49,530.97
Osage	Westphalia	1	6	$52,822.73	$8,803.79
Phelps	Phelps County	9	39	$2,195,507.57	$56,295.07
Phelps	Rolla	1	4	$239,938.18	$59,984.55
Pike	Clarksville	1	9	$121,234.74	$13,470.53
Pike	Louisiana	1	5	$30,425.81	$6,085.16
Pike	Pike County	5	86	$733,055.96	$8,523.91
Pulaski	Pulaski County	3	12	$430,859.20	$35,904.93
St. Charles	Portage Des Sioux	1	11	$162,406.08	$14,764.19
St. Charles	St. Charles County	29	277	$4,575,401.88	$16,517.70
St. Charles	St. Charles City	2	24	$1,131,323.24	$47,138.47
St. Charles	West Alton	12	101	$1,920,287.28	$19,012.75
St. Francois	St. Francois County	1	16	$539,485.46	$33,717.84
St. Louis	Breckenridge Hills	1	6	$81,353.66	$13,558.94
St. Louis	Eureka	1	4	$111,094.08	$27,773.52
St. Louis	Fenton	4	24	$600,674.04	$25,028.09
St. Louis	Hazelwood	1	5	$169,702.87	$33,940.57
St. Louis	St. Louis County	6	51	$1,865,136.30	$36,571.30
St. Genevieve	St. Genevieve Cnty	1	6	$130,074.07	$22,012.35
St. Genevieve	St. Genevieve	1	6	$51,677.07	$8,612.85
Taney	Branson	3	14	$729.519.72	$52,108.55
Taney	Taney County	3	13	$1,380,133.12	$106,164.09
Warren	Marthasville	1	4	$50,096.46	$14,774.12

Source: SEMA

Severe Repetitive Loss Summary

- Jefferson County has the greatest number of SRL properties with 40, followed by St. Charles County with 29 and West Alton in St. Charles County with 12.
- The median average SRL payment across all communities in the State is $22,012 and the mean is $28,584. This indicates that there are several outlier communities with average SRL payments significantly higher than the median average payment. For example, the average payment is $78,206 in the City of Pacific in Franklin County, $72,767 in McDonald County, and $106,164 in Taney County. High average payments may be an indication of high real estate prices and/or higher levels of coverage.
- Those communities in Missouri that have received the greatest total paid losses are Taney County with over $1.38 million in total paid losses, St. Louis County with nearly $1.87 million, the Village of Big Lake in Holt County with over $1.71 million, the Town of West Alton in St. Charles County with over $1.92 million, Phelps County with nearly $2.2 million, St. Charles County with nearly $4.58 million, and Jefferson County with nearly $7.14 million.
- The communities with the most paid claims to SRL properties are Lincoln County with 94 claims paid, Town of West Alton in St. Charles County with 101, St. Charles County with 277, and Jefferson County with 303.
- The counties with the highest average number of losses per SRL property are Boone County with 10, Lincoln County with 14.1, Pike County with 14.3, and St. Francois County with 16.

Figure 4.2. Severe Repetitive Loss Properties by County

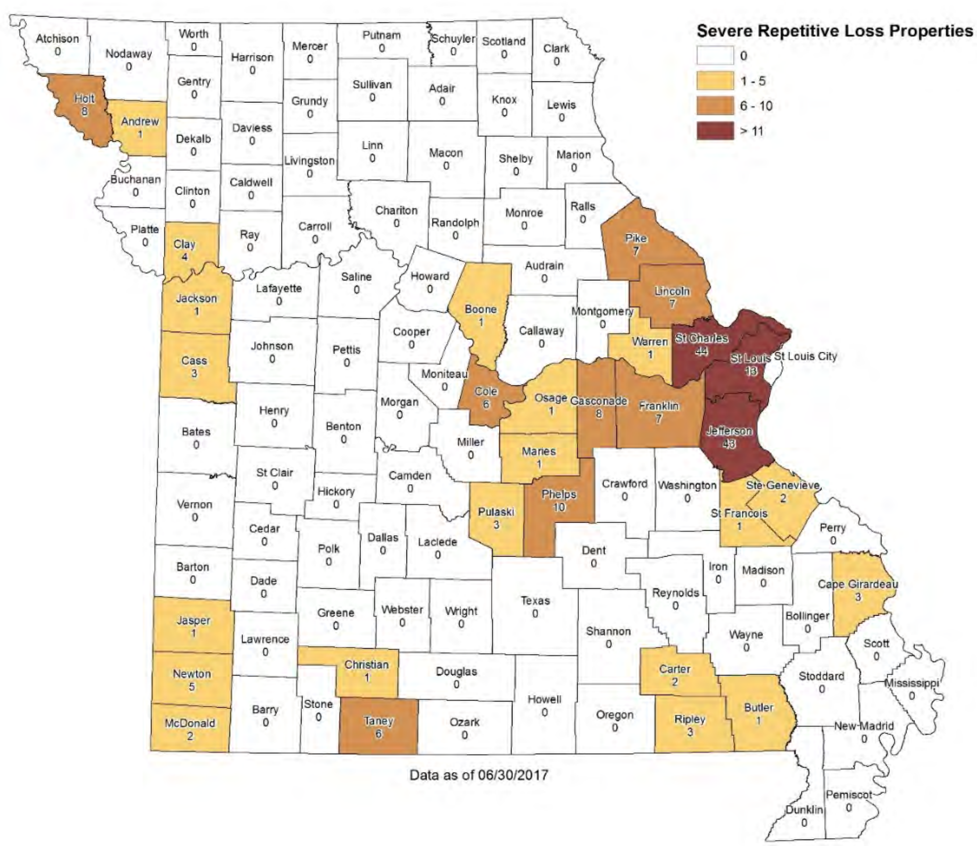


Table 4.20. Missouri Repetitive Loss County Summary

County	Community Name	Number of RL Properties	Number of Paid NFIP Claims	Total Paid Losses	Average Payment
Adair	Kirksville	1	2	$30,029.44	$15,014.72
Andrew	Andrew County	19	49	$1,612,124.03	$32,900.49
Andrew	Rosendale	2	4	$25,627.47	$6,406.87
Atchison	Rock Port	1	3	$16,867.96	$5,622.65
Atchison	Tarkio	3	7	$65,931.27	$9,418.75
Audrain	Mexico	2	7	$31,161.95	$4,451.71
Audrain	Vandalia	2	8	$63,247.40	$7,905.93
Barry	Monett	7	22	$1,896,642.02	$86,211.00
Barton	Lamar	1	3	$11,852.84	3,950.95
Bates	Butler	2	5	$199,906.23	$39,981.25
Bollinger	Bollinger County	4	8	$170,886.37	$21,360.80
Bollinger	Glen Allen	1	2	$19,302.06	$9,651.03
Bollinger	Lutesville	4	8	$33,534.19	$4,191.77
Bollinger	Marble Hill	11	26	$844,467.53	$32,479.52
Boone	Boone County	5	23	$375,302.65	$16,317.51
Boone	Columbia	5	27	$2,250,808.70	$83,363.29
Boone	Hartsburg	4	8	$121,572.21	$15,196.53
Buchanan	Buchanan County	11	28	$810,930.18	$28,961.79
Buchanan	Lewis and Clark	4	12	$776,168.50	$64,680.71
Buchanan	Rushville	1	3	$123,538.01	$41,179.34
Buchanan	St. Joseph	7	16	$156,353.09	$9,772.07
Butler	Butler County	55	130	$3,542,605.02	$27,250.81
Butler	Poplar Bluff	13	31	$1,668,095.79	$53,809.54
Butler	Qulin	1	2	$26,302.34	$13,151.17
Callaway	Callaway County	4	8	$158,831.95	$19,853.99
Callaway	Fulton	5	16	$152,992.83	$9,562.05
Callaway	Jefferson City	48	141	$3,358,000.17	$23,815.60
Callaway	Mokane	6	25	$166,041.04	$6,641.64
Camden	Camden County	8	17	$483,612.20	$28,447.78
Camden	Osage Beach	1	4	$121,291.12	$30,322.78
Cape Girardeau	Cape Girardeau Cnty	25	75	$1,198,728.32	$15,983.04
Cape Girardeau	Cape Girardeau	94	326	$3,295,410.50	$10,108.62
Cape Girardeau	Jackson	5	18	$225,748.31	$12,541.57
Carroll	Carroll County	8	18	$434,728.52	$24,151.58
Carroll	Carrolltown	9	26	$885,574.35	$34,060.55
Carter	Carter County	8	22	$1,073,213.59	$48,782.44
Carter	Van Buren	4	11	$159,813.65	$14,528.51
Cass	Lee's Summit	8	29	$456,243.84	$15,732.55
Cass	Belton	2	4	$13,545.70	$3,386.43
Cass	Cass County	7	24	$520,286.65	$21,678.61
Cass	East Lynne	1	2	$27,085.35	13,542.68
Cass	Freeman	1	2	$9,738.79	$4,869.40
Cass	Harrisonville	1	4	$239,508.16	$59,877.04
Cass	Lake Annette	3	10	$154,526.89	$15,452.69
Cass	Lake Winnebago	1	2	$139,702.49	$69,851.25
Cass	Peculiar	7	23	$336,323.68	$14,622.77
Cass	Pleasant Hill	10	35	$265,153.68	$7,575.82

County	Community Name	Number of RL Properties	Number of Paid NFIP Claims	Total Paid Losses	Average Payment
Cass	Raymore	1	3	$39,591.77	$13,197.26
Chariton	Brunswick	3	7	$52,000.96	$7,428.71
Chariton	Chariton County	3	6	$77,760.02	$12,960.00
Christian	Christian County	6	18	$397,077.89	$22,059.88
Christian	Ozark	3	11	$927,141.83	$84,285.62
Clark	Alexandria	1	2	$6,871.17	$3,435.59
Clark	Clark County	2	4	$274,544.67	$68,636.17
Clay	Avondale	5	24	$194,071.78	$8,086.32
Clay	Clay County	8	25	$333,558.30	$13,342.33
Clay	Claycomo	12	63	$1,735,116.64	$27,541.53
Clay	Excelsior Springs	10	47	$1,225,140.75	$26,066.82
Clay	Gladstone	2	4	$25,590.59	$6,397.65
Clay	Independence	21	55	$621,812.43	$11,305.68
Clay	Kansas City	160	521	$21,992,678.31	$42,212.43
Clay	Liberty	1	2	$14,041.70	$7,020.85
Clay	Missouri City	1	2	$10,998.96	$5,499.48
Clay	Mosby	13	36	$797,055.96	$22,140.44
Clay	North Kansas City	1	2	$28,330.20	$14,165.10
Clay	Smithville	7	14	$178,878.00	$12,777.00
Clay	Sugar Creek	2	5	$71,909.35	$14,381.87
Cole	Cole County	32	138	$2,532,721.53	$18,353.05
Crawford	Crawford County	12	42	$1,722,708.43	$41,016.87
Crawford	Steelville	2	6	$26,370.53	$4,395.09
Daviess	Pattonsburg	11	22	$319,529.84	$14,524.08
Dunklin	Cardwell	1	2	$3,686.42	$1,843.21
Dunklin	Dunklin County	2	4	$93,587.37	$23,396.84
Dunklin	Kennett	1	2	$3,602.11	$1,801.06
Franklin	Berger	2	7	$36,920.26	$5,274.32
Franklin	Franklin County	84	242	$7,150,030.26	$29,545.58
Franklin	Pacific	88	214	$7,802,179.39	$36,458.78
Franklin	St. Clair	2	6	$34,068.33	$5,678.06
Franklin	Union	1	2	$92,298.57	$46,149.29
Franklin	Washington	2	4	$32,369.22	$8,092.30
Gasconade	Gasconade County	41	173	$2,891,633.21	$16,714.64
Gasconade	Gasconade	6	20	$275,690.56	$13,784.53
Gasconade	Hermann	26	90	$3,117,383.72	$34,637.60
Gasconade	Morrison	1	2	$3,794.61	$1,897.31
Greene	Greene County	7	23	$461.018.83	$20,044.30
Greene	Springfield	13	29	$1,157,982.84	$39,930.44
Holt	Big Lake	203	543	$19,200,134.29	$35,359.36
Holt	Bigelow	3	7	$403,487.03	$57,641.00
Holt	Craig	2	7	$235,354.51	$33,622.07
Holt	Fortescue	3	6	$88,731.34	$14,788.56
Holt	Holt County	9	23	$681,486.83	$29,629.86
Holt	Mound City	1	2	$10,225.44	$5,112.72
Howard	Franklin	4	11	$56,244.58	$5,113.14
Howard	Howard County	2	5	$77,525.94	$15,505.19
Howard	New Franklin	1	3	$5,112.56	$1,704.19

County	Community Name	Number of RL Properties	Number of Paid NFIP Claims	Total Paid Losses	Average Payment
Howell	West Plains	1	4	$844,130.73	$211,032.68
Independent City	St. Louis	29	107	$3,044,588.35	$28,454.10
Iron	Ironton	3	7	$27,602.15	$3,943.16
Jackson	Blue Springs	2	5	$31,394.63	$6,278.93
Jackson	Buckner	1	5	$33,599.15	$6,719.83
Jackson	Grandview	3	7	$27,529.68	$3,932.81
Jackson	Jackson County	2	11	$125,778.10	$11,434.37
Jackson	Lake Lotawana	1	2	$29,388.93	$14,694.47
Jackson	Levasy	3	8	$42,929.13	$5,366.14
Jackson	Raytown	14	35	$267,635.56	$7,646.73
Jasper	Carthage	3	8	$133,432.55	$16,679.07
Jasper	Duquesne	1	2	$43,477.22	$21,738.61
Jasper	Jasper County	6	14	$376,016.14	$26,858.30
Jasper	Joplin	6	12	$229,587.04	$19,132.25
Jasper	Sarcoxie	1	2	$9,023.76	$4,511.88
Jefferson	Arnold	158	564	$9,288,002.25	$16,468.09
Jefferson	Byrnes Mill	1	7	$398,456.53	$56,922.36
Jefferson	Crystal City	44	184	$3,838,072.64	$20,859.09
Jefferson	De Soto	7	14	$404,170.08	$28,869.29
Jefferson	Festus	15	49	$782,567.70	$15,970.77
Jefferson	Herculaneum	7	26	$667,368.96	$25,668.04
Jefferson	Jefferson County	381	1,609	$32,128,179.07	$19,967.79
Jefferson	Kimmswick	1	2	$115,206.53	$57,603.27
Jefferson	Pevely	1	2	$31,060.54	$15,530.27
Johnson	Johnson County	1	2	$4,384.12	$2,192.06
Johnson	Knob Noster	1	2	$23,050.74	$11,525.37
Laclede	Laclede County	2	7	$480,175.11	$68,596.44
Laclede	Lebanon	2	4	$33,241.99	$8,310.50
Lafayette	Lafayette County	3	7	$133,703.50	$19,100.50
Lawrence	Mt. Vernon	1	2	$48,238.52	$24,119.26
Lewis	Canton	3	9	$83,378.50	$9,264.28
Lewis	Lagrange	8	26	$544,434.74	$20,939.80
Lincoln	Chain of Rocks	1	5	$47,671.24	$9,534.25
Lincoln	Elsberry	16	53	$540,881.17	$10,205.31
Lincoln	Foley	25	72	$888,981.40	$12,346.96
Lincoln	Lincoln County	175	686	$9,030,399.62	$13,163.85
Lincoln	Moscow Mills	1	5	$46,911.21	$9,382.24
Lincoln	Old Monroe	18	55	$727,527.35	$13,227.77
Lincoln	Silex	4	12	$258,960.85	$21,580.07
Lincoln	Troy	3	7	$103,607.85	$14,801.12
Lincoln	Winfield	10	26	$357,695.00	$13,757.50
Linn	Brookfield	3	8	$81,115.83	$10,139.48
Linn	Marceline	1	2	$3,204.65	$1,602.33
Livingston	Chillicothe	1	2	$41,138.63	$20,569.32
Madison	Fredericktown	20	45	$484,259.75	$10,761.33
Madison	Madison County	1	2	$71,137.01	$35,568.51
Madison	Marquand	2	4	$401,256.40	$100,314.10
Maries	Maries County	26	75	$2,693,168.79	$35,908.92

County	Community Name	Number of RL Properties	Number of Paid NFIP Claims	Total Paid Losses	Average Payment
Maries	Vienna	1	2	$18,310.16	$9,155.08
Marion	Hannibal	26	65	$2,052,022.44	$31,569.58
Marion	Marion County	19	46	$763,949.66	$16,607.60
McDonald	Anderson	2	4	$273,568.31	$68,392.08
McDonald	McDonald	16	46	$2,676,289.55	$58,180.21
McDonald	Noel	12	51	$4,581,742.16	$89,838.08
McDonald	Pineville	2	6	$222,255.48	$37,042.58
Miller	Eldon	1	10	$86,676.01	$8,667.60
Miller	Tuscumbia	1	2	$11,704.45	$5,852.23
Mississippi	East Prairie	1	3	$4,307.90	$1,435.97
Mississippi	Mississippi County	5	11	$101,573.38	$9,233.94
Mississippi	Wilson City	1	3	$139,508.09	$46,502.70
Monroe	Paris	1	3	$11,406.21	$3,802.07
Montgomery	Montgomery Cnty	16	35	$325,068.83	$9,287.68
Montgomery	Rhineland	14	34	$442,602.34	$13,017.72
New Madrid	Lilbourn	11	23	$637,177.40	$27,703.37
New Madrid	New Madrid County	3	6	$162,793.16	$27,132.19
New Madrid	New Madrid	7	15	$257,942.65	$17,196.18
New Madrid	Risco	1	2	$18,200.00	$9,100.00
New Madrid	Sikeston	5	11	$53,758.85	$4,887.17
Newton	Grand Falls Plaza	2	6	$385,331.30	$64,221.88
Newton	Neosho	1	5	$69,655.35	$13,931.07
Newton	Newton County	10	30	$1,320,347.97	$44,011.60
Newton	Saginaw	1	2	$2,363.79	$1,181.90
Newton	Seneca	3	6	$83,754.02	$13,959.00
Osage	Chamois	5	16	$361,807.82	$22,612.99
Osage	Osage County	20	48	$1,068,367.69	$22,257.66
Osage	Westphalia	1	6	$52,822.73	$8,803.79
Ozark	Gainesville	1	2	$99,747.13	$49,873.57
Pemiscot	Caruthersville	5	13	$206,569.38	$15,889.95
Pemiscot	Pemiscot County	3	12	$222,838.06	$18,569.84
Pemiscot	Steele	1	2	$14,562.66	$7,281.33
Perry	Perry County	3	6	$236,204.72	$39,367.45
Pettis	Pettis County	2	4	$192,846.26	$48,211.57
Pettis	Sedalia	3	6	$19,090.29	$3,181.72
Phelps	Newburg	1	2	$88,764.12	$44,382.06
Phelps	Phelps County	37	114	$6,098,409,56	$53,494.82
Phelps	Rolla	10	31	$14,576.77	$32,382.89
Pike	Annada	1	2	$14,576.77	$7,288.39
Pike	Clarksville	14	56	$614,008.74	$10,964.44
Pike	Louisiana	15	74	$1,065,959.58	$14,404.86
Pike	Pike County	62	360	$3,358,693.91	$9,329.71
Platte	Edgerton	3	6	$53,443.85	$8,907.31
Platte	Parkville	2	4	$36,142.10	$9,035.53
Platte	Platte County	25	70	$2,094,543.85	$29,922.06
Platte	Riverside	3	6	$308,701.34	$51,450.22
Platte	Tracy	3	7	$56,558.61	$8,079.80
Platte	Weston	1	3	$71,118.47	$23,706.16

County	Community Name	Number of RL Properties	Number of Paid NFIP Claims	Total Paid Losses	Average Payment
Pulaski	Pulaski County	30	76	$2,979,692.74	$39,206.48
Pulaski	Waynesville	10	24	$604,952.35	$25,206.35
Ralls	Ralls County	6	15	$367,873.19	$24,524.88
Ray	Hardin	3	6	$73,844.03	$12,307.34
Ray	Orrick	3	7	$159,983.24	$22,854.75
Ray	Ray County	4	12	$138,946.39	$11,578.87
Reynolds	Ellington	2	4	$21,488.06	$5,372.02
Reynolds	Reynolds County	6	15	$246,698.46	$16,446.56
Ripley	Doniphan	11	43	$1,600,918.19	$37,230.66
Ripley	Ripley County	29	77	$3,837,804.94	$49,841.62
Saline	Saline County	1	2	$25,361.06	$12,680.53
Scott	Commerce	28	77	$761,288.65	$9,886.87
Scott	Miner	1	2	$33,978.89	$16,989.45
Scott	Scott City	6	16	$149,708.65	$9,356.79
Scott	Scott County	20	70	$1,480,424.97	$21,148.93
Shannon	Eminence	3	7	$101,667.90	$14,523.99
Shannon	Winona	2	7	$28,458.36	$4,065.48
St. Charles	Lake St. Louis	1	2	$6,801.70	$3,400.85
St. Charles	Cottleville	1	4	$125,998.38	$31,499.60
St. Charles	Dardenne Prairie	1	2	$25,460.90	$12,730.45
St. Charles	O’Fallon	2	6	$85,841.75	$14,306.96
St. Charles	Portage Des Sioux	75	429	$9,777,699.98	$22,791.84
St. Charles	St. Charles County	866	3,990	$57,443,269.26	$14,396.81
St. Charles	St. Charles	61	197	$5,700,873.02	$28,938.44
St. Charles	St. Peters	12	55	$825,395.49	$15,007.19
St. Charles	Wentzville	1	2	$13,497.87	$6,748.94
St. Charles	West Alton	320	1,417	$22,140,824.62	$15,625.14
St. Francois	Bonne Terre	1	4	$71,653.66	$17,913.42
St. Francois	Park Hills	2	4	$83,216.13	$20,804.03
St. Francois	St. Francois County	5	28	$813,070.31	$29,038.23
St. Louis	Ballwin	3	13	$102,706.67	$7,900.51
St. Louis	Bellefontaine Neighbors	4	12	$61,483.24	$5,123.60
St. Louis	Berkeley	2	5	$35,940.17	$7,188.03
St. Louis	Breckenridge Hills	23	59	$425,848.24	$7,217.77
St. Louis	Brentwood	54	274	$19,834,957.59	$72,390.36
St. Louis	Bridgeton	5	11	$169,950.36	$15,450.03
St. Louis	Chesterfield	19	52	$3,282,136.00	$63,118.00
St. Louis	Cool Valley	1	2	$7,903.34	$3,951.67
St. Louis	Country Club Hills	1	2	$20,035.44	$10,017.72
St. Louis	Crestwood	2	5	$126,094.60	$25,218.92
St. Louis	Creve Coeur	4	12	$194,993.29	$16,249.44
St. Louis	Dellwood	3	6	$16,506.34	$2,751.06
St. Louis	Des Peres	3	13	$205,495.23	$15,807.33
St. Louis	Ellisville	1	2	$7,050.26	$3,525.13
St. Louis	Eureka	22	62	$2,116,498.22	$34,137.07
St. Louis	Fenton	96	395	$9,844,691.35	$24,923.27
St. Louis	Ferguson	31	72	$269,017.65	$3,736.36

County	Community Name	Number of RL Properties	Number of Paid NFIP Claims	Total Paid Losses	Average Payment
St. Louis	Florissant	26	68	$726,872.36	$10,689.30
St. Louis	Frontenac	4	11	$954,210.31	$86,746.39
St. Louis	Hazelwood	40	139	$7,657,712.96	$55,091.46
St. Louis	Jennings	2	4	$25,566.24	$6,391.56
St. Louis	Kirkwood	17	62	$852,888.78	$13,756.27
St. Louis	Ladue	13	54	$2,228,810.97	$41,274.28
St. Louis	Mackenzie	1	5	$53,762.55	$10,752.51
St. Louis	Manchester	7	25	$568,388.81	$22,735.55
St. Louis	Maplewood	12	39	$207,720.75	$5,326.17
St. Louis	Maryland Heights	8	22	$276,014.75	$12,546.13
St. Louis	Moline Acres	5	17	$105,528.62	$6,207.57
St. Louis	Northwoods	10	24	$233,294.01	$9,720.58
St. Louis	Oakland	1	2	$3,582.91	$1,791.46
St. Louis	Olivette	2	7	$38,107.46	$5,443.92
St. Louis	Overland	7	18	$75,606.78	$4,200.38
St. Louis	Pagedale	1	2	$31,044.98	$15,522.49
St. Louis	Riverview	1	4	$24,491.66	$6,122.92
St. Louis	Rock Hill	7	40	$5,214,183.06	$130,354.58
St. Louis	St. Ann	7	15	$126,191.24	$8,412.75
St. Louis	St. John	4	12	$56,209.26	$4,684.11
St. Louis	St. Louis County	399	1,484	$26,820,984.03	$18,073.44
St. Louis	Sunset Hills	23	85	$1,691,506.87	$19,900.08
St. Louis	Times Beach	2	6	$31,490.66	$5,248.44
St. Louis	University City	74	353	$4,997,005.18	$14,155.82
St. Louis	Valley Park	339	1,244	$25,538,175.69	$20,529.08
St. Louis	Velda Village Hills	1	2	$4,282.75	$2,141.38
St. Louis	Warson Woods	1	2	$10,855.25	$5,427.63
St. Louis	Webster Groves	3	8	$76,726.58	$9,590.82
St. Louis	Wellston	2	4	$51,611.42	$12,902.86
St. Louis	Wildwood	5	15	$451,864.06	$30,124.27
Ste. Genevieve	St. Mary	15	43	$309,474.48	$7,197.08
Ste. Genevieve	Ste. Genevieve Cnty	5	19	$278,771.49	$14,672.18
Ste. Genevieve	Ste. Genevieve	109	399	$3,697,336.40	$9,266.51
Stoddard	Advance	1	2	$29,264.94	$14,632.47
Stoddard	Stoddard County	9	20	$337,113.43	$16,855.67
Stone	Galena	4	8	$306,271.85	$38,283.98
Stone	Reeds Spring	3	8	$387,708.90	$48,463.61
Stone	Stone County	7	17	$648,700.22	$38,158.84
Taney	Branson	18	51	$2,699,561.61	$52,932.58
Taney	Bull Creek	3	6	$25,215.63	$4,202.60
Taney	Hollister	3	10	$225,539.42	$22,553.94
Taney	Rockaway Beach	4	13	$121,741.95	$9,364.77
Taney	Taney County	40	108	$10,546,985.92	$97,657.28
Texas	Houston	1	2	$56,870.18	$28,435.09
Vernon	Vernon County	2	4	$31,902.45	$7,975.61
Warren	Marthasville	4	11	$235,041.47	$21,367.41
Warren	Warren County	8	17	$354,022.97	$20,824.88
Warren	Warrenton	1	2	$165,367.34	$82,683.67

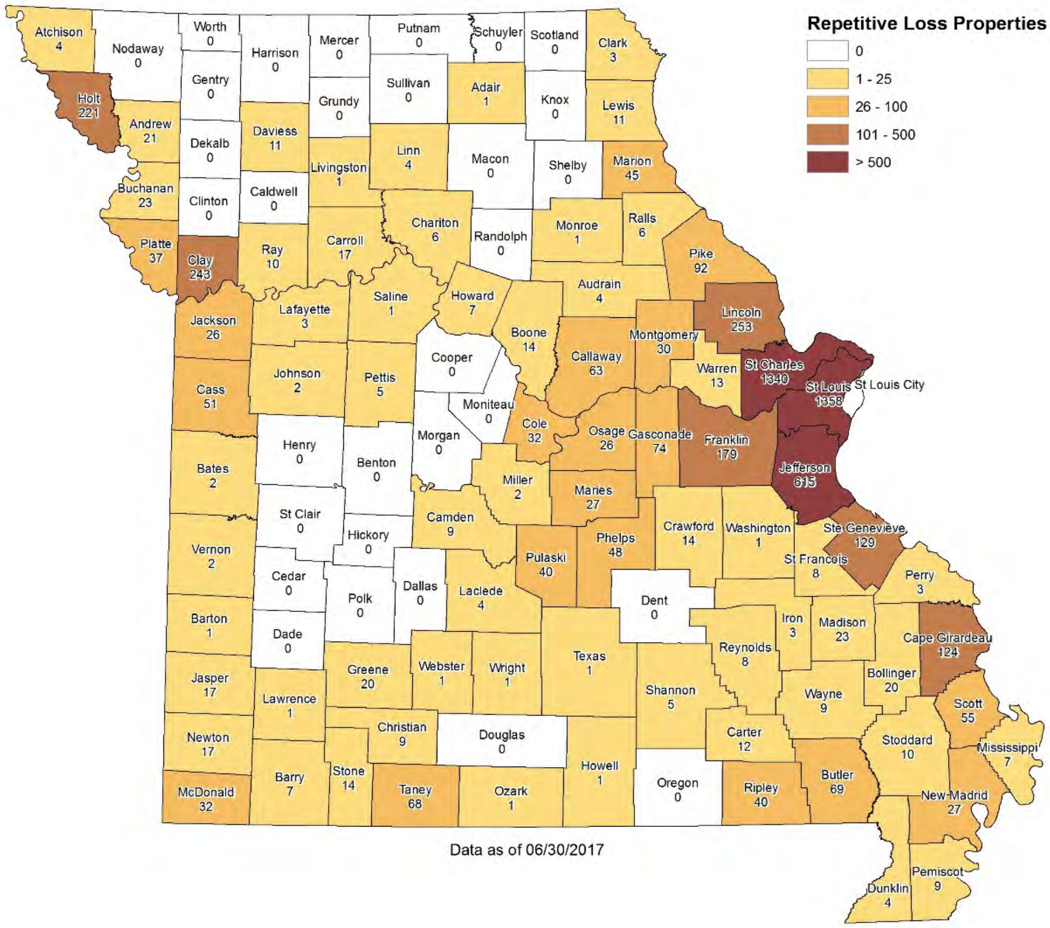
County	Community Name	Number of RL Properties	Number of Paid NFIP Claims	Total Paid Losses	Average Payment
Washington	Mineral Point	1	2	$15,338.16	$7,669.08
Wayne	Piedmont	5	15	$361,102.58	$24,073.51
Wayne	Wayne County	4	8	$76,756.95	$9,594.62
Webster	Webster County	1	4	$123,809.35	$30,952.34
Wright	Mountain Grove	1	2	$70,599.47	$35,299.74

Source: SEMA

Repetitive Loss Summary

- Those communities with the greatest number of RL properties are West Alton in St. Charles County with 320, Valley Park in St. Louis County with 339, Jefferson County with 381, St. Louis County with 399, and St. Charles County with 866.
- The median average RL payment across all communities in the State is $15,015 and the mean is $22,550. As with the SRL average payments, this indicates that there are several outlier communities with average RL payments significantly higher than the median average payment. For example, the average payment is $130,355 in the City of Rock Hill in St. Louis County, $100,314 in the City of Marquand in Madison County, and $211,033 in the City of West Plains in Howell County.
- Those communities that have received the greatest total paid losses on RL properties are Kansas City in Clay County with nearly $22.0 million in total paid losses, Jefferson County with over $32.1 million, St. Charles County with over $57.4 million, West Alton in St. Charles County with over $22.1 million, St. Louis County with over $26.8 million, and Valley Park in St. Louis County with over $25.5 million.
- The communities with the most paid claims to RL properties are Valley Park in St. Louis County with 1,244 claims paid, St. Louis County with 1,484 claims paid, West Alton in St. Charles County with 1,417 claims paid, St. Charles County with 3,990 claims paid, and Jefferson County with 1,609 claims paid.
- The counties with the highest average number of losses per RL property are Miller County with 6, Pike County with 5.3, St. Charles County with 4.6, St. Francois County with 4.5, and Cole County with 4.3.

Figure 4.3. Repetitive Loss Properties by County



4.3.8. State Hazard Mitigation Capabilities, Programs, and Policies that Support Reducing Repetitive Flood Loss Properties

Section 4.5.1, State Agency Capability Assessment, discusses the State's Community Buyout Program that has been successful since the Great Flood of 1993 and continues to be a priority for mitigation funding in Missouri. It also states that RL and SRL properties are a priority under this program.

The State Hazard Mitigation Officer (SHMO) has direct access to Bureau Net spreadsheets listing the RL properties and the SRL properties by address in Missouri. The SHMO uses these spreadsheets to track the mitigated and non-mitigated properties and thus supports the Repetitive Flood Loss Strategy. These Bureau Net spreadsheets are further used by the SEMA Lead Mitigation Planner dedicated to assisting the local planners. The SEMA Lead Mitigation Planner sends the list of RL & SRL properties with a privacy act disclaimer to the planners in local communities. The SEMA Lead Mitigation Planner also double checks their information in the county-level draft hazard mitigation plans against the Bureau Net spreadsheets to ensure accuracy.

In addition, the SHMO sends out Notice of Interest letters after presidential disaster declarations notifying counties of the availability of opportunities to apply for Hazard Mitigation Grant Program (HMGP) funding. Where applicable, this letter alerts the local elected officials that there are RL & SRL properties within their community and describes these properties as a priority for the volunteer buyout program in Missouri. Additional details concerning the SHMO duties and the mitigation planners' duties are discussed in Section 6.2.3 Staffing.

Local community hazard mitigation plans discuss and address their repetitive flood loss properties at differing levels. SEMA encourages local community mitigation plans to turn their discussion of repetitive loss properties into more local mitigation actions to further reduce the number of repetitive loss properties across the State.

4.3.9. State Mitigation Actions that Support Reducing Repetitive Flood Loss Properties

Section 4.2 Mitigation Actions, Category M4—Voluntary Property Acquisitions, discusses that one of SEMA's top priorities is repetitive flood loss and severe repetitive loss properties. This is supported by the amount of obligated funds for flood buyout projects since 2011. The state has obligated more than $10.4 million in that timeframe for property buyouts. Since 2013, the last State Hazard Mitigation Plan, the state has obligated $7.8 million for the buyout of 17 buyout projects.

To further demonstrate Missouri's action to reduce repetitively flooded properties, the tables below indicate the number of mitigated Severe Repetitive Loss (SRL) Properties and the number mitigated of Repetitive Loss (RL) Properties.

Over the history of the SRL program, the State of Missouri has mitigated 358 SRL properties with total paid NFIP claims of over $37 million in 15 counties. In St. Charles and St. Louis Counties, more than 100 SRL properties have been mitigated in each.

Likewise, the State of Missouri has mitigated 2,104 RL properties over the history of the RL program with total paid NFIP claims of more than $105 million in 48 counties and 1 independent city. In Jefferson, Lincoln, St. Charles and St. Louis Counties, more than 100 RL properties have been mitigated in each.

Table 4.21. Missouri Mitigated Severe Repetitive Loss County Summary

County	Community Name	Number of Mitigated Severe Repetitive Loss Properties	Number of Paid NFIP Claims	Total Payments	Average Payment*
Callaway County	Jefferson City	1	8	$111,651.57	$13,956.45
Cape Girardeau County	Cape Girardeau	3	16	$152,595.41	$9,470.55
Clay County	Mosby	1	7	$101,580.90	$14,511.56
Holt County	Big Lake	29	98	$4,018,198.51	$42,882.89
Holt County	Holt County	1	4	$205,709.70	$51,427.43
Jefferson County	Arnold	13	84	$1,527,891.60	$18,891.25
Jefferson County	Crystal City	2	12	$153,980.61	$13,250.75
Jefferson County	Jefferson County	19	126	$1,842,684.21	$14,298.76
Lincoln County	Lincoln County	7	42	$426,893.12	$10,982.17
Lincoln County	Old Monroe	1	5	$51,588.36	$10,317.67
Lincoln County	Winfield	1	6	$101,115.66	$16,852.61
Pemiscot County	Pemiscot County	1	7	$121,667.82	$17,381.12
Pike County	Pike County	2	28	$252,008.55	$9,308.77
Platte County	Platte County	1	3	$162,865.48	$54,288.49

County	Community Name	Number of Mitigated Severe Repetitive Loss Properties	Number of Paid NFIP Claims	Total Payments	Average Payment*
Pulaski County	Waynesville	1	4	$99,013.79	$24,753.45
St. Charles County	Portage des Sioux	8	48	$606,879.83	$13,517.75
St. Charles County	St. Charles County	122	951	$13,888,890.01	$14,972.41
St. Charles County	St. Peters	1	14	$246,233.69	$17,588.12
St. Charles County	West Alton	34	229	$3,110,577.88	$14,739.75
St. Francois County	Bonne Terre	1	4	$71,653.66	$17,913.42
St. Louis County	Brentwood	5	32	$407,994.98	$14,626.98
St. Louis County	Chesterfield	1	7	$41,283.27	$5,897.61
St. Louis County	Fenton	10	64	$738,449.98	$11,685.79
St. Louis County	Maryland Heights	1	5	$118,455.62	$23,691.12
St. Louis County	St. Louis County	41	245	$3,737,531.21	$15,658.80
St. Louis County	Sunset Hills	2	11	$110,590.02	$11,160.15
St. Louis County	University City	12	116	$1,299,460.48	$12,129.51
St. Louis County	Valley Park	31	178	$2,647,257.43	$15,351.62
Ste. Genevieve County	Ste. Genevieve	4	20	$233,796.40	$12,330.25
Taney County	Branson	2	4	$612,051.94	$153,012.99

*Average payment is calculated as the mean of all properties' average payments within each community.

Source: SEMA

Figure 4.4. Mitigated Severe Repetitive Loss Properties by County

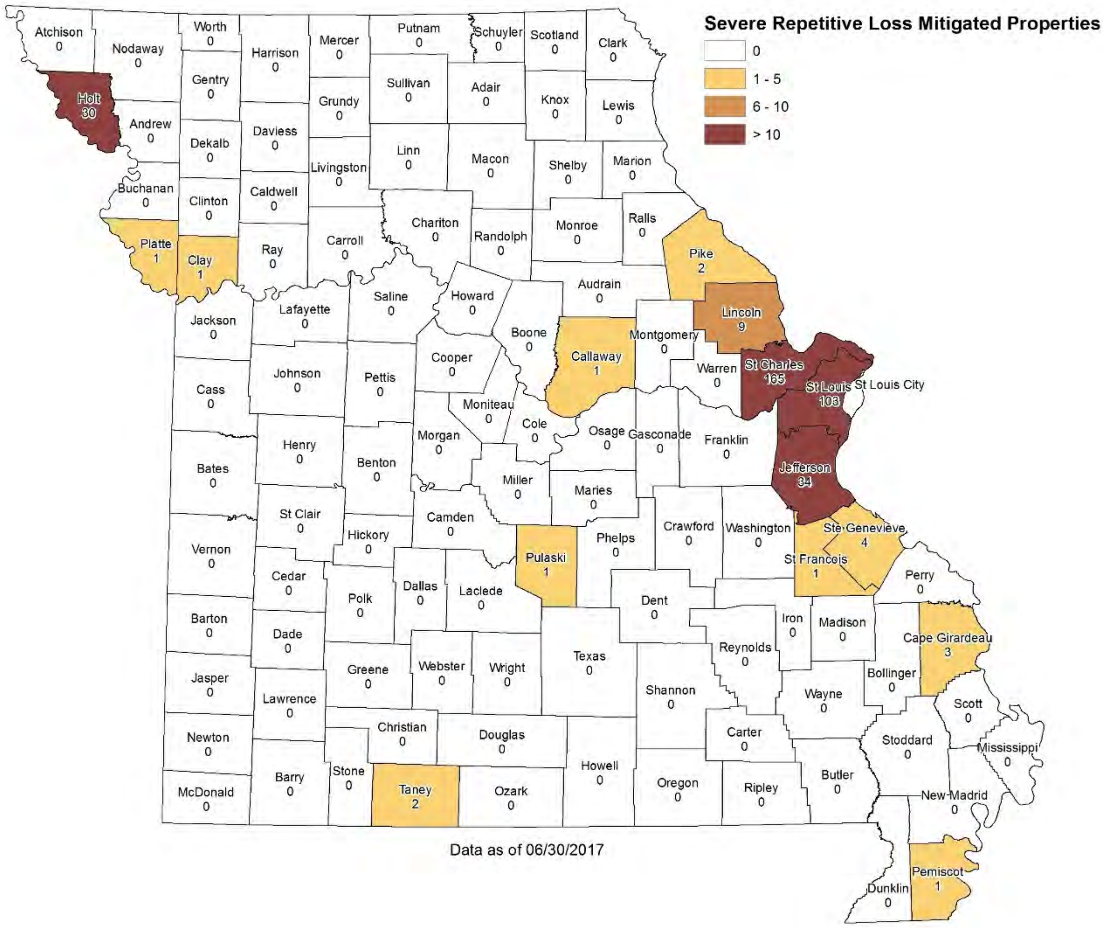


Table 4.22. Missouri Mitigated Repetitive Loss County Summary

County	Community Name	Number of Mitigated Repetitive Loss Properties	Number of Paid NFIP Claims	Total Payments	Average Payment
Andrew County	Andrew County	3	10	$322,7545.39	$35,447.35
Atchison County	Tarkio	1	2	$11,381.61	$5,690.81
Bollinger County	Lutesville	2	4	$25,045.18	$6,261.30
Bollinger County	Marble Hill	3	6	$186,807.11	$31,134.52
Boone County	Columbia	1	5	$33,386.26	$6,677.25
Buchanan County	Buchanan County	4	9	$162,498.81	$19,881.97
Buchanan County	Lewis and Clark	3	9	$663,927.82	$73,685.10
Buchanan County	Rushville	1	3	$123,538.01	$41,179.34
Buchanan County	St. Joseph	2	6	$80.997.79	$13,387.11
Callaway County	Callaway County	3	6	$72,853.29	$12,142.22
Callaway County	Jefferson City	26	69	$974,418.14	$14,665.26
Callaway County	Mokane	3	13	$81,584.28	$6,393.43
Camden County	Camden County	2	4	$63,664.08	$15,916.02
Cape Girardeau County	Cape Girardeau County	6	18	$251,725.02	$13,94.46

County	Community Name	Number of Mitigated Repetitive Loss Properties	Number of Paid NFIP Claims	Total Payments	Average Payment
Cape Girardeau County	Cape Girardeau	56	205	$1,491,193.62	$7,400.18
Carroll County	Carroll County	1	2	$10,128.88	$5,064.44
Carroll County	Carrollton	3	6	$160,404.18	$26,734.03
Cass County	Lake Annette	1	2	$16,745.26	$8,372.63
Cass County	Pleasant Hill	3	10	$69,009.50	$6,665.97
Chariton County	Brunswick	2	4	$45,674.30	$22,837.15
Clay County	Avondale	3	9	$88,109.19	$9,529.74
Clay County	Clay County	2	5	$117,778.19	$21,381.90
Clay County	Excelsior Springs	2	6	$107,224.64	$35,741.55
Clay County	Independence	10	30	$325,391.80	$11,393.74
Clay County	Kansas City	32	93	$3,030,209.23	$32,691.94
Clay County	Liberty	1	2	$14,041.70	$7,020.85
Clay County	Smithville	2	4	$25,929.70	$6,482.43
Daviess County	Pattonsburg	11	22	$319,529.84	$147,524.09
Franklin County	Franklin County	12	32	$252,429.86	$7,622.25
Franklin County	Pacific	2	4	$36,841.42	$9,210.36
Franklin County	St. Clair	1	4	$13,112.89	$3,278.22
Franklin County	Washington	1	2	$29,148.87	$14,574.44
Gasconade County	Hermann	10	23	$218,432.81	$9,883.04
Greene County	Greene County	2	8	$89,216.84	$16,994.75
Greene County	Springfield	1	2	$5,498.66	$2,749.33
Holt County	Big Lake	80	210	$7,462,632.14	$36,674.24
Holt County	Craig	2	7	$235,354.51	$34,744.59
Howard County	Franklin	2	4	$24,679.07	$6,169.77
Howard County	Howard County	1	2	$8,258.46	$4,129.23
Independent City	St. Louis	2	9	$49,459.90	$5,578.81
Iron County	Ironton	1	2	$8,940.44	$4,470.22
Jackson County	Levasy	1	2	$11,089.68	$5,544.84
Jefferson County	Arnold	114	359	$5,392,966.44	$15,819.10
Jefferson County	Crystal City	18	67	$678,310.34	$10,840.67
Jefferson County	Festus	5	12	$254,449.91	$24,150.06
Jefferson County	Herculaneum	3	10	$103,632.31	$7,216.35
Jefferson County	Jefferson County	81	251	$2,825,303.67	$10,376.67
Lafayette County	Lafayette County	1	3	$56,152.29	$18,717.43
Lawrence County	Mt. Vernon	1	2	$48,238.52	$24,119.26
Lewis County	Lagrange	2	6	$113,466.40	$17,262.20
Lincoln County	Elsberry	2	5	$33,976.18	$8,178.15
Lincoln County	Foley	11	28	$342,484.01	$12,559.51
Lincoln County	Lincoln County	84	245	$3,597,041.74	$14,897.54
Lincoln County	Old Monroe	4	10	$120,365.29	$11,734.09
Lincoln County	Winfield	1	2	$54,615.20	$27,307.60
Madison County	Fredericktown	6	13	$88,435.13	$6,666.26
Maries County	Vienna	1	2	$18,310.16	$9,155.08
Marion County	Hannibal	20	48	$1,161,617.07	$22,316.64
Marion County	Marion County	2	5	$78,154.48	$18,067.42
McDonald County	Pineville	1	3	$102,438.30	$34,146.10

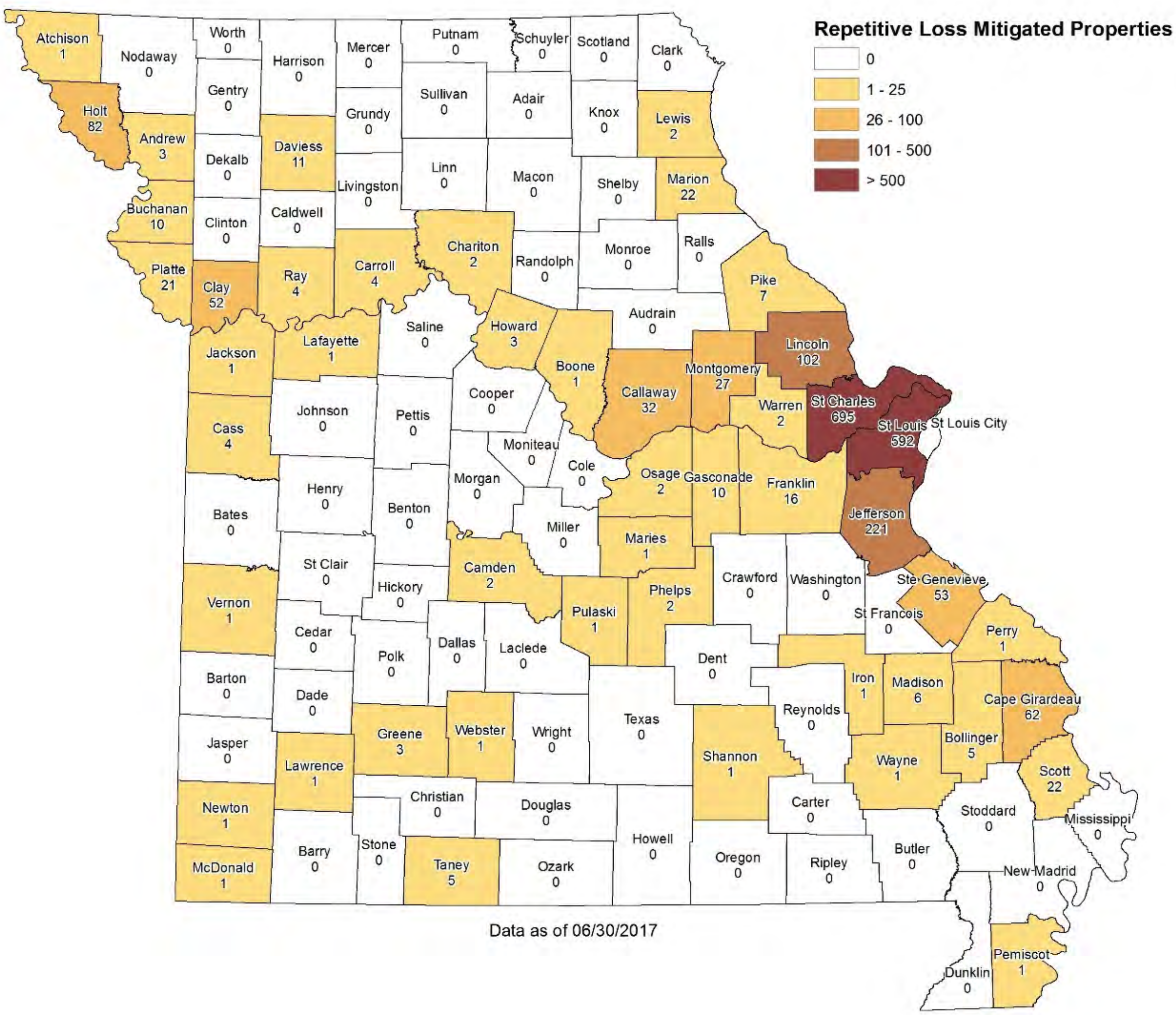
County	Community Name	Number of Mitigated Repetitive Loss Properties	Number of Paid NFIP Claims	Total Payments	Average Payment
Montgomery County	Montgomery County	15	33	$282,984.92	$8,306.85
Montgomery County	Rhineland	12	29	$407,500.34	$13,468.92
Newton County	Newton County	1	3	$95,955.11	$31,985.04
Osage County	Osage County	2	4	$102,750.43	$25,687.61
Pemiscot County	Caruthersville	1	4	$98,238.41	$24,559.60
Perry County	Perry County	1	2	$30,905.97	$15,452.99
Phelps County	Phelps County	2	6	$224,642.89	$37,440.48
Pike County	Clarksville	1	2	$44,618.36	$22,309.18
Pike County	Pike County	6	16	$414,973.21	$26,328.51
Platte County	Edgerton	3	6	$53,443.85	$8,907.31
Platte County	Parkville	1	2	$30,662.64	$15,331.32
Platte County	Platte County	15	40	$1,463,583.98	$35,767.84
Platte County	Tracy	2	4	$23,034.22	$5,758.56
Pulaski County	Waynesville	1	2	$11,514.33	$5,757.17
Ray County	Hardin	3	6	$73,844.03	$12,307.34
Ray County	Orrick	1	2	$60,330.58	$30,165.29
Scott County	Commerce	20	55	$486,737.00	$8,519.11
Scott County	Scott City	1	3	$8,630.40	$2,876.80
Scott County	Scott County	1	2	$7,018.53	$3,509.27
Shannon County	Winona	1	5	$22,165.35	$4,433.07
St. Charles County	Portage des Sioux	33	120	$1,348,600.55	$12,596.02
St. Charles County	St. Charles County	509	1743	$22,249,651.86	$12,860.05
St. Charles County	St. Charles	13	31	$607,952.51	$20,885.05
St. Charles County	St. Peters	3	13	$108,133.85	$7,497.66
St. Charles County	West Alton	137	475	$6,333,002.56	$13,553.56
St. Louis County	Berkeley	1	3	$16,965.17	$5,655.06
St. Louis County	Breckenridge Hills	4	10	$34,223.83	$3,532.14
St. Louis County	Brentwood	8	28	$484,099.49	$18,693.53
St. Louis County	Chesterfield	2	4	$962,393.10	$240,598.28
St. Louis County	Creve Coeur	1	3	$26,932.78	$8,977.59
St. Louis County	Ellisville	1	2	$7,050.26	$3,525.13
St. Louis County	Eureka	7	23	$144,8987.00	$6,505.75
St. Louis County	Fenton	41	109	$1,326,376.10	$12,179.59
St. Louis County	Ferguson	1	3	$16,146.80	$5,382.27
St. Louis County	Florissant	2	9	$49,791.34	$6,014.56
St. Louis County	Hazelwood	1	3	$101,331.34	$33,777.11
St. Louis County	Kirkwood	10	27	$318,294.13	$12,468.08
St. Louis County	Manchester	2	7	$168,630.21	$23,213.14
St. Louis County	Maplewood	6	19	$135,059.02	$7,333.05
St. Louis County	Maryland Heights	1	2	$3,603.55	$1,801.78
St. Louis County	Moline Acres	1	4	$53,175.75	$13,293.94
St. Louis County	St. Louis County	200	675	$8,282,399.36	$11,580.24
St. Louis County	Sunset Hills	3	6	$59,424.49	$9,904.09
St. Louis County	Times Beach	2	6	$31,490.66	$5,306.40
St. Louis County	University City	12	59	$375,611.15	$6,319.44
St. Louis County	Valley Park	285	958	$19,687,474.15	$19,102.91
St. Louis County	Wildwood	1	4	$39,206.45	$9,801.61

County	Community Name	Number of Mitigated Repetitive Loss Properties	Number of Paid NFIP Claims	Total Payments	Average Payment
Ste. Genevieve County	St. Mary	14	41	$262,490.27	$6,894.68
Ste. Genevieve County	Ste. Genevieve	39	128	$754,929.45	$6,158.04
Taney County	Branson	4	10	$481,468.85	$49,585.54
Taney County	Hollister	1	3	$97,519.40	$32,506.47
Vernon County	Vernon County	1	2	$7,867.37	$3,933.69
Warren County	Warren County	2	4	$103,266.60	$25,816.65
Wayne County	Piedmont	1	2	$36,331.46	$18,165.73
Webster County	Webster County	1	4	$123,809.35	$30,652.34

*Average payment is calculated as the mean of all properties' average payments within each community.

Source: SEMA

Figure 4.5. Mitigated Repetitive Loss Properties by County



4.3.10. Specific Implemented Actions that Support Reducing Repetitive Flood Loss Properties

In Missouri, there are 5,718 repetitive flood loss properties as of June 2017. Missouri has already mitigated 2,462 RL and SRL properties since implementing the State's Community Buyout Program. This program has been a huge accomplishment almost half the current number of repetitive loss properties have been taken out of harm's way and removed from the flood damage cycle.

There are numerous communities that can be highlighted that have aggressively bought out repetitive flood loss structures. As a "Best Case" example, the City of Arnold purchased 202 single family dwellings and 155 mobile home pads in the floodplain by the end of 1995. They also purchased nine additional homes that had four or more repetitive loss claims paid by NFIP totaling $961,846 by 1995. These additional homes accounted for 43 flood claims, for an average of 4.77 flood claims per property, incurred over roughly a 16-year period. In seven of the nine properties, the NFIP claims paid had already exceeded the fair market value of the properties. In three of those cases, the NFIP claims paid were close to double the fair market value of the properties. Based on those statistics and the potential for more severe flooding events in Missouri, it is possible that the entire $840,000 project cost can be recovered by the NFIP over the next 15-20 years because of losses avoided.

Increased attention to this Repetitive Flood Loss Strategy will be essential to further eliminate RL and SRL buildings from flood damage along with complying with these "Targeted Actions:"

Targeted Action 1: Work with communities through their mitigation planning process to fully understand the causes of repetitive flooding (riverine versus localized stormwater, etc.) including the location of these properties through appropriate mapping of repetitive loss areas so the total repetitive loss problem is addressed and FEMA's Privacy Act of 1974 is not violated.

Targeted Action 2: Enhance the outreach and education on FEMA's HMA Grants programs through additional opportunities to reach communities. Besides the normal web-based approach, consider additional regional workshops and promoting these grant programs through the Community Assistance Visits (CAVs) and Community Assistance Contacts (CACs). Finally, consider a more aggressive outreach approach at state sponsored workshops including providing "Best Case" examples.

Targeted Action 3: Promote Increased Cost of Compliance (ICC) coverage on flood insurance policies as a way for property owners to supplement the HMA Grants or to elevate a building to above the Base Flood Elevation (BFE) for better flood protection and to help reduce repetitive flooding.

Targeted Action 4: Identify communities with RL and SRL properties who have not mitigated any of their buildings (or only a few) and survey them to find out what issues outside of the willingness of the owner to participate in the buyout program are the biggest challenges to participation in the HMA Grant programs.

4.3.11. Funding that Supports Reducing Repetitively Flooded Properties

Section 4.2.4 Review and Progress of Mitigation Actions highlights the yearly funding programs, types of projects, and amounts. Several funding sources have been used in the past for the flood buyout projects: HMGP, FMA, RFC, SRL, and PDM. Since FEMA eliminated the RFC and SRL Grant programs and rolled them into FMA, now communities are eligible for funding from HMGP, FMA and PDM to fund buyouts or to elevate structures.

SEMA also has a list of questions to help prioritize the distribution of mitigation project funds to local communities, shown in Section 5.3.2 Project Grants. One bullet item states, "does the project result in mitigating flood damage to repetitive loss or severe repetitive loss properties." Thus, the State seriously considers RL & SRL properties when prioritizing local project funding.

From an implementation perspective, communities with multiple repetitive loss structures that can get the owners to agree with the buyouts or elevation projects are typically the communities that usually pursue grant funding first.

CDBG funds and the Disaster Recovery Supplemental CDBG are also used in Missouri to fund the State's Community Buyout Program and support mitigating RL and SRL properties. CDBG funds can be used for voluntarily buyouts of residential and non-residential properties.

4.4. Funding Sources

Requirement §201.4(c)(3)(iv): The State mitigation strategy shall include an] identification of current and potential sources of federal, state, local, or private funding to implement mitigation activities.

Missouri utilizes a variety of sources to fund state and local mitigation activities. While most of the funding is from the federal government, additional funding comes from state and local governments.

4.4.1. Primary Federal and State Funding

The State, through SEMA, has instituted an effective and comprehensive all-hazard mitigation program. Through a variety of programs, and the wise use of available federal and state funds, the State has been successful in mitigating areas against the devastating effects of disasters.

FEMA's Hazard Mitigation Assistance programs are the primary sources of current funding for Missouri's mitigation activities. These programs are the Hazard Mitigation Grant Program, the Pre-Disaster Mitigation Program, and Flood Mitigation Assistance Program. Additional details on the Hazard Mitigation Assistance grants are provided in the State Capabilities Section for SEMA under Unified Hazard Mitigation Assistance (HMA) Grants. SEMA also uses FEMA's Public Assistance Program (Section 406) to implement mitigation activities. Additional details on the FEMA Public Assistance Program are provided in the State Capabilities Section for SEMA under Public Assistance 406 Mitigation. All these grant programs are non-disaster (annually funded) grant programs except the HMGP and Public Assistance Program which are post disaster programs. More detail on how this assistance was used since 2002 can be found in Section 4.4.5

Other sources of Federal and State Funding and Technical Assistance

Additional sources of federal and state funding and technical assistance can be found in Appendix D. This appendix includes a resource for all state, regional, and local planners trying to find funding for their mitigation activities. Funding Assistance Programs are separated into the following categories:

- General emergency management grants, loans, and assistance
- Floods/flood control grants, loans, and technical assistance
- Earthquake grants, loans, and technical assistance
- All-hazard mapping grants, loans, and technical assistance
- Ancillary flood and natural resource projects grants, loans, and technical assistance
- Basic and applied research/development grants
- Other planning resources: Demographics, societal data, and transportation, agricultural, industrial, and economic statistics

4.4.2. Local Funding

Local governments receive most of their funding for mitigation projects from the federal programs discussed above. Other sources of local funding include tax-funded investments (predominantly from property and sales tax) in infrastructure improvements and dedicated transportation/capital improvements sales or use taxes, all of which can also serve to mitigate hazards. A sales tax or bond issue to fund mitigation would require a vote of residents and could be difficult to pass. More information about local funding can be found in Section 4.6.1 Local Policies, Programs, and Capabilities and Section 7.5 Effective Use of Available Mitigation Funding.

4.5. State Capability Assessment

Requirement §201.4(c)(3)(ii): The state mitigation strategy shall include a] discussion of the State's pre-and post-disaster hazard management policies, programs, and capabilities to mitigate the hazards in the area, including: an evaluation of State laws, regulations, policies, and programs related to hazard mitigation as well as to development in hazard-prone areas; [and] a discussion of State funding capabilities for hazard mitigation projects.

This section discusses Missouri's existing mitigation-related capabilities.

4.5.1. State Agency Capability Assessment

The roles and responsibilities of the Missouri State Emergency Management Agency (SEMA) and the other agencies involved in statewide emergency preparedness, response, recovery, and mitigation activities are outlined below. While each state agency administers its own programs, SEMA provides leadership for the overall state mitigation strategy. The agencies work together to ensure that the various mitigation programs complement each other and work toward achieving the State's overall strategy. One way that agencies work together is by participating on the SRMT, the group responsible for the preparation and review of this plan and for state review of all mitigation initiatives.

The primary existing state and federal programs and planning efforts that guide and regulate hazard mitigation activities are briefly described in this section. This section is organized by administrative agency. A description of each agency's emergency management functions is provided followed by details of the following mitigation-related capabilities, if applicable:

1) Mitigation-related Programs and Initiatives
2) Mitigation-related Outreach and Partnerships
3) Mitigation-related Plans and Reports
4) Mitigation-related Funding Sources

Many of the programs are pre-disaster such as the partnerships, plans, and policies. However, post-disaster capabilities are covered as well, such as the Structural Assessment and Visual Evaluation (SAVE) Coalition, volunteer recovery organizations, State Emergency Operations Plan, and the Drought Response Plan.

State Emergency Management Agency – SEMA

A division within the Department of Public Safety, SEMA is responsible for coordinating statewide emergency preparedness, response, recovery, and mitigation activities among federal, state, and local agencies. The SEMA director is the state coordinating officer during disasters and also serves as the governor's authorized representative and liaison to FEMA; this position is counterpart to the federal coordinating officer. During disaster operations, all departments of state government are expected to cooperate fully with requests for assistance from the SEMA director. The governor's declaration of a state emergency initiates the operation of the State Emergency Operations Plan, which is continually updated by SEMA to meet changing conditions. When the Governor declares a state of emergency in Missouri, SEMA operates the State Emergency Operations Center (SEOC) to lead the disaster response effort.

Preparedness Division

The Preparedness Division works to create coordinated statewide response plans and to provide training for local and state personnel so Missouri effectively responds to emergencies and disasters. The division has responsibility for All-Hazard Planning, Medical Countermeasures, Training and Exercises, Emergency Human Services, and the Missouri Emergency Response Commission and Radiological Emergency Program (REP). Examples of division work products include the preparation or update of: comprehensive disaster assistance plans; standard operating guides (SOGs) to execute responsibilities in state plans; training of state personnel in disaster recovery and mitigation; and emergency management seminars for local elected officials. It also develops and maintains the State of Missouri Emergency Operations Plan.

Emergency Human Services: Includes the Volunteer Coordinator, who, during disasters works with state agencies, and faith-based and volunteer organizations to coordinate disaster assistance. During recovery, the coordinator provides technical assistance to long-term recovery committees. The coordinator is the point of contact for the Governor's Faith-Based and Community Service Partnership for Disaster Recovery, Missouri Voluntary Organizations Active in Disasters and Missouri Community Organizations Active in Disaster. Working together they are commonly referred to as the Disaster Recovery Partnership. The Partnership is an essential part of Missouri's disaster response and recovery model and acts to enhance the state's ability to plan and prepare for, mitigate, respond to, and recover from any disaster by maximizing public and private resources to facilitate an efficient, integrated system for addressing human services, housing, infrastructure, community and economic development issues.

Training and Exercises: Jurisdictions across Missouri have found that the best way to respond to disasters is by preparing in advance with training activities and using the skills learned to build effective local teams and coalitions. The Emergency Management Training (EMT) curriculum delivered by SEMA offers an extensive array of training opportunities for Missouri state and local emergency managers, public officials, members of volunteer assistance organizations, and professionals in related fields. The EMT program offers comprehensive courses in disaster mitigation, preparedness, response, and recovery.

SEMA's Exercise Team provides support to local jurisdictions, regional and state agencies, and volunteer and community organizations to design, conduct and evaluate all levels of emergency exercises for threats ranging from local hazmat events to a major earthquake requiring a statewide response.

Readiness Section: The Readiness Section is responsible for developing comprehensive emergency operations plans and procedures for state and local governments. The section also assists local governments in developing and improving their emergency response capabilities and includes the SEMA Watch Center and is SEMA's WebEOC contact.

Radiological Emergency Preparedness (REP) Program: The Radiological Emergency Preparedness Program (REP) develops plans, training, and exercises to assist jurisdictions surrounding commercial nuclear power plants to respond to potential scenarios that might occur.

All-Hazard Planning Program: The All-Hazard Planning Program has primary responsibility for providing planning guidance and assistance to state departments, agencies, and local governments so that they can develop and maintain all-hazard (e.g. tornadoes, severe weather, flooding, earthquake) emergency operations plans (EOPs). SEMA planners are assigned to specific regions to establish bonds with local planners and create a common understanding of local hazards and resources.

Medical Countermeasures Program: The Medical Countermeasures Program manages the planning, receipt, distribution and storage for pharmaceuticals and other medical supplies and equipment necessary to respond to a major emergency or disaster when local supplies may become depleted. These supplies are provided through the federal Strategic National Stockpile (SNS) program, a national repository of critical drugs and medical supplies designed to supplement and resupply state and local public health agencies and hospitals in a major emergency. The goal is to deliver SNS lifesaving pharmaceuticals to any location within 12 hours once the federal decision to deploy is made.

Earthquake Program: The Earthquake Program informs Missourians about the earthquake risk associated with the New Madrid Seismic Zone and recommends safety and mitigation steps that can be taken to prepare for earthquakes and their potential consequences.

Response Division

The Response Division is responsible for disaster management operations whenever Missouri is affected by an emergency or disaster that may be beyond the capabilities of local governments and includes the Statewide Regional Coordinators, Readiness, and Logistics and Resources sections. Once a state of emergency (SOE) has been declared by the Governor, the Response Branch opens the State Emergency Operations Center (SEOC) and coordinates disaster response with local governments, state agencies, the Missouri National Guard faith-based and volunteer agencies, private sector partners and FEMA. The branch also develops emergency operations procedures for state and local governments, and assists local governments in the development of emergency response capabilities.

Statewide Regional Coordinators: SEMA's Regional Coordinators are the state's liaisons to local jurisdictions for emergency management activities. They assist local jurisdictions in all aspects of emergency management, including emergency operations plan development and revision, training and exercises. The state of Missouri is divided into nine regions, A-I, which correspond with the Missouri State Highway Patrol troops. The nine regional coordinators provide assistance to Missouri's 114 counties and their associated jurisdictions, and the independent City of St. Louis.

Logistics and Resources Section: The Logistics and Resources Section focuses on coordinating the delivery of key emergency life-saving and life-sustaining equipment, the provision of essential services and critical supplies to disaster areas. These supplies may include generators, pumps and other flood fighting materials, technical assistance teams, food, water, ice, and any temporary facilities that may be required. Logistics and Resources, along with the Missouri Public/Private Partnership (MOP3), also co-manages the Missouri Business Emergency Operation Center (BEOC). The BEOC provides for the exchange of situational awareness to the business community. The Field Services Section oversees SEMA's Area Coordinators, who are the state's liaisons to local jurisdictions for emergency management activities.

Missouri Emergency Response Commission (MERC): The Missouri Emergency Response Commission's (MERC) mission is to protect public health and the environment by assisting communities with chemical incident prevention, preparedness, response and recovery. MERC implements the federal Emergency Planning and Community Right-to-Know Act (EPCRA) and related Missouri laws pertaining to hazardous chemicals storage. The commission supports local emergency planning committees (LEPC), reviews hazardous chemical contingency plans, provides chemical emergency training, collects information on toxic and hazardous storage and makes this information available to the public. MERC administers the Hazardous Material Emergency Preparedness (HMEP) for hazardous material (HAZMAT) training to local public-sector employees and the Chemical Emergency Preparedness Funds (CEPF) for planning and training for LEPCs.

Recovery Division

When a disaster occurs that may require response and recovery efforts beyond the capabilities of the state and local jurisdictions, the Recovery Division coordinates and conducts damage surveys with local and federal agencies and prepares, at the Governor's direction, a federal disaster declaration request. Following a federally-declared disaster, the division is responsible for working with local and federal agencies to request and distribute federal and state funds for all recovery projects and eligible response expenditures. The division also works to coordinate efforts to mitigate against disasters and administers federal mitigation grants. The division is composed of the Public Assistance, Floodplain Management and Mitigation sections.

Public Assistance Section: Public Assistance Section responsibilities include state damage assessments; assistance in revising State Administrative Plans for Public Assistance and oversight of the FEMA Individuals and Households Program. The State Public Assistance program administers federal grants to eligible public entities for emergency protective measures, debris removal, and the repair, restoration or rebuilding of damaged public facilities in federally-declared disaster areas. Such entities include state agencies, local governments, and certain private, non-profit organizations.

SEMA also administers FEMA's Individuals and Households Program, which provides state-federal assistance to individuals and families for uninsured critical emergency needs when authorized in a federally-declared disaster.

Floodplain Management Section: The Floodplain Management Program administers the NFIP for the state of Missouri. Additional information on this is provided below under Mitigation-related Programs and Initiatives.

Mitigation Section: The Mitigation Section works with local communities to reduce or avoid the adverse impacts of disasters through the administration of the federal hazard mitigation grant program and assists Missouri counties to write mitigation plans to qualify for these grants. Community mitigation projects include voluntary flood buyouts, the replacement of community owned bridges and low water crossings, creek bank stabilization and "re-channelizing" streams to lessen the threat of future flooding. In recent years, mitigation funding has been used increasingly to protect Missourians from tornadoes and severe wind storms by constructing school and community tornado safe rooms across the state. Additional information is provided below under Mitigation-related Programs and Initiatives.

Mitigation-Related Programs and Initiatives

There are several programs administered by SEMA related to various aspects of development and implementation of the mitigation strategy in the State.

Mitigation Management

SEMA's Mitigation Management Section works with local communities to reduce or avoid the adverse impacts that disasters have on Missourians. Hazard mitigation is any sustained action taken to reduce or eliminate long-term risk to people and property from natural hazards and their effects. This definition distinguishes actions that have a long-term impact from those that are more closely associated with immediate preparedness, response, and recovery activities. Hazard mitigation is the only phase of emergency management specifically dedicated to breaking the cycle of damage, reconstruction, and repeated damage. Community mitigation projects range from voluntary flood buyouts to building community tornado safe rooms; replacing county- and community-owned culverts and low water crossings; stabilizing stream banks; and burying public electric utilities.

Missouri Floodplain Management/Floodplain Insurance Programs

The Floodplain Management Section administers the NFIP for the state of Missouri. Most homeowner insurance policies do not cover flood damage, so the purchase of specific flood insurance may be necessary. For those who live in a mapped high-risk Special Flood Hazard Area (SFHA), federal law requires federally backed mortgage lenders to require the purchase of flood insurance. This section works with NFIP-participating communities to ensure they comply with the requirements of the program, which provides nearly $4 billion in flood insurance coverage for homes and businesses in Missouri. This section also works with the US Army Corps of Engineers (USACE) Silver Jackets to educate communities on flood risk mitigation actions which can improve their CRS score for reduced cost insurance premiums. SEMA is also a Cooperating Technical Partner (CTP) with FEMA in the production of Digital Flood Insurance Rate Maps (DFIRM) under the federal "Risk MAP" program. In addition, the section partners with the Missouri Floodplain and Stormwater Managers Association (MfSMA) and others to offer NFIP training for local floodplain managers, planners, insurance agents, elected officials, engineers and surveyors, lenders and realtors.

Training and Exercises

The Emergency Management Training (EMT) curriculum delivered by SEMA offers an extensive array of training opportunities for Missouri state and local emergency managers, public officials, members of volunteer assistance organizations, and professionals in related fields. The EMT program offers comprehensive courses in disaster mitigation, preparedness, response, and recovery. Jurisdictions across Missouri have found that the best way to respond to a disaster is by preparing in advance with training activities and using the skills learned to build effective local teams and coalitions.

Earthquake Program

The Earthquake Program informs Missourians about the earthquake risk associated with the New Madrid Seismic Zone and recommends safety and mitigation steps that can be taken to prepare for earthquakes and their potential consequences.

Radiological Emergency Preparedness (REP) Program

The Radiological Emergency Preparedness Program (REP) develops plans, training, and exercises to assist jurisdictions surrounding commercial nuclear power plants to respond to potential scenarios that might occur.

All-Hazard Planning Program

The All-Hazard Planning Program has primary responsibility for providing planning guidance and assistance to state departments, agencies, and local governments so that they can develop and maintain all-hazard (e.g. tornadoes, severe weather, flooding) emergency operations plans (EOPs).

SAVE Coalition

The Missouri Structural Assessment and Visual Evaluation (SAVE) Coalition is a group of volunteer engineers, architects, building inspectors and other trained professionals that assists the Missouri State Emergency Management Agency with building damage inspections. After a disaster, SAVE volunteers are trained to move quickly to determine which buildings are safe to use and which should be evacuated.

Statewide Area Coordinator Program

SEMA's Area Coordinator's (AC) are the state's liaisons to local jurisdictions for emergency management activities. They assist local jurisdictions in all aspects of emergency management, including emergency operations plan development and revision, training and exercises. The state of Missouri is divided into nine areas, A-I, that correspond with the Missouri State Highway Patrol troops. The nine area coordinators provide assistance to Missouri's 114 counties and their associated jurisdictions, and the independent City of St. Louis.

State Public Assistance Program

The State Public Assistance program provides an organizational structure for the administration of federal grants to eligible public entities for the repair and restoration of damaged public facilities within a federally-declared disaster area. Such entities include state agencies, local governments, and certain private, non-profit organizations.

Individuals and Households Program

The Individuals and Households Program (IHP) program provides state-federal assistance to individuals and families for uninsured critical emergency needs when authorized in a federally-declared disaster.

Mitigation-related Outreach and Partnerships

State Risk Management Team

The State Risk Management Team has evolved over time to its current make-up and function. During the 1993 Midwest floods, an interagency hazard mitigation team was formed that was composed of representatives from FEMA, SEMA, USACE and various state agencies and departments (i.e., Governor's Office, Department of Economic Development, Department of Natural Resources, Department of Transportation). The wisdom in this approach can be found in the results. Only six months after hazard mitigation funding became available, all projects were approved. Subsequent disasters were also coordinated, and managed by the IHMT. The state members of the IHMT would later make up what is today the State Risk Management Team. The group is also responsible for the monitoring, evaluation, and updating of this plan. More information on the participants and responsibilities of the SRMT can be found in Chapter 2 Planning Process.

Mitigation Management Website

The SEMA Mitigation Management Website provides a platform for providing documents and resources related to the Hazard Mitigation Assistance Grants as well as Hazard Mitigation Planning. It is located here: https://sema.dps.mo.gov/programs/mitigation_management.php.

Floodplain Management Website

SEMA has developed a comprehensive floodplain management website to disseminate information to local floodplain managers, CEOs, emergency management personnel and the general public. This website, located at www.sema.dps.mo.gov/programs/floodplain/ includes basic NFIP information, forms used to manage development in the floodplain, information on upcoming training workshops, information on CFM training and exams, and related website links.

Risk MAP Global Outreach Plan

Each year, with implementation of Risk Mapping, Assessment, and Planning (Risk MAP), a Global Outreach Plan is developed that outlines the outreach efforts to communicate goals, activities, and programs related to floodplain management.

Risk MAP Outreach Website

SEMA has developed an online flood visualization tool to present the Risk MAP regulatory and non-regulatory mapping products. This outreach tool is a web-based flood visualization/awareness tool that integrates digital flood hazard data in an online mapping environment to provide specific information to communities and stakeholder agencies regarding Risk MAP efforts and products. Through this website, located at http://bit.ly/MOSEMAOutreach, users can access available data layers and apply them to a web-viewer of aerial imagery or street map data for Risk MAP study areas. This tool provides a clearinghouse of flood hazard information for use by developers, the insurance industry, government agencies, and the public as well as assist the State and local governments in their mitigation planning, floodplain management, and flood response efforts.

Public Information Program

The public information coordinator in SEMA's Executive Branch produces public awareness campaigns on a variety of natural hazards for local emergency management agencies to distribute to their media. News releases on SEMA programs and disaster response activities are distributed electronically and posted on the SEMA web site.

SEMA Newsletters

SEMA News, located at http://sema.dps.mo.gov/newspubs/sema-newsletter.php is a quarterly newsletter to address issues related to all aspects of emergency management including hazard mitigation. This newsletter is sent to emergency management and state and local elected officials. SEMA also publishes bulletins twice a month for first responders and officials that address issues that arise between distributions of the quarterly newsletter. The newsletter and the bulletin are used to explain state and federal mitigation planning requirements, solicit ideas and initiatives, and highlight community mitigation success stories.

SEMA/MEPA Spring Conference

The SEMA/Missouri Emergency Preparedness Association (MEPA) Spring Conference is an annual event and includes workshops on a variety of subjects, one of which addresses the mitigation program. MEPA helps coordinate emergency management officials and serves as a clearinghouse for ideas and actions to protect lives and properties in Missouri from natural and manmade disasters. Past topics of the conference have included the mitigation planning process, risk assessment, identification and development of viable mitigation projects, benefit-cost analysis, and public-private partnerships. Federal, state, and local emergency management officials; state and local elected representatives; business and industry representatives; and representatives from volunteer organizations are invited to attend.

Annual Missouri Floodplain and Stormwater Manager's Conference

SEMA supports, organizes, and sponsors the Missouri Floodplain and Stormwater Managers Association's annual conference. This event features the Certified Floodplain Manager Exam (and review) and seminars on topics such as the National Flood Insurance Program, floodplain mapping, and stormwater utilities. Speakers represent a variety of partner agencies and organizations (e.g., the Departments of Natural Resources and Conservation have given seminars on low impact design, which is based on the no adverse impact philosophy). SEMA staff also attend the annual Association of State Floodplain Managers conference.

Trainings and Workshops

SEMA mitigation staff schedule and conduct various trainings and workshops throughout the year to increase knowledge and understanding of mitigation and floodplain management. A few examples are bulleted below:

- Local Hazard Mitigation Plan Development Training – since 2015, this training has been offered in three locations throughout the State to assist Regional Planning Commissions and Councils of Government with the development of Local Hazard Mitigation Plans.
- Tools of Floodplain Management—this workshop is a 2-day course designed for local floodplain administrators. It covers various important issues as well as day-to-day activities. This course is designed to provide basic knowledge of the National Flood Insurance Program (NFIP).
- Digital Flood Insurance Rate Map (DFIRM) Workshops and DFIRM Plus Risk MAP Workshops—these trainings workshops are designed to walk through the DIFRM database and any non-regulatory Risk MAP products to describe the data and provide real world examples of how the datasets can be utilized in local communities. The primary audience for these workshops is the local floodplain administrator. Other local community officials such as community CEOs, emergency management officials, and community planners may also benefit from this workshop.
- Certified Floodplain Manager (CFM) Training—these trainings, typically offered three times throughout the year provide training as well as administration of the exam to receive Certified Floodplain Manager Certification.

Regional Planning Commissions

SEMA has very successful partnerships with the state's 19 Regional Planning Commissions/Councils of Governments (RPCs). SEMA equips these partners in mitigation with tools, training, and technical support to help local governments meet state and federal mitigation requirements. Specific services the RPCs provide to local governments include local mitigation plan development and GIS support. RPCs also assist the state with the approval of local plans. Because of their involvement in local plan development, the RPCs are more cognizant of mitigation, can convey their knowledge to the local communities, and can consider the basic principles of mitigation in their other planning efforts, including transportation, comprehensive, and capital improvement planning.

Ready in 3 Program

The Ready in 3 Program provides tools and materials free of charge to schools and families in Missouri for taking steps to provide for emergency situations. The program was developed by the Missouri Department of Health and Senior Services with endorsement from SEMA and the American Red Cross.

Central United States Earthquake Consortium

Since 1983, Arkansas, Illinois, Indiana, Kentucky, Mississippi, Missouri, and Tennessee have been members of the Central United States Earthquake Consortium (CUSEC), which was formed to improve public earthquake awareness and education; coordinate multistate planning for earthquake mitigation, preparedness, response, and recovery; and encourage research in earthquake hazard reduction. The earthquake program managers and state emergency management directors of the member states meet at least twice annually with CUSEC management and FEMA's regional earthquake program managers to formulate earthquake safety and mitigation programs and projects. Soils mapping developed by CUSEC was used in the HAZUS-MH models for the 2007 update of this plan.

University of Missouri Extension

The University of Missouri Extension uses science-based knowledge to help people understand change, solve problems, and make informed decisions on a wide variety of topics. The extension's Community Emergency Management Program provides education and technical assistance to individuals and families, local governments, businesses, schools, and organizations in preparing and responding to natural and manmade disasters.

Mitigation-related Plans and Reports

State Hazard Mitigation Plan

SEMA coordinates the development of the State Hazard Mitigation Plan (this plan) which must be revised and reviewed/approved by FEMA on a 5-year cycle. The purpose of this plan is to complete a risk and capability assessment as well as provide guidance, direction and prioritization for mitigation activities in the State. The plan contains an analysis of Missouri's hazards, risks and vulnerabilities, describes the manner in which mitigation is planned, programmed and carried out, and establishes the hazard mitigation goals, objectives and recommended actions and initiatives that will reduce injuries, damages, and loss of life caused by disasters.

State Emergency Operations Plan

Updated regularly, the State Emergency Operations Plan lays a framework that will allow the State of Missouri to save lives, minimize injuries, protect property and the environment, preserve functioning civil government, ensure constituted authority, and maintain essential economic activities in the event of an emergency or disaster, natural, technological, or otherwise. Specifically, it directs the actions of state departments and agencies in response to a variety of incidents where local need and suffering requires state assistance. Authority for the plan is set forth in Code of State Regulations 11 CSR 10-11.010, Chapter 44, Revised Statute of Missouri.

This plan emphasizes a comprehensive approach to emergency management that strives to integrate all hazards that pose a risk to the State, all phases of emergency management, and all levels of government and the private sector. Additionally, the SEOP institutionalizes the concepts and principles of the National Incident Management System and the Incident Command System into response and recovery operations conducted within the State of Missouri. It also sets the parameters for the development of local emergency operations plans and procedures.

This functional plan consists of three components: 1) The Basic Plan is the overall guide for state emergency management activities. It contains the policies and regulations that govern emergency management and assigns responsibilities for the execution of emergency functions to various state agencies and private organizations. 2) The functional annexes provide specific direction for the essential emergency functions outlined in the Basic Plan. Functions addressed by the 25 annexes include warning, damage assessment and analysis, evacuation, hazardous materials, disaster recovery, continuity of government, terrorism, and special needs. 3) Supporting documents explain how actions are to be carried out in support of each functional annex. Supporting documents include maps, charts, and resource lists that help organizations carry out their emergency responsibilities.

Threat and Hazard Identification and Risk Assessment (THIRA)

SEMA updates the THIRA annually in accordance with the Comprehensive Preparedness Guide 201. The purpose of this plan is to:

1) Identify the Threats and Hazards of Concern. Based on a combination of past experience, forecasting, expert judgment, and other available resources, communities identify a list of the threats and hazards of primary concern to the community.
2) Give the Threats and Hazards Context. Communities describe the threats and hazards of concern, showing how they may affect the community.
3) Establish Capability Targets. Communities assess each threat and hazard in context to develop a specific capability target for each relevant core capability. The capability target defines success for the capability.
4) Apply the Results. Communities estimate the required resources per core capability to meet the capability targets.

Mitigation-related Funding Sources

Unified Hazard Mitigation Assistance (HMA) Grants

Under the unified Hazard Mitigation Assistance Grants, SEMA administers three FEMA funding programs that provide funding for eligible mitigation planning and projects that reduce disaster losses and protect life and property from future disaster damages. The three programs are:

- Hazard Mitigation Grant Program
- Pre-Disaster Mitigation Program
- Flood Mitigation Assistance Program

The Hazard Mitigation Grant Program (HMGP)

Authorized by Section 404 of the Robert T. Stafford Disaster Relief and Emergency Assistance Act, as amended (the Stafford Act), Title 42, United States Code (U.S.C.) 5170c. The key purpose of HMGP is to ensure that the opportunity to take critical mitigation measures to reduce the risk of loss of life and property from future disasters is not lost during the reconstruction process following a disaster. HMGP is available, when authorized under a Presidential major disaster declaration, in the areas of the State requested by the Governor.

Amount: Federal funding under the HMGP is available following a major disaster declaration if requested by the governor. The amount of an HMGP grant will depend on the costs associated with each individual disaster. Since the Missouri State Hazard Mitigation Plan is an enhanced plan, the State is eligible for up to 20 percent of the total estimated federal assistance provided after a major disaster declaration. States with standard hazard mitigation plans are eligible for 15 percent for amounts not more than $2 billion, 10 percent for amounts of more than $2 billion and not more than $10 billion, and 7.5 percent on amounts more than $10 billion and not more than $35.3 billion.

Eligibility: HMGP funds are administered by SEMA. Local governments, eligible private non-profit organizations or institutions, and Indian tribes or authorized tribal organizations are eligible to apply to SEMA for assistance as subapplicants. Individuals and businesses are not eligible to apply to the State, but eligible local governments or private non-profit organizations may apply on their behalf. The SEMA mitigation administrative plan sets out the method for prioritization and review of applications. After SEMA review and determination, selected subapplications are sent to FEMA for review and approval. For project grants, subapplicants must have a FEMA-approved local mitigation plan. All activities submitted for consideration must be consistent with the local mitigation plan as well as the Missouri State Hazard Mitigation Plan.

Cost-Share Requirements: HMGP funds are provided on a 75 percent federal/25 percent nonfederal cost share basis. The nonfederal match does not does not need to be cash; in-kind services and/or materials may be used.

The Pre-Disaster Mitigation (PDM) Program

Authorized by Section 203 of the Stafford Act, 42 U.S.C. 5133. The PDM program is designed to assist States, Territories, Indian Tribal governments, and local communities in implementing a sustained pre-disaster natural hazard mitigation program to reduce overall risk to the population and structures from future hazard events, while also reducing reliance on Federal funding from future disasters.

Amount: Congress appropriates funds annually for this program. PDM grants are awarded on a competitive basis. Eligible subapplications will compete nationally for PDM grant funds.

Eligibility: In Missouri, SEMA serves as the applicant for all PDM grants. State-level agencies, including state institutions (e.g., state hospital or university); federally recognized Indian tribal governments; local governments (including state recognized Indian tribes and authorized Indian tribal organizations); public colleges and universities; and Indian Tribal colleges and universities are eligible to apply to SEMA for assistance as subapplicants. Private nonprofit organizations and private colleges and universities are not eligible to apply to the State, but an eligible, relevant state agency or local government may apply on their behalf. SEMA reviews and prioritizes subapplications and submits the grant application with subapplications to FEMA for review and approval.

For project grants, subapplicants must have a FEMA-approved local mitigation plan. All activities submitted for consideration must be consistent with the local mitigation plan as well as the Missouri State Hazard Mitigation Plan.

The Flood Mitigation Assistance (FMA) Program

Authorized by Section 1366 of the National Flood Insurance Act of 1968, as amended (NFIA), 42 U.S.C. 4104c, with the goal of reducing or eliminating claims under the NFIP.

Amount: Congress appropriates funds annually for this program. FMA grants are awarded on a competitive basis. Eligible subapplications will compete nationally for FMA grant funds.

Eligibility: In Missouri, SEMA serves as the applicant for all FMA grants. State-level agencies, federally recognized Indian tribal governments, and local governments (including state-recognized Indian tribes and authorized Indian tribal organizations) are eligible to apply to SEMA for assistance as subapplicants. Individuals and private nonprofit organizations are not eligible to apply to the State, but a relevant state agency or local community may apply on their behalf. SEMA reviews and prioritizes subapplications by the applications that include mitigating repetitive loss properties. SEMA then submits the grant application with subapplications to FEMA for review and approval.

All subapplicants must be participating and in good standing in the NFIP. Also, properties included in a project subapplication must be NFIP-insured at the time of the application submittal. For project grants, subapplicants must have a FEMA-approved flood mitigation plan or multi-hazard mitigation plan that meets FMA planning requirements. All activities submitted for consideration must be consistent with the local mitigation plan as well as the Missouri State Hazard Mitigation Plan.

Cost-Share Requirements: FMA funds are generally provided on a 75 percent federal/25 percent nonfederal cost share basis. The recipient must provide the 25 percent match, only half of which may be in-kind contributions. For severe repetitive loss properties, FEMA may contribute up to 100 percent of the total eligible costs and up to 90 percent of the total eligible costs for repetitive loss properties if the State has taken actions to reduce the number of severe repetitive loss/repetitive loss properties and has an approved state mitigation plan that specifies how it intends to reduce the number of severe repetitive and repetitive loss properties.

Public Assistance 406 Mitigation

Program Summary: Section 406 (Public Assistance) of the Stafford Act establishes the program for the repair, restoration, and replacement of facilities damaged as a result of a presidentially declared disaster. For damaged facilities, these funds can be used for hazard mitigation measures determined to be necessary to avoid future damage. Section 406 mitigation funds can only be used in the declared disaster areas (usually counties) and only in conjunction with identified, eligible disaster projects that will strengthen existing infrastructure and facilities to more effectively withstand the next disaster. One example would be replacing a blown-out culvert with one designed to convey higher flows, instead of one that will be easily damaged in a flood again.

Eligibility: State-level agencies, federally recognized Indian tribal governments, and local governments (including state-recognized Indian tribes and authorized Indian tribal organizations) are eligible to apply to SEMA for assistance.

Cost-Share Requirements: Public Assistance grants are provided at not less than 75 percent federal/25 percent nonfederal cost share basis for emergency measures and permanent restoration. All projects approved under State disaster assistance grants will be subject to the cost sharing provisions established in the FEMA-State Agreement and the Stafford Act.

Attorney General's Office

The Attorney General's Office represents the legal interests of the State and its agencies. The Attorney General's Office did not report any mitigation-related programs and initiatives, outreach and partnerships, plans and reports, or funding sources.

Department of Agriculture

The Missouri Department of Agriculture sets agriculture policy and provides assistance to farmers throughout the State. The Department of Agriculture is involved specifically with drought mitigation and mitigating agricultural damage from other hazard events.

Mitigation-Related Plans and Reports

Catastrophic Mortality and Associated Material Disposal, October 2008

This plan describes the outcome of a foreign animal disease outbreak or other natural or man-made disaster where Missouri livestock and poultry producers could be faced with the task of large-scale mortality and the disposal of other potentially contaminated materials associated with the foreign animal disease response and mitigation.

Department of Conservation

The Missouri Department of Conservation (MDC) is active in the State Emergency Operations Center (SEOC), during all state declared disasters. MDC has work teams and equipment throughout the State which provide assistance to cities, counties, and other state agencies as necessary during disasters. MDC also participates in all pre-disaster exercises, drills, and planning teams in the State.

MDC owns many undeveloped floodplain areas that provide storage during high flows. The MDC is also a member of numerous levee districts that provide flood protection to crops and structures. All lakes owned by the Department of Conservation with dams over 35 feet high are designed in accordance with the criteria of the Dam and Reservoir Safety Council of Missouri. The safety or redundancy factor built into these dams and levee construction projects is a higher standard than for commercially constructed projects. In addition, the department owns facilities for launching and landing boats that regularly flood and are designed to be "low profile" and relatively flood-proof.

MDC also participates in a statewide wildfire control program in cooperation with the forest industry, rural fire departments, and other agencies. Prescribed burning of prairies, glades, and savannas may increase the risks of fire hazards; however, prescribed burning reduces the availability of fire fuels and the potential for future, more serious fires to develop. The Department of Conservation, in coordination with SEMA, also performs endangered species reviews for proposed FEMA-funded mitigation projects.

Mitigation-related Programs and Initiatives

Missouri Department of Conservation (MDC) Statewide Wildfire Control Program

St. Louis Region Healthy Streams and Watersheds

Aims to conserve the ecological health of those St. Louis region streams and watersheds that are still healthy, but are most threatened by pollution.

Wetland Restoration Projects

MDC is involved with numerous mitigation projects throughout the State dealing with protection of wetlands, fish, wildlife, and floodplain lands. Many of these programs include the cooperation of several entities such as the U.S. Army Corps of Engineers, U.S. Fish and Wildlife, levee districts, MoDNR, and private landowners.

Mitigation-related Funding Sources

Stream Stewardship Trust Fund

Is an in-lieu fee stream mitigation program. If a developer's project impacts a Missouri stream, in many cases, they must mitigate for that damage. One way to mitigate is to pay a fee to the Trust Fund, which creates a funding mechanism to protect Missouri's best streams.

Department of Economic Development

The Department of Economic Development (DED) administers the Community Development Block Grant program (CDBG) which can provide funding for hazard mitigation and disaster recovery. The DED also administers programs for "distressed and targeted" communities.

Mitigation-related Funding Sources

Community Development Block Grant – Emergency

This program provides assistance to communities to address conditions that pose a serious and immediate threat to the health and welfare of the community. The need must be a serious threat to health or safety, be immediate, have developed or greatly intensified within the past 18 months, and be unique in relation to the problem not existing in all other communities within the state.

Grow Missouri Disaster Loan Program

To provide financial assistance and access to capital businesses and nonprofits directly impacted by flooding or tornados, located in disaster areas in the State.

HUD National Disaster Resilience Competition

In 2016, the National Disaster Resilience competition made $1 billion available to communities that had been struck by natural disasters in recent years. The competition promoted risk assessment and planning and funded the implementation of innovative resilience projects to better prepare communities for future events. Funding for the competition was from the community Development Block Grant disaster recovery appropriation provided by the Disaster Relief Appropriations Act, 2013 (PL 113-2). This competitive grant was administered in Missouri by the Department of Economic Development.

Mitigation-related Plans and Reports

Missouri Consolidated Plan

In 1995, the Consolidated Plan became the single planning document for all funds received by the State from the U.S. Department of Housing and Urban Development (HUD) including CDBG. The State's housing, community development, and economic development needs are outlined in the Consolidated Plan.

Department of Elementary and Secondary Education

The Department of Elementary and Secondary Education is within the Missouri State Board of Education. According to the Missouri Constitution, "The supervision of instruction in the public schools shall be vested in a state board of education ..." (Article IX, Section 2a). This provision gives the State Board of Education general authority for public education, within limits set by the General Assembly. The Board's major responsibilities include defining academic performance standards and assessment requirements for public schools; accrediting local school districts, establishing requirements for the education, testing, assessment, certification and recertification of all public school teachers and administrators; operating the Missouri School for the Blind (St. Louis), the Missouri School for the Deaf (Fulton), and the statewide system of Missouri Schools for the Severely Disabled; as well as overseeing federal education programs and the distribution of federal funds to school districts.

Mitigation-related Programs and Initiatives

Catastrophic Event Preparation

Discusses the State catastrophic event plan in collaboration with DESE, Missouri Center for Safe Schools, Missouri United School Insurance Council, and SEMA.

Department of Health and Senior Services

The Department of Health and Senior Services (DHSS) has internal emergency response plans in place, and as part of the State response the Missouri State Emergency Operations Plan has been fully tested with exercises for all aspects of response and recovery including those relating to public health, emergency response, terrorism, biological, chemical, and radiological/nuclear threats, pandemic influenza, and natural disasters. The Missouri Center for Emergency Response within the DHSS is responsible for coordinating regional and state planning for public health emergencies and disasters, including biological, chemical, and nuclear terrorism. Through partnerships with hospitals and other healthcare organizations; local entities including law enforcement agencies; and other partners, the center works to assure systems are in place to protect the health of Missourians during a public health emergency. The department also has responsibility for planning related to the Center for Disease Control and Prevention's Strategic National Stockpile, which provides life-saving medications and supplies in the event of a large health catastrophe.

The Division of Community and Public Health (DCPH) is responsible for areas of surveillance, disease investigation, and environmental public health. In order to further detect and analyze events of public health importance, DHSS has enhanced surveillance programs through the Public Health Emergency Preparedness grants. The Public Health Event Detection and Assessment Unit in DCPH manages the BioTerrorism Surveillance System and the Electronic Surveillance System for the Early Notification of Community-Based Epidemics (ESSENCE) to provide for early event detection. The ESSENCE system works by placing chief complaints from each emergency department visit into one or more syndromic groups. The system then determines whether the number of visits in the syndromic category was higher than expected for that hospital, county, or zip code. The system can also be used to increase situational awareness by augmenting information about a known health event and its consequences.

Mitigation-related Programs and Initiatives

Missouri's Planning Guide for Local Mass Prophylaxis: Distributing and Dispensing the Strategic National Stockpile, dated October 2003

This plan describes how DHSS can request, receive, and distribute the Strategic National Stockpile to local public health agencies, hospitals, and EMS providers.

Missouri Pandemic Flu Response Plan, dated December 2011

This plan is to provide an effective response to pandemic influenza resulting from natural causes or a terrorist attack. Pandemic plans describe strategies of preparedness, response and recovery to attempt to decrease illnesses and deaths during the pandemic period to manageable levels (i.e., that do not overwhelm the critical infrastructures of the State), and to promote community resiliency and rapid recovery. The response plan will be implemented after a novel influenza strain begins to spread readily from person to person. The plan is geared toward action and specific responsibilities and designed to complement existing DHSS emergency response plans.

Ready in 3 Program

Provides tools and materials free of charge to schools and families in Missouri for taking three steps you can take to prepare for many kinds of emergency situations. The program was developed by the Missouri Department of Health and Senior Services with endorsement from SEMA and the American Red Cross.

Show-Me Response

Is the online registration system for health professionals to volunteer to provide services during a disaster and/or emergency situation.

Department of Higher Education

At the direction of the Coordinating Board for Higher Education (CBHE), the Missouri Department of Higher Education (MDHE) strives to coordinate higher education policy that fosters a quality post-secondary system, as well as increase participation in Missouri's public institutions. The State system of higher education serves more than 620,600 students attending Title IV post-secondary institutions in the State of Missouri. There are 13 public four-year universities, 13 degree-granting public colleges, one state technical college, and 54 not-for-profit four year and above institutions, and more than 140 proprietary and private career schools. The MDHE convenes meetings of the Higher Education Subcommittee of the Homeland Security Advisory Council approximately five times per year as a pre-disaster initiative. The role of this group is to promote pre and post disaster emergency planning initiatives on all higher education campuses in Missouri, share best practices, and ensure that collegiate institutions throughout the State are informed about and engaged in emergency planning. To this end, the Higher Education Subcommittee maintains a list of campus liaisons for coordination of statewide emergency and homeland security operations. All public and independent Missouri institutions of higher education are members of the Missouri Alert Network, which ensures that each campus will receive a message from state officials within a few minutes if an extraordinary situation occurs impacting security and safety. The Higher Education Subcommittee is also working with institutions in reviewing and adapting the Emergency Response Information Program (ERIP) web-based tool to develop campus emergency response and all-hazard plans. Institutions can also provide tactical response information to community first responders using the ERIP system.

The Department of Higher Education did not report any additional mitigation-related programs and initiatives, outreach and partnerships, plans and reports, or funding sources.

Department of Insurance, Financial Institutions, and Professional Registration

The Department of Insurance, Financial Institutions, and Professional Registration has resources for insurance customers, companies, and producers. The department is capable to promote flood and earthquake insurance as a pre-mitigation measure.

Mitigation-related Programs and Initiatives

RSMo 379.975

The Department enforces *RSMo 379.975,* which requires insurers to provide information to applicants and policyholders about earthquake insurance for properties located in the New Madrid Seismic Zone (that is susceptible to Modified Mercalli intensity VII or above earthquake), and *RSMo 379.978,* which requires all insurance companies that provide earthquake coverage to prepare a written disaster plan that addresses earthquakes.

Section 207 of the Flood Insurance Reform Act of 2004

Section 207 of the Flood Insurance Reform Act of 2004 requires all producers selling policies under the NFIP to be properly trained and educated about the NFIP to ensure that clients are better served. The federal law directs the Department of Insurance to require producers to complete a one-time NFIP course which provides continuing education credit to those insurance agents. Additionally, this department suggests that insurance producers advise their clients of the availability of flood insurance coverage.

Department of Labor and Industrial Relations

The Department of Labor and Industrial Relations is responsible for administering programs that provide payment of unemployment insurance benefits to workers who become unemployed through no fault of their own.

When a Missouri county or region is impacted by a natural disaster or hazardous condition such as flooding or inclement weather, the Labor Department has the authority to suspend in-person reporting required of the unemployed for a period of time. This helps to assist in the post-disaster recovery of the local communities. The Labor Department is capable with the support of other state and/or other government agencies, of providing fairly prompt unemployment insurance benefits to workers in disaster-affected areas.

The Department of Labor and Industrial Relations did not report any additional mitigation-related programs and initiatives, outreach and partnerships, plans and reports, or funding sources.

Department of Mental Health

The Department of Mental Health (DMH) maintains an All-Hazard Emergency Operations Plan as a pre-disaster measure. The plan, developed with the input of the Mental Health Statewide Disaster Response Planning Committee, is designed to enhance department planning and response activities and minimizes the effects of disasters (natural, manmade or other) on DMH consumers and the residents of Missouri. The Department also ensures the DMH facilities maintain and exercise facility emergency operations plans; provide education and training for people with special needs, schools, healthcare workers, and other first responders to mitigate the emotional impacts of disaster events; and maintains a Continuity of Operations Plan and a Pandemic Flu annex to help mitigate against the effects of displacement.

Mitigation-related Plans and Reports

All-Hazards Emergency Operations Plan

Dated December 2012—this plan was developed with the input from the Mental Health Statewide Disaster Response Planning Committee. It was designed to enhance department planning and response activities in order to minimize the efforts of disaster or terrorism on DMH clients, the communities and the citizens of Missouri.

Mental Health Disaster Communication Guidebooks

The Department of Mental Health partnered with DHSS to develop a public education program on emotional preparedness for any event Missourians may face that included talking points to help promote emotional well-being and greater coping skills for those facing the negative effects of a disaster.

https://dmh.mo.gov/disaster/plans.html

Missouri Department of Natural Resources

The Missouri Department of Natural Resources (MoDNR) protects Missouri's air, land and water; preserves our unique natural and historical place; and provides recreational and learning opportunities for everyone. MoDNR includes the Division of Environmental Quality, the Missouri Geological Survey and Missouri State Parks. The department administers various projects designed to reduce stream bank erosion, reduce localized flooding, improve drainage, reduce discharge, improve water quality, ensure safe drinking water, and make sure that dams are constructed, maintained, and operated in a safe manner.

The Missouri Geological Survey (MGS) includes the Geological Survey Program, the Land Reclamation Program, the Water Resources Center and the Dam and Reservoir Safety Program MGS has many multi-disciplined geoscientists, engineers and technical professionals to assist in providing professional and technical advice to state and local emergency managers and other officials. Most of MGS's professional and technical staff hold certifications in various emergency response functions and can provide technical assistance, education, and guidance in the use and protection of Missouri's natural resources, as well as interpret the state's geological settings, resource potential and geological hazards.

The State Historic Preservation Office (SHPO) is in the department's Division of State Parks. The SHPO, in coordination with SEMA, performs historic preservation reviews of proposed FEMA-funded mitigation projects.

MoDNR's Division of Environmental Quality also has an Environmental Emergency Response (EER) section under the Environmental Services Program. This section responds to natural disasters to assist in providing potable water, restoring basic services such as water and wastewater, managing environmental clean-ups, etc. The EER section also has a 24-hour call response line, and provide staff to man the State Emergency Operations Center (SEOC) in times of emergency.

Mitigation-related Programs and Initiatives

Dam and Reservoir Safety Program

The Missouri Dam and Safety Reservoir Law of 1979 establishes a dam safety program in the Missouri Department of Natural Resources to ensure that dams in the state are constructed, maintained, and operated in a safe manner. This is accomplished by regulation of all nonagricultural, nonfederal dams of more than 35 feet in height and by providing technical assistance and informational resources to all dam owners. The law also establishes the Dam and Reservoir Safety Council, whose responsibilities are to adopt and amend technological guidelines, standard guidelines, rules, and regulations applicable to the permits, design, construction, maintenance operation, alteration, repair, reduction, removal, and natural physical changes that may occur to a dam or reservoir. The Dam and Reservoir Safety Program is leading an effort to develop Emergency Action Plans (EAPs) for regulated dams that will help save lives and reduce property damage during a dam safety emergency. EAPs increase preparedness by organizing emergency contact information and evacuation procedures into an official document, and by providing enhanced communications between dam owners and local emergency managers. The Program coordinates with SEMA when a problem develops with a dam. If this problem occurs after hours or on a weekend, SEMA's duty officer is notified. The SEMA duty officer responds as appropriate to the situation's needs, according to a manual of procedures.

Geological Survey Program's Earthquake Response Plan and Hazards Mapping

The Geological Survey Program (GSP) developed and maintains an Earthquake Response Plan which provides the post-earthquake geologic investigations procedures that will be undertaken by MGS staff in response to a significant earthquake within the state, or damage within the state caused by earthquakes located outside the state. This plan defines the criteria for initiation of an earthquake response and outlines the response objectives and subsequent plans of action. It also discusses the organization of the Post-Earthquake Technical Information Clearinghouse (PETIC) that will serve as a control for gathering and dissemination of scientific information and credentialed geoscientists and engineers into and out of the affected area. GSP created geologic hazards and debris management maps to assist emergency managers and first responders in their planning and response to a disaster. The geologic hazards maps highlight areas of the state prone to landslides, liquefaction and collapse due to karst or underground mines. The debris management maps provide site suitability, based on geologic and hydrologic conditions, for the disposal of waste and demolition debris following a major disaster. Geologic hazards maps are available state-wide. To date, debris management maps are available in the Poplar Bluff, Cape Girardeau, Farmington and St. Louis, Missouri areas.

GSP is actively pursuing and participating in education and outreach opportunities throughout the state targeting earthquake awareness and environmental stewardship. GSP participates in Earthquake Awareness Month conducting workshops and seminars with SEMA, the Central United States Earthquake Consortium (CUSEC), the Missouri Seismic Safety Commission (MSSC) and other public and private institutions to promote earthquake mitigation and education.

Missouri Water Supply Study, Amended 2009

To ensure availability of water information for effective decision making by communities and the Missouri Department of Natural Resources Water Resources Center. The scope of the study addresses surface water supplies for cities and communities that are expected to experience water shortages during an extended drought. In 2005, it analyzed 34 communities' water systems and the 2009 version includes several more. The Missouri Drought Assessment Committee developed this plan based on the State's Water Resources Law.

Stormwater Improvements Program

In 2001, the Missouri Department of Natural Resources awarded more than $9.9 million to 46 Missouri communities for stormwater improvements. Of these 46 communities, seven had populations of 3,000 or less. Funding for these grants came from bond issues approved by Missouri voters in 1998 for improvements to stormwater, wastewater treatment, and public drinking water systems. The last bond sale occurred in 2002. The types of projects approved included developing city and county stormwater management plans, replacing undersized drainage systems, buying and demolishing flood-prone homes, and implementing structural measures to alleviate erosion and prevent future channel degradation.

Mitigation-related Plans and Reports

MoDNR Missouri Drought Plan

The Missouri Drought Plan, 2002, addresses the need for coordinated response and advanced emergency planning. It complements and supports the State Consolidated Plan and the State Emergency Operations Plan. The Drought Plan outlines proactive strategic and tactical measures designed to better prepare Missouri for drought.

MoDNR Missouri Water Supply Study

The Missouri Department of Natural Resources' Water Resource Center and Public Drinking Water Branch have the responsibility to assist state residents by assuring them of adequate and safe water supply. The purpose of the water supply study is to ensure availability of water information for effective decision-making by communities and MoDNR program managers. In addition, it is expected to be used to determine and allocate existing water supplies.

MoDNR State Water Plan

The Missouri Water Resources Plan is a long-range, comprehensive strategy to provide an understanding of Missouri's resource needs. It will help ensure the quantity of Missouri's water resources will meet future demands by identifying future shortfalls in water supplies, and exploring options to address those water needs.

Department of Public Safety

The Department of Public Safety is comprised of the Office of Homeland Security, and the divisions of the Missouri State Highway Patrol (combined from separate Highway Patrol and Water Patrol since the 2013 plan), State Emergency Management Agency, Missouri National Guard-Office of the Adjutant General, Division of Fire Safety, Capitol Police, Division of Alcohol and Tobacco Control, Missouri Veterans Commission, and Missouri Gaming Commission.

The Department's desired outcomes that are specific to mitigation efforts are: to mitigate the threat of terrorism; reduce preventable injuries and fatalities; interoperable communications for law enforcement and emergency services; increase crime prevention; and to improve the ability to respond and provide recovery from all "hazard events".

The Department of Public Safety did not report any additional mitigation-related programs and initiatives, outreach and partnerships, plans and reports, or funding sources.

Department of Fire Safety

The Division of Fire Safety and the State Fire Marshal provide fire and life safety enforcement and education to all residents so they receive the highest quality of service to ensure safety and a sense of wellbeing. The State Fire Marshal provides post disaster assistance to local jurisdictions through Incident Support Teams and this initiative provides experienced command level personnel to assist in local Emergency Operation Centers (EOC).

Mitigation-related Programs and Initiatives

Missouri Systems Concept of Operational Planning for Emergencies (MoSCOPE), dated 2008

Started as a grant from the International Association of Fire Chiefs (IAFC) to the Missouri Association of Fire Chiefs (MoChiefs) to review and revise Missouri's Fire Mutual Aid program and produce a mutual aid template capable of being used by any responder discipline. This revision was completed in 2008 and was called MoSCOPE (Missouri Systems Concept of Operational Planning for Emergencies). In conjunction with the Division of Fire Safety, regional mutual aid coordinators and MoChiefs, IAFC held a tabletop exercise in October of 2008 to evaluate and validate the revised Fire Mutual Aid program based upon MoSCOPE. The exercise was successfully completed and the revised template validated for use. To assist with this mutual aid template, the Division obtained funding for a part time statewide fire mutual aid coordinator. This position is tasked with further development of the Statewide Mutual Aid program to assist other responder disciplines in establishment of their own mutual aid systems.

Office of Homeland Security

In Missouri, the Office of Homeland Security is within the Department of Public Safety. As a coordinator between the Department of Public Safety agencies that do the daily work that makes up homeland security, such as SEMA and the State Highway Patrol. "Homeland security" covers all of the public safety missions ranging from law enforcement, fire service, and first-responders, to emergency preparation, management, training and mitigation.

The Homeland Security Advisory Council (HSAC) was authorized to review state and local security plans and grant funding requests and make recommendations for changes to better protect Missourians by Executive Order on July 21, 2005. The HSAC was designed to include the Director of the Department of Public Safety and relevant Public Safety Division Directors, and equally important directors of other state departments. This ensures a statewide focus for homeland security and an effective means for coordinating resources.

On February 10, 2006, Executive Order 06-09 was issued making the HSAC a permanent governing body. The Executive Order created the position of Homeland Security Coordinator, under the direction of the Director of the Department of Public Safety. The order also added the Director of the Department of Mental Health to the HSAC, and facilitated the formation of the Regional Homeland Security Oversight Committees (RHSOCs) to give local input from all areas of Missouri to the HSAC. Virtually all of the federal homeland security grant money allocated to Missouri has been committed, and most of it already spent on vital homeland security programs and initiatives. To date, Missouri has not turned any money awarded back to the federal government.

The HSAC has been tasked with ensuring that homeland security plans and coordination are in place at the state and local level and that homeland security grant expenditures are done in a coordinated and efficient way.

State Highway Patrol

The Missouri State Highway Patrol enforces traffic laws and promotes safety on the highways. The State Highway Patrol provides all officers with training on weapons of mass destruction and gives additional terrorism training to sergeants and staff officers. They establish and maintain communications with all local police and sheriff departments, particular during and after natural disaster events. There are also four special emergency response teams located throughout the State that are available to assist at all times.

Mitigation-related Programs and Initiatives

Missouri Homeland Security Alert Network

Provides Missouri public safety officials with immediate phone, email and text message broadcast capabilities to the key individuals within each participating stakeholder community. By utilizing this network, public safety, health, and other officials will be able to instantly message up to 5,000 elected and appointed leaders in individual first responder and other stakeholder communities such as police, sheriff's, fire departments, county and city government, emergency medical services (EMS), 9-1-1 Centers, and even key private sector stakeholders. The system allows a message to be sent to just one discipline or community of stakeholders, or to everyone. A message can also be sent to a selected geographic area, or the whole state.

Department of Social Services

The Department of Social Services (DSS) is the lead state agency responsible for coordinating mass care activities during disaster events. Mass care activities primarily include coordination of sheltering for general populations, and food, water and bulk distribution coordination in affected areas in partnership with the American Red Cross, the Salvation Army, other non-governmental or volunteer organizations and other state agencies. DSS employees respond to the State Emergency Operations Center to staff the Emergency Support Function 6 (ESF 6) desk during disaster events. DSS employees have also been assigned to respond to the two State Area Coordination Centers as needed. DSS County Managers participate in local emergency planning activities. They immediately contact their local Emergency Management Directors during an emergency event and provide assistance if needed. On-going training is provided to all staffing levels to prepare for mass care responsibilities. Field staff provide daily reporting of local emergency management activities, i.e., shelter operations status, shelter locations, number of residents, special requests, etc. Field staff participate in Multi Agency Resource Centers following disaster events. DSS participates in exercises and exercise planning with SEMA and other state and federal agencies as well as other partners in an effort to be as prepared as possible to respond adequately and appropriately when a disaster event occurs.

Mitigation-related Programs and Initiatives

Emergency Operations Plan, Children's Division, dated 2008

Designed to help DSS, Children's Division respond in all four phases of emergency management by providing all services needed by the children and families they serve.

Department of Transportation

The Department of Transportation (MoDOT) is a key responder in most emergencies and disasters in the State of Missouri. The primary MoDOT mission as it relates to emergencies and disasters is to "get the roads open." During a response effort, MoDOT uses all of its resources including thousands of field staff and related equipment, administrative personnel and other personnel to manage emergency events and works in coordination with other emergency response agencies. MoDOT maintains a Traveler Information Map at www.MoDOT.org that provides real time information on road conditions, incidents and work zones. MoDOT also has traffic management systems in place that manage all of the urban and rural interstate highways and some other routes. These systems include 24/7 Traffic Management Centers in St. Louis and Kansas City, 24/7 emergency response crews around the State and field devices such as video cameras electronic message signs, weather stations and traffic detectors. MoDOT also provides a key coordination role with general aviation airports, public transit, waterway ports and railroads. MoDOT personnel provide technical assistance to various emergency management programs, including mitigation. In addition, MoDOT incorporates flood and earthquake standards into new bridge designs and is working on a database that identifies which Missouri bridges have been constructed or retrofitted to earthquake design standards. MoDOT also works on major river bridge projects and wetland reestablishment and rehabilitation. The agency also enforces hazardous materials regulations and manages the registration and licensing of carriers who haul hazardous waste through the State. HazMat response coordinators from the 7 districts work with the MoDNR on spill response.

Mitigation-related Programs and Initiatives

Statewide Transportation Improvement Program

Identifies all transportation projects planned by state and regional planning agencies. The program includes projects for highways, bridges, transit, aviation, rail, waterways, and other projects. It is a project-specific document that tells Missourians what improvements to expect on their transportation system. Projects must consider mitigation against hazards, specifically relating to flooding and earthquakes. This five-year plan is updated each year, and as one year of work is completed, a fifth year of new projects is added.

Office of Administration

The Office of Administration enforces floodplain management regulations for state facilities. The Office of Administration's Division of Design and Construction manages the State's facilities program. It selects consulting architectural and engineering firms for capital improvements projects, administers the construction program, and assists agencies in preparing their capital improvement budget requests.

The Office of Administration did not report any additional mitigation-related programs and initiatives, outreach and partnerships, plans and reports, or funding sources.

Public Service Commission

The Missouri Public Service Commission (PSC) regulates investor-owned public utilities operating in Missouri that can be affected by disaster events. The PSC has the statutory responsibility for ensuring that customers receive adequate amounts of safely delivered and reasonably priced utility services at rates that will provide the companies' shareholders with the opportunity to earn a reasonable return on their investments. The PSC must balance a variety of often competing private interests to ensure the overall public interest.

The Public Service Commission did not report any additional mitigation-related programs and initiatives, outreach and partnerships, plans and reports, or funding sources.

4.5.2. Policies and Regulations

The State has several statutes that address hazard mitigation through the creation of special councils or committees and rules and requirements for agencies and local governments to follow. These primarily address seismic hazards, floodplain management, water resources, dam and reservoir safety, as well as public health emergencies. **Table 4.23** summarizes the statutes and executive orders that enhance the State's capabilities to reduce the impacts of future disasters.

Table 4.23. Missouri State Statutes and Executive Orders

Policy	Requirements
RSMo 44.020: State Emergency Management Agency created	There is hereby created within the military division of the executive department, office of the adjutant general, the "State Emergency Management Agency," for the general purpose of assisting in coordination of national, state, and local activities related to emergency functions by coordinating response, recovery, planning and mitigation. This agency shall also serve as the statewide coordinator for activities associated with the National Flood Insurance Program
RSMo 44.028: State may accept federal goods and services on behalf of itself and its subdivisions	Whenever the federal government or officer or agency thereof shall offer to the State, or through the State to any political subdivision thereof, services, equipment, supplies, materials or funds by way of gift, grant or loan, for the purpose of emergency management, the State acting through the agency, or the political subdivision, through its executive officer with the consent of the governor, may accept the offer and may receive these services, equipment, supplies, materials or funds on behalf of the State or the political subdivision subject to the terms of the offer.
RSMo 44.080: All political subdivisions shall establish a local emergency management	Each political subdivision of this state shall establish a local organization for disaster planning in accordance with the state emergency operations plan and program

Policy	Requirements
RSMo 49.600: National flood insurance program, adoption and rescission procedure-exemptions (certain second-, third-fourth-class counties)	The county commission, in all counties which have not adopted county planning and zoning, may adopt or rescind by order or ordinance regulations to require compliance with FEMA standards, necessary to comply with the National Flood Insurance Program, in any flood hazard area designated by FEMA; provided, however, that no ordinance or order enacted pursuant to this section in any county shall be effective unless the county commission or governing body of the county submits to the voters of a county a proposal to authorize the county commission or governing body of the county to adopt such an order or ordinance.
RSMo 49.605:Permits, authorized requirements for applicant	No permit required by the provisions of order or ordinance regulations adopted pursuant to the provisions of sections 49.600 to 49.615 shall be denied an applicant if the proposed construction, use or other development will not raise the flood elevation of the 100-year flood level more than one foot; provided, however, that any permit may require that the lowest floor of an insurable structure shall be above the 100-year flood level and that all structures shall be adequately anchored to prevent flotation, collapse, or lateral movement of the structure.
RSMo 700.015: Code compliance required, when — seal required — exemptions from code requirements for sale of new recreational vehicles and park trailers	No person shall rent, lease, sell, or offer for sale any new manufactured home manufactured after January 1, 1974, unless such manufactured home complies with the code and bears the proper seal. No person shall manufacture in this state any manufactured home or modular unit for rent, lease or sale within the State which does not bear a seal evidencing compliance with the code. No person shall offer for rent, lease or sale a new modular unit or a unit used for educational purposes manufactured after January 1, 1974, unless such modular unit complies with the code and bears a seal issued by the commission evidencing compliance with the code.
RSMo 700.065: Manufactured homes to be anchored	All manufactured homes located in this state shall be anchored and tied down in accordance with the standards promulgated by the commission
RSMo 44.227-237:Commission on seismic safety created	Authorizes creation, duties, and powers of the Missouri Seismic Safety Commission, as well as gives the commission responsibilities to undertake a study to determine the feasibility of establishing a comprehensive program of earthquake hazard reduction to save lives and mitigate damage to property in Missouri.
RSMo 160.451:Earthquake emergency system to be established for certain school districts	The governing body of each school district which can be expected to experience an intensity of ground shaking equivalent to a Modified Mercalli of VII or above from an earthquake occurring along the New Madrid Fault with a potential magnitude of 7.6 on the Richter Scale shall establish an earthquake emergency procedure system in every school building under its jurisdiction
RSMo 160.453: Requirements for emergency system—public inspection of system authorized	This earthquake emergency system shall include 1) A school building disaster plan; 2) An emergency exercise to be held at least twice each school year; 3) Protective measures to be taken before, during, and following an earthquake; and 4) A program to ensure that the students and certified and noncertified employees of the school district are aware of, and properly trained in, the earthquake emergency procedure system.

Policy	Requirements
RSMo 160.455: Distribution to each student certain materials on earthquake safety—duties of school district	At the beginning of each school year, each school district shall distribute to each student materials that have been prepared by the Federal Emergency Management Agency, SEMA, or by agencies that are authorities in the area of earthquake safety and that provide the following objectives: 1) Developing public awareness regarding the causes of earthquakes, the forces and effects of earthquakes, and the need for school and community action in coping with earthquake hazards; 2) Promoting understanding of the impact of earthquakes on natural features and manmade structures; and 3) Explaining what safety measures should be taken by individuals and households prior to, during and following an earthquake.
RSMo 256.173: Cities and counties to be furnished geologic hazard assessment prepared by Missouri Geological Survey	The Missouri Geological Survey in the Missouri Department of Natural Resources shall provide each county as the information becomes available a geologic hazard assessment and assistance in the use and application of the geologic hazard assessments, which will be made available to the public. The Department of Natural Resources shall provide each recorder of deeds of each county in the State a map showing the downstream area that would be affected in the event of a dam failure.
RSMo 256.175: High seismic risk area data-duties of department	The Missouri Department of Natural Resources shall furnish to SEMA technical data, including soil liquefaction and seismic effects, on structural foundations that are located in a high seismic risk area. If requested by a local government entity, the department shall assist in the establishment of construction standards based on the data provided in this subsection. The Department shall be designated as the lead technical agency in the State to conduct studies concerning the geologic effects of earthquakes.
RSMo 319.200-207: Notice to cities and counties subject to earthquake to adopt seismic construction and renovation ordinances, when-standards	Each city, town, village, or county that can be expected to experience an intensity of ground shaking equivalent to a Modified Mercalli of VII or above from an earthquake occurring along the New Madrid Fault with a potential magnitude of 7.6 on the Richter
RSMo 379.978: Written disaster plan, insurer to develop, contents	Every insurance company that insures property for loss caused by earthquake shall prepare and retain a written disaster plan covering earthquakes. This plan shall include specific provisions regarding procedures for handling claims under the insurance company's issued policies or endorsements covering loss or damage from the peril of earthquake.
RSMo 640.412: Inventory to be maintained on ground and surface water uses, quantity, and users	The Department of Natural Resources shall inventory 1) existing surface water and groundwater uses; 2) the quantity of surface water and groundwater available for uses in the future; and 3) water extraction and use patterns, including regulated and unregulated users.

Policy	Requirements
RSMo 640.415: State water resource plan to be established for use of surface and ground water—annual report, contents—powers of department	Authorizes the Department of Natural Resources to develop, maintain, and periodically update a state water plan for a long-range, comprehensive statewide program for the use of surface water and groundwater resources of the State, including existing and future need for drinking water supplies, agriculture, industry, recreation, environmental protection, and related needs. This plan shall be known as the "State Water resources Plan". The department shall collect data, make surveys, investigations and recommendations concerning the water resources of the State as related to its social, economic and environmental needs.
RSMo 644.018: Reasonable use defined in cases involving surface water in flood-prone areas	In any contested case or judicial proceeding filed after January 1, 1998, involving surface water in any flood-prone area, if any defendant has obtained and fully complied with a permit from a political subdivision which has enacted orders or ordinances as required by FEMA as a prerequisite to participation in the National Flood Insurance Program, and which political subdivision has jurisdiction, pursuant to the zoning laws of this state or the laws and regulations of FEMA, over the area in dispute, then the proper permitting and compliance with all conditions of such permitting of such project shall be conclusive proof that the project is a reasonable use and meets any reasonable-use test imposed by law or by a court.
RSMo 245.015: Owners may form levee district, where—articles of incorporation to be filed in circuit court	The owners of a majority of the acreage in any contiguous body of swamp, wet or overflowed land or other property in the nature of individual or corporate franchises in this state, or land subject to overflow, wash or bank erosion, located in one or more counties or in any city, town, or village in this state not located within any county with a charter form of government and with more than two hundred fifty thousand but less than three hundred fifty thousand inhabitants, or in any city, town, or village of the third or fourth classification in this state which is located within any county with a charter form of government and with more than two hundred fifty thousand but less than three hundred fifty thousand inhabitants, may form a levee district for the purpose of having such land and other property reclaimed and protected from the effects of overflow and other water, for sanitary or agricultural purposes, or from the effect of wash or bank erosion, or when the same may be conducive to the public health, convenience or welfare, or of public utility or benefit, by levee, or otherwise.
RSMo 254.270. Fire control and timber trespass activities intensified, when—provisions for added protection	Fire control and timber trespass activities will be intensified and may be extended to include all woodlands in the State as deemed in need of such protection by the commission within the limits of funds provided. Any person whether or not his lands are classified as forest croplands may receive such assistance. Any owner may make application to the commission for special attention in forest fire control requiring expenditures in excess of those permitted within the limits of funds provided for general activities under this chapter, by subscribing a payment of not less than three cents per acre per year for such added protection as the commission may deem advisable and desirable.

Policy	Requirements
RSMo 640.130: Emergencies—actions to be taken—water systems in violation, penalties	Whenever the Department of Natural Resources determines that an emergency exists which endangers or could be expected to endanger the public health and safety with regard to drinking water supplies, the department may, without notice or hearing, issue an order reciting the existence of such a condition and requiring the person to take such action as will lessen or abate the danger. At the request of the department, the attorney general may bring an injunctive action or other appropriate action in the name of the people of the State Whenever the department determines that a public water system is in violation ... it may issue an administrative order requiring the public water system to comply with such rule or statute.
RSMo 640.140: Department may cooperate with others—may receive aid, conduct training and research—may financially assist in construction of water systems	The Department of Natural Resources may enter into agreements, contracts, or cooperative arrangements under appropriate terms and conditions with other state agencies, federal agencies, interstate agencies, political subdivisions, educational institutions, local health departments, or other organizations or individuals for the purpose of administering the State drinking water supply program. The department may solicit and receive grants of money or other aid from federal and other public or private agencies or individuals ... to conduct research and training activities or cause them to be conducted, to financially assist in the construction of water works systems or portions thereof, or for other program purposes.
RSMo 319-500: Pipelines transporting hazardous liquids to submit periodic reports to department of natural resources—content	Any owner or operator of pipelines transporting hazardous liquids, as defined in the federal Hazardous Liquid Pipeline Safety Act of 1979, 49 USC 2001, et seq., shall submit periodic reports to the department of natural resources as required by the director of the department of natural resources under this section.
RSMo 44.090: Repealed in 2009 & new section enacted for Missouri's mutual aid system	The Missouri mutual aid system shall be administered by the department of public safety, which may authorize any organization to assist in the administration of the mutual aid system.
19 CRS 20-20.020	Missouri disease reporting requirement to DHSS
Executive Order 93-40, 1993	Establishes the Task Force on Flood Plain Management and the composition of its members. The task force reviews and makes recommendations on 1) the building, rebuilding, or relocation of levees; 2) state highway and road projects in floodplains; and 3) expenditures of public funds for projects in floodplains which require state action or approval. The task force will make recommendations to the governor regarding proposed legislation and long-term policy regarding development of housing and other private and public structures in floodplain areas.
Executive Order 94-25, 1994	Establishes the Disaster Recovery Partnership to review and design new human services disaster response and recovery delivery methods, establish more rapid and complete communications to disaster victims and caregivers, and promote, train, and support local committees.

Policy	Requirements
Executive Order 98-3, 1998 (revised Executive Order 97-09, 1997).	Authorizes SEMA to issue floodplain development permits for any state owned or leased development in a special flood hazard area.
Executive Order 03-23, 2003	Reaffirms the endeavors of the Disaster Recovery Partnership and ascribes to it the additional functions of a state citizen council.
Executive Order 05-20, 2005	Establishes the Missouri Homeland Security Advisory Council to review and evaluate current state and local homeland security plans and make recommendations for changes to better protect Missourians and to review requests and provide recommendations on the appropriate use of Homeland Security grant funds from the federal government. Creates the Division of Homeland Security within the Department of Public Safety to coordinate activities to promote unity of effort among federal, state, local, private sector, and citizen activities related to emergency preparedness and homeland security.
Executive Order 06-10, 2006	Creates the Citizen Corps to help coordinate volunteer and individual or family preparedness activities in any emergency situation
Executive Order 06-41, 2006	Creates the Interdepartmental Coordination Council for Water Quality
Executive Order 09-25, 2009	Creates and establishes the Governor's Faith-Based and Community Service Partnership for Disaster Recovery. It is comprised of governmental and private agency representatives.

4.5.3. Development in Hazard-Prone Areas

Missouri is a "home-rule" state and does not have a statewide program for land use or a statewide building code; however, the State does address development in seismic and flood hazard areas. State statutes require that new public construction, additions, and alterations comply with certain standards for seismic design and construction if located in areas subject to a certain level of ground shaking. It is up to local governments to implement and enforce the use of building codes. SEMA emphasizes the use of building codes at mitigation training programs and when briefing new state legislators.

As a result of a 1998 Executive Order, SEMA issues floodplain development permits for any state-owned or leased development in a Special Flood Hazard Area. Local governments participating in the NFIP address development in flood hazard areas through their floodplain management ordinances.

4.5.4. State Funding Capability

The majority of funding for hazard mitigation projects in Missouri is attained through federal programs. More information on these funding sources is provided in Section 4.5.1 State Agency Capability Assessment under the Mitigation-Related Funding Sources Heading for each agency and Section 4.4, Funding Sources. The mitigation-related funding from the state budget includes partial funding of the floodplain management budget. For Fiscal Year 2016, the State General Revenue contribution for floodplain management was $52,510.50. For this same period, the State General Revenue contribution for the remainder of SEMA's operating budget was nearly $3,000,000.

Section 44.032 of the Missouri Revised Statutes establishes the Missouri Disaster Fund to "furnish immediate aid and relief." The fund is primarily for response and recovery costs, but the section states that "provisions of this section shall be liberally construed in order to accomplish the purposes of sections 44.010 to 44.130. Section 44.010 defines emergency management functions, emergency management activities, and emergency management service as "those functions required to prepare for and carry out actions to prevent, minimize and repair injury and damage due to disasters".

4.5.5. Changes and Challenges in Capabilities

As the Missouri State Hazard Mitigation Plan has evolved, the State's capabilities related to mitigation have also grown. The continued coordination and collaboration resulting from the regular meetings of the State Risk Management Team have provided a framework for regular discussion of pre- and post-disaster risk management and mitigation opportunities in Missouri. Additionally, SEMA's overall program has been strengthened by legislation (Missouri House Bill 579) that transferred SEMA from the Office of the Adjutant General to the Department of Public Safety. This allows for the deployment of workers and volunteers, such as healthcare providers, that are licensed, registered, or certified in Missouri or any other state during an emergency declared by the governor. Prior to the bill's passage, only workers and volunteers licensed, registered, or certified in Missouri could be deployed. This bill also granted volunteers immunity from civil damages for their services unless the damages are due too willful and wanton acts or omissions in rendering care.

An evaluation of pre- and post-disaster capabilities took place on a program level during the 2018 update. This program-level evaluation was based on increases in community participation in programs such as the NFIP and CRS, implementation of the Risk MAP program and successful use of pre- and post-disaster mitigation projects funds. A greater number of communities are participating in the NFIP, partnerships among federal and state agencies and local governments continue to grow, and new strategic planning efforts have been undertaken. These changes in programs, outreach and partnerships, plans, policies and regulations are summarized below. The end of this chapter discusses opportunities to continue to enhance state capabilities related to mitigation.

National Flood Insurance Program and Community Rating System

As of May 2018, 672 communities in Missouri participate in the National Flood Insurance Program. Of these communities, 10 (or 1.5 percent) participate in the Community Rating System. Of the top 50 Missouri communities (in terms of flood insurance policies in force), 6 participate in the CRS. The remaining 44 communities in the top 50 present an outreach opportunity for encouraging participation the CRS.

Table 4.24 provides additional details on changes in NFIP participation from 2013 to May 2018.

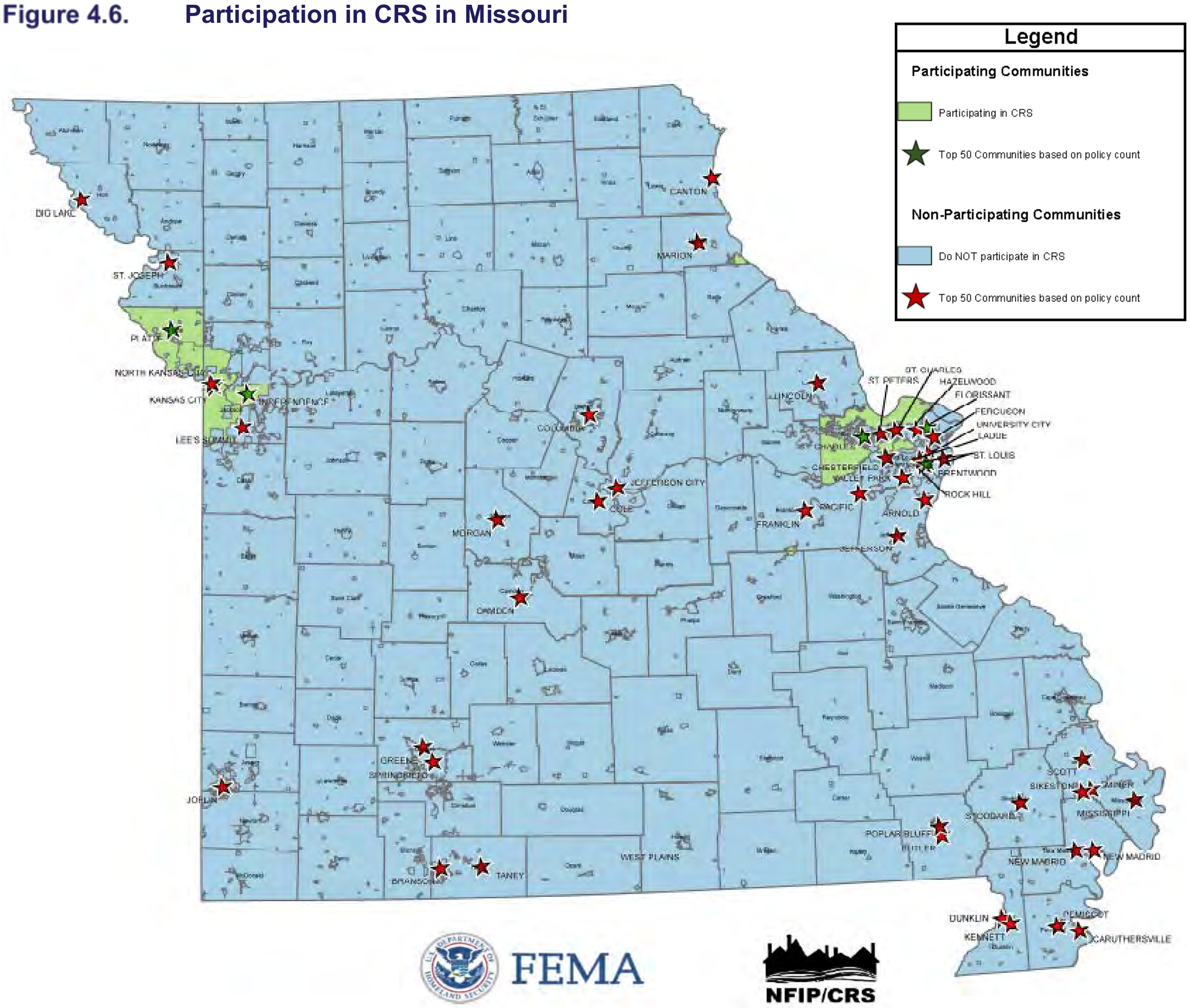
Table 4.24. Changes in NFIP Participation 2013 to 2018

NFIP Participation	2013	May 2018
Total in Regular Program	650	672
Total in Emergency Program	2	1
Total in NFIP	652	673
CRS Communities	5	10
Mapped Hazard Area, Not in Program	161	162
Total Suspended	8	6

Source: https://www.fema.gov/cis/MO.pdf

Figure 4.6 provides a statewide view of participation in the Community Rating System.

Figure 4.6. Participation in CRS in Missouri



Source: http://crsresources.org/files/100/maps/states/missouri_crs_map_may_2017.pdf

Challenges in implementation of the National Flood Insurance Program include:

- Lack of administrative capability in some small communities to effectively administer the NFIP.
- The current distinction of the 1-in-100-year flood zones for mandatory coverage may have led some consumers to believe erroneously that they do not have significant flood risk when they are not required to purchase flood insurance. It is politically and logistically infeasible to require mandatory flood insurance coverage for all property owners, or even to significantly expand the existing mandatory footprint. However, increasing consumers' awareness and educating them about their flood risk can potentially increase take-up in areas outside the mandatory coverage areas.
- Changing risk areas over time can pose a challenge in implementation of the NFIP.

- Changes in development as well as changing future conditions due to climate trends pose challenges with respect to creating a dynamic risk area.

Risk Mapping, Assessment, and Planning (Risk MAP) Program

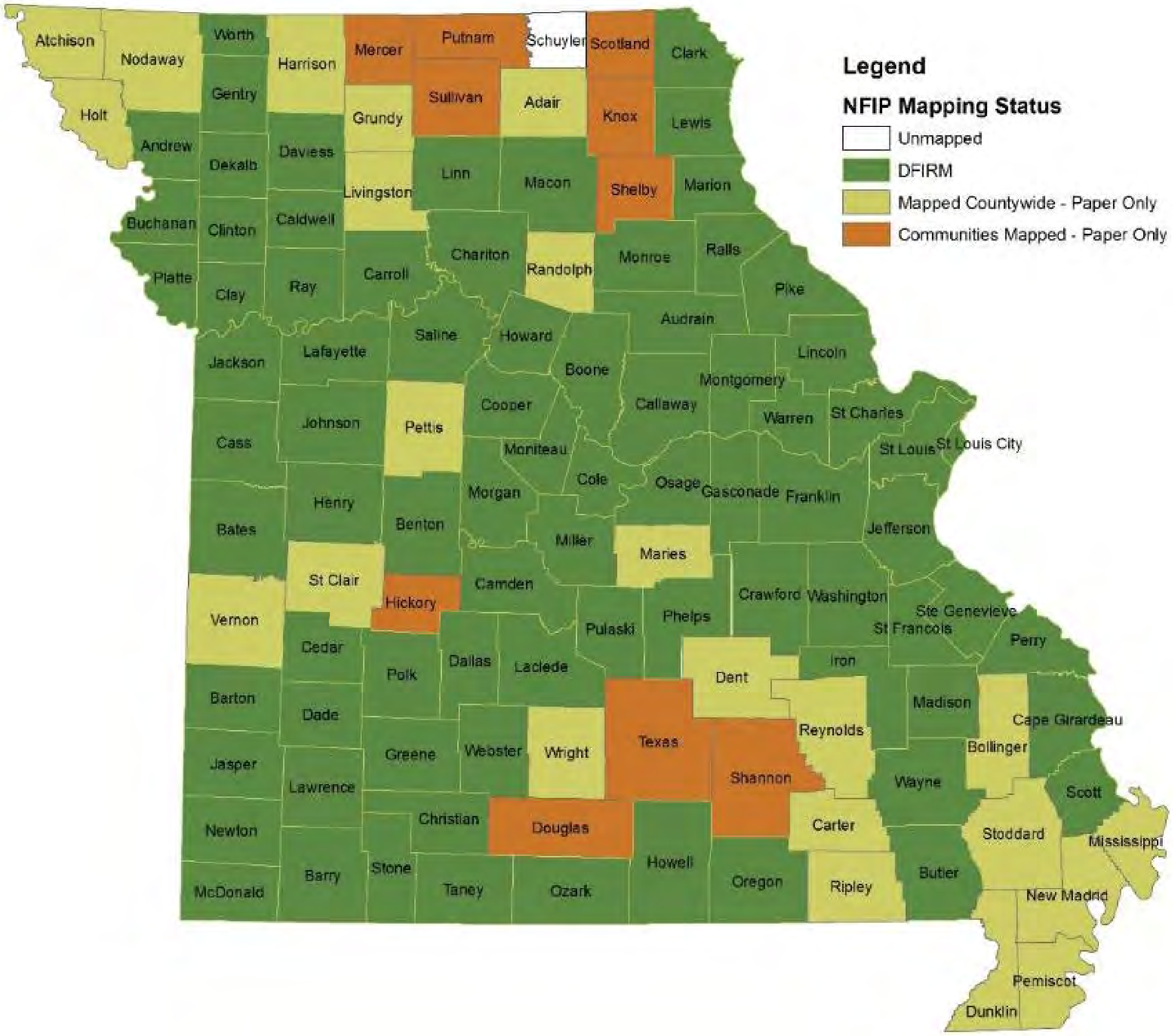
SEMA has made great progress towards meeting the outlined program mission and updating the State to the digital mapping standards. SEMA has developed the organization and functional team necessary to share resources and effectively fulfill the goals of this program. The first objective of the program is to have all flood hazard areas in the state accurately and digitally mapped by 2022, depending on FEMA's funding availability. The next objective is to organize continued operations dedicated to increasing the accuracy of those maps and maintaining the data on those maps. The summary status of the map update process through Fiscal Year 2016 is summarized in **Table 4.25** and the status for map production is provided in **Figure 4.7**. The current status for Risk MAP Deployment is provided in **Figure 4.8** followed by **Table 4.26** which lists the watersheds with Risk MAP deployment. Finally, **Figure 4.9** depicts the discovery status and planned discovery through Fiscal Year 2018.

Table 4.25. SEMA Risk MAP Performance through Fiscal Year 2016

	SEMA Performance	FEMA Metric
% of population with digital floodplains	94%	94%
# of Counties with digital floodplains (preliminary maps)	2 out of 114	NA
% of population with effective DFIRMS	90%	85%
# of Counties with effective DFIRMS	80 out of 114	NA

Source: SEMA Risk MAP Program 2017 Combined Strategic Business Plan

Figure 4.7. Missouri Map Production Status



Source: SEMA Risk MAP Program 2017 Combined Strategic Business Plan

Figure 4.8. Missouri Risk MAP Watersheds

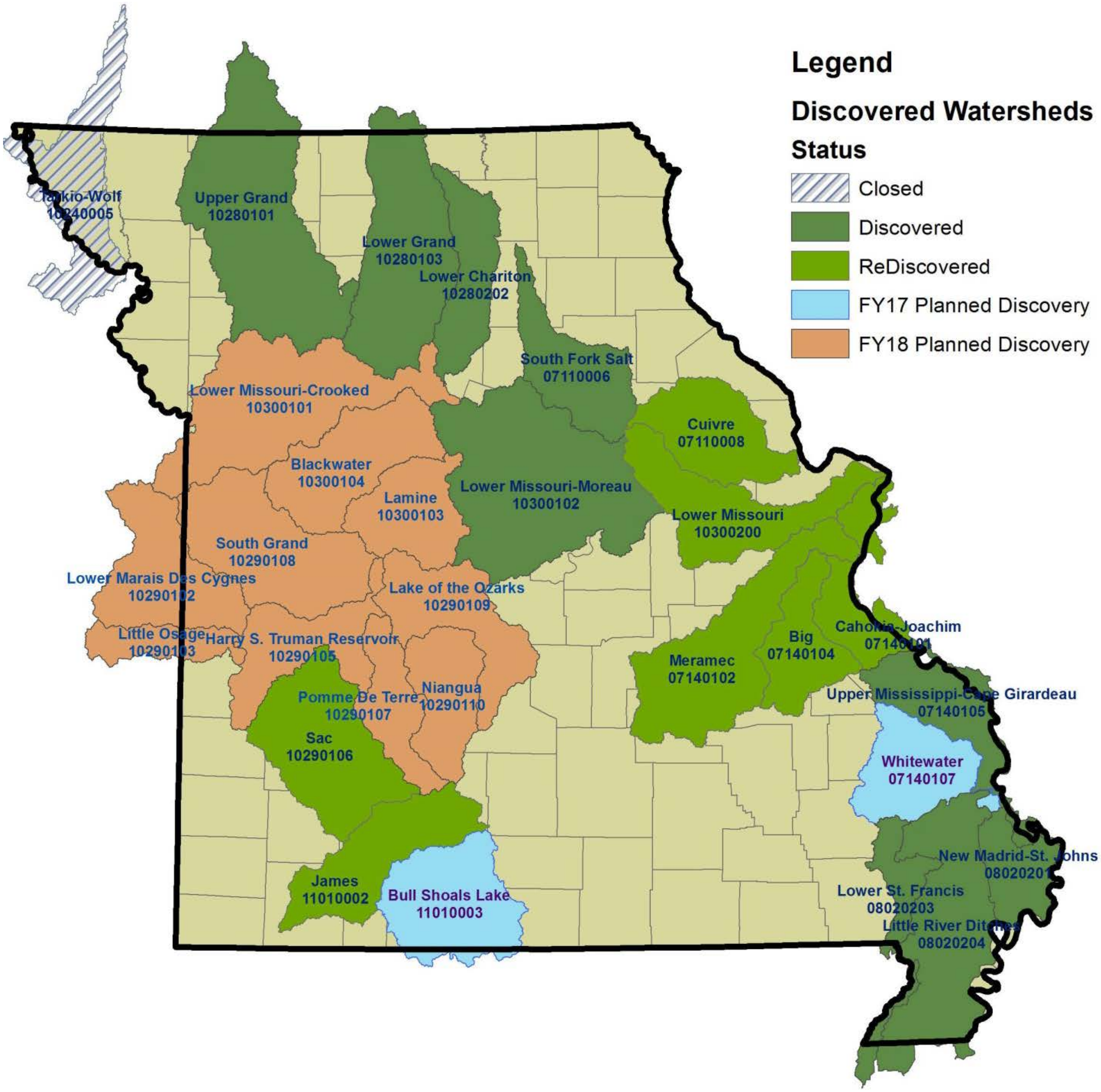
Source: SEMA Risk MAP Program 2017 Combined Strategic Business Plan

Table 4.26. Missouri Risk MAP Deployed Watersheds

RiskMAP Deployed Watershed Name	HUC8 Code
Big	07140104
Cahokia-Joachim	07140101
James	11010002
Lower Missouri	10290106
Lower Missouri-Crooked	10300101
Lower Missouri-Moreau	10300102
Meramec	07140102
Sac	10290106
Upper Grand	10280101

Source: SEMA Risk MAP Program 2017 Combined Strategic Business Plan

Figure 4.9. Missouri HUC8 Watersheds – Discovery Status / Planned Discovery



Source: SEMA Risk MAP Program 2017 Combined Strategic Business Plan

Challenges in implementation of Risk MAP include:

- Deployment of additional Risk MAP watersheds is contingent on available funding.
- Changes in risk areas over time can pose a challenge in maintaining currency in maps.
- Changes in development as well as changing future conditions due to climate trends pose challenges with respect to creating a dynamic risk area.

Hazard Mitigation Planning

As of December 2016, 114 county-level mitigation plans (including the independent City of St. Louis) in Missouri had been approved by the Federal Emergency Management Agency. In 2013, there were two counties with no local hazard mitigation plans: Dent County and Laclede County. Laclede County now has an approved plan and Dent County is in the process of developing a plan.

As with the NFIP, changing risk areas over time can pose a challenge with respect to development of risk assessments that take into account changing conditions. Changes in development that can impact future risk as well as changing future conditions due to climate trends that can impact future risk should be considered. This can present a challenge for local planners with respect to identifying risk areas that may be dynamic.

Use of Mitigation Funding

See Section 4.2.4, Review and Progress of Mitigation Actions and Section 7.5, Effective Use of Available Mitigation Funding.

Challenges in Use of Mitigation Funding include:

- SEMA's Mitigation Management program has historically maintained a staffing level to manage approximately $25 million in grants. However, due to the program's success in obtaining funding through the competitive Pre-Disaster Mitigation program and multiple disasters, SEMA has managed grant funds in excess of $100 million. This has created some challenges in staffing capacity to administer grants. SEMA has met this challenge by contracting with the Regional Planning Commissions for planning. Additionally, staffing in the Mitigation Management program has also increased over time.

4.5.6. Opportunities for Improving State Capabilities

This section summarizes the opportunities for improving state capabilities.

National Flood Insurance Program Opportunities

As of September 2017, there are 163 communities that are mapped with identified special flood hazard areas that do not have flood insurance. This presents an opportunity to continue to work with those communities to encourage them to participate in the program so that residents and business owners in flood risk areas have the opportunity to purchase flood insurance to protect their financial investment. Additionally, participation in the NFIP would facilitate future management of flood risk areas to prevent new development from increasing the number of structures at risk.

Community Rating System Opportunities

Of the top 50 Missouri communities (in terms of flood insurance policies in force), only 6 participate in the CRS (12 percent). The remaining 44 communities in the top 50 present an outreach opportunity for encouraging participation the CRS.

Risk Mapping, Assessment, and Planning (Risk MAP) Program Opportunities

Continued deployment of the Risk MAP program presents several opportunities to increase capabilities. The regulatory and non-regulatory products provide tools for community officials and planners to understand risk as well as take steps to minimize future risk. With the misconceptions that currently exist with the distinction of the 1-percent annual chance flood zones, the non-regulatory products provide additional resources to communicate risk. The Community Engagement and Risk Communication (CERC) component of Risk MAP is specifically designed to use the Risk MAP products to fully communicate risk as well as facilitate development of mitigation opportunities.

Hazard Mitigation Planning Opportunities

There are opportunities within the framework of local planning to address changing risk areas. With the implementation of the State Plan Guidance in March of 2013, State Plans are now required to consider not only changes in development that can impact future risk, but also consider other changing future conditions due to climate trends that can impact future risk. This presents a basis for opportunities at the local planning level to incorporate this same type of adaptive planning.

Use of Mitigation Funding Opportunities

The State of Missouri has a long history of making use of available mitigation funding to reduce risk within the state. With the development of this State Plan Update, the State of Missouri has again made the decision to go above and beyond standard plan requirement with the development of an updated enhanced plan. This provides the opportunity for the State of Missouri to continue to receive increased post-disaster hazard mitigation funding from the standard amount of 15-percent to the enhanced amount of 20-percent of disaster recovery costs.

4.6. Local Capability Assessment

Requirement §201.4(c)(3)(ii): [The State mitigation strategy shall include a] general description and analysis of the effectiveness of local mitigation policies, programs, and capabilities.

The local capability assessment provides a general description of local mitigation capabilities in Missouri, including examples of successful policies and programs, followed by an analysis of the effectiveness of these capabilities. The assessment concludes with a discussion of opportunities and obstacles to implementing and strengthening local capabilities.

4.6.1. Local Policies, Programs, and Capabilities

There are a wide range of policies, programs, and capabilities that can serve as a foundation for implementing local mitigation plans including the following:

- Planning Capabilities
- Building Codes, Policies, and Ordinances
- Mitigation-related Programs/Partnerships
- Specific Studies
- Staffing Positions
- Potential Funding Sources

Planning Capabilities

County Emergency Operations Plans

Each County and the independent City of St. Louis have an Emergency Operations Plan in place to guide direction and control in response to a disaster. Many larger cities also maintain their own Emergency Operations Plan to guide response activities. The State Emergency Management Agency provides guidance to local entities in development/update of these plans.

Local Hazard Mitigation Plans

There are 105 FEMA-approved local hazard mitigation plans in Missouri, representing 103 county level plans; two regional plans representing a total of 10 counties; one multi-jurisdictional plan representing two counties, and one plan for the Missouri electric cooperatives. Dent County is the only county without a current approved Hazard Mitigation Plan and they are currently in the process of developing a plan.

Comprehensive Development Plans (Master Plan)

A comprehensive development plan is an official document adopted by a city as a policy guide to decisions about the physical development of the community. The plan is not a regulatory ordinance, but a guide to be used when regulatory ordinances are developed and administered. Nor is the comprehensive development plan a detailed capital improvement program showing precise locations of public improvements and community facilities; it is used as a guide in the more detailed development planning that must occur before those facilities are built. The plan is a comprehensive document in that it covers all portions of the city and all facilities that relate to development.

Planning and Zoning

Planning and zoning is the mechanism with which municipalities design and control the development of private land. All cities, towns and villages in Missouri may adopt planning and zoning. Statutory authority to enact planning and zoning is found in Chapter 89 of the Revised Statutes of Missouri (RSMo). Chapter 89 establishes the procedural framework in which planning and zoning is enacted and administered. Planning and zoning gives municipal officials the opportunity to coordinate development activities within their community. Without this tool, land use decisions are left to the whims of a wide variety of private groups that are motivated by personal interests instead of the public interest.

According to a 2015 survey by the Missouri Municipal League, 417 out of 686 municipalities that responded have Planning and Zoning (see **Table 4.27**).

Table 4.27. Municipalities with Planning and Zoning by County (Responded to Survey)

County	Yes	No	Not Reported	Total Responses
Adair	1	3		4
Andrew	2			2
Atchison	2	2		4
Audrain	3	3	1	7
Barry	5	4		9
Barton	1	3		4
Bates	1	3		4
Bates|Cass		1		1
Benton	3			3
Bollinger	1		2	3
Boone	6	3		9
Buchanan	3			3
Butler	1	2	1	4
Caldwell	2	5		7
Callaway	4	2		6
Callaway, Cole	1			1
Camden	4	3		7
Camden|Miller	1			1
Camden|Morgan	1			1
Cape Girardeau	2	1		3
Carroll	2	2	1	5
Carter	1	2		3
Cass	13	2		15
Cedar	1	1		2
Chariton	2	1		3
Christian	7	1		8
City Not Within A			1	1
Clark		4		4
Clay	13	1	1	15
Clay|Clinton	1			1
Clay|Ray	2			2
Clinton	5			5
Clinton, DeKalb	1			1
Clinton|DeKalb		1		1
Cole	3	2		5
Cooper	2	2	2	6
Crawford	4			4
Crawford, Franklin	1			1
Dade		3		3
Dallas	1	2		3
Daviess	1	3	1	5
DeKalb	1	3		4
Dent	1			1
Dent|Reynolds		1		1
Douglas	1			1
Dunklin	5	3		8
Franklin	6	1		7
Franklin|St. Louis	1			1
Gasconade	4	1		5
Gentry	2	1		3
Greene	7			7
Greene|Webster	1			1
Grundy	1	2	1	4
Harrison	1	5	1	7
Henry	4	4		8
Hickory		4		4
Holt	1	4		5
Howard	3			3
Howell	3			3
Iron	3	2	1	6
Jackson	12	3	1	16
Jackson|Cass	1			1
Jasper	9	4		13
Jasper|Newton	1			1
Jefferson	8	1		9
Johnson	3	3		6
Knox		3	1	4
Laclede	1	2		3
Lafayette	8	6		14
Lafayette|Saline		1		1
Lawrence	5	1		6
Lewis	1	3		4
Lincoln	3	6		9

County	Yes	No	Not Reported	Total Responses
Linn	2	3	2	7
Linn|Sullivan		1		1
Livingston	1			1
Macon	3	3	1	7
Madison	1	1		2
Maries		1		1
Maries|Osage	1			1
Marion	2			2
McDonald	5	2		7
Mercer		2		2
Miller	1	1		2
Mississippi	2	2		4
Moniteau		2		2
Monroe	3			3
Montgomery	4	1	1	6
Morgan	2	3		5
New Madrid	4	7		11
Newton	4	4		8
Nodaway	1	2	1	4
Oregon	1	2		3
Osage	1	2	1	4
Ozark	2	1		3
Pemiscot	2	1		3
Perry	1			1
Pettis	3	3		6
Phelps	2	3		5
Pike	3	3	1	7
Platte	14	1		15
Polk	2	4		6
Pulaski	3	2		5
Putnam	1			1
Ralls	3			3
Randolph	2	5		7
Ray	5	3		8
Reynolds		1		1
Ripley	1	1		2
Saline	3	1		4
Schuyler		3	1	4
Scotland	1	1		2
Scott	6	1		7
Shannon	1	2		3
Shannon|Texas		1		1
Shelby	2	2		4
St. Charles	12			12
St. Clair	2	2		4
St. Francois	6	2		8
St. Louis	71	6		77
Ste. Genevieve	1	2		3
Stoddard	3	3		6
Stone	4	4	1	9
Sullivan	2	1	1	4
Taney	5	2	1	8
Texas	3	2		5
Vernon	1	1		2
Warren	3	2		5
Washington	2	1	1	4
Wayne		3	1	4
Webster	3	2		5
Worth	1			1
Wright	2	2		4
Total Responses	**417**	**239**	**28**	**684**

Source: Missouri Municipal League, 2015

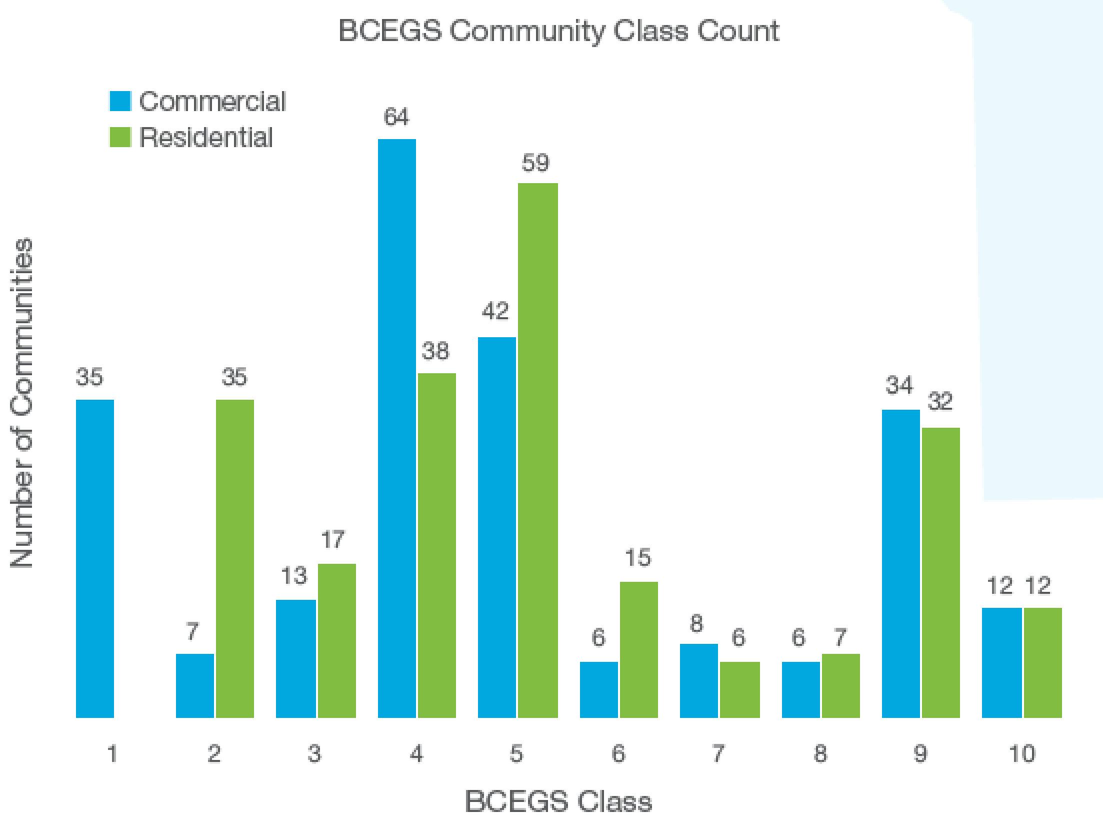
Building Codes, Policies, and Ordinances

Missouri does not have a mandated building code. So, local jurisdictions are not required to have building codes.

Studies following the 1992 devastation from Hurricane Andrew indicated that lax enforcement of building codes had significantly increased the number and severity of claims and structural losses. That link between building code adoption and enforcement to potentially mitigate catastrophic losses ultimately resulted in the development of ISO's Building Code Effectiveness Grading Schedule (BCEGS) program in 1995. The BCEGS program assesses a community's building code enforcement in three areas: code administration, plan review, and field inspection. Over 1,000 data points are collected to calculate two scores: one for one-and two-family residential construction and one for commercial or industrial construction. The scores range from 0 to 100 which are then translated to a scaled class rating of 1 (exemplary commitment to building code enforcement) to 10.

According to the 2015 National Building Code Assessment Report published by ISO, the average Building Code Effectiveness Grade Score for the State of Missouri is a Class 5 for both residential and commercial structures.

Figure 4.10. Missouri BCEGS Community Class Count



Source: National Building Code Assessment Report, ISO's Building code Effectiveness Grading Schedule, 2015

Seismic Design and Construction Ordinance

47 Counties in Missouri (41 percent) are within the State Statute, *RSMo 319.200-207*, and are required to adopt an ordinance requiring that new public construction and alterations comply with the standards for seismic design and construction of the BOCA code or UBC.

Floodplain Ordinance

Many local plans discuss the value of land use planning and building codes for hazard mitigation but are not able to implement these measures due to their designations by the State as third- or fourth-class counties. Approximately 89 counties that are designated as third class based on their assessed valuation cannot implement certain zoning, land use, and building regulations without voter approval. Among the restricted regulations are floodplain ordinances necessary to comply with the National Flood Insurance Program. *RSMo 49.600* mandates that no floodplain ordinance is effective unless authorized by voters in certain second-, third-, or fourth-class counties.

Mitigation-related Programs/Partnerships

Some local governments have intergovernmental or interagency committees that meet regularly. These organizations often take the form of an emergency management committee that meets monthly. Other communities use their local emergency planning committee (LEPC) to coordinate emergency management and mitigation issues. LEPCs are required by the Emergency Planning and Community Right-to-Know Act of 1986. The purpose of this act is to encourage and support emergency planning efforts at the State and local levels and provide the public and local governments with information concerning potential chemical hazards. Membership of the LEPCs includes representatives of public and private organizations as well as representatives from every facility in the jurisdiction subject to the emergency planning requirements of the act. At least one Missouri county has combined their LEPC and emergency management committee into one entity; other counties have both types of committees operating simultaneously.

Many counties promote seasonal hazard awareness campaigns, such as severe weather awareness week. Many counties use their websites and social media such as Facebook to communicate information to residents about hazards. Many communities also do some education programs in elementary and secondary schools.

Community Rating System

The NFIP Community Rating System (CRS) is a voluntary incentive program that recognizes and encourages community floodplain management activities that exceed the minimum NFIP requirements. Activities credited by the CRS provide direct benefits to the community, including enhanced public safety, reduction in flood damage and environmental protection. Residents are reminded that the community is working to protect them from flood losses, and money stays in the community instead of being spent on insurance premiums. For communities that receive credit through public information activities, these build a knowledgeable constituency interested in supporting and improving flood protection measures.

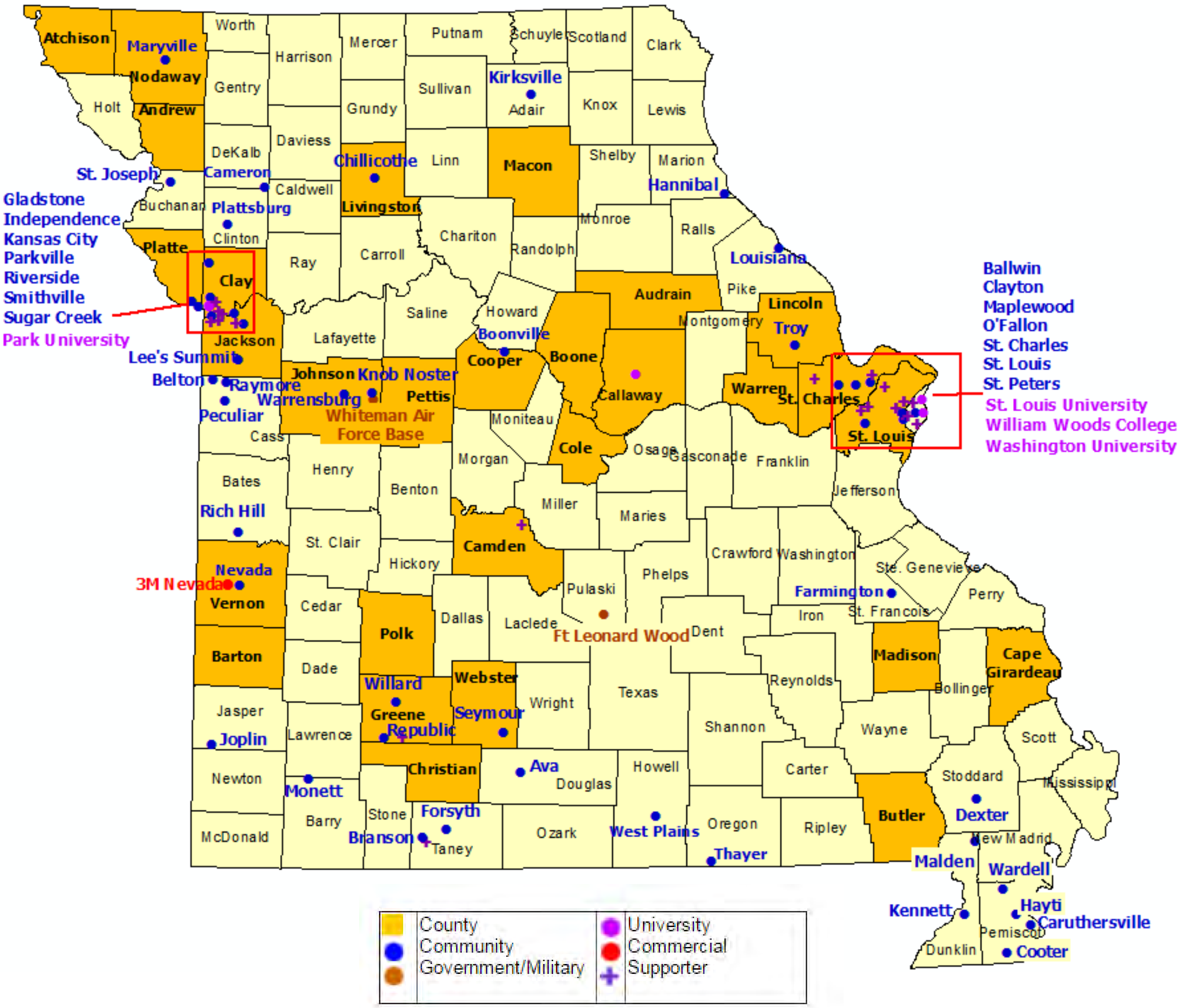
There are currently ten Community Rating System communities in Missouri as follows:

- City of Brentwood—Class 9
- City of Florissant—Class 8
- City of Hannibal—Class 9
- City of Independence—Class 9
- City of Kansas City –Class 7
- Lincoln County—Class 7
- City of Maryland Heights—Class 7
- City of O'Fallon—Class 9
- Platte County—Class 5
- St. Charles County—Class 7

NOAA StormReady®

StormReady® is a voluntary program that was developed by the National Oceanic and Atmospheric Administration (NOAA) National Weather Service (NWS) to help communities better prepare for and mitigate effects of all types of severe weather—from tornadoes to flooding. In Missouri, there are 84 StormReady® Designated communities as seen in **Figure 4.11** below.

Figure 4.11. Storm Ready® Designated Communities in Missouri



Source: Source: National Weather Service StormReady® Program, http://www.weather.gov/stormready/mo-sr

Table 4.28. StormReady® Designated Communities in Missouri

Counties		Communities			
Andrew	Jackson	Ava	Forsyth	Malden	Smithville
Atchison	Johnson	Ballwin	Gladstone	Maplewood	St. Charles
Audrain	Lincoln	Belton	Hannibal	Maryville	St. Joseph
Barton	Livingston	Boonville	Hayti	Monett	St. Louis
Boone	Macon	Branson	Independence	Nevada	St. Peters
Butler	Madison	Cameron	Joplin	O'Fallon	Sugar Creek
Callaway	Nodaway	Caruthersville	Kansas City	Parkville	Thayer
Camden	Pettis	Chillicothe	Kennett	Peculiar	Troy
Cape Girardeau	Platte	Clayton	Kirksville	Plattsburg	Wardell
Christian	Polk	Cooter	Knob Noster	Raymore	Warrensburg
Clay	St. Charles	Dexter	Lee's Summit	Republic	West Plains
Cole	St. Louis	Farmington	Louisiana	Rich Hill	Wildwood
Cooper	Vernon			Riverside	Willard
Greene	Warren			Seymour	
	Webster				

Government/Military Sites	Universities	Supporters	
Fort Leonard Wood	Park University	American Century Investments	SSM DePaul Health Center
Whiteman Air Force Base	St. Louis University	Battlefield Mall	SSM St. Joseph Health Center
	Washington University	Busch Stadium/St. Louis Cardinals	SSM St. Joseph Health Center-Wentzville
Commercial Site	William Woods University	Branson Airport	SSM St. Joseph Health Center-West
3M Nevada		Charles B. Wheeler Airport	SSM St. Mary's Health Center
Honeywell Plant		FEMA Region VII Headquarter	St. Louis Premium Outlets
		Independence Centers	St. Louis Zoo
		KCTV5, *Kansas City*	Taubman Prestige Outlets
		Osage Beach Premium Outlets	Urban Chestnut Brewery
		SSM Cardinal Glennon Children's Medical Center	Worlds of Fun
		SSM St. Clare Health Center	

Source: National Weather Service StormReady® Program, http://www.weather.gov/stormready/mo-sr

Firewise

The National Fire Protection Association's (NFPA) Firewise Communities Program encourages local solutions for safety by involving homeowners in taking individual responsibility for preparing their homes from the risk of wildfire. Firewise is a key component of Fire Adapted Communities – a collaborative approach that connects all those who play a role in wildfire education, planning and action with comprehensive resources to help reduce risk.

The program is co-sponsored by the USDA Forest Service, the US Department of the Interior, and the National Association of State Foresters.

To save lives and property from wildfire, NFPA's Firewise Communities program teaches people how to adapt to living with wildfire and encourages neighbors to work together and take action now to prevent losses. We all have a role to play in protecting ourselves and each other from the risk of wildfire.

Using a five-step process, communities develop an action plan that guides their residential risk reduction activities, while engaging and encouraging their neighbors to become active participants in building a safer place to live. Firewise participants in Missouri include the following:

- Cliff Village, Joplin, 2010
- Dennis Acres, Joplin, 2010
- Eastern Douglas County, Drury, 2015

- Grand Falls, Joplin, 2010
- Lake Ozark, Lake Ozark, 2012
- Leawood, Joplin, 2010
- Loma Linda, Joplin, 2010
- Pontiac, Pontiac, 2013
- Redings Mill Fire Protection District, Joplin, 2010
- Redings Mill Village, Joplin, 2010
- Saginaw, Joplin, 2010
- Shoal Creek Drive, Joplin, 2011
- Shoal Creek Estates, Joplin, 2010

Source: http://www.firewise.org/usa-recognition-program.aspx

Staffing Positions

All 114 counties in Missouri have an Emergency Manager position and currently none are vacant.

Other personnel capabilities vary greatly across the State. Larger, counties have full-time planners and engineers and geographic information System coordinators; smaller, less affluent counties do have these positions. To some degree, the Regional Planning Commissions (RPCs) that are contracted by the State to develop local hazard mitigation plans, supplement local staffing by providing planning assistance, including GIS support.

Of 631 municipalities that responded to a 2015 survey from the Missouri Municipal League, 183 had less than four employees, 157 had 4-10 employees, 79 had 11 to 20 employees, 99 had 21- 50 employees, 54 had 51-100, and 59 had over 100 employees

Potential Funding Sources

The analysis of local plans revealed that most local governments do not have specific local funding sources for mitigation and rely on federal programs, such as the HMGP, PDM, and FMA Programs, to fund pre- and post-disaster mitigation projects. Through tax-funded investments in infrastructure improvements, local governments are able to fund some projects that have mitigation effects, such as replacing culverts or structural improvements to critical facilities. These funds come predominantly from property and sales tax revenues and are generally allocated directly to schools, public works, and other essential government functions. Mitigation can be accomplished with this revenue stream through projects that meet multiple objectives. For instance, money allocated for school repairs can be used to replace a school’s roof with better wind resistant materials.

Some counties and municipalities have dedicated transportation or capital improvements sales or use taxes that can be obligated to fund mitigation projects. Many counties have fully allocated their current tax collections and do not have significant additional amounts for mitigation projects. A sales tax or bond issue to help fund mitigation actions would require a vote of the citizenry and could be difficult to pass.

4.6.2. Effectiveness of Local Mitigation Capabilities

To analyze the effectiveness of local mitigation policies, programs, and capabilities in accordance with Requirement §201.4(c)(3)(ii), a survey was developed to obtain input from local governments, state, federal, and stakeholder agencies. In all, 100 responses were received to the survey. The remainder of this section summarizes the results of the survey. **Table 4.29** provides a summary of the types of entities that responded to the survey.

Table 4.29. Number of Responses for Each Type of Entity

Type of Entity	% of Responses	# of Responses
City Government	40.00%	40
School District	20.00%	20
County Government	15.00%	15
Other	9.00%	9
Private Non-Profit	5.00%	5
Private For-Profit	5.00%	5
Regional Planning Commission/Council of Governments	5.00%	5
State Agency	1.00%	1
Federal Agency	0.00%	0

Respondents were asked the following question: "In your opinion, please rate the effectiveness of the following Local Mitigation Capabilities to Contribute to mitigation of damage from hazard events IN YOUR Community. (Opinions of State, Federal, and other agencies may refer to your experience statewide)". Response choices were: Highly Effective = 3, Somewhat Effective =2, Not Effective = 1, and Not Applicable = 0. **Table 4.30** provides the summarized results of the responses to this question. According to the survey respondents, warning systems are considered to be the most effective local mitigation capability followed by the emergency operations plan, the local/countywide / regional hazard mitigation plan, generators, and flood risk studies (including Risk MAP).

Table 4.30. Effectiveness of Local Mitigation Capabilities

Local Mitigation Capabilities	Weighted Average
Warning Systems (tornado/flood)	2.51
Emergency Operations Plan	2.41
Local / Countywide / Regional Hazard Mitigation Plan	2.31
Generators	2.28
Flood Risk Studies (including Risk MAP)	2.25
Floodplain Management Regulations	2.23
Firewise Program	2.21
Comprehensive / Master Planning	2.18
Planning / Zoning Ordinance	2.17
National Flood Insurance Program's Community Rating System	2.12
StormReady Program	2.12
Hazard Awareness/Public Information Programs	2.12
Stormwater Management Regulations	2.10
Building Codes	2.07
Subdivision Regulations	1.89
Earthquake Design Requirements	1.83

The final question in the survey asked respondents to rate their jurisdiction based on their opinion of how proactive their jurisdiction is in implementation of mitigation initiatives. **Table 4.31** summarizes the results of this question.

Table 4.31. Level of Proactiveness in Implementation of Mitigation Initiatives

Level of Proactiveness	# of Responses	% of Responses
Not Proactive in Mitigation	7	7.07%
Somewhat Proactive in Mitigation	60	60.61%
Highly Proactive in Mitigation	30	30.30%
Not Applicable or Unknown	2	2.02%

4.6.3. Opportunities for Improving Local Capabilities

This section discusses opportunities for strengthening local capabilities that have been identified based on the analysis of local programs, policies, and capabilities. The State will use these opportunities to strengthen local capabilities identified in this assessment and to update their mitigation strategy and enhance local planning coordination.

Local Funding

The analysis of local plans indicates that most local governments use federal funds for implementation of mitigation projects. Local governments have met federal mitigation program match requirements for mitigation projects through in-kind services, local general funds, and state general revenue; however, state general revenue is no longer available for this purpose due to budget constraints.

One approach communities are using to overcome this funding obstacle is by improving the integration of mitigation plans with other local plans and programs, such as capital improvement plans. This helps to achieve mitigation through other community objectives. Another approach is taking cost-effective mitigation measures into consideration when developing capital improvement projects.

A dedicated tax revenue source for mitigation is difficult to implement because tax increases are generally unpopular with the public. The public is also often unaware of the real costs of disasters and benefits of mitigation. Continued public education and awareness of hazard vulnerabilities and mitigation options may help attract funding for mitigation through tax dollars and private sources. The best time to implement such a campaign is in the immediate aftermath of a disaster. A tax designated to targeted, tangible benefits, such as funding an emergency manager position and/or an advance warning system, may be more acceptable to the public. The State has had local success with federal funding programs by efficiently managing the programs and providing assistance to local governments with applications, ideas for meeting match requirements, and continued eligibility.

Public Education and Outreach

Public education and awareness about natural hazards risks and mitigation is an important component in most local plans. Education and outreach has led to greater household preparedness, public participation in and support for mitigation policies and programs, as well as political support to address and fund mitigation needs. Seasonal hazard awareness campaigns are one outreach tool that many local governments use to enhance public awareness.

Technical Support

GIS and other technical assistance from the State remains an important resource for smaller communities with limited capabilities. Regional Planning Commissions (RPCs) provide additional GIS and technical support to communities who need such assistance. The State has helped and will continue to help local governments with limited capabilities overcome this obstacle by collecting information on what types of technical assistance are needed. To further assist local governments with their planning, SEMA is sharing the data collected in development of the State Hazard Mitigation Plan through the Web-Accessible Risk Assessment Data Layers and PDF Map-maker for Local Planner Access that was developed in conjunction with this plan update (See Section 3.3 for additional information).

Regional Planning

The use of RPCs in Missouri to facilitate local mitigation planning has been quite effective (see Section 5, Coordination of Local Mitigation Planning for more information). As mentioned previously, the RPCs are important resources to strengthen local technical capabilities. Regional planning efforts also enable the coordination of land use issues to prevent one jurisdiction from engaging in activities that adversely impact another. As local governments begin to update their local hazard mitigation plans, partnerships with the RPCs will allow the State to exchange information and reinforce capabilities with local governments.

Local Plan Update Guidance and Training

As a part of its ongoing support to local communities, SEMA has created a Hazard Mitigation Plan Outline to use for local plans. This Plan Outline provides a framework/format for development of local hazard mitigation plan updates. It is organized with headings and subheadings to present meaningful information as well as ensure compliance with the local hazard mitigation planning requirements. The Plan Outline includes some sample text as well as instructions on the information that should be included under each heading / subheading. The Plan Outline also serves to provide useful resources and links where data may be researched and obtained.

Use of the Plan Outline promotes greater consistency among plans, allowing information from the local plans to roll up to the State Plan more effectively as well as allow data from the State Plan to roll down to the local plans. This system provides continuity of data and planning efforts which increases the success of meeting goals while also reducing the duplication of effort in creating both local and State Plan updates. To support the Plan Outline, SEMA has also provided a series of workshops for local hazard mitigation planners focused specifically on use of the Plan Outline. Each year since 2015, three on-site planning workshops have been provided throughout the state. The tables below summarize participation by each of the Regional Planning Commissions (RPC) in these workshops since 2015. It should be noted that the East-West Gateway Council of Governments and the Mid-American Regional Council of Governments develop regional plans for counties in the metropolitan planning areas serviced by them. As a result, the Plan Outline and workshop were not applicable to them.

Table 4.32. RPC Participation in Workshops for Local Hazard Mitigation Planners

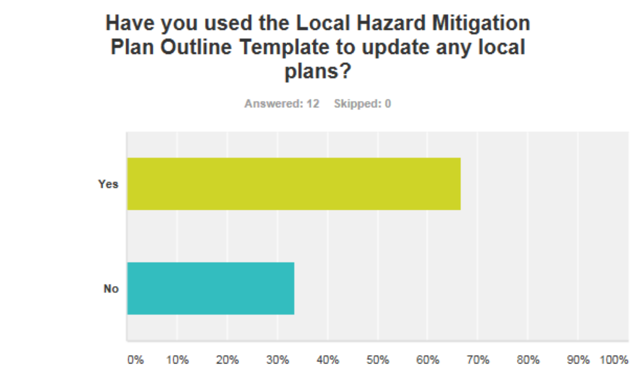
	2015	2016	2017
Agency	Workshop Attended	Workshop Attended	Workshop Attended
Boonslick	10/6/2015		
Bootheel	10/7/2015	5/6/2016	6/9/2017
East-West Gateway			
Green Hills	8/19/2016	8/23/2016	4/14/2017

Agency	2015 Workshop Attended	2016 Workshop Attended	2017 Workshop Attended
Harry S. Truman	10/6/2015	5/6/2016, 9/8/2016*	6/9/2017
Kaysinger Basin	10/6/2015	9/8/2016	6/27/2017
Lake of the Ozarks		9/8/2016	
Mark Twain	8/19/2015 10/6/2015	8/23/2016	4/4/2017
Meramec	10/6/2015	9/8/2016	6/27/2017
Mid-American			
Mid-Missouri		9/8/2016	
Mo-Kan	8/19/2015	8/23/2016	
Northeast Missouri	8/19/2015		
Northwest Missouri		8/23/2016	4/14/2017
Ozark Foothills	10/7/2015	5/6/2016	6/9/2017
Pioneer Trails	8/19/2015	5/6/2016, 9/8/2016*	4/4/2017
South Central Ozark	10/7/2015		
Southeast Missouri	10/7/2015	5/6/2016	6/9/2017
Southwest Missouri	8/19/2015		6/27/2017
SEMA	10/6/2015	9/8/2016	6/27/2017

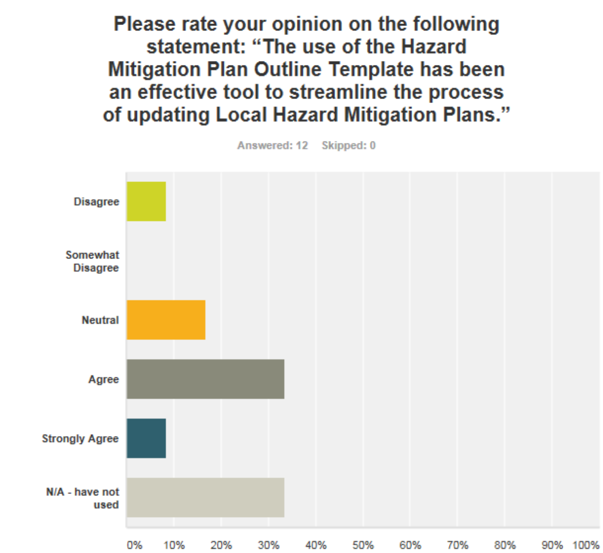
In 2016, these local planning workshops were enhanced with provision of Meeting Kits that were developed for the suggested three-meeting local hazard mitigation planning process. The meeting kits included sample meeting agendas, minutes, sign-in sheets, PowerPoint presentations and more. These meeting kits were provided to workshop recipients on CD with the capability to be modified and tailored to suit the needs of community planners.

Prior to the workshops in 2017, the Regional Planning Commissions completed a survey related to the use of the Plan Outline. Results of this survey are provided in **Figure 4.12** and **Figure 4.13**.

Figure 4.12. Regional Planning Commission Survey Results – Use of Outline

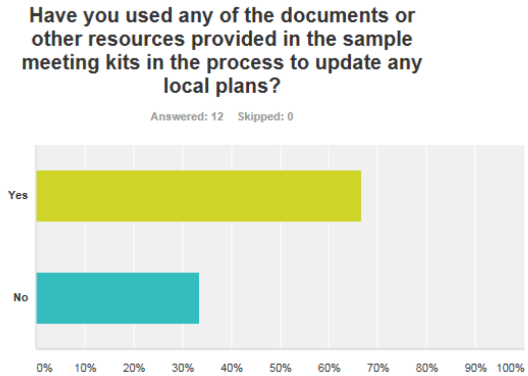


Answer Choices	Responses	
Yes	66.67%	8
No	33.33%	4
Total		12

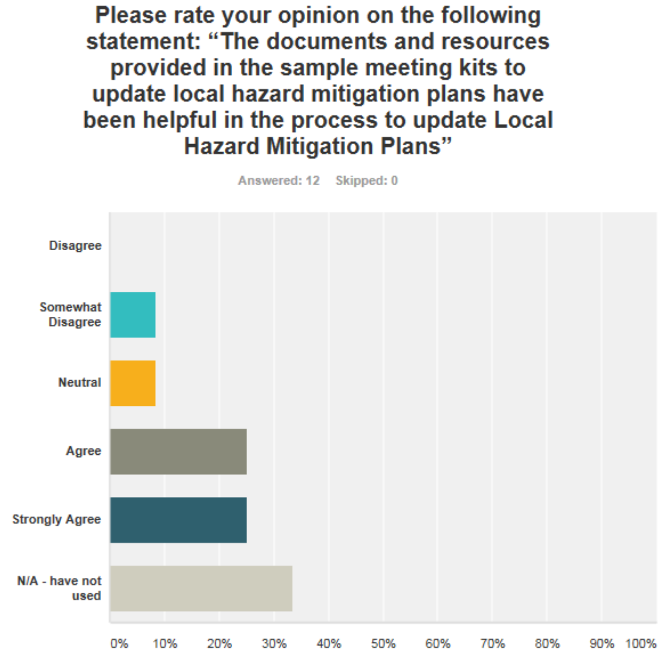


Answer Choices	Responses	
Disagree	8.33%	1
Somewhat Disagree	0.00%	0
Neutral	16.67%	2
Agree	33.33%	4
Strongly Agree	8.33%	1
N/A - have not used	33.33%	4
Total		12

Figure 4.13. Regional Planning Commission Survey Results – Use of Meeting Kits



Answer Choices	Responses	
Yes	66.67%	8
No	33.33%	4
Total		12



Answer Choices	Responses	
Disagree	0.00%	0
Somewhat Disagree	8.33%	1
Neutral	8.33%	1
Agree	25.00%	3
Strongly Agree	25.00%	3
N/A - have not used	33.33%	4
Total		12

In July 2017, FEMA issued a “Mitigation Best Practices” publication highlighting the SEMA Plan Outline Template for local hazard mitigation plans. The article, titled “Hazard Mitigation Local Plan Made Easy” states that the plan outline is “not only user friendly but also minimizes the chance of the local plan being returned numerous times for corrections” (see **Figure 4.14**).

Figure 4.14. Mitigation Best Practices – Hazard Mitigation Local Plan Made Easy

BEST PRACTICES FEDERAL EMERGENCY MANAGEMENT AGENCY July 2017

Mitigation Best Practices

Mitigation Working in Missouri DR-4317

Hazard Mitigation Local Plan Made Easy

Missouri State Hazard Mitigation Plan 2018

Photo of the State of Missouri Hazard Mitigation Plan which includes local plans. *Photo courtesy of Elizabeth Weyrauch*

JEFFERSON CITY, Mo. – Although mitigation plans are considered the key to breaking the cycle of disaster damage, reconstruction, and repeated damage, creating the plan or even updating an existing plan can be challenging. Plans have to be developed at the local level and then become a part of the State Hazard Mitigation Plan prior to FEMA's acceptance of the state's plan. In response to these issues, a State Hazard Mitigation Officer (SHMO) has devised a plan outline that is not only user friendly but also minimizes the chance of the local plan being returned numerous times for corrections.

Elizabeth Weyrauch, SHMO for Missouri is pleased with how well the plan outline has been received.

"We all know that planning is essential," Weyrauch said. "People often view plans as obstacles, something they have to do. But it's an opportunity to develop resiliency. So we developed an outline for local plans that gives planners simple language, a format, plan guidance and relevant data sources. When the format for local plans is consistent, the plans can easily roll up into the state's master plan."

Created in handbook format, the plan outline includes:

- Instructions on how to use the outline
- An executive summary
- Chapters

This publication was produced by FEMA Region VII Mitigation Division as a part of DR-4317-MO

BEST PRACTICES FEDERAL EMERGENCY MANAGEMENT AGENCY July 2017

(1) Introduction and Planning Process
(2) Profile and Capabilities
(3) Risk Assessment
(4) Mitigation Strategy
(5) Plan Maintenance

- Other Documents
  Plan Review Tool
  Data Collection Questionnaire for Local Governments
  Data Collection Questionnaire for School Districts

It's important to note, each section and subsection of the outline includes instructions on the information that should be included in that section or subsection. It also includes sample language that can be modified to fit the planning area and its participating jurisdictions as well as tips for formatting.

The outline assumes that the plan being developed is an update of a previously approved plan, since this is the case in almost all of the Missouri local plans.

Developing a hazard mitigation plan enables state, tribal, and local governments to:

- Increase education and awareness around threats, hazards, and vulnerabilities;
- Build partnerships for risk reduction involving government, organizations, businesses, and the public;
- Identify long-term, broadly-supported strategies for risk reduction;
- Align risk reduction with other state, tribal, or community objectives;
- Identify implementation approaches that focus resources on the greatest risks and vulnerabilities; and
- Communicate priorities for potential sources of funding.

Municipalities are made aware of the fact that a FEMA-approved hazard mitigation plan is a condition for receiving certain types of non-emergency disaster assistance, including funding for mitigation projects. Hazard mitigation planning enables action to reduce loss of life and property, lessening the impact of disasters.

"The outline works," Weyrauch said. "Prior to using the outline, local plans were returned for revisions nearly 100 percent of the time. Missouri now has a plan that helps municipalities develop quality plans and FEMA has noted the marked improvements in our plans."

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Land Use Planning and Regulations

Local governments are using land use planning to identify areas at risk to natural hazards and to keep those areas from developing inappropriately. Local governments are also starting to look at the negative impacts of existing and future planned subdivision developments and what measures can be implemented to reduce or eliminate them. Combinations of stormwater retention/detention projects along with locally funded buyouts are making a significant difference in this area.

Floodplain Management

Local governments rank floodplain management and NFIP as highly effective mitigation capabilities. Floodplain management and the NFIP remain key opportunities to strengthen local capabilities. The State has facilitated this by continuing to enhance its program that encourages and supports new participation in the NFIP and in the CRS Program. Additionally, the State is helping existing participants in the NFIP and CRS promote and enforce their floodplain management programs.

5 Coordination of Local Mitigation Planning

5.1. Local Funding and Technical Assistance

Requirement §201.4(c)(4)(i): [The section on the coordination of local mitigation planning must include a] description of the State process to support, through funding and technical assistance, the development of local mitigation plans.

5.1.1. Background

Per DMA 2000, all local governments must have a hazard mitigation plan approved by FEMA to receive project grants from the HMGP, Pre-Disaster Mitigation Program, and Flood Mitigation Assistance Program. It is the role of the State to provide assistance to local governments for plan development and to ultimately use the local plans to improve the statewide plan.

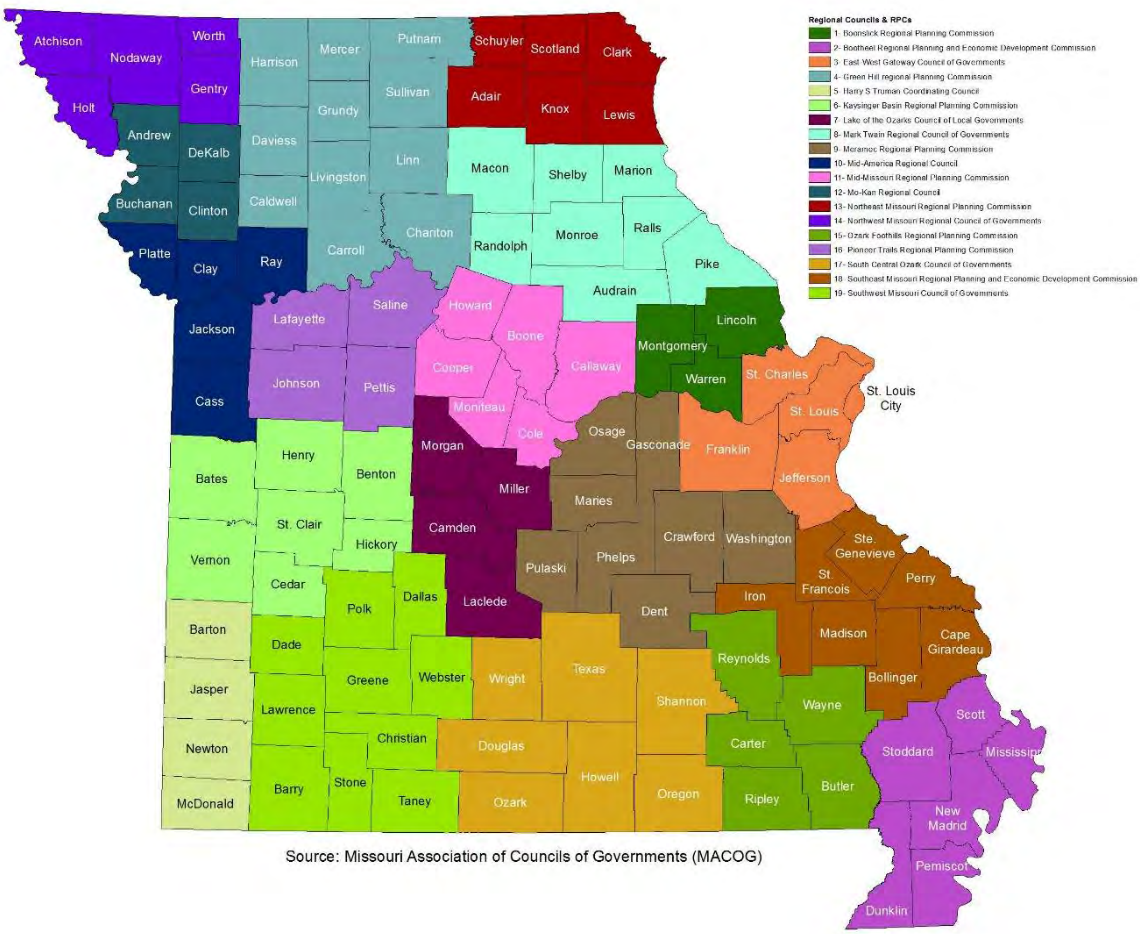
When the 2004 version of the Missouri State Hazard Mitigation Plan was being compiled, local community mitigation plans were largely unavailable and local community information was limited. Now, through multiple state plan updates, the local community information continues to improve. Back in 2004, SEMA's Logistics, Resources, Mitigation and Floodplain Management Branch reviewed all the options and decided to contract the Missouri Association of Councils of Government (MACOG), the umbrella organization for Missouri's 19 Regional Planning Commissions/Councils of Government (RPCs) (see Figure 5.1), for help with the development of multi-jurisdictional county-level plans. This remains the current process for the development or updates to the multi-jurisdictional county-level plans. With guidance and prioritization (see Section 5.3 Prioritizing Local Assistance) from SEMA, RPCs were asked to develop mitigation plans for the counties in their region that would:

- Meet the requirements of DMA 2000 for local hazard mitigation plans
- Include the unincorporated and incorporated parts of the county, regardless of population
- Include the public school districts
- Specifically address natural hazards and mitigation strategies and initiatives for each incorporated jurisdiction

Because of two presidentially declared disasters in 2002 (DR 1403 and DR 1412) and one in 2003 (DR 1463), SEMA had a limited amount of planning funds that they allocated to fund the RPCs' local hazard mitigation planning efforts. Counties that did not receive initial funding were provided with planning documents, guidance, and information from SEMA's Logistics, Resources, Mitigation and Floodplain Management Branch. As more funding for planning became available, SEMA's Recovery Division, Mitigation Management Section now uses a list of questions to help prioritize how best to distribute the funds (see Section 5.3 Prioritizing Local Assistance).

In November 2007, SEMA added a Lead Planner to their staff. This planner provides technical assistance with local mitigation plan projects and has assisted in the increase in overall effectiveness of the local plans. The Mitigation Planner is able to give the local RPC planners ideas for specific hazards data, sample vulnerability analysis based on available data for their area, thus creating a more detailed local multi-hazard mitigation plan particularly for more vulnerable jurisdictions (i.e. highly populated communities).

Figure 5.1. Missouri Regional Planning Councils



Source: Missouri Association of Councils of Governments (MACOG)

5.1.2. Status of Local Plan Development

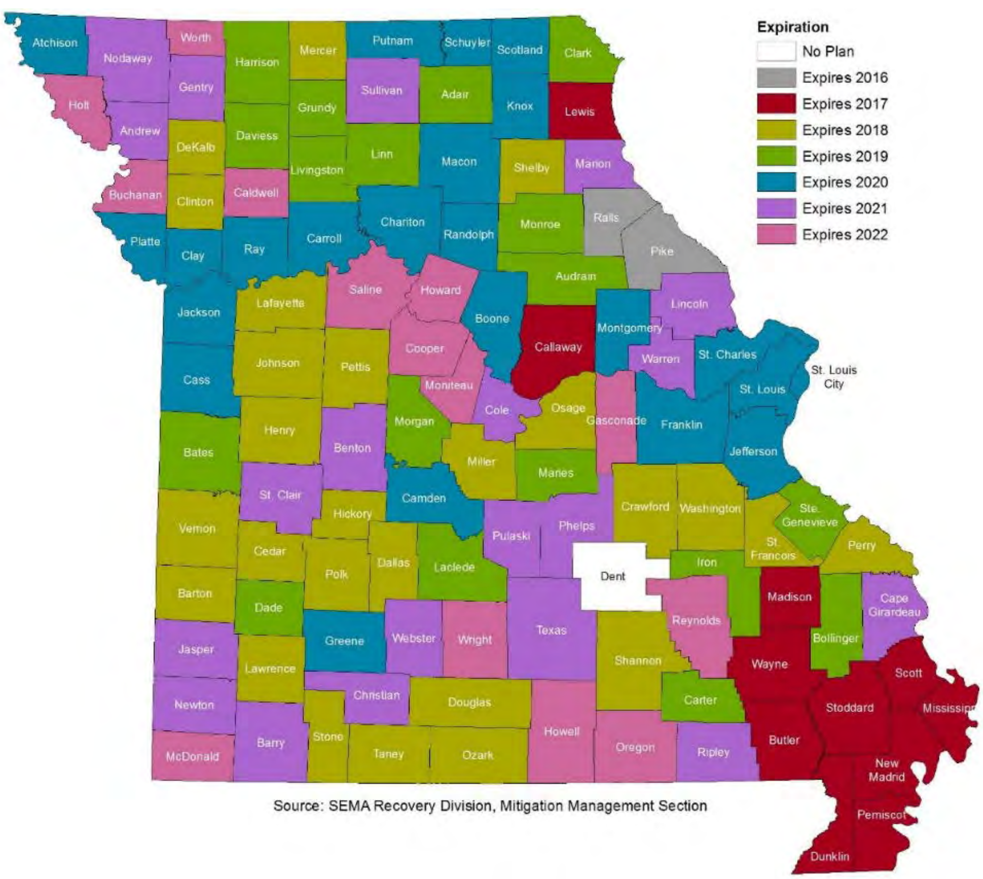
As of November 2017, 101 of the 114 or 88% of Missouri counties (plus the independent City of St. Louis) had FEMA-approved hazard mitigation plans that met the requirements of both the DMA 2000 and the Flood Mitigation Assistance Program (see **Figure 5.2**). For the remaining 14 counties, 13 are in the process of updating their plan and/or in the stages of plan review and approval. Only one county does not have a mitigation plan.

With many county-level plans available, SEMA can effectively coordinate its efforts with local jurisdictions and assess how to most efficiently distribute project funding, technical assistance, and training. Section 5.1.3 describes the process the State uses to provide planning support to local jurisdictions and the types of funding and technical assistance they make available for initial and future planning efforts. A list of the Missouri Local Hazard Mitigation Plans, with expiration dates, is available on SEMA's website https://sema.dps.mo.gov/programs/mitigation_management.php under *Hazard Mitigation Plans: Approved and Expiration Dates*. A nationwide map of FEMA Approved Local Hazard Mitigation Plans is also available on this SEMA website. To obtain a copy of a Missouri Local Hazard Mitigation Plan, the MACOG website provides links to each of the individual RPC websites which in turn post the Local Hazard Mitigation Plans for download and/or viewing. The MACOG website link is available here: http://www.macogonline.org/rpcs.htm. All of the Missouri Local Hazard Mitigation Plans are available on their respective RPC website, with the exception of Greene County, which is available here: https://greenecountymo.gov/files/files.php?id=29958.

In addition to the county-level plans, multi-jurisdictional hazard mitigation plans have been prepared for Missouri's Electric Cooperatives and the regional areas of St. Louis and Kansas City, as described below:

- The Association of Missouri Electric Cooperatives (AMEC) worked in cooperation with the MACOG and the 19 RPCs to develop the 2012 Plan. The Northwest Missouri Regional Council of Governments (NWMORCOG) served as the lead agency for plan development with each regional planning commission completing up to four local cooperative chapters for inclusion in the statewide plan. A 5-year plan update for the electric cooperatives is currently in progress.
- Since 2004, the five counties in eastern Missouri (Franklin, Jefferson, St. Charles and St. Louis Counties and the independent City of St. Louis) making up the Missouri portion of the St. Louis region and the 135 municipalities located within them have collaborated as members of the East-West Gateway Council of Governments (EWG) to develop an All Hazard Mitigation Plan. The communities share common geographic, climatic and related risk factors that make them similarly susceptible to certain natural hazards.
- Since 2004, the Mid-American Regional Council (MARC), at the invitation of SEMA and in partnership with the MACOG, has worked with local officials in Jackson, Clay, Platte, Cass and Ray Counties and jurisdictions within those counties to prepare a Regional Multi-Hazard Mitigation Plan for the Kansas City metropolitan area that helps local governments, school districts, businesses, community groups and citizens in those jurisdictions with their planning and mitigation efforts. For the 2015 Plan, nearly 60 communities, school districts, and fire/ambulance districts worked to update the Regional Hazard Mitigation Plan.

Figure 5.2. Local Mitigation Plan Status by County, November 2017



Source: SEMA Recovery Division, Mitigation Management Section

5.1.3. Process to Provide Local Support

Most jurisdictions require some form of assistance to develop and update their local hazard mitigation plans (FEMA requires that local plans be updated every five years, but plans may be updated more frequently if needed—e.g., after a major disaster). Since funding for planning purposes is generally minimal, and SEMA is unable to provide planning funds to every jurisdiction that requires a local hazard mitigation plan, technical assistance, training, and coordination with the RPCs are the primary methods that SEMA uses to provide planning support to local jurisdictions. Disaster declarations and the availability of post-disaster mitigation funds have provided further incentive to complete local plans.

Since local plans are required to be updated every five years, SEMA focuses resources on updating plans as they are expiring. SEMA has developed planning guidance and plan outline documents and offers one-on-one technical assistance and training sessions, often in conjunction with FEMA. The FEMA *Local Mitigation Plan Review Guide* released in October 2011 and the *Local Mitigation Planning Handbook* released in March 2013 assist with local planning efforts and are available on SEMA's website: https://sema.dps.mo.gov/programs/mitigation_management.php under *Eligibility Planning Requirements*. Training sessions are also offered with communities when new Flood Insurance Rate Maps (FIRMs) are issued.

To facilitate the update process, SEMA works with the RPCs by providing updated State-level and FEMA guidance, county-level risk assessment results for all 22 of the hazards profiled in the State Plan, and by hosting planning workshops. Sections 4.6.3 and 5.1.5 provide additional details about the workshops that have been provided over the last three years. SEMA also provides additional planning assistance through the services of a full-time mitigation planner specializing in local mitigation plans. Support for the update process will continue indefinitely to ensure that plans expiring in 2018, 2019, and beyond are fully supported and updated.

SEMA continues to encourage local governments without mitigation plans to apply for PDM planning grants. SEMA encourages participation in multi-jurisdictional plans and is considering how to handle jurisdictions that chose not to participate in their county-level plans but are now interested in developing individual plans.

5.1.4. Funding

There are two primary sources of funds available to help local jurisdictions develop and update hazard mitigation plans. These sources are FEMA's HMGP and PDM planning grants. Detailed information about these programs is available in Section 4.5 Funding Sources.

Hazard Mitigation Grant Program

Planning Applicability

Up to 7 percent of the HMGP funds set aside following a Presidential Disaster Declaration may be used to develop FEMA-approved mitigation plans.

SEMA Fund Administrator

Recovery Division, Mitigation Management Section, State Hazard Mitigation Officer

Missouri Local Hazard Mitigation Grant Program Planning Distributions

Table 5.1 shows the HMGP funds used to fund the local mitigation planning from Presidential disasters in 2002 through 2017. There were no HMGP funds available for local planning in 2004, 2005, 2010, or 2012. It is anticipated that additional funds from presidential disaster declaration DR 4317 which occurred in 2017, may also be used in the development of local mitigation plans, but the funding level has not yet been determined.

Table 5.1. HMGP funds used for Local Planning 2002-2017

Year of Federal Declaration	Declaration Number	Federal 75% share
2002	DR 1403	$529,366
2002	DR 1412	$135,600
2003	DR 1463	$139,689
2006	DR 1635	$294,736
2007	DR 1676	$750,000
2007	DR 1708	$81,758
2007	DR 1736	$235,620
2008	DR 1749	$150,000
2009	DR 1809	$153,972
2009	DR 1822	$334,454
2009	DR 1847	$299,997
2011	DR 1980	$369,666
2011	DR 4012	$12,000
2013	DR 4144	$118,948
2014	DR 4200	$83,625
2015	DR 4238	$366,525
2016	DR 4250	$516,000
Total		**$4,571,956**

Source: State Emergency Management Agency

Pre-Disaster Mitigation Program

Planning Applicability

PDM grants can be used for mitigation plan development, upgrades, comprehensive reviews and updates. Recipients of PDM planning grants must produce FEMA-approved hazard mitigation plans.

SEMA Fund Administrator

Recovery Division, Mitigation Management Section, State Hazard Mitigation Officer

Missouri Local Pre-Disaster Mitigation Program Planning Distributions

PDM grants are also used for the development of local mitigation plans. In **Table 5.2** below, the PDM funds used for local planning for 2002, 2003, 2005, 2014, and 2015 total over $1.7 million. PDM funds from 2006-2013 and 2016-2017 have not been used for local planning, but for projects instead.

Table 5.2. PDM funds used for Local Planning 2002-2017

Year of PDM Funding	Federal 75% share
2002	$367,466
2003	$248,375
2005	$627,580*
2014	$299,843
2015	$250,000
2016	$575,000
Total	**$2,368,264**

Note: * The 2005 funds included State and Local Planning Source: State Emergency Management Agency

Flood Mitigation Assistance Program

Planning Applicability

FMA funding is available through the National Flood Insurance Fund (NFIF) for flood hazard mitigation projects, as well as, plan development and is appropriated by Congress.

SEMA Fund Administrator

Recovery Division, Mitigation Management Section, State Hazard Mitigation Officer

Missouri Local Pre-Disaster Mitigation Program Planning Distributions

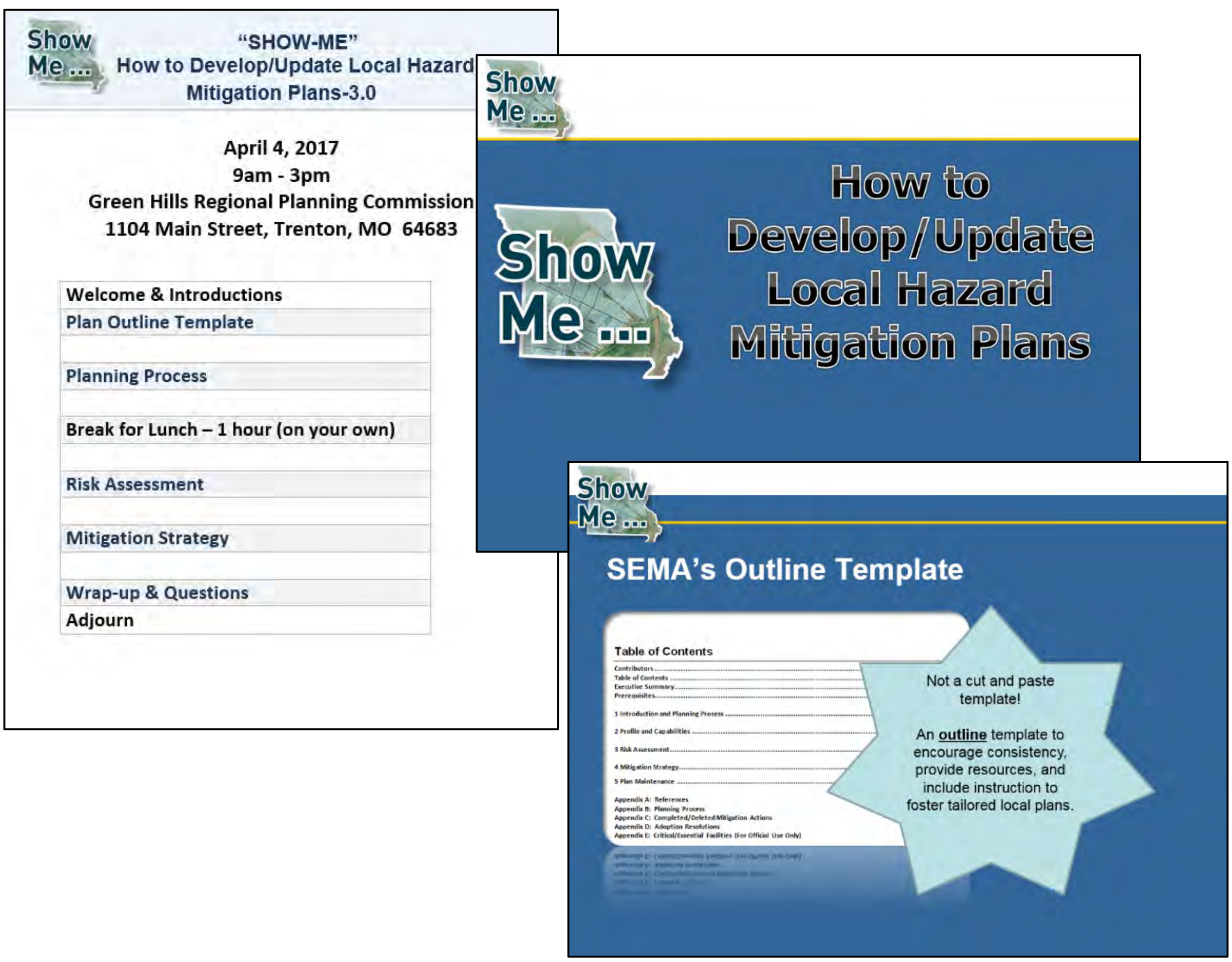
FMA funds have not been used for local planning in Missouri, but for projects instead.

5.1.5. Technical Assistance and Training

SEMA provides technical planning support to local jurisdictions through the Recovery Division, Mitigation Management Section. As discussed in Section 5.1.3 Process to Provide Local Support, SEMA contracted with the RPCs and provided them with guidance written by the State Hazard Mitigation Officer to develop mitigation plans for the local governments in their regions.

Since 2015, Local Hazard Mitigation Plan Development Training has been offered in three locations throughout the State to assist RPCs with the development of Local Hazard Mitigation Plans. This training is an in-person, 2-day workshop covering the fundamentals of mitigation planning requirements for communities to develop new or updated Local Mitigation Plans that address community priorities and needs and meet requirements established in 44 CFR 201.6. This workshop describes the SEMA developed plan outline template, the planning process, the requirements for stakeholder involvement, assessing risks and developing effective mitigation strategies (see **Figure 5.3**). In addition, SEMA's Mitigation Management Section provides program specific information related to federal/state mitigation policy, state mitigation priorities, program administration, funding sources, and project eligibility requirements.

Figure 5.3. Sample Local Hazard Mitigation Plan Development Training Agenda and Presentation



In 2015, SEMA created a hazard mitigation plan outline to use for local plans. This plan outline provides a framework and format for development of local hazard mitigation plan updates. It is organized with headings and subheadings to present meaningful information as well as ensure compliance with the local hazard mitigation planning requirements. The plan outline includes some sample text as well as instructions on the information that should be included under each heading and subheading. The plan outline also serves to provide useful resources and links where plan data may be researched and obtained.

The use of the plan outline will promote greater consistency among local plans, allowing information from the local plans to roll up to the State Plan more effectively as well as allow data from the State Plan to roll down to the local plans. This system will provide continuity of data and planning efforts which increases the success of meeting goals while also reducing the duplication of effort in creating both local and State Plan updates.

In 2016, SEMA developed planning meeting "kits" which included sample planning meeting agendas, minutes, sign-in sheets, PowerPoint presentations and more. These planning meeting kits were provided to workshop recipients on CD with the capability to be modified and tailored to suit the needs of community planners.

Instructional methodology for preparing the hazard risk assessments, as well as, risk assessment results and mapping are offered through the update and revision of the State Hazard Mitigation Plan. This 2018 state plan update included vulnerability analyses for all 22 hazards. If a local community does not have a methodology to use for their local hazard vulnerability, then the state plan methodology is an option for them to use. Additionally, with the 2018 state plan update, an online web-application for accessible risk assessment data was developed. This web-application streamlines access for State and Local planners to the 2018 State Hazard Risk Assessment results/data and associated mapping. The web-application includes a Map Viewer with a legend or clearly labeled features, a north arrow, a base map that is either aerial imagery or a street map, risk assessment data symbolized the same as in the State Plan for easy reference, search and query capabilities, zoom levels to County level data, and the capability to prepare and format downloadable PDF maps, as well as, Microsoft Excel data tables.

Since November 2007, staff support has also been available for local communities through SEMA's full-time Lead Planner. This Lead Planner is available to provide technical assistance and to review the local plan documents in all stages of development. Planning information, including regulatory updates, are provided by the Lead Planner to the MACOG and RPCs. The MACOG will then post information to both their news board http://www.macogonline.org/index.htm and their bulletin board http://macog.proboards.com/, which includes a messaging service.

With the dedicated Lead Planner, the overall effectiveness of the local plans has increased. The Lead Planner is able to give the local RPC planners ideas for specific hazards data and direct them to the risk assessment results and vulnerability analysis for their area, thus creating a more detailed local multi-hazard mitigation plan particularly for more vulnerable jurisdictions (i.e. highly populated communities).

5.1.6. Barriers to Local Mitigation Planning

Within the process of developing or updating, adopting and implementing FEMA-approved local hazard mitigation plans there may be barriers which hinder the local community from moving the process forward. **Table 5.3** presents a summary of potential barriers utilizing the STAPLEE framework and a summary of SEMA Mitigation Management Section's approach to addressing and removing these barriers in order to advance local mitigation planning.

Table 5.3. Barriers to Local Mitigation Planning and Approach to Remove

Barriers to Local Mitigation Planning	Summary of SEMA's Approach to Remove Barriers
Social: Perceived importance and/or community acceptance of mitigation planning	SEMA promotes the requirements and benefits of local mitigation planning through multiple planning workshops across the State, post-disaster coordination activities, publication of mitigation success stories, regular communication with MACOG and the 19 RPCs, and posting of outreach materials on the SEMA website.
Technical: Lack of resources to develop risk assessments	With the 2018 State Plan Update, a web-application for accessible risk assessment data was developed. This application removes a barrier for local mitigation planners to performing all the needed local Risk Assessments by providing default data developed for the State Plan which can be accessed online and is available in both a tabular and spatial mapping format.
Administrative: Lack of personnel to prepare the plan	In Section 5.1.5, SEMA provides the local planning community with training workshops; planning "kits" with meeting materials; a plan development outline with instructions; and a full-time Lead Planner to answer questions, provide instruction, and review plan documents. While SEMA does not provide personnel to prepare plans, numerous planning materials are provided to streamline the planning process for the local community.
Political: Lack of local champion to lead planning process	Since 2004, SEMA has partnered with the MACOG and the 19 RPCs, the Mid-American Regional Council (MARC), the East-West Gateway Council of Governments (EWG), the Springfield-Greene County Office of Emergency Management, and Missouri's Electric Cooperatives to assist with the development of multi-jurisdictional local hazard mitigation plans. As a result of these partnerships, there are 105 FEMA-approved local hazard mitigation plans in Missouri, representing 103 county level plans; two regional plans representing a total of 10 counties; one multi-jurisdictional plan representing two counties, and one plan for the Missouri electric cooperatives. Dent County is the only county without a current approved Hazard Mitigation Plan and they are currently in the process of developing a plan.
Legal: Requirement for Mitigation Planning	Legal precedence for local mitigation planning is addressed in the Robert T. Stafford Disaster Relief and Emergency Assistance Act (Stafford Act), as amended by the Disaster Mitigation Act of 2000, requiring local governments to develop and adopt FEMA-approved hazard mitigation plans as a condition for receiving certain types of non-emergency disaster assistance.
Economic: Lack of available funding	As mentioned in Section 5.1.4, there are two primary sources of funds available to help local jurisdictions develop and update hazard mitigation plans, FEMA's HMGP and PDM. SEMA provides information on all FEMA HMA grant programs, including eligibility, application needs, and deadlines on their website: https://sema.dps.mo.gov/programs/mitigation_management.php SEMA encourages local governments to apply for FEMA planning grants, as well as, to participate in multi-jurisdictional plans to share the financial burden.
Environment	Although not required for local mitigation plans, with the 2018 State Plan update SEMA has addressed changing future conditions, including the effects of long-term changes in weather patterns and climate on the identified hazards. As local mitigation plans consider inclusion of changing future conditions in their update processes, SEMA and the information provided within the State Plan update will support this effort.

5.2. Local Plan Integration

Requirement §201.4(c)(4)(ii): [The section on the coordination of local mitigation planning must include a] description of the State process and timeframe by which the local plans will be reviewed, coordinated, and linked to the state mitigation plan.

Plan Update Requirement §201.4(d): Plan must be reviewed and revised to reflect changes in development, progress in statewide mitigation efforts, and changes in priorities.

5.2.1. Review and Approval of Local Plans

The DMA 2000 (Section 322(b)) calls for each local plan to “describe actions to mitigate hazards, risks, and vulnerabilities identified under the plan and establish a strategy to implement those actions.” FEMA expanded on these basic criteria and established specific requirements for local mitigation plans in *Local Mitigation Planning Handbook*, March 2013. SEMA’s hazard mitigation plan guidance dictates that local hazard mitigation plans be developed to meet all federal requirements, address the specific hazard mitigation needs of the applicable jurisdictions, and complement the Missouri State Hazard Mitigation Plan. The state plan is used as a reference for locals to refer to in plan development. To ensure that local hazard mitigation plans meet these established criteria, SEMA works closely with the RPCs and local jurisdictions.

Local hazard mitigation plans undergo a continuous review during development that involves state and local officials and concerned members of the applicable communities. This helps to ensure that plans develop smoothly and that the final plan is acceptable to the jurisdiction, its citizens, and the State. In 2004, SEMA reviewed all of the local plans before sending them on to FEMA. In 2007, SEMA began contracting the reviews out to one of the RPCs in order to assist in reviewing the large number of plans generated. At that time SEMA’s process for local plan review and approval was as follows:

- SEMA contracts with the reviewing RPC to review the plan.
- The submitting RPC submits the plan to SEMA.
- SEMA sends the plan to the reviewing RPC.
- The reviewing RPC works with the submitting RPC to resolve any concerns, as necessary.
- Prior to adoption, the submitting RPC submits a revised draft to SEMA.
- SEMA sends the draft to FEMA Region VII for conditional approval.
- FEMA notifies SEMA of conditional approval.
- SEMA notifies the submitting RPC of conditional approval.
- The jurisdictions adopt the plan.
- The submitting RPC sends the adopted plan with the resolutions to SEMA.
- SEMA sends an electronic copy of the adopted plan with the resolutions to FEMA Region VII.
- FEMA grants final approval (this determines the date of approval).
- SEMA notifies the submitting RPC of final approval with a letter.

This process changed significantly in November 2007 with the addition of a full-time lead planner at SEMA that specializes in local mitigation planning. Rather than submitting plans to another RPC for review, plan reviews are now completed by the full-time mitigation planner. These reviews are completed as quickly as possible in order to provide for sufficient time to complete any necessary revisions prior to submission to FEMA.

The current process used to review and approve both new and updated plans is outlined below:

- The submitting RPC submits the adopted plan with resolutions to SEMA.
- The SEMA mitigation planner works with the submitting jurisdiction or RPC to resolve any concerns as necessary and completes a formal review of the plan.
- After successful integration of the required plan elements the plan is approved by SEMA.
- SEMA sends the plan document to FEMA Region VII for approval.
- FEMA reviews and grants final approval (this determines the date of approval).
- SEMA notifies the submitting jurisdiction or RPC of final approval with a letter.

SEMA's goal is to complete local plan reviews within three weeks from the date of final plan receipt. During times of peak demand for review, plans are prioritized based on date of expiration for review in order to ensure that the expiration of plans is avoided.

Local mitigation projects and initiatives are based on the goals and objectives of local plans. However, it is understood that funding, situations, and priorities change. SEMA and FEMA allow jurisdictions the flexibility to add/subtract mitigation projects as priorities, due to funding and other changing circumstances. Changes may be made to the plan review process, if needed, to comply with FEMA's guidance for local plan updates.

5.2.2. Integrating the Local Plans with the State Plan

The process of integrating state and local mitigation planning began with state staff involvement and guidance in the local planning process. It is understood by all levels of government that the success of the Missouri mitigation program depends on the degree to which everyone works together toward the common goal of reducing future disasters in Missouri. This is accomplished by involving as many interested groups and individuals as possible in the planning process. State mitigation staff meet with the RPCs and jurisdictions as needed throughout the planning process. While there is no specific schedule for these meetings, they occur:

- During scheduled public meetings
- At the start of the planning process
- At the mid-point of plan completion
- At plan completion
- As requested by the RPC and/or affected jurisdiction

It is also widely acknowledged that the local plans can benefit from data in the state plan, and the state plan can benefit from data in local plans. For this 2018 plan update, the SRMT reviewed and summarized information from the local plans. This information included:

- Hazard identification and risk assessment
- Goals and objectives
- Local capabilities
- Mitigation initiatives

The process in 2018 involved reviewing all of the local community plans and capturing the information related to the four categories above in spreadsheets for further review and comparison purposes. (For more details on this process, and how the information was collected and incorporated, see Section 3.6 Assessing Vulnerability and Estimating Losses by Jurisdiction: Integration of Local Plans, Section 4.1 Hazard Mitigation Goals and Objectives, Section 4.2 Mitigation Actions, and Section 4.6 Local Capability Assessment). This information was used to reassess state hazard and capabilities priorities and the progress in statewide mitigation efforts. Specifically, SEMA is interested in:

- Adding initiatives that proved successful at the local level
- Researching development of mitigation initiatives that address local concerns
- Reviewing state initiatives to determine if they are meeting the overall mitigation needs of the State
- Changing or eliminating mitigation initiatives that have not produced anticipated results

Additionally, SEMA has conducted, or is in the process of conducting a series of resilience meetings where information on tracking and coordinating NFIP/RiskMAP/Mitigation actions is being provided to local communities.

As of November 2017, this state plan update is integrated with existing and updated information from 114* local hazard mitigation plans. This includes 101 FEMA-approved hazard mitigation plans; 13 plans in the process of updating their plan and/or in the stages of plan review and approval; and only one county without an active, or FEMA approved hazard mitigation plan. Based on the 115 counties (including St. Louis City) in the state, approximately 99% of the counties have an active plan in effect. These 114 plans cover 99.15% of Missouri's population. New and updated plans will continue to be incorporated into the state plan during the next five-year update cycle due in 2023.

Note: 114 includes 113 local county plans, plus the City of St. Louis, that have been FEMA approved, updated, and/or expired.*

5.2.3. Successes and Challenges in Integration

This 2018 update reflects the successful integration of 105 updated local hazard mitigation plans, representing 103 county level plans; two regional plans representing a total of 10 counties; one multi-jurisdictional plan representing two counties, and one plan for the Missouri electric cooperatives. Over 1,500 incorporated cities, towns, and villages participated in the development of and updates to these local hazard mitigation plans. SEMA has streamlined the integration process by:

- Encouraging local governments to participate in multi-jurisdictional county-level plans, which has reduced the total number of plans that need to be reviewed and integrated into the State Plan and has brought communities together to focus on mitigation. A prime example, flooding problems do not stop at corporate boundaries and coordinated planning is necessary to tackle these hazard events.

- Providing guidance through the full-time lead mitigation planner, Local Hazard Mitigation Plan Development Training Workshops, and a standardized Hazard Mitigation Plan Outline.

- Providing technical support through Hazus-developed county level maps of the 100-year floodplain developed in the 2013 State Plan update to be used in local flood risk assessments which will help locals assess/reassess their potential flood risk. Moving forward, instructional methodology for preparing the hazard risk assessments, as well as, the 2018 State Plan risk assessment results and mapping will be available through a web-application.

- Simplifying hazard data for 2018 State Plan by combining each hazard profile with the associated state risk assessment for ease in locating information for individual hazards, as well as, clarifying definitions of extent and severity to standardizing these terms and avoid future confusion at the local level.

There do, however, remain challenges with integration of local plans into the state plan. Going forward, SEMA will continue to try and resolve inconsistences with the local plans, as well as, the following challenges:

- Timing of local plan updates and approvals. Because of hazard mitigation assistance grant funding availability, the plans are cycled to expire in different years and thus some county-level plans were updated following the cut-off date for plan integration.
- Variations in hazard identification. The integration process revealed that the county-level plans did not include manmade hazards in their analysis, but rather focused on the natural hazards. In addition, only a limited number of local plans discussed levee failure as a hazard separate from flood; lightning as a hazard separate from thunderstorms; and land subsidence/sinkholes.
- Methods for local risk assessments. Local risk assessments use different methods and interpretations to determine vulnerability and use different measures to assess risk. Rankings were primarily described in terms of high, moderate, or low. However, in some instances, the overall ranking was done on a five-step scale ranging from high to moderate-high to moderate to low-moderate to low. For integration purposes, these five-step scales were adjusted as follows: high and mod-high rankings were summarized as high; moderate as moderate; and low and low-mod as low. In cases where overall vulnerability ranking information was not available, rankings were determined from the individual hazard probability and severity rankings.

More information about local plan integration can be found in Section 3.4 Integration of Local Plans: Vulnerability and Loss Estimates; Section 4.1 Hazard Mitigation Goals and Objectives, Section 4.2 Mitigation Actions, and Section 4.6 Local Capability Assessment.

5.3. Prioritizing Local Assistance

Requirement §201.4(c)(4)(iii): [The section on the coordination of local mitigation planning must include] criteria for prioritizing communities and local jurisdictions that would receive planning and project grants under available funding programs which should include:

-Consideration for communities with the highest risks,
-Repetitive loss properties, and
-Most intense development pressures.

Further that for non-planning grants, a principal criterion for prioritizing grants shall be the extent to which benefits are maximized according to a cost benefit review of proposed projects and their associated costs.

Plan Update Requirement §201.4(d): Plan must be reviewed and revised to reflect changes in development, progress in statewide mitigation efforts, and changes in priorities.

This section describes the criteria Missouri uses to prioritize distribution of planning and project grants to communities and local jurisdictions. The criteria and process remain the same as was indicated in the previous State Hazard Mitigation Plans. SEMA, however, is constantly striving to improve the number of practical and fundable mitigation projects that are identified in local plans and funded by the State.

5.3.1. Federal Planning Grants

Federal and state funding for mitigation planning is limited and in some instances not available. The Flood Mitigation Assistance Program, Hazard Mitigation Grant Program, and Pre-Disaster Mitigation program are the primary sources of funding for mitigation planning. In the past, funding to meet the non-federal match requirement of these grants came from Missouri's general revenue and local sources (cash and in-kind). Future non-federal matches will need to come primarily from local sources; as State general revenue will no longer be available.

There are always more requests for financial assistance for mitigation planning funds than there are funds available. Funding for mitigation planning is based primarily on the availability of funds and whether the requesting jurisdiction has demonstrated the desire and ability to complete their plan as well as to follow through with the initiatives developed in the plan (which should not be dependent on the availability of state or federal funds). The expiration date of any current plan is also taken into consideration when evaluating the possibility of a plan update project.

As previously mentioned, following two presidentially declared disasters in 2002 (DR 1403 and DR 1412) and one in 2003 (DR 1463), SEMA had a limited amount of planning funds available. The decision was made to use these funds to help meet the local hazard mitigation planning requirement. Since these funds were not sufficient to develop all of the required plans, SEMA developed criteria to select counties for funding in every region of the State: relationship to major rivers, population, number of federal disaster declarations (past 25 years), participation in the National Flood Insurance Program, and past mitigation funding.

Over time, SEMA has developed a more sophisticated method of prioritizing funding. SEMA now uses the following list of questions to help guide the distribution of mitigation planning funds. These criteria evolved as funding levels and expiration dates shifted over time. The most effective strategies included the integration of community planning capacity, staggering of plans with Regional Planning Commissions in order to prevent overload, and providing funds directly to communities instead of RPCs where appropriate.

- Does the community meet the criteria for the applicable grant program (FMA, HMGP, PDM)?
- Based on the State and local risk assessment, what is the susceptibility of the community to

natural and manmade disasters?

- Based on presidential disaster declarations, how many times has the community experienced disasters and what was the resulting damage (community infrastructure as well as families and businesses)?
- How many disasters that did not receive presidential declarations affected the community and what was the resulting damage (community infrastructure as well as families and businesses)?
- Does the community participate in the National Flood Insurance Program? If so, how many insured, repetitive loss structures are in the community?
- Is the community a small and impoverished community or does it have special developmental pressures?
- Based on previous grant experiences (such as disaster grants, mitigation projects, other grants, etc.) what is the community's record of successful performance?
- Based on previous grant experiences with other state agencies (e.g., the Department of Economic Development Community Development Block Grant program) and the community's Regional Planning Commission/Council of Government, what is the community's record of successful performance?
- Has the community demonstrated the ability to form effective public-private hazard mitigation partnerships?
- Does the Community have a current plan which may expire without additional funding support?

5.3.2. Federal Project Grants

Federal and state funding for mitigation projects is also limited and thus, the State is required to prioritize proposed local mitigation projects. The Flood Mitigation Assistance Program, Hazard Mitigation Grant Program, and Pre-Disaster Mitigation program remain the primary sources of funding for mitigation projects. Funding to meet the non-federal match requirement of these grants comes mostly from U.S. Department of Housing and Urban Development (HUD) Community Development Block Grants (CDBG) and Missouri's general revenue. As state general revenue is no longer available, future matching funds will have to come primarily from local sources. Ideally, all communities will participate in some form of mitigation; however, due to differences in local capabilities and priorities, including the status of local mitigation plans, the degree of participation varies greatly from community to community.

In evaluating mitigation projects that have been submitted for review and possible approval, SEMA considers several factors, which include, but are not limited to, the following:

- The specific requirements and/or restrictions placed on the projects by the funding source
- There will always be more requests for mitigation funds than there will be available funds
- Federal and state funding for mitigation projects will be limited and in some instances, may not be available
- Whenever possible, local jurisdictions should develop mitigation projects and initiatives that can be funded locally
- Local jurisdictions should actively pursue public-private partnerships, where appropriate, to achieve desired mitigation goals
- The requested mitigation project should complement the goals and objectives of the State and local mitigation strategy
- With the implementation of RiskMAP, the mapped areas of mitigation interest (AoMI), and

the tracking of mitigation actions, SEMA prioritizes projects that are identified within FEMA's Mitigation Action Tracker (or as a mitigation action in the hazard mitigation plan).

When determining which communities will receive project grants, SEMA considers the basic criteria for assistance awards established by the Disaster Mitigation Act of 2000 (Section 203(g)):

- The extent and nature of the hazards to be mitigated
- The degree of commitment of the local government to reduce damages from future natural disasters
- The degree of commitment of the local government to support the hazard mitigation measures to be carried out using the technical and financial assistance
- The extent to which the hazard mitigation measures to be carried out using the technical and financial assistance contribute to established state/local mitigation goals and priorities
- The extent to which prioritized, cost-effective mitigation activities that produce meaningful and definable outcomes are clearly identified
- The extent to which the activities above are consistent with the local mitigation plan
- The opportunity to fund activities that maximize net benefits to society
- The extent to which assistance will fund activities in small and impoverished communities

Missouri's highest project priorities consider hazards, vulnerability, capabilities. Flood buyout projects (especially for repetitive and severe repetitive loss properties), and other flood mitigation and structural projects to protect essential infrastructure are the first priority. Projects to protect individuals from tornadoes and high wind rank second, followed by projects to reduce losses from earthquakes.

Specifically, SEMA uses the following list of questions to help guide the distribution of mitigation project funds:

- What is the hazard to be mitigated?
- Does the applicant have a FEMA-approved mitigation plan?
- Does the project complement state and local mitigation goals and objectives identified in the mitigation plans?
- Is the hazard being mitigated a priority hazard in the applicant's mitigation plan
- Is the project cost-effective based on FEMA's benefit-cost analysis module?
- Does the project have the potential to substantially reduce the risk of future damage, hardship, loss, or suffering that may result from a major disaster?
- Does the project result in mitigating flood damage to repetitive loss or severe repetitive loss properties?
- In the past, what mitigation efforts were undertaken by the applicant using local funds and initiatives and what were the outcomes?
- What is the applicant's disaster history?
- Are sufficient mitigation funds available to complete the project?
- Does the applicant have sufficient funds (if other funds are not available) to meet the local share of the project?
- Does the applicant have the capabilities to complete the project as submitted?
- Does the project independently solve a problem?
- Does the project have the potential to have a larger impact on the local and state mitigation program than other submitted projects?
- Does the project have any negative impacts on neighboring communities?

When funding comes from the HMGP (post-disaster funding), priority is given to mitigation projects related to the hazard that necessitated the disaster declaration and those jurisdictions included in the disaster declaration.

Additional information about the process SEMA uses to evaluate and prioritize mitigation actions and determine cost-effectiveness is available in Section 7.2.1 Process Used to Evaluate and Prioritize Mitigation Actions, Section 7.2.2 Eligibility Criteria for Multi-Hazard Mitigation Projects, Section 7.2.3 Eligibility Criteria by Mitigation Project Type, and Section 7.2.4 Pre-Project Determination of Cost-Effectiveness of Mitigation Measures.

5.3.3. Small and Impoverished Communities

44 CFR 201.2 establishes the following definition for small and impoverished communities:

> *"Small and impoverished communities means a community of 3,000 or fewer individuals that is identified by the State as a rural community, and is not a remote area within the corporate boundaries of a larger city; is economically disadvantaged, by having an average per capita annual income of residents not exceeding 80 percent of national, per capita income, based on best available data; the local unemployment rate exceeds by one percentage point or more, the most recently reported, average yearly national unemployment rate; and any other factors identified in the state plan in which the community is located."*

Hazard Mitigation Grant Program

In regard to the plan requirement for HMGP project funds, the FEMA regional administrators may waive this requirement for small and impoverished communities. In these cases, a plan must be completed within 12 months of the award of the project grant. This process is to be used judiciously and should not be viewed as the normal sequence of the planning process.

Pre-Disaster Mitigation Grant Program

Small and impoverished communities that receive grants from the PDM program may receive a federal cost share of up to 90 percent of the total amount approved under the grant award (as opposed to the typical 75 percent federal cost share). Documentation must be submitted with the sub-application to support the eligibility for the higher cost share.

5.3.4. Non-Federal Planning and Project Grants

Currently, SEMA's Mitigation Management Section neither manages nor disburses funds for non-federal planning or project grants.

6 PLAN MAINTENANCE PROCESS

6.1. Monitoring, Evaluating, and Updating the Plan

Requirement §201.4(c)(5)(i): [The standard state plan maintenance process must include an] established method and schedule for monitoring, evaluating, and updating the plan.

Plan Update Requirement §201.4(d): Plan must be reviewed and revised to reflect changes in development, progress in statewide mitigation efforts, and changes in priorities.

As described in detail in Chapter 2, this update to the Missouri State Hazard Mitigation Plan is the result of the combined efforts of members of the State Risk Management Team (SRMT) which is composed of state, federal, local, and voluntary agency representatives. For a detailed listing of agencies represented on the SRMT, see Section 2.1.2.

Hazard mitigation planning is a continuous and ongoing process. Policies and procedures established in this plan reflect the current emergency management and hazard mitigation philosophy at both the state and national level. Changes in hazard mitigation programs and/or priorities, including changes in legislation and available funding, may necessitate modifications to this plan. A major disaster could also prompt modifications to this plan.

6.1.1. Plan Maintenance Process - Responsible Agency and Schedule

The Mitigation Management Section of the Recovery Division within SEMA is the lead group responsible for developing, monitoring, and updating the State Hazard Mitigation Plan. Meetings of the SRMT are scheduled by the Mitigation Management Section, as needed, to review and update this plan. Moving forward, these meetings are to be conducted at a minimum:

- In the event of a major disaster and/or upon receiving a Presidential Disaster Declaration, if needed/warranted
- As part of the State's hazard mitigation plan review/update every five years or as required
- When required/needed due to changes in federal/state regulations and/or legislation that impact the hazard mitigation program

In addition to the update requirements mentioned above, annually SEMA conducts an in-house review and update in order to assess the plan on a more regular basis. This review, done in conjunction with the development of SEMA's annual threat and hazard identification and risk assessment (THIRA), continues to allow the State to direct its priorities in the appropriate manner before disasters occur.

The following SEMA branches and other state agencies and departments participate in the development, review, and update of the state plan:

- SEMA's Recovery Division (Mitigation Management, Floodplain Management, and Public Assistance)
- SEMA's Preparedness Division (Emergency Human Services, Training and Exercises, Missouri Emergency Response Commission, Radiological Emergency Preparedness Program, All-Hazard Planning Program, Medical Countermeasures Program, and Earthquake Program)
- SEMA's Response Division (Statewide Regional Coordinators, Readiness Section, and Logistics and Resources Section)
- SEMA's Fiscal Division (Emergency Management Performance Grant Section and Fiscal Administration Section)

- Members of the SRMT
- Other SEMA branches and/or state agencies and departments that may be asked to assist in the review of this plan based on legislative changes, FEMA policy changes, or State priorities affecting the state hazard mitigation program

Representatives from the various agencies and departments on the SRMT are responsible for reviewing the plan, providing input and suggesting changes to the plan based on the mitigation initiatives being undertaken by their respective organizations.

During updates, state agencies:

- Review the risk assessment and revise if necessary
- Review the vulnerability assessment and loss estimates and revise if necessary
- Review goals and objectives and revise if necessary
- Review hazard mitigation projects and initiatives to ensure there are no potential conflicts with ongoing agency initiatives
- Review hazard mitigation projects and initiatives to ensure they complement the statewide mitigation strategy
- Review existing state/federal programs to ensure that the state is taking full advantage of possible funding sources in its implementation of the State hazard mitigation program

A review of plan goals and objectives is emphasized as part of the regular plan review process. The review is in conjunction with the review and approval process of local hazard mitigation plans. This helps to ensure that the state and local hazard mitigation plans complement each other and that both state and local governments are working together to accomplish Missouri's mitigation goals. Additionally, proposed mitigation projects are reviewed to determine how they help state and local governments meet their established goals and objectives.

Plan maintenance implies an ongoing effort to monitor and evaluate plan implementation and to update the plan as progress, roadblocks, or changing circumstances are recognized. Evaluation of progress can further be achieved by monitoring changes in vulnerabilities identified in the plan.

Public involvement in the hazard mitigation process is accomplished through open public meetings as part of the development and review of local hazard mitigation plans. This process began when the Regional Planning Commissions got involved with local mitigation planning meetings in 2004 and continues as local mitigation plans are developed and updated. State and local representatives participate in these meetings and public input is sought and taken into consideration in developing mitigation priorities. Additionally, the SRMT consists of a broad range of stakeholders from various sectors, agencies, and organizations.

6.1.2. 2018 Plan Update

For this update to the Missouri State Hazard Mitigation Plan, the previously approved plan maintenance process was followed and evaluated. The SRMT determined that the elements and processes originally proposed to monitor, evaluate, and update the plan were effective. With 6 Presidential Disaster Declarations in a 5-year period since the 2013 Mitigation Plan Update, the State again capitalized on post-disaster coordination activities with other state and federal agencies to incorporate monitoring and evaluation activities for the Hazard Mitigation Plan.

As part of the disaster declaration process the State Emergency Operations Center was activated with each declaration. The members of the SRMT that participated in the response and recovery of those disasters came together to discuss implementation of the mitigation strategy as additional post-disaster mitigation funds became available. In an effort to act more expeditiously following a disaster, SEMA will be developing a Statewide flood buyout strategy in 2018 to guide the selection process for mitigation grant funding. The State Hazard Mitigation Officer (SHMO) will lead the development of this strategy with funding through the USACE Silver Jackets program and in coordination with multiple local, State, and Federal partners.

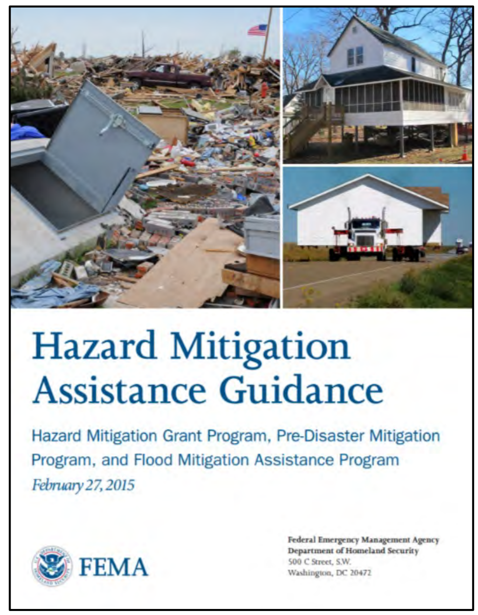
6.2. Monitoring Progress of Mitigation Activities

Requirement §201.4(c)(5)(ii): [The standard state plan maintenance process must include a] system for monitoring implementation of mitigation measures and project closeouts.

Requirement §201.4(c)(5)(iii): [The standard state plan maintenance process must include a] system for reviewing progress on achieving goals as well as activities and projects identified in the mitigation strategy.

6.2.1. Monitoring Implementation of Mitigation Measures Funded by FEMA

The State of Missouri ensures all Hazard Mitigation Assistance (HMA) grants are implemented in accordance with current FEMA guidance. The most current FEMA guidance is the February 27, 2015 *Hazard Mitigation Assistance Guidance: Hazard Mitigation Grant Program, Pre-Disaster Mitigation Program, and Flood Mitigation Assistance Program* and *Addendum.* The State has established a monitoring system for tracking the implementation and closeout of mitigation actions. With this 2018 plan update, the State is developing a web-based system and coordinated strategy to track and measure the effectiveness of mitigation actions. This loss avoidance tool is discussed in more detail in Section 6.2.2. The tool will link existing tracking systems to allow for one integrated system to track mitigation grants and their effectiveness.


Hazard Mitigation Assistance Guidance

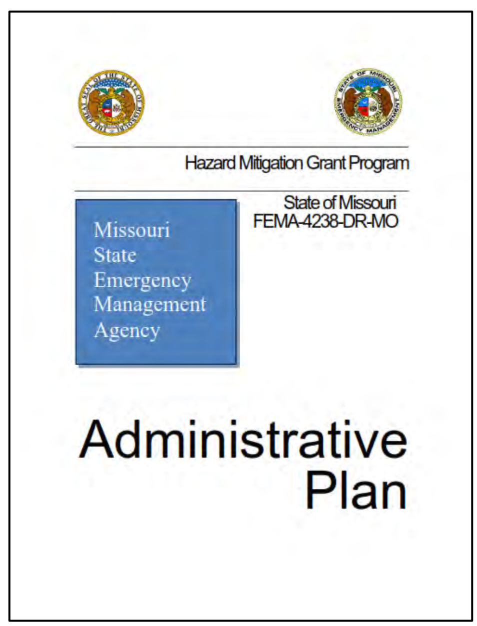
Hazard Mitigation Grant Program, Pre-Disaster Mitigation Program, and Flood Mitigation Assistance Program

February 27, 2015

FEMA

Federal Emergency Management Agency
Department of Homeland Security
500 C Street, S.W.
Washington, DC 20472

The most current Administrative Plan, approved by FEMA, is the September 1, 2015 Administrative Plan, 2016 Addendum #1, and 2017 Addendum #2. The Administrative Plan provides details on how the State monitors implementation of mitigation measures and conducts project closeouts for the Hazard Mitigation Grant Program (HMGP). Although not all Hazard Mitigation Assistance Grants require a detailed State Administrative Plan, the State applies the basic monitoring and closeout procedures set out in the HMGP Administrative Plan consistently in the other applicable HMA programs where the State serves as grantee. This section includes a description of the current state monitoring system and modifications to the system identified during the 2018 plan update.


Hazard Mitigation Grant Program

State of Missouri
FEMA-4238-DR-MO

Missouri State Emergency Management Agency

Administrative Plan

Mitigation Measures Monitoring System

The following paragraphs detail how the State tracks the implementation of mitigation actions and project closeouts.

Project Management and Responsible Agency

The State Emergency Management Agency is the recipient for project management and accountability of funds in accordance with 2 CFR Part 200. Approved applicants are considered subrecipients and are accountable to the recipient for funds awarded them.

Upon notification from FEMA that a project has been approved and is eligible for funding, the SHMO will notify the subrecipient and will arrange a meeting to provide the subrecipient with appropriate information on regulatory program requirements, State policy and grant management in accordance with 2 CFR Part 200. Materials provided to the subrecipient, dependent on the type of project, may include:

- For tornado safe room projects, a *Hazard Mitigation Community Safe Room Project Administration Guidebook*. It will provide the policy and procedures specific to the type of project. For all other projects, guidebooks will be provided that are specific to the project.
- For buyout projects, *A Local Officials Guide to Managing a Voluntary Buyout*. It will provide the policy and procedures specific to the type of project.
- 2 CFR, Part 200 including OMB Circulars A-87 (as relocated to 2 CFR, Part 225), A-122 (as relocated to 2 CFR Part 230), A-133, and/or other applicable circulars.
- Example procurement, financial, etc. documentation.

Technical Assistance and Project Monitoring

SEMA (as recipient) recognizes their regulatory responsibilities for all HMA grants: The State, serving as recipient, has primary responsibility for project management and accountability of funds as indicated in 2 CFR Part 200. The State is responsible for ensuring that subrecipients meet all program and administrative requirements.

SEMA is committed to monitoring and providing technical assistance to all eligible and funded subrecipients. The SHMO, project manager, and/or technical support staff attend subrecipient meetings to ensure the policies and procedures are explained correctly. Numerous worksheets, financial forms, and targeted guidebooks for local officials (e.g., the Mitigation Planning Workshop for Local Governments and the All-Hazard Mitigation Planning Guidebook for Communities) have been developed by SEMA and have proven successful. SEMA also directs local governments to locate FEMA's Local Mitigation Planning Handbook and Review Guide, as well as, multiple hazard data resource websites.

To track mitigation projects from initiation to closeout, a project tracking spreadsheet is used that includes the following information:

- Subrecipient name
- Project name
- Grant amount
- Percent expended
- Percent completed
- Grant end date
- Completion description (by project task and percent complete)

A system to track each individual grant process completion has been developed and is tied to steps associated with specific project types. **Table 6.1** shows an example for a buyout project and how a percent is tied to a specific action completed.

Table 6.1. Project Tracking System—Buyout Example

Buyout	Percent Complete of the Project Process
Buyout Policy	10%
Voluntary Agreements	20%
Appraisals Contracted	30%
Appraisals Completed	40%
Title Search Completed	50%
Properties Closed	60%
Asbestos Determination	70%
Demolition Contracted	80%
Demolition Completed	90%
Final Invoices Paid	100%

When necessary, a SEMA Mitigation Management Staff Member attends the first closing of a buyout project to offer assistance in completing the necessary FEMA forms (e.g., Voluntary/ Uniform Relocation Act, Duplication of Benefits, Closing Statement).

Site visits, telephone conversations, e-mails, and facsimiles remain the best communication tools for the buyout program and any other mitigation project. Past mitigation successes reflect this; thus, SEMA is confident these mechanisms ensure subrecipients success in administering the HMA grants within federal and state regulations and policies. SEMA requires monthly progress reports (instead of quarterly) from subrecipients so that issues with implementation can be identified and handled in a timely manner.

A modified Standard Form 270, Request for Advance or Reimbursement, is used by SEMA for processing fund requests. General principles for processing Request for Funds (RFF) forms are as follows:

- Verify the RFF contains the original signature and is signed by the authorized signor.
- Verify spreadsheet columns are correct and check the mathematical accuracy.
- Check for supporting documentation (property list, invoices etc.).
- If a buyout project, verify all properties requested to be funded have received duplication of benefit information and SHPO clearance. Ensure other environmental compliance measures have been met if applicable to the RFF.
- Enter amounts requested on tracking spreadsheet to ensure the subrecipient does not receive more than the amount awarded.
- Forward RFF to SEMA's Fiscal Branch for processing.
- Copy all documents to project file.

As a general rule, only 50 percent of project management funds will be released prior to project closeout. Planning projects will be paid in phases of project completion, with a percentage withheld pending FEMA's approval of the mitigation plan. For construction projects, only 95 percent of the total project management funds will be reimbursed prior to completion of the construction.

Cost Overruns

Immediately upon recognition that an original scope of work approved and funded cannot be accomplished with the grant funds allocated, the subrecipient must submit a request for additional funds with appropriate justification along with a recalculated Benefit Cost Analysis, if applicable. Upon receipt, the State will review the documents and make a determination. If the request is justifiable and funding is still available, the State will forward the request with its recommendation to the FEMA Regional Administrator. If the request is not justifiable the State will deny the request. In no case will the total amount obligated to the State exceed the specific the funding limits set forth in 44 CFR 206.432(b).

For purposes of the mitigation buyout program, cost overruns are defined to be additional funds necessary to complete the acquisition of the target area defined in the original HMGP application submitted to FEMA for funding. Cost estimates for individual structure/lots on applications can be somewhat volatile. Property closings resulting in an overrun based on the estimate that can be offset by property closings resulting in a net under-run are not considered cost overruns for this purpose and thus do not need FEMA approval as outlined in 44 CFR 206.432(b).

Any properties “added” to the property list after initial submission to FEMA would be considered a change in scope and will require SEMA and FEMA approval. No changes can be made to the property list after the application period has passed and the application has been approved by FEMA. In addition, adjustments to budget line items based on the Buyout Application do not need FEMA approval.

For tornado safe room projects, cost overruns are defined to be additional funds necessary to complete the design and construction of the safe room to FEMA Publication 361 standards. Construction costs in materials continue to rise at indeterminate times. The additional costs may be offset by cost under-runs in other services. The same holds true for all other mitigation construction projects.

Appeals

All subrecipient appeals to FEMA decisions are administered in accordance with implementing program regulations.

A subrecipient may appeal any decision regarding projects submitted for HMA funding. The appeal must be submitted in writing and contain sufficient documentation to support the subrecipient’s position. The appeal must specify the monetary figure in dispute and the provisions in Federal law, regulation, or policy with which the appellant believes the initial action is inconsistent. The appeal must reach the Recipient within 60 days from the date the subrecipient was notified of denial of funding.

On behalf of the subrecipient, the State may appeal any FEMA denial for Federal assistance. Within 60 days of the date of the receipt of the appeal from the subrecipient, the State will review the material submitted, make additions if necessary, and forward the appeal with a written recommendation to the FEMA Region VII Administrator.

Quarterly Reports

Quarterly Reports based on the federal fiscal year will be provided to the FEMA Region VII Administrator as required by regulation within 30 days of the quarter end date.

Any problems or circumstances affecting completion dates, scope of work, or project costs which would cause non-compliance with FEMA approved grant conditions shall be described in a letter to FEMA requesting an extension, change in scope of work, etc.

Environmental, Historic, and Floodplain Management Reviews

All projects that involve the floodplain will be coordinated with SEMA's Recovery Division, Floodplain Management Section staff. In addition, the SEMA Mitigation Management Section will coordinate with other state agencies as appropriate. This coordination will depend on the type of project as required by 44 CFR. For example, project descriptions will be provided to the Department of Natural Resources State Historic Preservation Office for review of potential historic and archeological issues, the Department of Conservation for potential fish and wildlife impacts. In addition, SEMA may use the services of the Department of Transportation for more complex environmental reviews.

Review

Upon completion of a hazard mitigation grant project, the SHMO, Hazard Mitigation Specialist, or other SEMA staff will conduct a closeout site visit to review all files (or a representative sample) and the documents pertaining to the use of 404 and State General Revenue funds when applicable. In addition, all procurement files and contracts to third parties will be reviewed. Worksheets have been created to aid in the closeout review.

All reports generated at the closeout site visit are compared with Requests for Funds submitted throughout the duration of the project. Any significant findings are reported to the SHMO for final determination in corrective action. Corrective Action notices will be sent to subrecipients and another site visit will be conducted (if necessary) prior to the release of remaining project funds.

Project Closeout

Upon completion of a HMA grant project, the program manager and/or hazard mitigation grant auditor conducts a closeout site visit to review all files (or a representative sample) and all documents pertaining to the use of HMA grant and state general revenue funds. In addition, all procurement files and contracts to third parties are reviewed. Worksheets have been created to aid in the closeout review.

All reports generated at the closeout site visit are compared with Requests for Funds submitted throughout the duration of the program. Any significant findings are reported to the SHMO for final determination in corrective action. If necessary, Corrective Action notices are sent to subrecipients, and another site visit may be conducted if deemed necessary prior to the release of remaining project funds. Closeout reports will be submitted for each subrecipient upon expiration of the grant. The closeout report will summarize the following:

- Grant Application and Approval Award
- Procurement
- Environmental Compliance, if necessary
- Final Scope of Work Completed (i.e. if a buyout project, the final list of properties acquired)
- Verification of Project Monitoring and Correspondence
- Summary of Costs Incurred and Reimbursement Received
- Pictures of work completed
- GIS coordinates of the project site

Closeout reports will generally be submitted 90 days after notification by a quarterly report that the project has been completed. Note: delays could occur due to extenuating circumstances, such as another disaster declaration.

Audit Requirements

2 CFR Subpart F Audit Requirements: OMB A-133, and the Single Audit Act of 1984, as amended in 1996 all require subrecipients expending $750,000 or more in Federal assistance to have an audit conducted in accordance with the Single Audit Act. Copies of such reports, if applicable, will be requested.

All general audit requirements in 2 CFR Part 200 (Subpart F) and in accordance with 44 CFR 206.437(b)(4)(xii) will be adhered to by SEMA as well as subrecipients expending FEMA hazard mitigation grant awards.

2018 Plan Update

As part of the update to the Missouri State Hazard Mitigation Plan, the previously approved plan's monitoring system for implementation of mitigation measures and project closeout was evaluated. It was determined that the monitoring system described herein to track the initiation, status, and closeout of mitigation activities was taken largely from the former effective Administrative Plan. Therefore, the changes to this section involved incorporating changes that were integrated into the Administrative Plan approved in September of 2015. The SHMO continues to have primary responsibility for continued management and maintenance of the monitoring system. Future reviews will be conducted in accordance with the process and schedules established for the plan maintenance process.

The review of mitigation actions implemented since the last plan update revealed that the mitigation actions were implemented as planned. A description of mitigation actions implemented since the 2013 State Hazard Mitigation Plan development is in Section 4.2.5 Review and Progress of Mitigation Actions. Table 4.7 in that section provides a summary of mitigation actions implemented and estimated funding amounts for 2002–2017. This table demonstrates that the actions implemented fall within the overall State priorities for mitigation.

6.2.2. Loss Avoidance Study (LAS) Tool

As further described in Section 7.4, Assessment of Mitigation Actions, SEMA has developed a web-based tool to collect and store the data necessary to complete a loss avoidance study (LAS) following a hazard event. The web-based LAS tool formalizes loss avoidance documentation serving as both a database of structural data and as a data collection tool for storm event data.

6.2.3. Monitoring Implementation of Mitigation Measures Not Funded by FEMA

Currently, SEMA's Mitigation Management Section neither manages nor disburses funds for non-federal planning or project grants.

6.2.4. Monitoring Progress for Mitigation Goals, Objectives, and Activities

A review and update of the State's system for conducting a progress review of mitigation goals, objectives, and actions is also conducted as part of the plan maintenance process. This section includes a description of the State's process for monitoring the progress of mitigation goals, objectives, and actions and any modifications to the system identified during the 2018 plan update.

Mitigation Progress Review System

In order for any program to remain effective, the goals and objectives of that program must be reviewed periodically. That review should answer, at a minimum, the following questions:

- Are the established goals and objectives realistic? (Take into consideration available funding, staffing, state/local capabilities, and the overall state mitigation strategy.)
- Has the State clearly explained the overall mitigation strategy to local governments?
- Are proposed mitigation projects evaluated based on how they help the State and/or local government meet their overall mitigation goals and objectives?
- How have approved mitigation projects complemented existing state and/or local government mitigation goals and objectives?
- Have completed mitigation projects generated the anticipated cost avoidance or other disaster reduction result?

A thorough and realistic evaluation of the benefits of a mitigation project may be delayed until the area of the project is impacted by another disaster. The lack of realized benefits from a completed mitigation project may result in the disapproval or modification of similar projects in the future. At the same time, mitigation projects that have proven their worth may be repeated in other areas of the State.

Based on the results of the review/evaluation of mitigation progress described above, the State may need to adjust its goals and objectives to meet the current and future mitigation needs of the State and local governments. A formal mitigation status report is prepared by SEMA's Recovery Division, Mitigation Management Section on an annual basis. This report is provided to the SEMA director and deputy director for review and distribution, as needed.

2018 Plan Update

For this update to the Missouri State Hazard Mitigation Plan, the system for reviewing progress on achieving goals as well as progress of mitigation activities was evaluated. It was determined that the process stated herein to monitor progress was effective. As part of the 2018 plan update process, the goals and objectives outlined in the 2013 plan were reviewed to determine if they still address current and anticipated future conditions. This was accomplished during a planning meeting and during focused meetings with SEMA mitigation staff. The SRMT also evaluated the goals and objectives based on following:

- The updated 2018 statewide risk assessment, including changes in development, recent disasters, and analysis of local risk assessments.
- Assessment of changes and challenges in state and local capabilities since the 2013 plan.
- Analysis of the similarities and differences of the state mitigation plan goals with local mitigation plan goals and objectives.
- Identification of achieved mitigation objectives from the 2013 plan.

This review of the 2013 goals and objectives and modifications to the review process are described in more detail in Section 4.1.2 Process for Identifying, Reviewing, and Updating State Goals and Objectives.

The status of each mitigation action was also evaluated to ensure that the State is making progress with its overall mitigation strategy. Conducting a comprehensive review of state goals and objectives in conjunction with identified mitigation actions helps ensure consistency with Missouri's overall mitigation goals.

Progress of identified mitigation actions is measured based on the following variables:

- The number of projects implemented over time
- The successful disbursement of mitigation grant funds over time
- The disaster losses avoided over time (given a post-disaster event)
- Plans, partnerships, and outreach developed over time

There has been significant progress made in the implementation of the State's hazard mitigation strategy since the previous plan update. This has included the completion of 54 safe room projects for a total of $69 million, 17 flood buyout projects for a total of $7.8 million, 11 siren/generator projects for a total of $0.6 million, two low water crossing projects for a total of $0.4 million, and eight miscellaneous mitigation projects that cost a total of $5.4 million. SEMA has also continued to coordinate with local jurisdictions, to ensure that local hazard mitigation plans are updated and in effect throughout the State. Technical assistance and funding have been provided where needed.

6.2.5. Agency Roles and Responsibilities

In addition to the duties of the SRMT, SEMA implements and updates the State Mitigation Plan and administers the HMA grant programs using the following positions:

State Hazard Mitigation Officer

The Governor's Authorized Representative (GAR) designates the SHMO. Pursuant to 44 CFR 206.437(b)(2), the GAR identifies the SHMO. At SEMA, the SHMO has overall management responsibility for the mitigation program and is the State official who is ultimately responsible for ensuring that the State properly carries out its Section 404 responsibilities subsequent to a presidential disaster declaration. In this regard, the SHMO monitors and oversees the activities of the Mitigation Specialists, other staff support and the State Risk Management Team. The SHMO coordinates with other SEMA staff and other state executive departments as necessary to ensure the program work required of the State is accomplished to fairly and effectively deliver all Hazard Mitigation Assistance grants to eligible subrecipients.

Deputy State Hazard Mitigation Officer

The Deputy SHMO reports directly to the SHMO with empowerment to act, in their behalf, should a substitution be necessary. On a daily basis, the Deputy SHMO assists the SHMO in organizing, coordinating, implementing and administering hazard mitigation projects, including planning projects, and the promotion, direction and evaluation of mitigation issues.

Hazard Mitigation Specialists

Hazard Mitigation Specialists serve two primary roles: (1) to complete the necessary program work required of the State to deliver the Hazard Mitigation Grant Program to eligible subgrantees; and (2) to provide technical assistance to locals as they develop their hazard mitigation plans.

Mitigation Management Team(s)

At various times, for various lengths of time (depending on the workload, complexity, and duration of the plans and projects for the multiple disasters covered by this plan), a management team(s) of the following (full, temp and/or part-time) positions will be filled by SEMA staff, and/or contracted consulting staff, and/or services:

- Hazard Mitigation Specialists
- Accounting Specialists
- Emergency Management Officers/Specialists
- Environmental Specialists
- Planners
- Engineers
- Surveyors
- Appraisers
- Real Estate Specialists
- IT/GIS Specialists/Technicians
- Legal Specialists
- Admin Executives/Office Support Assistants
- Other technical and/or fiscal/clerical/admin specialists as needed

The team(s) will assist the SHMO to manage (organize, promote, coordinate, assist, train, research, analyze, apply, implement, administer, direct, review, prepare and submit etc.) hazard mitigation plans, Benefit-Cost Analyses, projects, issues, outreach, evaluations, Close Out Reports, Success Stories and Loss Avoided Studies, etc. The team(s) continue to support SEMA's program work/activities required to perfect, preserve and deliver the Hazard Mitigation Grant Program (HMGP) assistance provided to eligible subrecipient.

Responsibilities of the SHMO, hazard mitigation staff, and others include, but are not limited to:

- Ensuring the Missouri Hazard Mitigation Grant Program Administrative Plan is updated, outlining how the State will administer the Hazard Mitigation Grant Program and implementing it during a disaster.
- Ensuring that the Missouri State Hazard Mitigation Plan is active, identifying potential hazard mitigation projects, and establishing priorities among those projects.
- Coordinating with the federal hazard mitigation officer in determining the composition of the interagency hazard mitigation team or hazard mitigation survey team when one is established (and its schedule of activities), in estimating the amount of FEMA money available for the Section 404 program, and in administering the program, including submitting required reports to FEMA (all coordination will take into consideration the priorities and procedures as set by the Missouri State Hazard Mitigation Plan).
- Coordinating with state and federal officials to ensure that they understand the involvement of the hazard mitigation effort in the Public Assistance program.
- Ensuring that potential applicants are notified of the mitigation grant programs and receiving the assistance to which they are entitled.
- Developing and implementing a process for identifying potential hazard mitigation projects and for setting priorities among those projects.
- Ensuring that a proper initial application and benefit-cost analysis, and any necessary supplemental applications, including SF-425's, are prepared, coordinated, and submitted in a timely fashion to the FEMA regional administrator.
- Ensuring that technical assistance is provided to potential applicants and/or eligible subrecipients in developing and submitting applications and benefit-cost analyses and in managing and completing approved mitigation projects, to include site visits as necessary.
- Ensuring development of a system to monitor the status of approved projects, for processing

extension requests and appeals, and for closing out completed projects.

- Ensuring that adequate procedures are developed for the distribution of financial assistance to eligible subrecipients.
- Ensuring that a system exists to monitor subrecipient accounting systems and compliance with 44 CFR parts 13 and 14.
- Ensuring a computer management system and/or files are maintained for hazard mitigation activities and products.
- Ensuring that appropriate state agencies and divisions are involved as necessary with the hazard mitigation process to include coordination with the SEMA Floodplain Management Section.
- Ensuring that the required performance reports, such as quarterly progress reports, closeout reports, success stories and loss avoidance studies are prepared and submitted in a timely manner to FEMA.

Other SEMA Staff Involvement

The SEMA director (GAR) and deputy director provide overall guidance, direction, and support for the mitigation program.

The Recovery Division Manager provides direct supervision of, as well as general guidance, direction, and support for the SHMO who manages the mitigation program. Within the Recovery Division, the following Sections provide support to the Mitigation Management Section:

- The Floodplain Management Section performs numerous mitigation related activities, training, and technical support functions that are associated with managing statewide local government participation in the National Flood Insurance Program (NFIP), serving as a state cooperating technical partner in developing and updating floodplain flood insurance rate maps and directly performing flood permitting for all state-owned construction projects. The personnel in the Floodplain Management Section include the Floodplain Management Section Manager and State NFIP Coordinator, a floodplain engineer, floodplain management officer, and emergency management officer II.
- The Public Assistance staff assist in determining the feasibility of mitigation projects in support of Public Assistance following disasters. The personnel in the Public Assistance Section include the Disaster Section Manager, public assistance coordinators, public assistance specialists, and an administrative assistant.

The Response Division is responsible for disaster management operations whenever Missouri is affected by an emergency or disaster that may be beyond the capabilities of local governments and includes the Statewide Regional Coordinators, Readiness, and Logistics and Resources sections. Once a state of emergency has been declared by the Governor, the Response Branch opens the State Emergency Operations Center and coordinates disaster response with local governments, state agencies, faith-based and volunteer agencies, private sector partners and FEMA. Mitigation and Floodplain Management Section personnel directly support the Response Division during emergency response and then transition to their normal duties during the recovery. The performance of the initial disaster logistics needs assessments in the disaster areas enables the participating mitigation staff members to perform a quick assessment of potential mitigation success stories, projects, and the possible need for a dedicated hazard mitigation survey team as well as determine if structures might be substantially damaged.

The Preparedness Division develops coordinated statewide response plans and provides training for local and state personnel to effectively respond to emergencies and disasters across the State. The Preparedness Division is also responsible for all-hazards, medical countermeasures, radiological emergencies and earthquake planning and preparedness activities. One of the Recovery Division's key roles and support effort for the Mitigation Management Section is developing and maintaining the State Hazard Analysis.

The Mitigation Management Section also is supported by the Fiscal Division staff as related to the financial aspects of administering the awarded grants for projects and plans through interaction of the Recipient (state) with FEMA.

SEMA's Recovery Division augments the staff in each of the three sections of the Mitigation, Floodplain Management, and Public Assistance as needed with contracted services from Missouri's 19 Regional Planning Commissions (especially planning, planning reviews, and project management.), a local engineering firm (for training, surveying, and low cost—mostly floodplain management—minor engineering projects), and a larger engineering firm with a team of partners (mitigation training, benefit-cost analysis assistance, mitigation application development, map modernization program management, complex engineering projects, special projects, etc.). This enables SEMA to surge during times of disaster to more effectively manage larger numbers of mitigation projects and to keep up with the administrative requirements of managing a larger number of mitigation grants.

7.0 ENHANCED PLAN

Contents

7.1. Integration with Other Planning Initiatives

Requirement §201.5(b)(1): [The enhanced plan must demonstrate] that the plan is integrated to the extent practicable with other State and/or regional planning initiatives (comprehensive, growth management, economic development, capital improvement, land development, and/or emergency management plans) and FEMA mitigation programs and initiatives that provide guidance to State and regional agencies.

The State of Missouri has established a comprehensive State hazard mitigation program that is multi-directional. State mitigation initiatives are integrated with Federal Emergency Management Agency (FEMA) programs and are designed to combine both federal and State programs into local planning efforts. State mitigation planning is also integrated with other State emergency management efforts as well as other State and regional planning initiatives.

As initially presented in Section 4.5.1, the State Capability Assessment, SEMA provides leadership for the overall state mitigation strategy and works in collaboration with other state agencies to ensure that the various mitigation programs complement each other and work toward achieving the State's overall strategy. While Section 4.5.1 presented the integration of mitigation into many of the state agency plans, programs, and decision-making tools, this section describes the integration into the State Hazard Mitigation Plan and 2018 planning process. It also discusses integration with USACE mitigation programs, FEMA mitigation programs, new initiatives that have been implemented since the 2013 plan, and integration challenges and successes.

7.1.1 Integration with Emergency Management Planning Initiatives

The State planning documents at SEMA are organized into three volumes: Volume One (1) the Missouri State Hazard Mitigation Plan; Volume Two (2) The Missouri State Emergency Operations Plan (SEOP); and Volume Three (3) The Missouri State Recovery Plan.

Missouri State Emergency Operations Plan (SEOP)

The SEOP outlines the framework for the State of Missouri to save lives, minimize injuries, protect property and the environment, preserve functioning civil government, ensure constituted authority, and maintain economic activities essential to the survival and recovery from natural, technological, and national security hazards. The SEOP, as updated in 2017, is an all-hazards plan which utilizes the concepts and principals of the National Incident Management System (NIMS) and the Incident Command System (ICS) into response operations for the State of Missouri. The plan integrates all phases of emergency management, including mitigation, and all levels of government, including the private sector.

The State Hazard Mitigation Plan is used in coordination with the SEOP to identify the multiplicity of hazards that exist at varying locations and degrees of magnitude throughout the State and to determine the potential impacts of these hazards on residents, property, and the environment. The SEOP references the State Hazard Mitigation Plan as providing the basis for activities proposed during the State planning efforts and recommends its use by state and local officials to plan and prioritize resource allocations. The SEOP encourages local officials to use information in the State Hazard Mitigation Plan to develop their own localized hazard analysis.

The Missouri State Recovery Plan, formerly Annex Q of the SEOP, is under-development as a stand-alone document (Volume Three). The purpose of the State of Missouri Recovery Plan is to provide a conceptual overview of state disaster recovery operations. Volume 3 will identify the key functional roles and responsibilities of the internal and external agencies, organizations, departments, and positions that participate in disaster recovery operations; this includes management and administration of federal grants for hazard mitigation.

Missouri All-Hazard Emergency Planning Guidance

The Missouri All-Hazard Emergency Planning Guidance was created by SEMA to assist local jurisdictions develop and maintain their local all-hazard emergency operations plans (EOPs). The information in the guide complements the SEOP and the National Response Framework (NRF).

The guidance document recommends jurisdictions develop all-hazard functional EOPs that can be implemented during any emergency or disaster (i.e., tornado, earthquake, flood, terrorism event, etc.), rather than developing separate plans for each hazard. The guidance document also recommends the local jurisdiction to utilize existing hazard analyses as a baseline. The hazard identification and risk assessment of the local hazard mitigation plan, with data support for the State Hazard Mitigation Plan, serves this role.

Missouri Emergency Response Commission (MERC)

For the 2018 State Plan Update, SEMA coordinated with MERC and the Missouri Environmental Emergency Response Tracking System (MEERTS) to obtain statewide hazardous materials storage and spill information. This information was utilized in the hazard profile and state risk assessment for hazardous materials release, as well as, the analysis of state-owned and operated facilities. All of the risk assessment results are available to local, state, and federal agencies, as well as the public, through the ArcGIS online application, the Missouri Hazard Mitigation Viewer. While the county-level plans are not required to include manmade hazards in their analysis, this new availability of data and mapping would assist communities with the incorporation of this hazard, as interested.

Additionally, SEMA provided back to MERC the state-owned and operated facilities identified within a 0.5-mile radius of each of the Tier II reporting facilities. This will allow MERC to assist local jurisdictions in addressing response measures, as necessary.

Threat and Hazard Identification and Risk Assessment (THIRA)

The Missouri State Hazard Mitigation Plan is also linked with the Missouri THIRA. The THIRA is updated annually in accordance with the Comprehensive Preparedness Guide 201, and is incorporated into this plan as Section 3.2 Hazard Identification and Section 3.3 Hazard Profiles and Risk Assessment.

The THIRA adds context to the hazard information and risk assessment provided by the Hazard Mitigation Plan and identifies desired outcomes and target capabilities based on the core capabilities established by the National Preparedness Goal.

GIS at SEMA

SEMA utilizes ESRI's ArcGIS as a critical tool in emergency management. During an emergency or disaster in Missouri, SEMA's GIS Program harnesses GIS technology to better assess and visualize damage statewide, develop response priorities and logistics planning, and to track progress throughout the response. SEMA GIS also provides important geospatial services that aid in mitigation efforts. GIS-based risk modeling was utilized in the 2018 State Plan update for the hazards of flooding, levee failure, dam failure, earthquake, land subsidence/sinkholes, and wildfire. The known locations of areas at risk were mapped utilizing ArcGIS to show areas of the State that are at greatest risk. The plan update also utilized ArcGIS to map the results of statistical and data presentation risk analyses.

Additionally, the 2018 risk assessment data will be available to local, state, and federal agencies, as well as the public, through an ArcGIS online application, the Missouri Hazard Mitigation Viewer. This application removes a barrier for local mitigation planners to performing all the needed local risk assessments by providing default data developed for the State Plan in both a tabular and spatial mapping format. **Table 7.1** provides a listing of all the maps presented within the 2018 Hazard Mitigation Plan Update and the associated spatial and tabular data available through SEMA and the Missouri Hazard Mitigation Viewer. The Mitigation Viewer can be accessed here: http://bit.ly/MoHazardMitigationPlanViewer2018.

Table 7.1. Spatial and Tabular Data Layers Developed for the 2018 Plan Update

Subject Area	Figure #	Map Topic/Title	Spatial Data	Tabular Data Shown Spatially
General Mapping Layers	n/a	Declared Disaster Regions	X	
	n/a	County Boundaries	X	
	n/a	MSDIS Structure Points	X	
	3.42	Number of Declared Disasters by County, 1965 - February 2018		X
	5.1	Missouri Regional Planning Councils	X	
	5.2	Local Mitigation Plan Status by County, November 2017		X
Assets at Risk	3.1	Population by County, 2015		X
	3.2	Numerical Change in Population by County, 2010-2015		X
	3.3	Percent Change in Population by County, 2010-2015		X
	3.4	Numerical Change in Housing Units by County, 2010-2015		X
	3.5	Percent Change in Housing Units by County, 2010-2015		X
	3.6	Population Density by County, 2015		X
	3.7	Percent Change in Population Density by County, 2010-2015		X
	3.8	Social Vulnerability Rating, 2016		X
	3.164	Percent of Mobile Homes by County		X
	3.219	Number of State Owned Facilities by County		X
	3.22	Number of State Leased Facilities by County		X
	3.221	Number of DHE Facilities per County		X
	3.222	Number of MoDOT Facilities and State-Owned Bridges	X	X
	3.189	Number of Tier II Facilities by County		X
Flood Hazard	3.49	Flood-Related Disaster Declarations by County, 1965 - February 2018		X
	3.52	RiskMAP, DFIRM and Hazus based Depth Grids used in Hazus Analysis by County, 2018		X
	3.56	Flood Hazard Areas used in Hazus Analysis, 2018	X	
	3.57	Dollars Paid for Flood Insurance Claims by County, 1978-January 2018		X
	3.58	Number of Flood Insurance Claims by County, 1978-January 2018		X
	3.59	Hazus Countywide Base-Flood Scenarios: Building and Income Loss		X
	3.60	Hazus Countywide Base-Flood Scenarios: Building Loss Ratio		X
	3.61	Hazus Countywide Base-Flood Scenarios: Displaced People		X
	3.228	State Facilities in 100-Year Floodplain	X	
	3.229	MoDOT State-Owned Flood Scour Critical Bridges	X	
	4.2	Severe Repetitive Loss Properties by County		X
	4.3	Repetitive Loss Properties by County		X
	4.4	Mitigated Severe Repetitive Loss Properties by County		X
	4.5	Mitigated Repetitive Loss Properties by County		X
	4.6	Participation in CRS	X	
	4.7	Missouri Map Production Status		X
	4.8	Missouri Risk MAP Watersheds	X	

Subject Area	Figure #	Map Topic/Title	Spatial Data	Tabular Data Shown Spatially
	4.9	Missouri HUC-8 Watersheds - Discovery Status/Planned Discovery	X	
	7.1	DFIRM Status in Missouri as of May 2017		X
	7.16	Missouri Communities Participating in the NFIP by County		X
	7.17	Missouri Communities Not Participating in the NFIP by County		X
Levee Failure Hazard	3.64	Missouri Counties Impacted by Levees	X	
	3.68	Population Exposure: Missouri Levees in USACE Levee Safety Program Providing 100-year or Greater Flood Protection		X
	3.69	Residential Building Exposure: Missouri Levees in USACE Levee Safety Program Providing 1 percent annual chance or greater Flood Protection		X
	3.226	State Facilities in Areas Protected by Levee	X	
	3.227	DHE, MoDOT, and MDC Facilities in Areas Protected by Levee	X	
Dams Failure Hazard	3.71	Number of Dams by County		X
	3.72	Number of High Hazard Dams by County		X
	3.73	Number of Significant Hazard Dams by County		X
	3.74	Number of Low Hazard Dams by County		X
	3.75	Number of State Regulated Dams by County		X
	3.76	Number of Class 1 State Regulated Dams by County		X
	3.77	Number of Class 2 State Regulated Dams by County		X
	3.78	Number of Class 3 State Regulated Dams by County		X
	3.81	Number of State and Federally-Regulated Dams with Provided Inundation Areas by County		X
	3.82	Number of Structures in State-Regulated Dam Inundation Areas by County		X
	3.83	Value of Structures in State-Regulated Dam Inundation Areas by County		X
	3.84	Number of Structures in USACE-Regulated Dam Inundation Areas by County		X
	3.85	Value of Structures in USACE-Regulated Dam Inundation Areas by County		X
	3.86	Population at Risk to Dam Failure in State-Regulated Dam Inundation Areas by County		X
	3.87	Population at Risk to Dam Failure in USACE-Regulated Dam Inundation Areas by County		X
	3.223	State Facilities in Potential Dam Failure Inundation Zones	X	X
Earthquake Hazard	3.91	HAZUS-MH Earthquake Loss Estimation: Annualized Loss Scenario - Direct Economic Loss to Buildings		X
	3.92	HAZUS- MH Earthquake 2% Probability of Exceedance in 50 Years —Ground Shaking and Liquefaction Potential	X	
	3.93	HAZUS-MH Earthquake Loss Estimation with a 2% Probability of Exceedance in 50 Years Scenario—Total Building Loss		X

Subject Area	Figure #	Map Topic/Title	Spatial Data	Tabular Data Shown Spatially
	3.94	HAZUS-MH Earthquake Loss Estimation with a 2% Probability of Exceedance in 50 Years Scenario—Loss Ratio		X
	3.224	State Facilities with Potential Earthquake Damages	X	
	3.225	State Owned Bridges with Potential Earthquake Damages	X	
	Apx C	Study Area and Sub-Regions Analyzed in Hazus	X	
	Apx C	Map of Bridge Damage Probability	X	
	Apx C	Map of Hazardous Materials Tier II Facilities and Damage Potential	X	
	Apx C	Map of EPA-Tracked Hazardous Materials Facilities and Damage Potential	X	
Land Subsidence/Sinkhole Hazard	3.101	Sinkhole Areas as delineated by the MoDNR	X	
	3.102	Number of Sinkholes by County		X
	3.103	Number of Mines by County		X
	3.105	Vulnerability Rating of Sinkhole Hazard by County		X
	3.106	Vulnerability Rating of Mine Subsidence by County		X
	3.107	Value of Structures Potentially Impacted by Sinkholes by County		X
	3.108	Population Potentially Impacted by Sinkholes by County		X
Drought Hazard	3.111	Drought Probability by Climate Division Based on Palmer Drought Severity Index 1895 - 2016		X
	3.113	Vulnerability Rating of Drought Hazard by County		X
	3.114	Annualized Crop Insurance Claims due to Drought, 2007 - 2016		X
Extreme Temp Hazard	3.118	Likelihood of Occurrence for Extreme Heat Events by County		X
	3.119	Vulnerability Rating of Extreme Heat Hazard by County		X
	3.120	Likelihood of Occurrence for Extreme Cold Events by County		X
	3.121	Vulnerability Rating of Extreme Cold Hazard by County		X
Severe Thunder-storms Hazard (Includes Wind, Hail, and Lightning)	3.127	Likelihood of Occurrence for High Wind Events by County		X
	3.128	Likelihood of Occurrence for Hail Events by County		X
	3.129	Likelihood of Occurrence for Lightning Events by County		X
	3.130	Vulnerability Rating of Severe Thunderstorms Hazard by County		X
	3.131	Annualized Property Loss due to High Wind Damage by County		X
	3.132	Annualized Property Loss due to Hail Damage by County		X
	3.133	Annualized Property Loss due to Lightning Damage by County		X
	3.134	Annualized Property Loss Ratio for High Wind by County		X
	3.135	Annualized Property Loss Ratio for Hail by County		X
	3.136	Annualized Property Loss Ratio for Lightning by County		X
Severe Winter	3.144	Likelihood of Severe Winter Weather Events by County		X
	3.145	Vulnerability Rating of Severe Winter Weather Hazard by County		X

Subject Area	Figure #	Map Topic/Title	Spatial Data	Tabular Data Shown Spatially
Weather Hazard	3.146	Annualized Property Loss due to Severe Winter Weather Damage by County		X
	3.147	Annualized Property Loss Ratio for Severe Winter Weather by County		X
Tornado Hazard	3.150	Number of Historic Tornado Events by County		X
	3.165	Likelihood of Occurrence for Tornado Events by County		X
	3.166	Vulnerability Rating of Tornado Hazard by County		X
	3.167	Annualized Property Loss due to Tornado Damage by County		X
	3.168	Annualized Property Loss Ratio for Tornadoes by County		X
Wildfire Hazard	3.172	Likelihood of Occurrence for Wildfire Events by County		X
	3.173	Average Annual Acreage Burned by County		X
	3.174	WUI Areas	X	
	3.175	Number of Structures within WUI Interface/Intermix Areas by County		X
	3.176	Value of Structures within WUI Interface/Intermix Areas by County		X
	3.177	Population at Risk within WUI Interface/Intermix Areas by County		X
	3.178	Annualized Property Loss due to Wildfire Damages by County		X
Urban/ Structure Fire Hazard	3.184	Likelihood of Occurrence for Structural Fire by County		X
	3.185	Historical Number of Deaths and Injuries due to Urban/Structure Fire		X
	3.186	Vulnerability Rating of Urban/Structure Fire Hazard by County		X
	3.187	Annualized Property Loss due to Urban/Structure Fire by County		X
	3.188	Annualized Property Loss Ratio due to Urban/Structure Fire by County		X
Hazardous Materials Release	3.230	State Facilities within 0.5 Miles of a Tier II Facility		X
Public Health Emergency	3.200	Vulnerability Rating of Pandemic Influenza Hazard by County		X
	3.197	Streams and Lakes Deemed Impaired by 2016 MO Water Quality Report	X	
	3.201	Missouri Air Quality Monitoring Sites	X	
Local Plan Integration	3.207	Risk Summary from Local Plans: Dam Failure		X
	3.207	Risk Summary from Local Plans: Drought		X
	3.207	Risk Summary from Local Plans: Earthquake		X
	3.207	Risk Summary from Local Plans: Fires (Structural, Urban, Wild)		X
	3.208	Risk Summary from Local Plans: Extreme Temperatures		X
	3.208	Risk Summary from Local Plans: Land Subsidence/Sinkholes		X
	3.208	Risk Summary from Local Plans: Flooding (Riverine & Flash)		X

Subject Area	Figure #	Map Topic/Title	Spatial Data	Tabular Data Shown Spatially
	3.208	Risk Summary from Local Plans: Levee Failure		X
	3.209	Risk Summary from Local Plans: Severe Winter Weather		X
	3.209	Risk Summary from Local Plans: Severe Thunderstorms		X
	3.209	Risk Summary from Local Plans: Tornadoes		X
	3.209	Risk Summary from Local Plans: Lightning		X
	3.210	Local Plans, Flood Risk Summary: Persons Impacted		X
	3.211	Local Plans, Flood Risk Summary: Number of Buildings Impacted		X
	3.212	Local Plans, Flood Risk Summary: Value of Buildings Impacted		X
	3.213	Local Plans, Earthquake Risk Summary: Persons Impacted		X
	3.214	Local Plans, Earthquake Risk Summary: Number of Buildings Impacted		X
	3.215	Local Plans, Earthquake Risk Summary: Value of Buildings Impacted		X
	3.216	Local Plans, Tornado Risk Summary: Persons Impacted		X
	3.217	Local Plans, Tornado Risk Summary: Number of Buildings Impacted		X
	3.218	Local Plans, Tornado Risk Summary: Value of Buildings Impacted		X

Emergency Management Accreditation Program (EMAP)

Among the extra steps demonstrating Missouri's commitment to mitigation is the participation in the National Emergency Management Accreditation Program (EMAP). EMAP is a voluntary assessment and peer-reviewed accreditation process for state and local government programs responsible for coordinating prevention, mitigation, preparedness, response, and recovery activities for natural and manmade disasters. Accreditation is based on compliance with collaboratively developed national standards, the EMAP Standard. The EMAP Standard is a rigorous yet scalable industry standard for emergency management programs. It was collaboratively developed through a series of working groups of emergency management stakeholders from government, business and other sectors, and continues to evolve to represent the best in emergency management.

By complying with the EMAP mitigation standards, Missouri has demonstrated the importance it places on emergency management, including mitigation, and is better prepared to protect its residents and property from hazards. A reference table is presented in Section 2.3.3 which outlines the 2016 EMAP standards and the corresponding location in the 2018 State Mitigation Plan.

Other SEMA Plans and Program Initiatives

Additional SEMA mitigation-related plans and programs are presented below. Details are provided in Section 4.5.

- Mitigation Management Program
- Missouri Floodplain Management/Floodplain Insurance Programs
- Training and Exercises
- Missouri Disaster Recovery Partnership
- Community Organizations Active in Disaster (COAD)
- Missouri Voluntary Organizations Active in Disaster (MOVOAD)

- Governor's Faith-Based and Community Service Partnership for Disaster Recovery
- Earthquake Program
- Missouri Seismic Safety Commission Strategic Plan for Earthquake Safety in Missouri, Updated in 2007
- Radiological Emergency Preparedness (REP) Program
- All-Hazard Planning Program
- SAVE Coalition
- Statewide Area Coordinator Program
- State Public Assistance Program
- Individuals and Households Program
- State Risk Management Team
- Mitigation Management Website
- Floodplain Management Website
- Risk MAP Global Outreach Plan
- Risk MAP Outreach Website
- Public Information Program
- SEMA Newsletters
- SEMA/MEPA Spring Conference
- Annual Missouri Floodplain and Stormwater Manager's Conference
- Trainings and Workshops
- Regional Planning Commissions
- Ready in 3 Program
- Central United States Earthquake Consortium
- University of Missouri Extension
- Show-Me Response

7.1.2 Integration with Other State and/or Regional Planning Initiatives

The integration of the mitigation plan with other State planning initiatives occurs through regularly scheduled meetings and coordination of the SRMT. This occurs in the mitigation planning process through data-sharing between different State plans, and through participation on planning committees and policy commissions. Through the SRMT, SEMA planners are made aware of the data, programs, and priorities of other State agencies, and other agencies become more knowledgeable about mitigation policies and programs and how they can be integrated into their own plans.

During the 2018 plan update, the SRMT reviewed the mitigation-related plans and programs of other State agencies. Since response and recovery plans and programs also typically have a mitigation component, the SRMT incorporated those plans in this review. The purpose of this review was to identify changes, updates, and/or additions since the 2013 Mitigation Plan update to incorporate relevant data and capabilities into the mitigation plan and to better understand areas where mutual responsibilities and policies could be leveraged.

A summary of integration measures is provided in Table 7.2. This includes State agency plans and program initiatives which address economic development, land use development, housing, health and social services, infrastructure, and natural and cultural resources. Additional details of mitigation integrated in these state agencies and programs are provided in Section 4.5.

Table 7.2. State Plan Integration with Other State Agency Plans and Program Initiatives

State Agency Plan and Program Initiatives	Sector	Summary of Integration Activities	Reference Locations in State Mitigation Plan
Regional Planning Commissions	Economic Development Land Use and Development	One of the best examples of the continued integration of State mitigation planning into regional and local planning initiatives from the last five years is SEMA's relationship with Missouri's RPCs. Because of the RPCs involvement in the development of local mitigation plans, they are more cognizant of mitigation and can consider the basic principles of mitigation in the other planning efforts they coordinate, including highway planning, comprehensive planning, and capital improvement planning. For example, they can promote regional water interconnects between municipalities to create supply alternatives should a hazard event disrupt this critical utility. This would also serve and support homeland security considerations and requirements. The RPCs are active in the implementation of state mitigation actions as support agencies for actions 1, 2, 3, 8, 9, 10, 13, and 14. Through the web-accessible risk assessment data that is part of the 2018 State Plan Update, the Regional Planning Commission mitigation planners will have direct access to risk assessment data collected for the State Plan Update for inclusion and to inform the risk assessments in local plans.	Section 4.2.3 Section 4.5
Department of Health and Senior Services (DHSS)	Health and Social Services	DHSS has internal emergency response plans in place, and as part of the State response the Missouri State Emergency Operations Plan has been fully tested with exercises for all aspects of response and recovery including those relating to public health, emergency response, terrorism, biological, chemical, and radiological/nuclear threats, pandemic influenza, and natural disasters. DHSS incorporates information from the State Mitigation Plan into the development and update of their internal emergency response plans. For the 2018 State Mitigation Plan, the hazard profiles and risk assessments for extreme temperature and public health emergencies/environmental issues included updated analysis of statistical data provided by the Missouri Department of Health and Senior Services. Noted integrated programs and documents include: Missouri's Planning Guide for Local Mass Prophylaxis: Distributing and Dispensing the Strategic National Stockpile, dated October 2003; Missouri Pandemic Flu Response Plan, dated December 2011; and Ready in 3 Program.	Section 3.3.7 Section 3.3.19 Section 3.3.21 Section 3.5.19 Section 4.5.1
Seismic Safety Commission	Emergency Management	SEMA participates on the Seismic Safety Commission and provides information for the State's Strategic Plan for Earthquake Safety. This includes incorporation of the enhanced earthquake analysis that was performed for bridges, hazardous materials facilities and essential facilities (schools, fire and medical facilities) to further refine the vulnerability assessment and to identify areas that may warrant further analysis or targeted mitigation.	Section 2.3.1 Section 3.5 Appendix C

State Agency Plan and Program Initiatives	Sector	Summary of Integration Activities	Reference Locations in State Mitigation Plan
Central United States Earthquake Consortium (CUSEC) and National Earthquake Hazards Reduction Program	Emergency Management	An enhanced earthquake analysis and report, completed in June and July 2017, was performed as a parallel effort to the 2018 Missouri State Hazard Mitigation Plan Update. Wood E&IS performed a Hazus V 3.2. Level II Hazus earthquake analysis under a contract with the Central Unites States Earthquake Consortium to incorporate additional hazard data (groundwater depths to refine the liquefaction data inputs); and updated hazardous materials facility and bridge inventory to further refine the vulnerability assessment to identify areas that may warrant further analysis or targeted mitigation. The Central United States Earthquake Consortium provided state-wide National Earthquake Hazards Reduction Program (NEHRP) site classification and soil liquefaction characteristics.	Section 3.3.4 Section 3.5 Appendix C
Department of Agriculture	Land Use and Development	The Department of Agriculture is involved specifically with drought mitigation and mitigating agricultural damage from other hazard events. Critical facilities/ infrastructure data from the Office of Administration for DOA facilities was incorporated into the 2018 exposure and analysis of State assets at risk. This analysis and digital data was provided back to DOA for integration into their agricultural mitigation activities. Noted integrated programs and documents include: Catastrophic Mortality and Associated Material Disposal, October 2008.	Section 3.1.1 Section 3.5 Section 4.5.1
Department of Conservation	Natural and Cultural Resources	MDC is active in the State Emergency Operations Center during all state declared disasters. MDC also participates in all pre-disaster exercises, drills, and planning teams in the State. MDC is a member of numerous levee districts that provide flood protection to crops and structures. All lakes owned by MDC with dams over 35 feet high are designed in accordance with the criteria of the Dam and Reservoir Safety Council of Missouri. The safety or redundancy factor built into these dams and levee construction projects is a higher standard than for commercially constructed projects. MDC participates in a statewide wildfire control program in cooperation with the forest industry, rural fire departments, and other agencies. For the 2018 State Mitigation Plan, the hazard profile and risk assessment for wildfires included updated analysis of statistical data provided by MDC. Critical facilities/ infrastructure data from MDC was incorporated into the exposure and analysis of State assets at risk. This analysis and digital data was provided back to MDC for continued integration into their pre- and post-disaster emergency planning initiatives.	Section 3.1.1 Section 3.3.11 Section 3.5 Section 3.5.2 Section 4.2.3 Section 4.5.1

State Agency Plan and Program Initiatives	Sector	Summary of Integration Activities	Reference Locations in State Mitigation Plan
		Noted integrated programs and documents include: Missouri Department of Conservation (MDC) Statewide Wildfire Control Program; St. Louis Region Healthy Streams and Watersheds; and Wetland Restoration Projects. The MDC is active in the implementation of state mitigation actions as a support agency for action 15.	
Department of Economic Development	Economic Development Housing	DED administers the Community Development Block Grant program which can provide funding for hazard mitigation and disaster recovery. The DED CDBG Administrative Manual outlines the process for jointly funded SEMA/CDBG Buyout projects. Critical facilities/ infrastructure data from the Office of Administration for DED was incorporated into the 2018 exposure and analysis of State assets at risk. Future development was addressed in the 2018 plan with reference to MDC and their role in economic growth and support of Missouri's businesses by providing data and resources, such as the State Mitigation Plan, for businesses, industries, and communities to grow and expand. Noted integrated programs and documents include: Missouri Consolidated Plan; Community Development Block Grant – Emergency; Grow Missouri Disaster Loan Program; and HUD National Disaster Resilience Competition. The DED and associated CDBG funding are active in the implementation of state mitigation actions as a support agency for action 7.	Section 3.1.1 Section 3.5 Section 4.2.3 Section 4.5.1
Department of Elementary and Secondary Education	Health and Social Services	DESE participates with SEMA for catastrophic event planning in collaboration with the Missouri Center for Safe Schools, and the Missouri United School Insurance Council. For the 2018 State Mitigation Plan, the hazard profile and risk assessment for public health emergencies included updated data provided by DESE. Critical facilities/ infrastructure data from the Office of Administration for DESE was incorporated into the exposure and analysis of State assets at risk. This analysis and digital data was provided back to DESE for continued integration into their catastrophic event planning initiatives. Noted integrated programs and documents include: Catastrophic Event Preparation. The DESE is active in the implementation of state mitigation actions as a support agency for action 8.	Section 3.1.1 Section 3.3.19 Section 3.5 Section 4.2.3 Section 4.5.1
Department of Higher Education	Health and Social Services	DHE convenes meetings of the Higher Education Subcommittee of the Homeland Security Advisory Council approximately five times per year as a pre-disaster initiative. The Subcommittee promotes pre- and post-disaster emergency planning initiatives on all higher education campuses in Missouri,	Section 3.1.1 Section 3.5

State Agency Plan and Program Initiatives	Sector	Summary of Integration Activities	Reference Locations in State Mitigation Plan
		shares best practices, and ensures that collegiate institutions throughout the State are informed about and engaged in emergency planning. Critical facilities/ infrastructure data from DHE was incorporated into the 2018 exposure and analysis of State assets at risk. This analysis and digital data was provided back to DHE for continued integration into their pre- and post-disaster emergency planning initiatives. Noted integrated programs and documents include: Department of Higher Education (DHE) Disaster Resistant University KC Metro Community Colleges. The DHE is active in the implementation of state mitigation actions as a support agency for action 8 and 15	Section 3.5.3 Section 4.2.3 Section 4.5.1
Department of Insurance, Financial Institutions, and Professional Registration	Economic Development	The Department of Insurance, Financial Institutions, and Professional Registration has resources for insurance customers, companies, and producers. The department is able to promote flood and earthquake insurance as a pre-mitigation measure. Additionally, the department enforces *RSMo 379.975,* which requires insurers to provide information to applicants and policyholders about earthquake insurance for properties located in the New Madrid Seismic Zone and *RSMo 379.978,* which requires all insurance companies that provide earthquake coverage to prepare a written disaster plan that addresses earthquakes. Critical facilities/ infrastructure data from the Office of Administration for DIFP was incorporated into the 2018 exposure and analysis of State assets at risk. This analysis and digital data was provided back to DIFP for integration into their mitigation initiatives, including insurance purposes. Noted integrated programs and documents include: RSMo 379.975 and Section 207 of the Flood Insurance Reform Act of 2004.	Section 3.5 Section 4.5.1
Department of Labor and Industrial Relations	Economic Development	When a Missouri county or region is impacted by a natural disaster or hazardous condition such as flooding or inclement weather, the Labor Department has the authority to suspend in-person reporting required of the unemployed for a period of time. This helps to assist in the post-disaster recovery of the local communities. Critical facilities/ infrastructure data from the Office of Administration for DLIR was incorporated into the 2018 exposure and analysis of State assets at risk.	Section 3.1.1 Section 3.5 Section 4.5.1
Department of Mental Health	Health and Social Services	DMH maintains an All-Hazard Emergency Operations Plan as a pre-disaster measure. The plan, developed with the input of the Mental Health Statewide Disaster Response Planning Committee, is designed to enhance department planning and response activities and minimizes the effects of disasters	Section 3.1.1 Section 3.5

State Agency Plan and Program Initiatives	Sector	Summary of Integration Activities	Reference Locations in State Mitigation Plan
		(natural, manmade or other) on DMH consumers and the residents of Missouri. The Department also ensures the DMH facilities maintain and exercise facility emergency operations plans; provide education and training for people with special needs, schools, healthcare workers, and other first responders to mitigate the emotional impacts of disaster events; and maintains a Continuity of Operations Plan and a Pandemic Flu annex to help mitigate against the effects of displacement. Critical facilities/ infrastructure data from the Office of Administration for DMH facilities was incorporated into the 2018 exposure and analysis of State assets at risk. This analysis and digital data was provided back to DMH for integration into their mitigation initiatives, including incorporation into their Hazard Emergency Operations Plan. Noted integrated programs and documents include: All-Hazards Emergency Operations Plan and Mental Health Disaster Communication Guidebooks.	Section 4.5.1
Missouri Department of Natural Resources	Natural and Cultural Resources	The department administers various projects designed to reduce stream bank erosion, reduce localized flooding, improve drainage, reduce discharge, improve water quality, ensure safe drinking water, and make sure that dams are constructed, maintained, and operated in a safe manner. For the 2018 State Mitigation Plan, the hazard profile and risk assessment for dam failure, earthquakes, land subsidence/sinkholes, drought, wildfires, hazardous materials release, and public health/environmental issues incorporated data provided by MoDNR. Additionally, for the land subsidence/sinkhole hazard, MoDNR has created a statewide sinkhole inventory that was used in coordination with new sinkhole data developed for newly mapped floodplain areas. The new sinkhole data is being developed using methods outlined in the Missouri Sinkhole Analysis Policy paper "Analysis and Communication of Flood Risk for Sinkholes in Missouri" funded in 2016 by SEMA. Critical facilities/ infrastructure data from the Office of Administration for MoDNR facilities was incorporated into the 2018 exposure and analysis of State assets at risk. This analysis and digital data was provided back to DMH for integration into their mitigation initiatives. Noted integrated programs and documents include: Dam and Reservoir Safety Program; Dam and Reservoir Safety Program Emergency Action Plan Template; Geological Survey Program's Earthquake Response Plan and Hazards Mapping; Central United States Earthquake Consortium (CUSEC); Missouri Water Supply Study, Amended 2009; Stormwater Improvements Program; DNR Missouri Drought Plan; and the DNR State Water Plan.	Section 3.3.3 Section 3.3.4 Section 3.3.5 Section 3.3.6 Section 3.3.11 Section 3.3.16 Section 3.3.19 Section 4.2.3 Section 4.5.1

State Agency Plan and Program Initiatives	Sector	Summary of Integration Activities	Reference Locations in State Mitigation Plan
		MoDNR is active in the implementation of state mitigation actions as a support agency for action 9, 10, 11, and 17.	
Missouri Dam and Safety Reservoir Program	Natural and Cultural Resources	The Missouri Dam and Safety Reservoir Law of 1979 establishes a dam safety program within MoDNR to ensure that dams in the state are constructed, maintained, and operated in a safe manner. The Dam and Reservoir Safety Program is leading the effort to develop Emergency Action Plans (EAPs) for regulated dams that will help save lives and reduce property damage during a dam safety emergency. Additional dam safety initiatives are coordinated with the USACE. MoDNR State-regulated dam inventory as reported to the Missouri Spatial Data Inventory System, supplemented with additional state hazard class information from the Dam Safety Program for 2018 State Plan update.	Section 3.3.3 Section 4.5.1
Department of Public Safety	Emergency Management	The Missouri Office of Homeland Security (OHS) is a part of the DPS, and directly under the Director of the DPS. The Department's desired outcomes that are specific to mitigation efforts are: to mitigate the threat of terrorism; reduce preventable injuries and fatalities; interoperable communications for law enforcement and emergency services; increase crime prevention; and to improve the ability to respond and provide recovery from all "hazard events". Critical facilities/ infrastructure data from the Office of Administration for DPS facilities was incorporated into the 2018 exposure and analysis of State assets at risk. This analysis and digital data was provided back to DPS for integration into their mitigation initiatives.	Section 3.1.1 Section 3.3.21 Section 3.5 Section 4.5.1
Division of Fire Safety	Emergency Management	MDFS is tasked with the development of the Statewide Mutual Aid program to assist other responder disciplines in establishment of their own mutual aid systems. MDFS also continues to actively promote the enactment of a statewide fire code. For the 2018 State Mitigation Plan, the hazard profile and risk assessment for urban/structure fires was created separately from the wildfire hazard. Noted integrated programs and documents include: Missouri Systems Concept of Operational Planning for Emergencies (MoSCOPE), dated 2008	Section 3.3.15 Section 4.5.1
Office of Homeland Security	Emergency Management	The homeland security coordinator, who works directly for the director of the DPS, manages the Office of Homeland Security and is tasked with implementing Missouri's Homeland Security Strategy. The coordinator is responsible for the overall Homeland Security program in Missouri, and works with the Homeland Security Advisory Council, the Regional Homeland Security Oversight Committees, and the various initiatives to ensure that Missouri's program is focused on an all threats, all hazards approach.	Section 3.3.21 Section 4.5.1

State Agency Plan and Program Initiatives	Sector	Summary of Integration Activities	Reference Locations in State Mitigation Plan
State Highway Patrol	Emergency Management	The State Highway Patrol provides all officers with training on weapons of mass destruction and gives additional terrorism training to sergeants and staff officers. For the 2018 State Mitigation Plan, the hazard profile and risk assessment for land subsidence/sinkholes, civil disorder, and mass transportation included updated data provided by the Missouri State Highway Patrol Statistical Analysis Center. Noted integrated programs and documents include: Missouri Homeland Security Alert Network.	Section 3.3.5 Section 3.3.13 Section 3.3.17 Section 4.5.1
Department of Social Services	Health and Social Services	The Department of Social Services (DSS) is the lead state agency responsible for coordinating mass care activities during disaster events. Critical facilities/ infrastructure data from the Office of Administration for DSS facilities was incorporated into the 2018 exposure and analysis of State assets at risk. This analysis and digital data was provided back to DSS for integration into their mitigation initiatives and disaster event planning activities. Noted integrated programs and documents include: Emergency Operations Plan, Children's Division, dated 2008.	Section 3.1.1 Section 3.5 Section 4.5.1
Department of Transportation	Infrastructure	MoDOT uses mitigation in its capital improvement planning and environmental planning which involves locating facilities, retrofitting bridges, and assessing open space and floodplain issues. MoDOT personnel provide technical assistance to various emergency management programs, including mitigation. In addition, MoDOT incorporates flood and earthquake standards into new bridge designs and is working on a database that identifies which Missouri bridges have been constructed or retrofitted to earthquake design standards. MoDOT also works on major river bridge projects and wetland reestablishment and rehabilitation. The agency also enforces hazardous materials regulations and manages the registration and licensing of carriers who haul hazardous waste through the State. For the 2018 State Mitigation Plan, the hazard profile and risk assessment for severe winter weather, hazardous materials release, and mass transportation included updated data provided by MoDOT. Critical facilities/ infrastructure data, including scour critical bridges, from MoDOT was incorporated into the exposure and analysis of State assets at risk. This analysis and digital data was provided back to MoDOT for integration into their mitigation initiatives and disaster event planning activities. Noted integrated programs and documents include: Statewide Transportation Improvement Program.	Section 3.1.1 Section 3.3.9 Section 3.3.16 Section 3.3.17 Section 3.5 Section 4.2.3 Section 4.5.1 Appendix C

State Agency Plan and Program Initiatives	Sector	Summary of Integration Activities	Reference Locations in State Mitigation Plan
		An enhanced earthquake analysis and report, completed in June and July 2017, was performed as a parallel effort to the 2018 Missouri State Hazard Mitigation Plan Update. This enhancement included an updated bridge inventory to further refine the vulnerability assessment to identify areas that may warrant further analysis or targeted mitigation. Vulnerable bridge data was provided back to MoDOT for consideration. MoDOT is active in the implementation of state mitigation actions as a support agency for action 15.	
Office of Administration	Economic Development	The Office of Administration enforces floodplain management regulations for state facilities. For Missouri state-owned or operated facilities, SEMA applied FEMA's guidelines for determining critical facilities to the asset use/facility types. Over 8,000 OA facilities were determined to be critical facilities. The inventory was then geo-referenced with available information (latitude longitude or address) and utilized in the exposure and analysis of State assets at risk. Additionally, for the 2018 State Mitigation Plan, the hazard profile and risk assessment for cyber disruption included updated data provided by OA. The OA is active in the implementation of state mitigation actions as a support agency for action 15.	Section 3.1.1 Section 3.3.14 Section 3.5 Section 4.2.3 Section 4.5.1
Public Service Commission	Economic Development	The Missouri Public Service Commission (PSC) regulates investor-owned public utilities operating in Missouri that can be affected by disaster events. For the 2018 State Mitigation Plan, the hazard profile and risk assessment for utilities (disruption and system failures) included updated data provided by PSC. Noted integrated programs and documents include: Missouri Energy Task Force Action Plan, 2006. The PSC is active in the implementation of state mitigation actions as a support agency for action 12.	Section 3.3.22 Section 4.2.3 Section 4.5.1

As noted throughout **Table 7.2**, critical facilities/ infrastructure data from numerous State agencies were incorporated into the exposure and analysis of State assets at risk. For those facilities for which GIS data was provided, the State agencies have been provided with the results indicating specific facilities potentially at risk to inundation from failure of state-regulated and USACE-regulated dams, flooding from a 100-year flood event, and levee failure; location relative to sinkholes and potential wildfires; and damage from an earthquake event with a 2% probability of exceedance in 50 years. Results were provided in both GIS (geodatabase) and Excel spreadsheet formats. Provision of this data is provided specifically so that those State- agencies are made aware of potential risks to determine if mitigation opportunities are necessary and/or feasible.

7.1.3 Integration with USACE Mitigation Programs and Initiatives

The USACE Kansas City District is charged with leading coordination for the USACE in Missouri. In support of the Missouri State Hazard Mitigation Plan update, the USACE has contributed to mitigation planning efforts through integration of:

- Civil Works Programs
- Risk assessments
- Actions supporting hazard mitigation
- Risk communication

The Lead Silver Jackets Coordinator for Missouri participates on the SRMT, representing all the USACE districts within the state. Each district also has a Silver Jacket Coordinator, whom is encouraged to attend. The Lead Silver Jackets Coordinator provides regular status updates at the SRMT meetings, including detailed information on active USACE Civil Works projects and programs; supports risk assessment development, providing input and data, as requested; and assists in update and development of mitigation actions, as related to USACE risk reduction measures.

Civil Works Programs

Several relevant USACE Civil Works programs are integrated with the State Hazard Mitigation Plan and planning process and are further defined below:

- The **USACE Levee Safety Program** activities have included establishing a National Levee Database, inspecting levees, communicating risks, taking steps to reduce risks, and establishing a levee safety portfolio internally at USACE for prioritizing levee work. Integration efforts include the addition of a new mitigation action (See Chapter 4) to encourage the creation of a State-level Levee Safety Program similar to MoDNR's Dam and Reservoir Safety program.
- The **USACE Dam Safety Program** focuses on the large reservoirs, many of which are multipurpose. Reservoirs act together with levees and other infrastructure to reduce impacts of floods, and the reservoirs may also maintain flows for navigation downstream. The program is a little older than the USACE program on levee safety and also has a risk portfolio for prioritizing dam work. Integration efforts include data delivery for the dam failure hazard profile and risk assessment.
- The **USACE Flood Risk Management Program** includes planning studies (General Investigations, or GI, and other programs), projects under design phase (Preconstruction Engineering and Design, or PED), and others in construction phase (Construction General, or GI) within the State of Missouri. Integration efforts include data delivery for the flood hazard profile and risk assessment, as well as, implementation of structural flood mitigation projects at the local level. It is an objective of the program to reduce the Nation's flood risk and increase resilience to disasters.

- **USACE Civil Works Emergency Management Program** addresses activities such as flood fighting and the rehabilitation of damaged infrastructure, such as levees or dams. In addition, major disasters and emergencies are also coordinated through this program. Integration efforts include data delivery for the state capability assessment. It is an objective of the program to support DHS/FEMA to provide life-cycle public works and engineering support in response to disasters.

Risk Assessments

The USACE Dam Safety Program developed and released dam safety action classifications (DSACs) between 2006 and 2009. The system is intended to provide consistent and systematic guidelines for appropriate actions to address the dam safety issues and deficiencies of USACE dams. USACE dams are placed into a DSAC class based on their individual dam safety risk considered as a combination of probability of failure and potential life safety, economic, environmental, or other consequences.

For the 2018 State Mitigation Plan Update and dam failure risk assessment, the Silver Jackets coordinator obtained inundation areas for USACE dams that could impact Missouri, including USACE dams outside and upstream of Missouri that have inundation pathways that impact areas and communities within the State.

In May of 2012, the Levee Safety Program began a similar effort with the state hazard mitigation teams. Silver Jackets Coordinators and Levee Safety Program Managers are establishing the revised Levee Safety path forward with state teams and plan specific actions through new processes.

- Both the dam safety action classifications and levee safety action classifications, as available, were utilized in the State Hazard Mitigation Plan to determine vulnerability (See Sections 3.3.2 and 3.3.3).

Actions Supporting Hazard Mitigation

Similar to mitigation actions, the USACE develops interim risk reduction measures related to the USACE Dam and Levee Safety Programs. Interim risk reduction measures (IRRMs) are effective, interim actions taken to reduce flood risks while longer term solutions are planned and implemented. IRRMs are in line with the State Hazard Mitigation Plan's Goal #1 (see Section 4.1) to implement mitigation actions that improve the protection of human life, health, and safety from the adverse effects of disasters. IRRMs are a critical part of responsible, adaptive flood risk management.

Examples of IRRMs for dams in Missouri include the following:

- **Smithville Lake**. The Smithville lake dam has had observed seepage at the left abutment since initial pool filling, which has generated stability concerns. A large amount of instrumentation was installed to better define the seepage pressures beneath the dam during the 1980's, which has provided data that substantiate adequate stability. Drainage provisions were also installed to reduce seepage pressures.
- **Rathbun Lake.** Two drainage systems were installed, one at the Chariton embankment in 1988 and deepened in 1994, and one at the Buck Branch embankment in 2011. Spillway erosion was determined to be adequate to pass the spillway design flood, but is a maintenance concern because of the increased likelihood of use. During the 2010 flood, the stilling basin was improved to handle higher flood control releases. Downstream channel capacity has likely increased in recent years due to changes in land use. A Water Control Manual revision study has been initiated, which should lead to higher allowable releases and a better balance between lake benefits and downstream benefits.
- **Pomme de Terre Lake.** The original stilling basin had severe concrete erosion problems because of rockfill and resulting ball milling during discharges. The stilling basin concrete was repaired in

2009-11. The dam was initially placed in the DSAC 3 category because of the stilling basin condition and concern for foundation and abutment seepage concerns through rock joints, filters in the embankment, and possible deterioration in the grout curtain. Secondary concerns included stability issues in the rim dike and possible spillway erosion with spillway design floods. A periodic assessment was completed in 2012 that addressed all these concerns, and downgraded the project risk to the DSAC 4 level.

- **Stockton Lake.** IRRM measures addressing the stability concerns included replacing caulking on the spillway piers, adding/replacing instrumentation to measure water levels below the spillway structure and to monitor seepage on the right abutment.
- **Mark Twain Lake.** IRRM measures include scour survey, settlement survey, vegetation maintenance, flood damage repair, stilling basin inspection, periodic inspection, additional dam safety inspections, additional walk over inspections, post-earthquake inspections, annual periodic inspection review, periodic assessment, toe drain inspection, update PMP/PMF, update pool frequency data, seepage analysis, emergency action plan, EAP exercise, dam safety training, annual meetings with local authorities, communication plan, news and press releases, stockpile materials, equipment availability, new inundation maps
- **Lake Wappapello.** IRRM measures include additional piezometer installation, update earthquake instrumentation, periodic inspection, stilling basin inspection, foundation drain inspection, dam safety training, SPRA recommendations, spillway erosion study, inundation maps, P&S to repair and paint gates, additional piezometer readings, additional walk-over inspections, additional dam safety inspections, annual periodic inspection review, EAP exercise, repair and paint gates, remove vegetation, annual meetings with local authorities, EAP, news and press releases, communications plan.

Planning and implementing IRRMs for levees are ultimately the levee sponsors responsibility. The USACE districts that operate and/or maintain levee systems are required to develop IRRM plans. For federally authorized - locally operated and maintained levee systems, IRRMs are ultimately the levee sponsors' decision but the USACE may advise and recommend the need for IRRM's. Potential USACE programs for joint collaboration of IRRM's (USACE participation in advising levee sponsors concerning IRRMs) include Silver Jackets interagency teams, Planning Assistance to the States (PAS), or Floodplain Management Services (FPMS). Some events that may lead to recommendations for IRRM's include:

- Scheduled inspections
- Risk assessments or levee screenings
- Flood events or incidents revealing performance issues
- System-wide Improvement Framework requests for participation in the PL 84-99 recovery assistance program

Risk Communication

As previously noted, the Lead Silver Jackets Coordinator provides USACE status updates to the SRMT. In the updates, current projects (General Investigations, or studies, and Construction General) including dam and levee construction and studies, are provided. The USACE programs, Floodplain Management Services (FPMS) program, Planning Assistance to States (PAS), and Silver Jacket Pilot Projects are also listed in the status updates. The updates can also be found on each of the USACE districts' websites.

Additional forms of risk communication with the USACE include:

- The **Regional State Risk Management Team** is a combination of the hazard mitigation teams in the four state region of Kansas, Iowa, Missouri, and Nebraska, with a focus on the Missouri River. The team is primarily composed of the state agency officials directing those state teams and representatives from the local USACE Districts. The SRMT co-leads are one of the four states leading this broader team.

- Tools such as **fact sheets and Strong Points**, a USACE news bulletin, on topics including risk assessment, risk-informed decision-making, and IRRMs specifically developed for communicating flood risk associated with levee systems are available through a USACE Silver Jackets Coordinator.
- The USACE offers assistance in questions about floodplains through the **Floodplain Management Services Program**.

Interagency Non-Structural Project

Through the Silver Jackets program, SEMA has proposed, and was awarded funding in late 2017, to develop a Missouri Flood Buyout Strategy to guide the selection process for distribution of mitigation grant funding for acquisition/demolition projects. The developed buyout strategy will identify a variety of selection factors, in addition to historic and potential flood damage, such as impacts to water quality, water quantity, local economy, and housing. The strategy will rank the identified factors and allow the state to better reduce risk through identifying and prioritizing the most flood prone, highest risk properties for buyouts across the state.

Experts from a variety of State and Federal agencies and local partners will work together to develop the strategy. The work will include a series of five partner meetings to identify the potential relevant factors, determine which factors to incorporate into the overall buyout strategy, and develop the strategy to append to the 2018 State Hazard Mitigation Plan.

The strategy will also allow the state to act more expeditiously following a disaster. This project will contribute products that will serve other active interagency nonstructural projects within USACE St. Louis District's Silver Jackets Program. Specifically, actions involving buyouts for the floodplain management plans addressing recent Meramec Basin flooding.

Other USACE Programs Conducting Hazard Mitigation

Leading the nation's environmental engineering efforts, the USACE manages one of the largest federal environmental missions: restoring degraded ecosystems; constructing sustainable facilities; regulating waterways; managing natural resources; and, cleaning up contaminated sites from past military activities. USACE environmental cleanup programs focus on reducing risk and protecting human health and the environment in a timely and cost-effective manner. USACE manages, designs and executes a full range of cleanup and protection activities, such as:

- Cleaning up sites contaminated with hazardous, toxic or radioactive waste or ordnance through the Formerly Used Defense Sites program
- Cleaning up low-level radioactive waste from the nation's early atomic weapons program through the Formerly Utilized Sites Remedial Action Program
- Supporting the U.S. Environmental Protection Agency by cleaning up Superfund sites and working with its Brownfields and Urban Waters programs
- Supporting the Army with the Base Realignment and Closure Act program
- Ensuring that facilities comply with federal, state and local environmental laws
- Conserving cultural and natural resources
- Integration efforts for the USACE environmental missions include data delivery for the for environmental consequences in the hazard profiles, as well as, implementation of mitigation projects at the local level.

7.1.4 Integration with FEMA Mitigation Programs and Initiatives

The State Mitigation Plan is integrated with FEMA mitigation programs primarily through its mitigation strategy, the local mitigation planning program, and the floodplain management functions.

Hazard Mitigation Assistance Grants

Mitigation actions, as described in detail in Section 4.2 and expanded in Section 7.5, are designed to reduce long-term risk in Missouri and improve the State's eligibility for and management of FEMA Hazard Mitigation Assistance (HMA) grant programs listed below:

- Hazard Mitigation Grant Program (HMGP)
- Pre-Disaster Mitigation Program (PDM)
- Flood Mitigation Assistance (FMA) Program
- FEMA Public Assistance Mitigation (406)

The table below presents the number of total mitigation projects (HMGP, PDM, and FMA) approved or completed since 2002 to demonstrate integration.

Table 7.3. Summary of FEMA Funded Mitigation Projects, 2002-2017

Project Type	Action Category	Number of Projects	Estimated Funding Amount
State and Local Hazard Mitigation Plans	M1	263	$8,982,407
Flood Buyouts	M3	85	$55,795,906
Flood Elevations	M4	3	$488,573
Tornado Safe Rooms	M5	195	$228,501,038
Tornado Safe Rooms - Multipurpose	M5	1	$686,493
Bridge Replacements	M8	1	$449,787
Low Water Crossings	M8	10	$1,321,142
Streambank Stabilizations	M8	2	$92,267
Basin	M8	1	$1,333,333
Culvert	M8	2	$553,625
Water Supply Interconnects	M8	1	$66,701
Buried Electric Lines	M9	10	$11,959,530
State 5% Initiative Projects	M10	22	$2,352,244

Through implementation of the FEMA HMA grants, SEMA further integrates and utilizes the information provided by FEMA including:

- FEMA P-320, Taking Shelter from the Storm: Building a Safe Room for Your Home or Small Business (4th Edition, 2014)
- FEMA P-361, Safe Rooms for Tornadoes and Hurricanes: Guidance for Community and Residential Safe Rooms (3rd Edition, 2015)
- Mitigation Planning Guidance

Public Assistance C-G

Since 1998, there have been almost 9,000 permanent Public Assistance projects completed within the State. This includes:

- C - Roads and Bridges – 7,259
- D - Water Control Facilities - 73
- E - Public Buildings - 712
- F - Public Utilities - 599
- G - Recreational or Other - 341

The integration of hazard mitigation measures into the permanent restoration of these damaged facilities during post-disaster recovery through the Public Assistance Mitigation (406) program is presented in Section 7.6 of this Chapter.

Risk Mapping, Assessment, and Planning (Risk MAP)

Risk MAP is an action-driven program through community participation, adopting mitigation planning, communicating risk to citizens, implementing mitigation actions to reduce risk, and utilizing mitigation plans to secure grant funding. Through Risk MAP, FEMA provides information to enhance local mitigation plans, improve community risk awareness outreach, and increase local resilience to flooding. Through collaboration with State, Tribal, and local entities, Risk MAP delivers quality data that increases public awareness and leads to action that reduces risk to life and property.

Missouri Risk MAP Program Business Plan

SEMA has developed a 5-year Combined Strategic and Community Engagement and Risk Communication (CERC) and Risk MAP Business Plan to emphasize its comprehensive and integrated approach that includes floodplain mapping, risk assessment and mitigation planning unified by risk communication that meets or exceeds FEMA goals and program intent. The Business Plan outlines the path for the state of Missouri to reach “Map Maintenance” status by Fiscal Year (FY) 2022. Activities following the Map Maintenance Status will focus on mapping individual streams, rapid growth communities, areas that experienced a flood of record or other significant topographic accuracy changes, hydrologic and/or hydraulic changes, or other natural/man made features that would alter the accuracy of the flood risk assessments.

Mapping

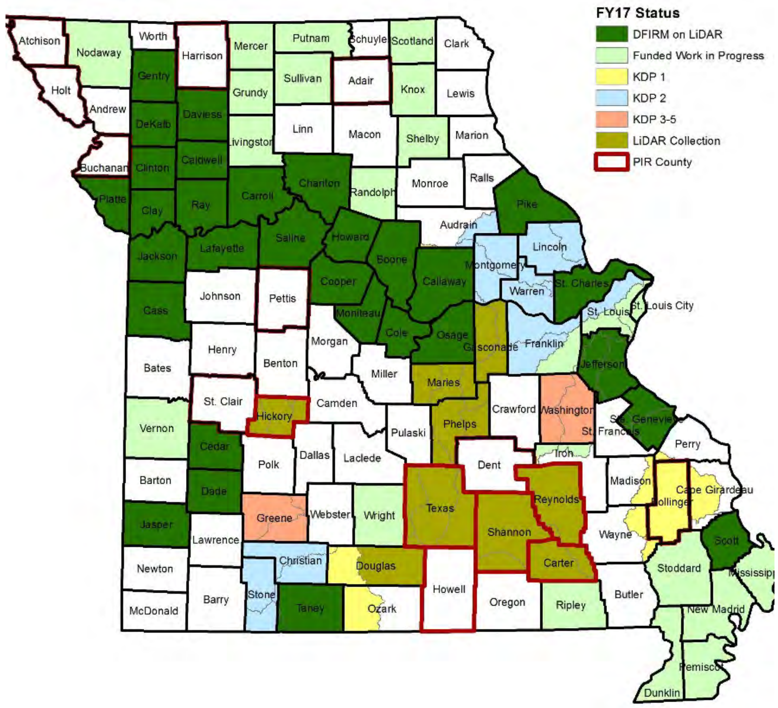
As of May 2017, SEMA has updated 79 counties to a countywide digital flood insurance map, representing 69% of the State. Thirty-four (34) counties are model-based on LiDAR topography 1-meter digital elevation model (DEM) and 45 counties are model-based on USGS 10-meter DEM. The remaining 33 counties are still paper (non-digital and community based not countywide) except for Schuyler County, which does not have any existing digital or paper floodplain maps.

For the Fiscal Year 2017, SEMA began updating 21 of the 33 paper-only counties through FEMA’s temporary Paper Inventory Reduction (PIR) program. SEMA embraced this new program and will eliminate the paper maps in Missouri by FY2019. With these additional 21 mapped counties, SEMA will have a total of 100 counties, or 88% of the State, with updated and identified flood hazard areas. The databases for the PIR counties will be countywide, not watershed-based, and will also define risk in previously unmapped areas. Additionally, SEMA started the process to update eight of the 45 counties modeled with 10-meter DEM to be modeled on LiDAR topography with 1-meter DEM.

Assessment

This 2018 State Mitigation Plan update is integrated with the Risk MAP activities within the State through the utilization of the FIRM depth grids for 79 Missouri Counties and the City of St. Louis and through the utilization of Hazus-generated floodplain data for the remaining 35 counties. By integrating the existing depth grids generated as part of the Risk MAP products and developing depth grids based on the DFIRM databases, the flood risk assessment for these areas is much more refined and accurate. The State intends to continue to incorporate FIRM depth grids for additional counties as they become available.

Figure 7.1. DFIRM Status in Missouri as of May 2017



Planning

Local Mitigation Plans

As part of a FEMA CERC funded grant, a User Guide and accompanying Workshop was developed which utilizes the available SFHA and the MSDIS Structure points, described in Section 4.5.1 to identify mitigation actions and potential areas of mitigation interest that can be used in local mitigation planning efforts. These actions are categorized according to the six broad mitigation categories defined by FEMA. Specific examples from each of the 23 subcategories under flooding are then shown. Nine workshops were held across the state in 2017 where this User Guide and Workshop material were presented. In 2018, it is planned that these workshop materials will also be distributed at the 20 Community Coordination Officer (CCO) meetings being held across the state as part of the mapping updates.

SEMA created a local mitigation plan outline and accompanying workshop to aid local and regional planning efforts in meeting the FEMA Guidance and Specifications for Local Plans with minimal cost and time expenditures. To date nine workshops have been held across the State to present this Outline, this includes 3 workshops held annually in 2015, 2016, and 2017. Additionally, meeting kits for each of the three meetings required for local plans were developed that contain templates for agendas, invitation letters, sign-in sheets, presentations, sample public surveys, data collection questionnaires, action tracking spreadsheets, STAPLEE worksheets and meeting minutes.

Other actions include helping local governments with their multi-jurisdictional local hazard mitigation plans (new and updated), which are funded primarily through FEMA's Pre-Disaster Mitigation program and Hazard Mitigation Grant Program, and to provide training and outreach to local governments on the benefits of FEMA mitigation programs and how they can get involved.

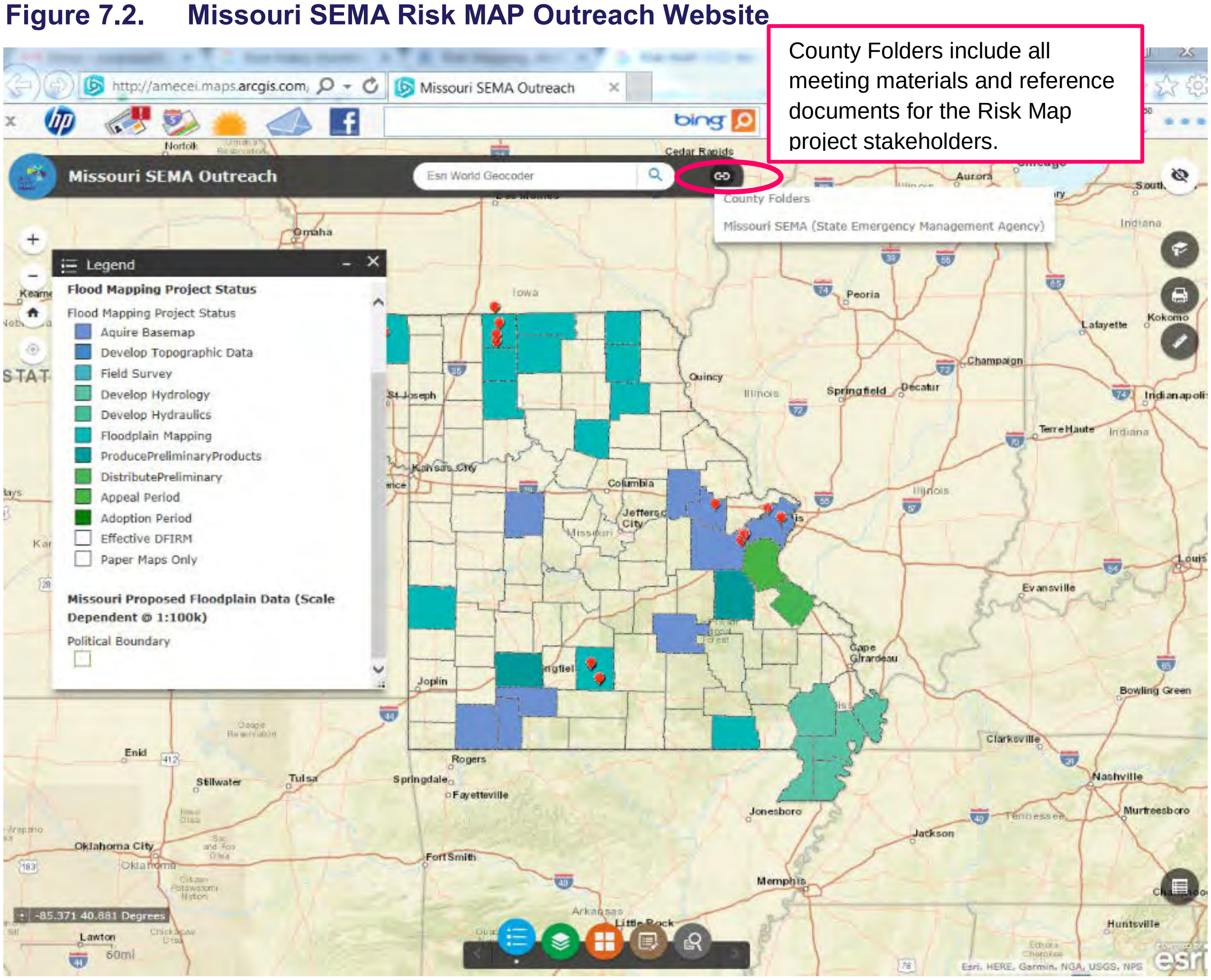
Risk Communication

SEMA is fully committed to ongoing communications with the Risk MAP project area stakeholders for each mapping study, as well as, incorporating mitigation into the process. Communication and outreach includes:

- Meetings conducted within the project study areas for Project Initiation/Discovery, Flood Study Review, Community Compliance Officer (CCO) meetings and Open Houses. Areas of mitigation interest (AOMI) and mitigation actions identified during these meetings are added to FEMA's mitigation action tracker, included in local hazard mitigation plan, and included in the prioritization process for SEMA mitigation project approvals.
- Outreach website (http://bit.ly/MOSEMAOutreach) showing flood mapping project status and meeting materials, including mitigation topics and reference materials (see **Figure 7.2**).
- Answering any communications received from persons in a study area and quarterly communications sent to the project stakeholders.
- Coordination with the State NFIP Coordinator and SEMA staff to assist communities to join the NFIP if they have not previously done so and to update ordinances during the Community Map Adoption Period.
- Training workshops for communities who have recently had mapping update or are being updated so that community officials can better understand the powerful tools available to them for mitigation action identification and hazard mitigation planning.

Consistency of personnel attending outreach meetings is also a large component of SEMA's outreach program. The same staff attend all the meetings to ensure that follow through on needs are met and relationships with the State are built and maintained from year to year.

Figure 7.2. Missouri SEMA Risk MAP Outreach Website



SEMA has developed an Online Loss Avoidance Tool, as further described in Section 7.4, which will be accessible at the SEMA Website. This Loss Avoidance Tool allows for "what If" scenarios to be conducted with minimal time invested by allowing users to draw a selection area or upload an already defined selection area such as a Disaster Declaration Area and export the Losses Avoided for the Buyout locations that fall within the selection area. This data can easily become a part of any report or local plan.

National Flood Insurance Program and the Community Rating System

Coordination of the National Flood Insurance Program was transferred from the Department of Natural Resources to SEMA in 1995. Since that time, there has been an enormous effort by SEMA staff to bring heightened awareness and technical assistance to local communities. The Floodplain Management Section staff consists of the Floodplain Management Section Manager and State NFIP Coordinator, a floodplain engineer, floodplain management officer, and emergency management officer II. Staff perform numerous mitigation related activities including:

- training and technical support functions that are associated with managing statewide local government participation in the National Flood Insurance Program (NFIP)
- serving as a state cooperating technical partner in developing and updating floodplain flood insurance rate maps
- directly performing flood permitting for all state-owned construction projects

NFIP Participation

According to FEMA's Community Status Book, 88 communities have joined the National Flood Insurance Program since 2007, representing a 15.1% increase in participation. In addition, the number of communities participating in the NFIPs Community Rating Service (CRS) has increased by 400% from 2 to 10 communities. Table 7.4 provides additional details on progress made in NFIP participation.

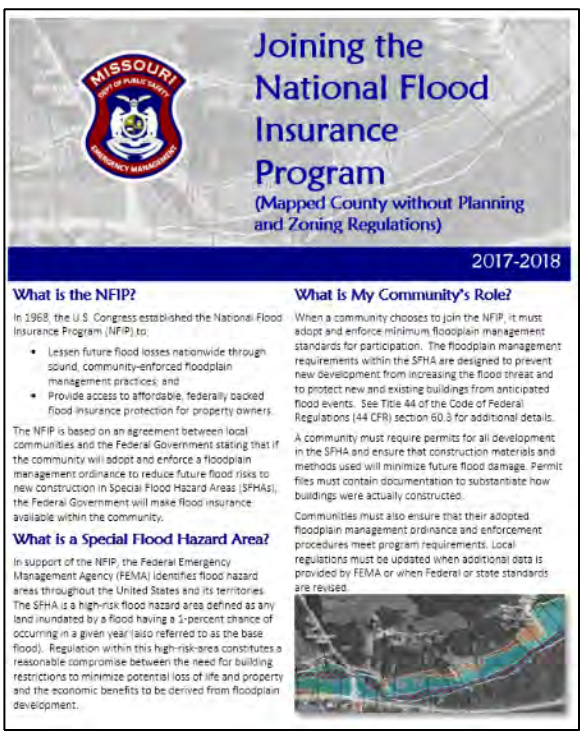
Table 7.4. Changes in NFIP Participation, 2007-2018

NFIP Participation	2007	2010	2013	2018	10-Year Numerical Change	10-Year Percent Change
Total in Regular Program	584	604	652	672	+88	15.1%
Total in Emergency Program	7	10	2	1	-6	-85.7%
Total in NFIP	591	614	650	673	+82	13.9%
CRS Communities	2	4	N/A	10	+8	400.0%
Mapped Hazard Area, Not in Program	138	118	168	162	+24	17.4%
Total Suspended	13	10	2	6	-7	-53.8%

Source: NFIP Community Status Book May 14, 2018; CRS April 1, 2018

The CRS program is a voluntary incentive program that recognizes and encourages community floodplain management activities that exceed the minimum NFIP requirements. The CRS program is aligned and integrated with hazard mitigation and local planning, through the award of activity points for protecting natural floodplains, preserving open space, regulating development, planning, and taking structural mitigation actions. SEMA's Floodplain Management Section administers the NFIP for the state of Missouri and coordinates with communities throughout the RiskMAP process and encouraging participation in the NFIP, as well as the CRS. Handouts covering the process to join the NFIP have been developed by SEMA to assist non-participating communities.

Figure 7.3. Sample NFIP Handout for Non-Participating Communities



Joining the National Flood Insurance Program
(Mapped County without Planning and Zoning Regulations)

2017-2018

What is the NFIP?

In 1968, the U.S. Congress established the National Flood Insurance Program (NFIP) to:

- Lessen future flood losses nationwide through sound, community-enforced floodplain management practices; and
- Provide access to affordable, federally backed flood insurance protection for property owners.

The NFIP is based on an agreement between local communities and the Federal Government stating that if the community will adopt and enforce a floodplain management ordinance to reduce future flood risks to new construction in Special Flood Hazard Areas (SFHAs), the Federal Government will make flood insurance available within the community.

What is a Special Flood Hazard Area?

In support of the NFIP, the Federal Emergency Management Agency (FEMA) identifies flood hazard areas throughout the United States and its territories. The SFHA is a high-risk flood hazard area defined as any land inundated by a flood having a 1-percent chance of occurring in a given year (also referred to as the base flood). Regulation within this high-risk-area constitutes a reasonable compromise between the need for building restrictions to minimize potential loss of life and property and the economic benefits to be derived from floodplain development.

What is My Community's Role?

When a community chooses to join the NFIP, it must adopt and enforce minimum floodplain management standards for participation. The floodplain management requirements within the SFHA are designed to prevent new development from increasing the flood threat and to protect new and existing buildings from anticipated flood events. See Title 44 of the Code of Federal Regulations (44 CFR) section 60.3 for additional details.

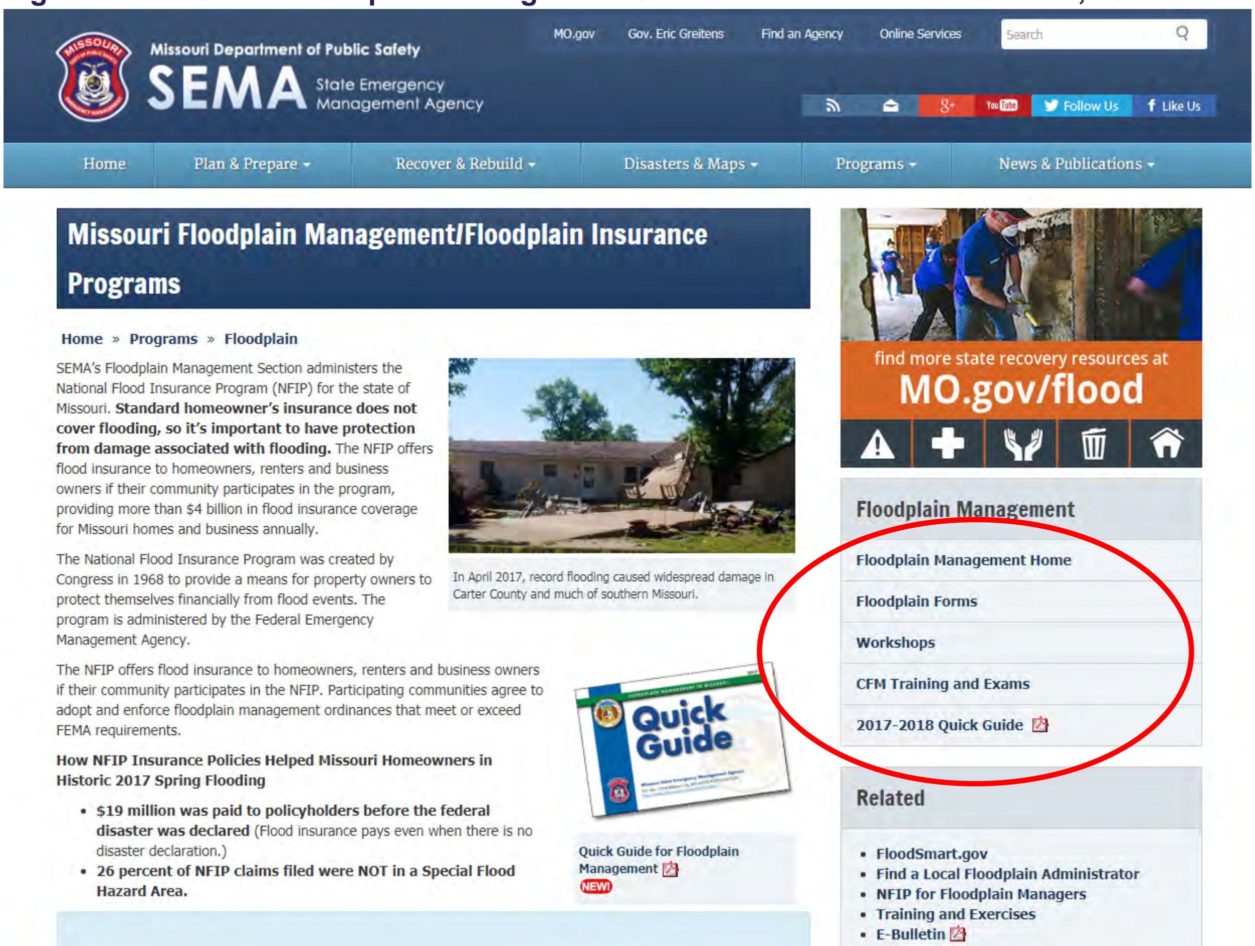
A community must require permits for all development in the SFHA and ensure that construction materials and methods used will minimize future flood damage. Permit files must contain documentation to substantiate how buildings were actually constructed.

Communities must also ensure that their adopted floodplain management ordinance and enforcement procedures meet program requirements. Local regulations must be updated when additional data is provided by FEMA or when Federal or state standards are revised.

Technical Support

The Floodplain Management Section website presents information and data sources for helping communities with floodplain regulations and flood insurance information (See Figure 7.4). Floodplain development forms are available including sample permits, engineering “no-rise” certificates, elevation certificates, and floodproofing certificates. Training workshops are outlined for the upcoming year along with registration applications. Certified floodplain manager workshops and exam dates are provided. The FEMA/SEMA Quick Guide is also available for reference and download. The Quick Guide helps local officials and citizens understand why and how Missouri communities must manage development in floodplains to protect people and property.

Figure 7.4. SEMA Floodplain Management Section Website and Resources, 2017



Training

Training courses conducted by SEMA and the Floodplain Management Branch for the past three years have included the following:

- 2015
  - Developed four-hour and six-hour Workshops along with training materials on how to use Risk MAP products in floodplain management.
  - 4 - Workshops for how to use Risk MAP Products were held across the state which allowed local floodplain administrators to see examples of how the GIS data could be used for everyday floodplain management issues.
- 2016
  - 5 - Trainings were conducted as part of the "Show Me" Series on how to use regulatory and risk map products to identify areas of need for risk reduction and potential mitigation actions along with a User Guide.
  - 4 - Workshops for how to use DFIRM Products were held across the state.
- 2017
  - 5 - Trainings were conducted as part of the "Show Me" Series on how to use regulatory and risk map products to identify areas of need for risk reduction and potential mitigation actions along with a User Guide under the CERC Grant.
  - 4 - Workshops for how to use RiskMAP Products were held across the state which allowed local floodplain administrators to see examples of how the GIS data could be used for everyday floodplain management issues.

- SEMA continues to provide training and administer the Certified Floodplain Manager (CFM) exam and as of January 2018, there are a total of 180 CFMs in Missouri. This is an additional 54 CFMs since 2010, representing a 43% increase. Additionally, SEMA annually attends and sponsors the Missouri Association of Floodplain and Stormwater Managers Association (M*f*SMA) annual conference as well as the National Association of State Floodplain Managers (ASFPM) conference.

Cooperating Technical Partners

SEMA and five local governments (City of Jackson, City of Lee's Summit, City of Springfield, Cass County and Greene County) participate in FEMA's Cooperating Technical Partners Program and collaborate on maintaining up-to-date flood maps and other flood hazard information. Participation allows CTP communities to develop more detailed maps by incorporating local data; receive streamlined FEMA customer service, access to existing FEMA data, and technical assistance; as well as, mentoring support, shared best practices, online resources, and free training to achieve more efficient and effective flood risk development.

SEMA and the five communities applied for and were awarded CTP Grants for scoping, production, and post-preliminary processing and mapping of Missouri's floodplains. These activities were integrated into a 2018 flood hazard risk assessment.

Flood Permitting

In July 1997, Executive Order 97-09 was signed by the lieutenant governor authorizing SEMA to issue floodplain permits for any state-owned or leased development in a special flood hazard area. This is accomplished through coordination with the State's Office of Administration that oversees the State's owned and leased assets.

National Dam Safety Program

The National Dam Safety Program (NDSP) is a partnership of State agencies, Federal agencies, and other stakeholders that encourages and promotes the establishment and maintenance of effective Federal and state dam safety programs to reduce the risks to human life, property, and the environment from dam related hazards. Within Missouri this is implemented through:

- The Missouri Dam and Safety Reservoir Law of 1979 – this law established a dam safety program within MoDNR to ensure that dams in the state are constructed, maintained, and operated in a safe manner. This is accomplished by regulation of all nonagricultural, nonfederal dams of more than 35 feet in height and by providing technical assistance and informational resources to all dam owners.
- The Missouri Dam and Reservoir Safety Council – this council was also established by the Dam and Safety Reservoir Law of 1979. The Council's responsibilities are to adopt and amend technological guidelines, standard guidelines, rules, and regulations applicable to the permits, design, construction, maintenance operation, alteration, repair, reduction, removal, and natural physical changes that may occur to a dam or reservoir.
- The Dam and Reservoir Safety Program is leading an effort to develop Emergency Action Plans (EAPs) for regulated dams that will help save lives and reduce property damage during a dam safety emergency. EAPs increase preparedness by organizing emergency contact information and evacuation procedures into an official document, and by providing enhanced communications between dam owners and local emergency managers.

Emergency Management Performance Grant Program (EMPG)

The Emergency Management Performance Grant Program (EMPG) plays an important role in the implementation of the National Preparedness System by supporting the building, sustainment, and delivery of core capabilities essential to achieving the National Preparedness Goal of a secure and resilient Nation. For Missouri, the EMPG Program is administered by SEMA and provides resources for local government emergency management agencies for the sustainment and enhancement of all-hazard emergency management capabilities. SEMA also facilitates an EMPG working group to provide recommendations for priorities of EMPG funding and parameters of the grant. The EMGP working group includes 9 regional EMD representatives and 9 regional MOEMA representatives.

SEMA baseline requirements for local government emergency management agencies interested in EMPG include the following:

- Designate a 24/7 Emergency Operations Center (EOC)
- Maintain a Local Emergency Operations Plan (LEOP)
- Implement the National Incident Management System (NIMS)
- Complete FEMA/SEMA training requirements
- Participate in at least three (3) annual exercises
- Conduct or participate in an annual Training and Exercise Plan Workshop (TEPW)
- Utilize WebEOC during incidents, events and trainings
- Participate in Threat and Hazard Identification and Risk Assessment (THIRA) updates

Table 7.5 presents the total EMPG awards for FY2015 and FY206 which includes funding for essential emergency management personnel and benefits, essential EOC supplies and operating expenses, essential emergency management travel, and essential EOC equipment.

Table 7.5. EMPG Projects, FY2015 – FY2016

Year	Personnel	Supplies	Travel	Equipment	Total EMPG Funding
FY2015	$2,952,445.77	$560,272.68	$52,981.74	$15,063.43	$3,580,763.62
FY2016	$2,975,237.34	$502,278.20	$40,972.14	$7,608.41	$3,526,096.09

Source: FEMA Open datasets; https://www.fema.gov/openfema-dataset-emergency-management-performance-grants-v1

Mitigation is integrated with the EMPG program through FEMA/SEMA training requirements, including mitigation-related training, and data support for THIRA updates through sharing of the State Hazard Mitigation Plan risk assessment and results.

New Madrid Seismic Zone (NMSZ) Earthquake Preparations

Joint State of Missouri and Region VII Response Operations Plan (OPLAN), 2014

The joint OPLAN provides a concept of operation and the assignment of roles and responsibilities to local, state, and federal agencies to meet regional planning and response needs following a Moment Magnitude (Mw) Scale 7.7 earthquake within the NMSZ affecting the State of Missouri. Priorities for mitigation include approved mitigation projects in the declared disaster area, change to cost/benefit of the pre-approved project, and acknowledgement that repair costs will likely be substantial, exceeding 50-perent of the structure value.

Great ShakeOut Exercises

SEMA regularly participates in the annual Great ShakeOut earthquake drills. These exercises are designed to promote awareness and increase earthquake preparedness nationwide. The Great Central U.S. ShakeOut is a multi-state drill spanning much of the central United States. Of the 719 participants registered to participate in the upcoming 2018 ShakeOut exercise, 202 are from Missouri.

Enhancements to the 2018 Earthquake Vulnerability Assessment

The earthquake portion of Missouri's previous 2013 State Hazard Mitigation Plan incorporated essential facility data from the Homeland Security Infrastructure Program (HSIP, 2011) and geological site classification and soil liquefaction characteristics from National Earthquake Hazards Reduction Program (NEHRP) and Missouri Department of Natural Resources. Two scenarios addressed earthquake vulnerability:

1) Annualized loss scenario
2) Scenario based on an event with a 2% probability of exceedance in 50 years to model a worst-case earthquake using a level of ground shaking recognized in earthquake-resistant design

For the 2018 Plan Update with additional funding through SEMA and the Central United States Earthquake Consortium (CUSEC), the risk assessment was enhanced to incorporate additional hazard data (groundwater depths and liquefaction data); and updated hazardous materials facilities; bridge information; and schools, fire and medical facilities to improve damage computations and further refine the vulnerability assessment to identify areas that may warrant further analysis or mitigation. The risk analysis summarizes the facilities most at risk based on Hazus estimates of damage probability and functionality. This summary may then inform local hazard mitigation plans and include recommendations for targeted mitigation and building-specific seismic safety analyses.

7.2. Project Implementation Capability

Requirement §201.5(b)(2)(i) and (ii): [The enhanced plan must document] the State's project implementation capability, identifying and demonstrating the ability to implement the plan, including:
- **(i) Established eligibility criteria for multi-hazard mitigation measures.**
- **(ii) A system to determine the cost-effectiveness of mitigation measures, consistent with OMB Circular A-94, Guidelines and Discount Rates for Benefit-Cost Analysis of Federal Programs, and [a system] to rank the measures according to the State's eligibility criteria.**

Over the years, the State has developed and demonstrated mechanisms to implement mitigation plans and projects, including this Missouri State Hazard Mitigation Plan and the processes explained herein. SEMA has established criteria for projects, including multi-hazard considerations. SEMA uses FEMA's recommended benefit-cost analysis system to determine if potential mitigation activities are cost-effective and assigns priority to potential mitigation activities.

This section describes the Missouri State Hazard Mitigation Plan's eligibility criteria and procedures for determining the cost-effectiveness of mitigation measures. It also demonstrates how Missouri addresses the effectiveness and adequacy of the State's established eligibility criteria for multi-hazard mitigation actions; the effectiveness of its system for determining cost-effectiveness of those actions consistent with OMB Circular A-94, *Guidelines and Discount Rates for Benefit-Cost Analysis of Federal Programs*; and the effectiveness of its approach to using cost-effectiveness as part of its eligibility criteria.

In addition, this section also describes how the State evaluates cost-effectiveness. The procedures for this evaluation are consistent with Missouri's Hazard Mitigation Grant Program Administrative Plan. It is now the responsibility of each local government submitting a grant application to perform a benefit-cost analysis (BCA) for projects. SEMA trains applicants on how to perform BCAs using FEMA software and then reviews the application submittals for accuracy and cost-effectiveness. SEMA also recruits the assistance of RPCs in providing BCA assistance to local jurisdictions.

Effectiveness is based on the fact that over 90 percent of projects submitted have been funded, and potential losses were avoided in cases where a hazard affected a project site after its completion, e.g., significant savings were realized following the 1995 floods that succeeded the 1993 post-flood buyouts. Additionally, the national Multi-hazard Mitigation Council report, *Natural Hazard Mitigation Saves: An Independent Study to Assess the Future Savings from Mitigation Activities* (2006), determined that mitigation projects, nationwide, are providing a return on investment (ROI) of 4-to-1. This report was updated in 2017 with the *National Hazard Mitigation Saves 2017 Interim Report.* This interim report presents study results demonstrating that mitigation grants funded through select federal government agencies for well-designed mitigation projects, on average, can save the nation $6 in future disaster costs, for every $1 spent on hazard mitigation. The report also demonstrates that, on average, investments in hazard mitigation measures that exceed provisions of the 2015 model building code can save the nation $4 for every $1 spent. The full report can be accessed through this link: http://www.nibs.org/page/mitigationsaves. For more information about loss avoidance in Missouri, see Section 7.4.2 Post-disaster Progress Assessment/Review of Mitigation Goals, Objectives, and Measures.

7.2.1 Process Used to Evaluate and Prioritize Mitigation Actions

This section explains the process used to evaluate and prioritize mitigation actions. Local jurisdictions are strongly encouraged to incorporate mitigation actions, based on established natural hazard risk assessments, into all proposed development projects and as improvements to existing projects.

Funding will always be an important issue when considering mitigation actions. Generally mitigation funds are limited to the Hazard Mitigation Assistance grants. These programs are the Pre-Disaster Mitigation Program, Legislative Pre-Disaster Mitigation Program, Flood Mitigation Assistance Program, and Hazard Mitigation Grant Program. SEMA also uses FEMA's Public Assistance Program (Categories C-G) to implement mitigation activities. All these grant programs are non-disaster (annually funded) grant programs except the HMGP and Public Assistance Program which are post-disaster programs. To fairly and efficiently utilize these grant programs to achieve mitigation across the State, a sound process has been developed to evaluate and prioritize proposed mitigation actions so that limited grant funds are used most effectively in Missouri.

SEMA has the primary responsibility for reviewing and evaluating mitigation projects submitted by local jurisdictions. The SRMT may also be involved in the event of a large disaster. Broadly, SEMA uses the STAPLEE (social, technical, administrative, political, legal, economic, and environmental) criteria in evaluating mitigation projects and the following criteria to rank mitigation actions:

1) Flood mitigation projects (repetitive loss properties high priority)
2) Tornadoes and high wind mitigation projects
3) Earthquake mitigation projects
4) Other, not direct life safety

STAPLEE is used as a screening tool to determine if the project makes sense and is worthy of consideration and implementation. During the 2018 update, SEMA utilized a modified STAPLEE scoring system to evaluate all state mitigation actions that were identified in the mitigation strategy. See Section 4.2.2 for a more detailed discussion.

Specifically, SEMA uses the following list of questions to help guide the distribution of mitigation project funds:

- What is the hazard to be mitigated?
- Does the applicant have a FEMA-approved mitigation plan?
- Does the project complement State and local mitigation goals and objectives identified in the mitigation plans?
- Is the hazard being mitigated a priority hazard in the applicant's mitigation plan?
- Is the project cost-effective based on FEMA's benefit-cost analysis module?
- Does the project have the potential to substantially reduce the risk of future damage, hardship, loss, or suffering that may result from a major disaster?
- Does the project result in mitigating flood damage to repetitive loss or severe repetitive loss properties?
- In the past, what mitigation efforts were undertaken by the applicant using local funds and initiatives and what were the outcomes?
- What is the applicant's disaster history?
- Are sufficient mitigation funds available to complete the project?
- Does the applicant have sufficient funds (if other funds are not available) to meet the local share of the project?
- Does the applicant have the capabilities to complete the project as submitted?
- Does the project independently solve a problem?
- Does the project have the potential to have a larger impact on the local and State mitigation program than other submitted projects?
- Does the project reduce impacts in an area experiencing growth and development pressures?
- Does the project have any negative impacts on neighboring communities?

With the implementation of RiskMAP, the mapped areas of mitigation interest (AoMI), and the tracking of mitigation actions, SEMA also places priority on projects that are identified within FEMA's Mitigation Action Tracker (or as a mitigation action in the hazard mitigation plan).

When funding comes from the Hazard Mitigation Grant Program (post-disaster funding), priority is given to mitigation projects related to the hazard that necessitated the disaster declaration and those jurisdictions included in the disaster declaration.

This plan does not differentiate or classify mitigation initiatives as primary or secondary. Mitigation initiatives will be evaluated and prioritized based on the criteria described above. Any mitigation project that is approved for funding is done so on the basis that it will benefit the community at large and, therefore, the State.

Information on this process is also included in Section 4.2.2 Process for Identifying, Evaluating, Prioritizing, and Updating Mitigation Actions and Section 5.3.2 Federal Project Grants.

As mentioned in Section 7.1.3 Integration with USACE Mitigation Programs and Initiatives, SEMA is working with the Silver Jackets to develop a Missouri Flood Buyout Strategy to guide the selection process for distribution of mitigation grant funding for acquisition/demolition projects. Experts from a variety of State and Federal agencies and local partners will work together to develop a buyout strategy that will identify a variety of selection factors, in addition to historic and potential flood damage, such as impacts to water quality, water quantity, local economy, and housing. Development of the Missouri Flood Buyout Strategy will begin in 2018.

7.2.2 Eligibility Criteria for Multi-hazard Mitigation Projects

This section of the plan addresses the eligibility criteria for multi-hazard mitigation projects. The criteria listed in this section are the basic criteria for each type of project. These criteria may be modified based on any of the following issues:

- The specific disaster situation
- Location of affected areas
- Availability of funds
- Unique program requirements of the fund source
- Current State and/or local hazard mitigation priorities
- Number/type of mitigation projects submitted by local governments

All hazard mitigation projects submitted for HMGP funding consideration must meet the criteria outlined in 44 CFR 206.434. To meet FEMA's minimum hazard mitigation project criteria, the project must:

- Be in conformance with the hazard mitigation plan developed as a requirement of Section 322
- Have a beneficial impact upon the designated disaster area, whether or not located in the designated area
- Be in conformance with 44 CFR 9, Floodplain Management and Protection of Wetlands, and 44 CFR 10, Environmental Considerations
- Solve a problem independently or constitute a functional portion of a solution where there is assurance that the project as a whole will be completed (projects that merely identify or analyze hazards or problems are not eligible)
- Be cost-effective and substantially reduce the risk of future damage, hardship, loss, or suffering resulting from a major disaster

The project must also meet the following State criteria:

- The project must complement existing or proposed State mitigation goals and objectives
- The project must complement existing or proposed mitigation goals and objects for the jurisdiction submitting the project
- The jurisdiction requesting the project must be able to complete the project as submitted
- The jurisdiction submitting the project must be able to meet any matching funds requirements (if required)
- The project must be able to make a bigger impact on the local and State mitigation program than other non-selected projects

The systems in place continue to work well; therefore, the 2018 update did not add or eliminate any of the eligibility criteria or alter the system for determining the cost-effectiveness of mitigation actions.

7.2.3 Eligibility Criteria by Mitigation Project Type

SEMA considers many types of projects to be eligible for mitigation, in particular the 11 "M" action categories identified in Section 4.2 Mitigation Actions. All projects must be in conformance with at least one of these mitigation action categories. Flood mitigation projects continue to be the State's highest priority, followed by tornado projects and finally earthquake projects. Among the actions that mitigate these hazards, those that provide for or protect life safety are given the highest priority.

Flood Mitigation Projects

In each type of flood mitigation project discussed below, homeowner participation must be voluntary and the homeowner must be able to prove ownership of the property involved in the project.

Property Acquisition

While buyouts are not the only mitigation projects considered and undertaken by the State and local governments, they have been the type of projects most frequently submitted and approved. Voluntary property acquisition is SEMA's most successful, and usually most cost-effective, mitigation project, because the people and property are totally and permanently removed from flooding danger.

In general, SEMA works with local governmental entities to acquire and remove, elevate, relocate, or perform minor structural projects on privately owned residential structures and/or privately owned lots that are located in the floodplain and/or floodway. In addition to the requirements listed in the previous section, these projects must also meet the following criteria:

- The project chosen must independently solve or be a functional part of a solution to a problem that is repetitive or poses a significant risk to health and safety. The proposed solution must be the most practical, effective, cost-effective, and environmentally sound alternative among a range of alternatives that contribute to a long-term solution of the problem.
- Local governmental entities (and certain private nonprofit entities) must apply through the State, specifically SEMA, to FEMA for funding to perform a project or projects. The applications must specifically identify the properties to be included in the project or projects. All projects must be proven cost-beneficial in accordance with a determination method that is acceptable to SEMA and FEMA (e.g., FEMA's benefit-cost analysis software).
- Local governmental/nonprofit entities must be in good standing in the National Flood Insurance Program (or have not yet been mapped) and otherwise eligible to receive federal funding. Nonfederal matches and all other federal grant requirements must be satisfied by the local

entity, sometimes with monetary assistance from local property owners or possibly SEMA or the Missouri Department of Economic Development.

- Hazard Mitigation Grant Program, Pre-Disaster Mitigation, and Flood Mitigation Assistance projects must be consistent with the Missouri State Hazard Mitigation Plan. Projects must also conform to 44 CFR 9, Floodplain Management and Protection of Wetlands, and 44 CFR 10, Environmental Considerations.
- Only local governmental/certain nonprofit entities, eligible special districts, or contractors representing these applicants may manage the project or projects. All projects must be managed in accordance with local, state, and federal ordinances, laws, and regulations. Individual property owners are not eligible to receive federal funds directly as an applicant or subapplicant and are not authorized to manage grant projects.

To be eligible to participate, the local governmental/nonprofit entity must agree to the following:

- The offer is based on pre-flood fair market value determined by a State board-certified appraiser or a post-flood sales contract value.
- Duplication of Benefits, Small Business Administration loans, and private mortgages must be satisfied from proceeds first.
- The buyout property must be demolished within 90 days of the closing.
- Local governmental entities, and certain nonprofit entities, must accept all buyout property titles, which are officially annotated to comply (in perpetuity) with federal open space deed restrictions. SEMA verifies that the appropriate restrictions have been put in place as part of the project closeout process.
- The buyout property becomes ineligible for any future federal disaster assistance, except possibly Federal Crop Insurance.

Currently, it is SEMA policy that there will be no acquisition of commercial properties due to the generally higher expense.

Elevation

Elevation is a voluntary option that may be used if it is the more cost-effective and desirable option in the long run (e.g., when the cost of the land is so high that a buyout is impractical). To be eligible to participate, the local governmental/nonprofit entity must agree to the following:

- The elevation project must be a practical, cost-effective, and structurally sound alternative (in compliance with local building code and zoning rules) that elevates the lowest floor to an elevation at or above the base-flood elevation (BFE, also equivalent to water surface elevation of the 1 percent or 100-year flood) or to an elevation that complies with local floodplain management regulations, if more stringent, by:
    - Extending the walls of the house upward and raising the lowest floor (where appropriate, such as within an area with a moderate or greater earthquake risk, SEMA adds multi-hazard stipulations, e.g., requiring shear walls as part of an elevation project).
    - Converting the existing lower area of the house to non-habitable space and building a new second story for living space.
    - Lifting the entire house, with the floor slab attached, and building a new foundation to elevate the house.
- In A zones, property owners may elect to elevate buildings either on fill, an open foundation, or on continuous foundation walls that extend below the base-flood elevation. If continuous walls

are used below the BFE, they must be equipped with openings that allow floodwaters to flow into and out of the area enclosed by the walls.

- Owners of substantially damaged homes in special flood hazard areas (SFHA) must be willing to relocate outside the SFHA, or voluntarily demolish the remnants of the house and build a new house on the same site with an elevated lowest floor at or above the BFE or at an elevation that complies with local floodplain management regulations, if more stringent.
- Alternatively, owners of substantially damaged houses in special flood hazard areas may elect to repair the house and elevate the lowest floor at or above the BFE or an elevation that complies with local floodplain management regulations, if more stringent, as part of the repair process.

Relocation

Relocation is a voluntary option that may be used if it is more practical/cost-effective or when the threat is so repetitive and/or severe that it is more advantageous to relocate a structure or structures, up to and including entire communities, entirely out of harm's way. Relocation is also an alternative to rebuilding following a declaration of substantial damage. To be eligible to participate, the local governmental/nonprofit entity must agree to the following:

- Structures relocated from acquired property must be placed entirely outside the 100-year floodplain
- Generally, structures must be relocated from acquired property within 90 days of closing
- Ownership of acquired property may not be conveyed to private citizens or entities; ownership may be conveyed to other public entities or nonprofit organizations with the approval of the State and FEMA
- Local governmental entities, and certain nonprofit entities, must accept all buyout property titles, which are officially annotated to comply (in perpetuity) with federal open space deed restrictions
- Any buyout property (i.e., any vacated lots acquired through the project) becomes ineligible for any future federal disaster assistance, except possibly Federal Crop Insurance

Floodproofing

Floodproofing is a voluntary option that may be most practical in limited areas. To be eligible to participate, the local governmental/nonprofit entity must agree that this measure will best remove the danger to the property. To be eligible, the following must apply:

- The property is in an area that is not subject to flash flooding
- Extensive cleanup normally is not required after a flood event
- One of the two floodproofing processes described below is the most advantageous measure to employ in the long run:
    - ***Wet floodproofing*** allows water to enter the structure, thereby equalizing pressure on walls and floors. Building contents such as furnaces and appliances are relocated out of reach of the floodwater.
    - ***Dry floodproofing*** is a process that uses waterproofing compounds, sheeting, or other impermeable materials to prevent floodwaters from entering the structure. To maintain consistency with National Flood Insurance Program regulations, FEMA will not fund dry floodproofing of residential structures. FEMA may fund dry floodproofing of commercial structures, but protection must be up to at least one foot above the BFE or an elevation that complies with local floodplain management regulations, if more stringent.

Structural Mitigation Projects

Structural mitigation projects are most often infrastructure type projects sometimes associated with FEMA's post-disaster Public Assistance (PA) program. To be eligible for funding for structural mitigation projects, a jurisdiction and the project must meet all of the criteria of the federal/state public assistance program. Those criteria include, but are not limited to, the following:

- The project is required as a result of the declared event
- The project is within the designated disaster area
- The project is the legal responsibility of an eligible applicant

When these stipulations are met, a community can incorporate improvements into the repair or replacement of a damaged facility (e.g., replace a damaged culvert with a larger one, as long as it can be demonstrated to be technically feasible, cost-effective, and environmentally sound). There are other types of structural flood mitigation projects that can be promoted and encouraged in addition to those achieved through the PA program. For example, structural flood mitigation projects such as drainage improvements or low-water bridge crossings don't require a disaster declaration or damage to a specific facility.

Tornado Mitigation Projects

In addition to the relevant requirements for flood mitigation projects, tornado safe rooms and other similar mitigation measures that protect people from tornadoes and high winds, must comply with FEMA publications *Taking Shelter from the Storm: Building a Safe room Inside Your House* (320) and *Design and Construction Guidance for Community Shelters* (361). Only eligible construction-related costs will be reimbursed by FEMA.

Earthquake and Other Mitigation Projects

The majority of Missouri's approved mitigation projects have resulted from flood-related disasters. The recent frequency of tornadoes has made tornado safe room projects the next most frequent type of mitigation project sought. Other projects listed below may also be approved depending on the availability of funds, state and local priorities, and proof of benefit-cost and project submissions:

- Burial of power lines underground
- Structural seismic retrofit of undamaged critical facilities
- Nonstructural seismic retrofit of undamaged critical facilities (such as filming windows, strapping and bracing equipment, etc.)
- Development of educational programs and materials
- 5% State Initiative Projects

SEMA promotes a project identification framework from the NFIP's CRS. The following six types of mitigation categories emphasize flood solutions; however, they can also be applied to other natural hazards:

- Local Plans and Regulations
- Structure and Infrastructure Projects
- Natural Systems Protection
- Education and Awareness Programs

7.2.4 Pre-Project Determination of Cost-Effectiveness of Mitigation Measures

A key criterion for mitigation projects to be eligible for funding is that they must be cost-effective. If the project benefits are higher than the project costs, then the project is cost-effective. The purpose of this section is to address the process used by the State to determine the cost-effectiveness of mitigation actions. The only change to this process since the 2007 Mitigation Plan update is the utilization of FEMA's updated benefit-cost analysis software. Other than incorporating the updated software, changes to the process to determine cost-effectiveness of mitigation measures has not changed since the 2007 Mitigation Plan update.

In order to ensure a consistent approach in determining the cost-effectiveness of all mitigation projects, the State uses FEMA's BCA module and process, which is consistent with OMB Circular A-94, *Guidelines and Discount Rates for Benefit-Cost Analysis of Federal Programs*. Since this is the method developed and used by FEMA to determine the cost-effectiveness of a project, it is reasonable for the State to use the same method. A BCA assesses a mitigation project based on the project, hazard, and benefit data provided in a grant application. SEMA encourages applicants to pre-screen their proposed mitigation projects by using an upper-bound analysis, so an early determination of cost-effectiveness can be made. Upper-bound analyses are also used to identify projects that are not cost-effective.

SEMA organizes annual grant mentoring workshops, one for each grant cycle, to help local governments develop Hazard Mitigation Assistance subrecipient applications, benefit-cost analyses, and eGrant (Electronic Grant Application) applications. This includes the non-disaster (annually funded) grant programs of PDM, FMA, and the post-disaster grant program – HMGP. The workshops assist local governments and RPC planners with their applications. In October 2013 and May 2015, SEMA held two-day BCA workshops.

It is understood that a positive benefit-cost ratio (greater than one) does not necessarily guarantee that a hazard mitigation project will be approved. However, by applying project specific information to the benefit-cost analysis module it is possible to get a good look at the mitigation potential associated with a project. The results of this analysis can also help communities evaluate current and future mitigation projects and adjust their overall mitigation strategy accordingly.

The following information serves to summarize the three-step process for determining a mitigation project's cost-effectiveness. This process is used for determining the cost-effectiveness of all HMA project applications regardless of the type of mitigation measure.

1) Screen Project Application Data

The first part of the process is screening the project application to gather data related to cost-effectiveness. This includes economic, environmental, and engineering data. This data is often missing or limited. The amount of data available will determine the type of benefit-cost analysis used. The screening process involves three separate but related tasks. Each task is conducted simultaneously and is essential to developing an overall profile of the project before conducting the benefit-cost analysis.

- **Engineering Review**—This review, conducted by the applicant, establishes whether the project is feasible from an engineering standpoint and whether it will reduce damage as claimed. The reviewer may suggest changes to make the project more efficient in reducing damage and loss.
- **Environmental Assessment**—This part of the screening process alerts reviewers to any potential environmental concerns raised by the project.
- **Project Application Data Review**—This part of the screening process determines whether the application contains sufficient information and data for input into the benefit-cost model.

Table 7.6 shows the basic data that must be obtained from hazard mitigation applications before a benefit-cost analysis can be performed. This data is plugged into the benefit-cost module to determine whether the project is cost-effective or not. The examples below are key data used for analyzing flood, tornado, and earthquake hazard mitigation projects. Nevertheless, the same basic information and analysis is needed for mitigation projects related to any type of hazard.

Table 7.6. Key Data Needed for Analyzing Project Applications

Subject	Flood Project Data	Tornado Safe room Project	Earthquake Project Data
Hazard Data (often not included in application)	Flood insurance study data or historical flood data from application	Windspeed Zone	Seismic hazard data from a credible source
First Floor Elevation	Is this available from engineering surveys or can it be estimated from observed flood depths?	Not applicable	Not applicable
Scope	What problem does the project address? How vulnerable is the building, item, or area?	Same as flood	Same as flood
Cost	Is there a well-documented cost-estimate or only a rough estimate?	Same as flood	Same as flood
Useful Lifetime	How long will the project provide protection (mitigation) against damage and losses?	Same as flood	Same as flood
Economic Considerations	What is the square footage of the building? What are the replacement values of the building (or other facility) and contents?	Not applicable	Same as flood
Occupancy	Not usually applicable	Occupancy by hour	What are the levels of occupancy and visitors during various times throughout the day?
Function	What is the function of the facility and is it entirely or partially related to emergency response and recovery?	Same as flood	Same as flood
Damage Estimates—Before Mitigation	➢ What type of building is it? ➢ Why does damage occur? ➢ What is the historically-observed damage?	Not applicable (life safety mitigation)	➢ Same as flood ➢ Are engineering reports available that describe building/ facility seismic vulnerabilities?
Damage Estimates—After Mitigation	How effective will the mitigation project be in reducing future damage? (Reduced damage can be percent or dollar values)	Not applicable (life safety mitigation)	Same as flood

2) Conduct a Benefit-Cost Analysis

The second part of the process is determining which benefit-cost analysis tool to use. Ideally, the project application contains all the data needed. However, project applications often have incomplete or limited data. This is one of the main reasons that a streamlined process was developed to determine project cost-effectiveness without all data included. It is also the reason that federal, state, and local mitigation specialists must work closely together to ensure that all proposed mitigation projects are thoroughly reviewed and comply with the mitigation goals and objectives. For applications that don't have all required information, because some required information may not exist or be available, FEMA has developed several shortcuts that allow a benefit cost analysis to be conducted with limited information.

Screening the project data (step 1) helps determine which type of analysis to perform. If the project application data are limited or incomplete, then a benefit-cost analysis that uses limited data should be employed. If, however, the data in the project application are more or less complete, then a more robust method of analysis can be used.

A Benefit-cost analysis must be used for all cost-effectiveness determinations. At its most basic level, benefit-cost analysis determines whether the cost of investing in a mitigation project today (the "cost") will result in sufficiently reduced damage in the future (the "benefits") to justify spending money on the project. If the benefit is greater than the cost, then the project is cost-effective; if the benefit is less than the cost, then the project is not cost-effective. The benefit-cost ratio (BCR) is a way of stating whether benefits exceed projects costs, and by how much. It is figured by dividing the benefits by the costs. If the result is 1.0 or greater, then the project is cost-effective.

Example 1: The project cost is $1,000, and the value of damage prevented after the mitigation measure is $2,000. The BCR ($2,000/$1,000) is 2.0. Because the dollar value of benefits exceeds the cost of funding the project, and the BCR is greater than 1.0, the project is cost-effective.

Example 2: The project cost is $2,000, and the value of damage prevented after the mitigation measure is $1,000. The BCR ($1,000/ $2,000) is of 0.50. Because the cost of funding the project exceeds the dollar value of the benefits, and the BCR does not meet the 1.0 required for cost-effectiveness, the project is not cost-effective.

While these examples are oversimplifications, the process and the associated benefit-cost analysis calculations are basically the same for all mitigation projects. It is important to understand that benefit-cost analysis is essentially the same for each type of hazard mitigation project. The only differences are the types of data that are used in the calculations. The types of data depend on whether the project is for floods, tornadoes, or earthquakes.

Three approaches are used to determine a project's benefit-cost ratio: lower-bound analysis, upper-bound analysis, and best estimate. The lower-bound and upper-bound methods are used in many cases to make final determinations of cost-effectiveness when there is limited data. In other cases, quick screening analysis with these approaches yields inconclusive results and additional data and screening may be required. Best estimate analysis produces the most accurate results.

Lower-Bound Analysis

Lower-bound analysis is a powerful tool that can demonstrate that projects are cost-effective even if the available data is not complete. A project's cost-effectiveness can sometimes be determined by using only one or two key pieces of data. The lower-bound analysis was developed with this in mind.

The lower-bound analysis considers only some of a project's benefits (those that are the most important or those for which data exist) and ignores other benefits that may be difficult to estimate or for which data may not be available. In other words, this analysis purposely uses only a few pieces of information and undercounts, or ignores other benefits that may be gained by implementing the project. If results indicate that a project is cost-effective, then no further analysis is needed and no additional data has to be collected.

Lower-bound analysis at a glance:

- It should be used when data is incomplete
- It can determine that a project is cost-effective
- It cannot determine that a project is not cost-effective
- It uses data for one or two significant benefits

Upper-Bound Analysis

If a lower-bound analysis shows that a project is not cost-effective, then the next step is an upper-bound analysis. Sometimes an upper-bound analysis is used if, at first glance, the project appears not to be cost-effective. Like lower-bound analysis, upper-bound analysis relies on limited project data. Upper-bound analysis, however, also uses professional judgment to estimate which input data produce the highest reasonable benefits.

It is extremely important to note that upper-bound analysis cannot determine if a project is cost-effective because it relies on the highest reasonable estimate of benefits. An upper-bound analysis can only determine whether the project BCR is less than 1.0 and thus not cost-effective.

Upper-bound analysis at a glance:

- It can only determine that a project is not cost-effective
- It is used as the next step if the lower-bound analysis is negative (not cost-effective)
- It is used if a project appears, at first glance, unlikely to be cost-effective
- It uses the highest reasonable estimate of benefits for a project
- It analyzes as many inputs as possible, assigning the highest reasonable value to each

Best Estimate Analysis

A best estimate analysis is used when the project application data is complete, or almost complete. This analysis provides a more accurate BCR than either lower- or upper-bound, because it considers more data in the analysis. As discussed earlier, in many cases lower-bound or upper-bound analysis can provide firm decisions about cost-effectiveness without requiring as much data as a best estimate analysis.

A best estimate analysis can determine if a project is either cost-effective or not, because all significant data are considered. Because this method of benefit-cost analysis provides the best estimate of cost-effectiveness, it can be used to rank or set priorities among competing projects. Neither lower-bound nor upper-bound analysis are used to rank or set priorities among projects. They do not consider enough data to determine accurate BCRs; they only produce “bounds” on BCRs (i.e., BCR > 1.0 or BCR < 1.0).

Best estimate analysis at a glance:

- It should be used when the project application data is complete, or almost complete
- It produces a more accurate analysis than lower-bound and upper-bound analyses
- It determines whether a project is cost-effective or not cost-effective
- BCR can be used for ranking or setting priorities among projects

3) Review the Results of Benefit-Cost Analysis

The final step of the review process is to determine whether a project is cost-effective or whether further analysis is required. There are three possible outcomes to a benefit-cost analysis: the project is deemed cost-effective (BCA > 1.0), the project is deemed not cost-effective (BCA < 1.0), or additional data may be required.

Typically, if the project is cost-effective as determined by a lower-bound or best estimate analysis, then no further analysis or additional data collection is required. Then the application moves to the next level in the funding process. If the project is not cost-effective as determined by an upper-bound or best estimate analysis, then no further analysis or additional data collection is required and the project is rejected. In some cases, additional information may be requested, or the applicant may be shown how the mitigation effort can be redirected. In general, for the Pre-Disaster Mitigation grant program, it is an advantage to maximize benefits (e.g., BCA > 1.0) to make the application more competitive.

If the cost-effectiveness of a project cannot be determined, then additional data must be collected. It is important to recognize that only the minimum data necessary to reach a decision on project cost-effectiveness must be collected. In many cases, the collection of one or two pieces of information is sufficient to reach a decision. A complete analysis is conducted for those relatively few cases where the BCA is close to 1.0.

7.3. Program Management Capability

> **Requirement §201.5(b)(2) (iii A-D): [The enhanced plan must demonstrate] that the state has the capability to effectively manage the HMGP as well as other mitigation grant programs, [and provide] a record of the following:**
>
> **a) Meeting HMGP and other mitigation grant application timeframes and submitting complete, technically feasible, and eligible project applications with appropriate supporting documentation;**
> **b) Preparing and submitting accurate environmental reviews and benefit-cost analyses;**
> **c) Submitting complete and accurate quarterly progress and financial reports on time; and**
> **d) Completing HMGP and other mitigation grant projects within established performance periods.**
>
> **Requirement §201.4(c)(5)(i): [The standard state plan maintenance process must include an] established method and schedule for monitoring, evaluating, and updating the plan.**
>
> **Plan Update Requirement §201.4(d): Plan must be reviewed and revised to reflect changes in development, progress in statewide mitigation efforts, and changes in priorities.**

7.3.1 State Capability for Hazard Mitigation

Since Section 322 of the Disaster Mitigation Act of 2000 provides for a significant increase in Hazard Mitigation Grant Program (HMGP) funding available to the State, it is critical that the State demonstrate its ability to manage the HMA grants and its commitment to mitigation.

The following factors were initially developed by FEMA for considering a state for “managing state” status. Missouri meets all of these requirements and was initially designated as a “managing state” for hazard mitigation in February 2001. SEMA’s HMA grant management performance from 2013 through 2017 is also summarized in **Table 7.7.**

Past Performance of the State

Grant Application Submittals

Following receipt of letters of notification, SEMA reviews subapplicant HMA proposals that include a brief project description, location, work schedule, cost estimate, and explanation of how the project solves a problem. Initial eligibility is determined by SEMA (See Section 7.2.2) and eligible project applications are then accepted.

Upon receipt of each full application the Mitigation Management Section reviews the submitted documents to ensure that adequate information has been provided and that the projects will meet the minimum criteria as defined by 44 CFR Part 206.434. Priority is given to flood mitigation, tornado/severe wind, and earthquake mitigation projects located in the declared counties.

Following the review and any site visits deemed necessary, the Mitigation Management Section conducts final preparation of the selected applications for submittal to FEMA. SEMA submits selected applications to FEMA Region VII in the order that they are received and reviewed. All HMGP applications are submitted to FEMA through the National Emergency Management Information System (NEMIS) within 12 months from the date of the disaster declaration. ALL FMA and PDM applications are submitted to FEMA through the eGrants system within the application cycle which typically runs from August to November each year.

<u>Grant Application Selection and Prioritization</u>

In the previous years, a committee, appointed by the Governor, selected, coordinated, and managed the residential buyout projects of 1993, 1994, and 1995. The wisdom in this multi-agency approach can be found in the results. Six months after funding became available, all projects were approved and one project was completed. Similarly, after flooding in 2008, the Governor called together a steering committee to re-emphasize flooding awareness with a subcommittee comprised of state agencies with resources for flood response and mitigation. For additional description of successful multi-agency coordination, see the description of the Silver Jackets Program that followed the 2008 flood event in Section 7.3.2 Mitigation Success.

As noted in Section7.1.3, SEMA is currently working through the Silver Jackets Program to develop a Missouri Flood Buyout Strategy to guide the selection process for distribution of mitigation grant funding for acquisition/demolition projects. The developed buyout strategy will identify a variety of selection factors, in addition to historic and potential flood damage, such as impacts to water quality, water quantity, local economy, and housing. The strategy will rank the identified factors and allow the state to better reduce risk through identifying and prioritizing the most flood prone, highest risk properties for buyouts across the state.

Smaller mitigation projects are coordinated with the agencies responsible for environmental approvals, partial funding, or other projects with similar objectives, stakeholders, or locations, such as the Departments of Economic Development, Conservation, Natural Resources, and Transportation; the U.S. Army Corps of Engineers; and others as the situation dictates. This practice will continue with a more formal body used in the event that large project opportunities are presented.

Accurate Environmental Reviews and Benefit-Cost Analyses

SEMA and State agency partners work together to prepare environmental documentation and conduct benefit-cost analyses. This is further proven by the roles of the Department of Natural Resources and the Department of Conservation in providing environmental documentation to ensure compliance with the National Environmental Policy Act. The Department of Natural Resources' State Historic Preservation Officer (SHPO) coordinates with SEMA on all mitigation projects to ensure that any and all historic preservation concerns are recognized and addressed. The Department of Conservation is consulted to ensure compliance with the Endangered Species Act.

Until recently, SEMA performed benefit-cost analyses for all hazard mitigation grant applications. Since the 2004 plan, the RPCs and the local governments have all been offered training on FEMA's BCA software at least once annually and many are now capable of performing the required benefit-cost analysis to be submitted with HMA grant applications. SEMA continues to provide technical assistance regarding BCAs, but only for communities that do not have the capability to do it themselves. SEMA also reviews all benefit-cost analysis results during the project eligibility time frame.

All current SEMA mitigation staff members have received formal FEMA benefit-cost training and use the software on a regular basis to keep knowledge and skills current.

Quarterly Progress and Financial Reports

Missouri's Hazard Mitigation Grant Program (HMGP) Administrative Plan, quarterly reporting system, and HMGP applications have all been used as models for other states as well as FEMA headquarters. The Hazard Mitigation Grant Program Administrative Plan developed by SEMA in 1995 was one of the first procedural plans developed that addressed additional elements not required by the Code of Federal Regulations. In addition, Missouri's standard HMGP buyout application and quarterly reports were requested by FEMA headquarters to use as the National Emergency Management Information System standard.

Missouri consistently provides quarterly reports on time. Missouri maintains a record for meeting all HMA grant application timeframes, utilizing allowed and approved extensions only when necessary. When extensions to timeframes are deemed necessary or critical, the State has consistently requested such extensions prior to lapse of initial timeframes.

Recently in 2016, SEMA was commended by the Mitigation Division Director from FEMA Region VII regarding quarterly reporting:

> *We want to commend you [the SEMA Mitigation Management Section] and your staff on an outstanding job submitting Quarterly Progress Reports. This is a major metric tracked by our HQ Office of Chief Financial Officer Field Based Operations. Region VII leads the nation in these metrics, but what is more impressive is MO is one of two states nation-wide receiving perfect scores in the three graded areas. Your staff scored 100% in Timeliness, Completeness and Reasonableness … Well done and appreciate the teamwork!*
>
> Michael R. Scott, CEM
> Mitigation Division Director
> FEMA Region VII, Kansas City, MO

Grant Project Completion

Prior to 2002, Missouri used mitigation funding for buyouts, elevations, and relocations; however, the nature of hazards in Missouri and types of mitigation projects broadened. Flood mitigation remains a priority, but changes in threats required SEMA to broaden its perspective in mitigation projects. Since the last State plan update in 2013, the State has successfully completed 18 flood buyout projects, 62 tornado safe room projects, two low water crossing projects, 10 siren and generator projects, and five mitigation planning projects. All projects were completed within the performance period including all financial reconciliations.

Table 7.7. Summary of HMA Grant Management Performance

HMA Grant Management Performance Activities	Enhanced Plan Review Element	FY2103	FY2014	FY2015	FY2016	FY2017
All applications and amendments were submitted by the end of each program's respective application period.	E6.a	100%	100%	100%	100%	100%
All applications were entered into FEMA's electronic data systems (such as, NEMIS and/or eGrants).	E6.b	100%	100%	100%	100%	100%
Eligibility and completeness checklists were prepared for all applications.	E6.c	100%	100%	100%	100%	100%
All applications were determined to be complete by FEMA within 90 days of submittal or selection for further review.	E6.d	100%	100%	100%	100%	100%
All applications and amendments … included all data requested by FEMA to support cost effectiveness determinations and environmental/ historic preservation compliance reviews.	E7	100%	100%	100%	100%	100%
All progress reports were submitted complete and on time.	E8.a	100%	100%	100%	100%	100%
All Federal financial reports (FFR), Standard Form (SF) SF-425 were submitted on time.	E8.b	100%	100%	100%	100%	100%

HMA Grant Management Performance Activities	Enhanced Plan Review Element	FY2103	FY2014	FY2015	FY2016	FY2017
State consistently complied with the Financial Management Standard requirements described in 2 CFR §§200.300 to 200.309.	E8.c	100%	100%	100%	100%	100%
All work as part of HMA subawards was completed by the end of Period of Performance.	E9.a	100%	100%	100%	100%	100%
There were no major findings on single audits obtained by the state related to HMA programs.	E9.b	✓	✓	✓	✓	✓
All grant close-out activities, including financial reconciliation, were completed within 90 days from the end of the performance period.	E9.c	100%	100%	100%	100%	100%
Actual expenditures have been documented and are consistent with SF-424A or SF-424C.	E9.d	100%	100%	100%	100%	100%

Adequate and Experienced Staff at Both the State and Regional Level

The Mitigation Management Section's permanent full-time staff includes the state hazard mitigation officer, the deputy state hazard mitigation officer, two hazard mitigation specialists, and one clerical assistant. The hazard mitigation specialists provide technical assistance to local jurisdictions regarding planning issues and mitigation project development. All staff have attended FEMA-training on local Hazard Mitigation Planning. In addition, the State uses an area coordinator system for emergency planning. These nine area coordinators have been instrumental in dealing with communities on a one-on-one basis.

All staff members are proficient in their technical skills. To ensure consistency and smooth transitions, great care has been taken to ensure that all staff members are cross-trained and receive appropriate FEMA training. The Mitigation Management Section has directly administered over $100 million in HMA grant funding since 1993. All current staff members have received formal benefit-cost analysis training. Three staff members have taken the FEMA grants management and NEMIS training. All staff members have attended several all-hazard mitigation workshops or state hazard mitigation officer training courses.

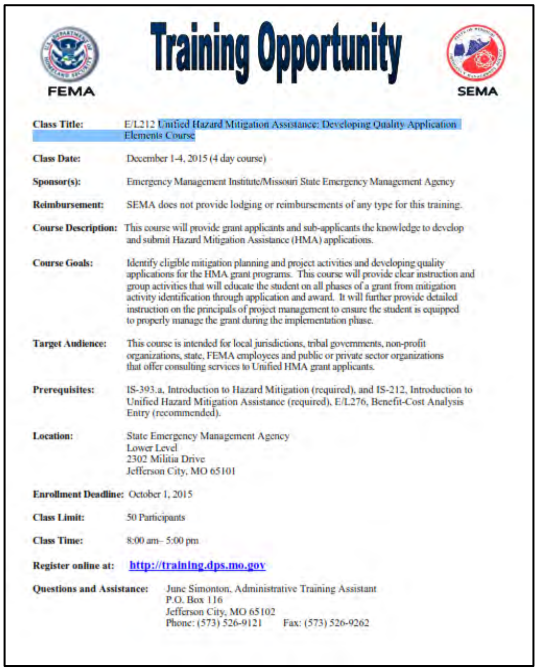
Newly hired staff will receive direct training either from existing staff or through partnerships with other state hazard mitigation officers and will attend formal FEMA training as appropriate. See Section 6 for further descriptions of staff responsibilities.

Commitment to Training by the State and FEMA

All current SEMA mitigation staff members have received formal benefit-cost analysis training. Additional staff members have taken the FEMA grant management and NEMIS training. All staff members have attended several all-hazard mitigation workshops or state hazard mitigation officer training efforts.

Newly hired staff will receive direct training either from existing staff or through partnerships with other state hazard mitigation officers and will attend formal FEMA training as appropriate.

Training for local units of government before and following an HMA award is ongoing. Formality depends on the needs of the community. Currently, SEMA offers annual training on basic mitigation planning, Pre-Disaster Mitigation grant applications, and using FEMA's BCA software. Additional training is offered as new training or software modules are released by FEMA.



FEMA Training Opportunity SEMA

Class Title:	E/L212 Unified Hazard Mitigation Assistance: Developing Quality Application Elements Course
Class Date:	December 1-4, 2015 (4 day course)
Sponsor(s):	Emergency Management Institute/Missouri State Emergency Management Agency
Reimbursement:	SEMA does not provide lodging or reimbursements of any type for this training.
Course Description:	This course will provide grant applicants and sub-applicants the knowledge to develop and submit Hazard Mitigation Assistance (HMA) applications.
Course Goals:	Identify eligible mitigation planning and project activities and developing quality applications for the HMA grant programs. This course will provide clear instruction and group activities that will educate the student on all phases of a grant from mitigation activity identification through application and award. It will further provide detailed instruction on the principals of project management to ensure the student is equipped to properly manage the grant during the implementation phase.
Target Audience:	This course is intended for local jurisdictions, tribal governments, non-profit organizations, state, FEMA employees and public or private sector organizations that offer consulting services to Unified HMA grant applicants.
Prerequisites:	IS-393.a, Introduction to Hazard Mitigation (required), and IS-212, Introduction to Unified Hazard Mitigation Assistance (required), E/L276, Benefit-Cost Analysis Entry (recommended).
Location:	State Emergency Management Agency Lower Level 2302 Militia Drive Jefferson City, MO 65101
Enrollment Deadline:	October 1, 2015
Class Limit:	50 Participants
Class Time:	8:00 am– 5:00 pm
Register online at:	http://training.dps.mo.gov
Questions and Assistance:	June Simonton, Administrative Training Assistant P.O. Box 116 Jefferson City, MO 65102 Phone: (573) 526-9121 Fax: (573) 526-9262

The schedule of training that SEMA provided for mitigation planning and HMA grants since 2015 is provided below:

- 2015
  - BCA Training (2-day)
  - L212 Workshop Unified Hazard Mitigation Assistance: Developing Quality Application Elements Course
  - Individual Technical Assistance
  - Grant manager assigned to each subapplicant for application period to project completion.
- 2016
  - P-361 Workshop - Design and Construction Guidance for Safe Rooms
  - Individual Technical Assistance
  - Grant manager assigned to each subapplicant for application period to project completion.
- 2017
  - Individual Technical Assistance
  - Grant manager assigned to each subapplicant for application period to project completion.

State and Regional Relationship

The relationship between the State and FEMA Region VII has always been maintained in an open, professional manner.

Demonstrated Relationship between the State and Local Governments

Throughout the extensive voluntary buyout program and for all mitigation projects, the State has operated on a basic principle—centralized planning with decentralized execution. To the extent that local governments can manage projects, they are allowed to do so. However, compliance with established procedures, priorities, and "safe guard measures" is required. Local governments have been vocal in their enthusiastic support for this approach. SEMA is routinely told that they provide local governments with exactly what they need to be successful.

7.4. Assessment of Mitigation Actions

Requirement §201.5(b)(2) (iv): The enhanced plan must document the system and strategy by which the state will conduct an assessment of the completed mitigation actions and include a record of the effectiveness (actual cost avoidance) of each mitigation action.

This section explains how the State assesses the effectiveness of mitigation projects, both pre- and post-disaster. Also explained is how SEMA has improved their ability to monitor and track each completed project and potential losses avoided since development of the original plan in 2004.

7.4.1. Annual Progress Assessment/Review of Mitigation Goals, Objectives, and Measures

In order for any program to remain effective, the goals and objectives of that program must be reviewed periodically. The Missouri State Hazard Mitigation Plan is reviewed annually. This provides the simplest, direct and ongoing methodology for assessing and reviewing mitigation goals, objectives, and actions. At a minimum, the review addresses the following issues:

- Are the established goals and objectives realistic? (Take into consideration available funding, staffing, and state/local capabilities, and the overall state mitigation strategy.)
- Has the State clearly explained the overall mitigation strategy to local governments?
- Are proposed mitigation projects evaluated based on how they help the State and/or local government meet their overall mitigation goals and objectives?
- How have approved mitigation projects complemented existing State and/or local government mitigation goals and objectives?
- Have completed mitigation projects generated the anticipated cost avoidance or other disaster reduction result?

For the 2018 update, the SRMT reconsidered the validity of the goals and objectives of this mitigation plan and of the State mitigation program. This is detailed in Section 4.1 Hazard Mitigation Goals and Objectives. The SRMT decided to maintain the current goals and objectives as they are considered to remain valid and applicable in guiding the mitigation strategy of the State.

The overall mitigation strategy is clearly communicated to local governments throughout the year and is an ongoing process. The strategy is explained through SEMA mitigation training and workshops (BCA, HMA, mitigation planning) and at annual meetings of the Missouri Emergency Preparedness Association, the Missouri Floodplain and Stormwater Managers Association, and the Missouri Association of Councils of Governments.

In order to earn SEMA approval, mitigation projects must complement the overall mitigation strategy of the State as well as the applicable local government. This is included in the list of questions to help guide the distribution of mitigation project funds detailed in Section 5.3.2 Federal Project Grants.

How SEMA determines whether or not completed mitigation projects generate the anticipated loss avoidance or other disaster reduction result is explained in Section 7.4.2 Post-disaster Progress Assessment/Review for Mitigation Goals, Objectives, and Measures.

Finally, the Mitigation Management Section of SEMA furthers this programmatic progress assessment through the ongoing tracking of:

- Mitigation activities during the past year
- Mitigation grants in progress, including

- Affected jurisdiction
  - Brief description of the project
  - Project cost
  - Source of funding
  - Summary of project status (percent complete)
- Executed mitigation grant support contracts
- Floodplain management activities during the past year, including
  - NFIP statewide statistics
  - NFIP training activities conducted

All of the above information is captured in SEMA's fiscal year annual report.

It may be difficult to determine the actual loss avoidance and effectiveness of many mitigation projects during project development. Initially, the potential impact of mitigation projects and initiatives can only be estimated. However, based on past experience with similar projects, SEMA can make an educated determination as to the potential for success of the proposed mitigation project.

Based on the results of this information and the annual review, the State considers making adjustments to its goals, objectives, and actions to meet the current and future mitigation needs of the State and its local governments.

7.4.2. Post-disaster Progress Assessment/Review of Mitigation Goals, Objectives, and Measures

Following a hazard event, SEMA mitigation staff query local officials to document how mitigation actions instituted in the affected areas reduced the amount of damage or loss of life that could have resulted from an event. SEMA has updated this query process and formalized loss avoidance documentation through a newly-developed web-based tool which follows the loss avoidance methodology developed by FEMA.

FEMA developed the loss avoidance methodology to evaluate the effectiveness of mitigation projects based on the analysis of actual events. This methodology can be applied to the mitigation of any type of natural hazard. Losses avoided are determined by comparing the damage that would likely have been caused by the same storms without the project (Mitigation Project Absent, MP_A) with damage that actually occurred with the project in place (Mitigation Project Complete, MP_C). There are three phases of the general methodology for loss avoidance studies:

1) Initial Project Selection
2) Project Effectiveness Analysis
3) Loss Estimation Analysis

Phase 1 focuses on the selection of the completed project area to be included in the loss avoidance study. Structures are screened based on the availability of data required for completion of the study. This includes actual project costs, construction completion dates, first floor elevations, structure location information, and structure information, including the type, basement information, number of floors, square footage, and building replacement value. Structures with adequate data advance to Phase 2.

Phase 2 includes a storm event analysis, to determine whether a post-construction storm event is severe enough to have caused damage if the project had not been completed (MP_A scenario), and a hazard analysis, to determine the impact of the hazard event (e.g., depth of flooding) at the mitigation project location.

Phase 3 includes two steps. First, an economic evaluation of the project scope is completed for both the MP_A and MP_C scenarios for each hazard event analyzed. The difference between the total losses for the two scenarios is calculated and losses avoided are determined. Second, the return on investment (ROI) is assessed by comparing the losses avoided to the total project investment.

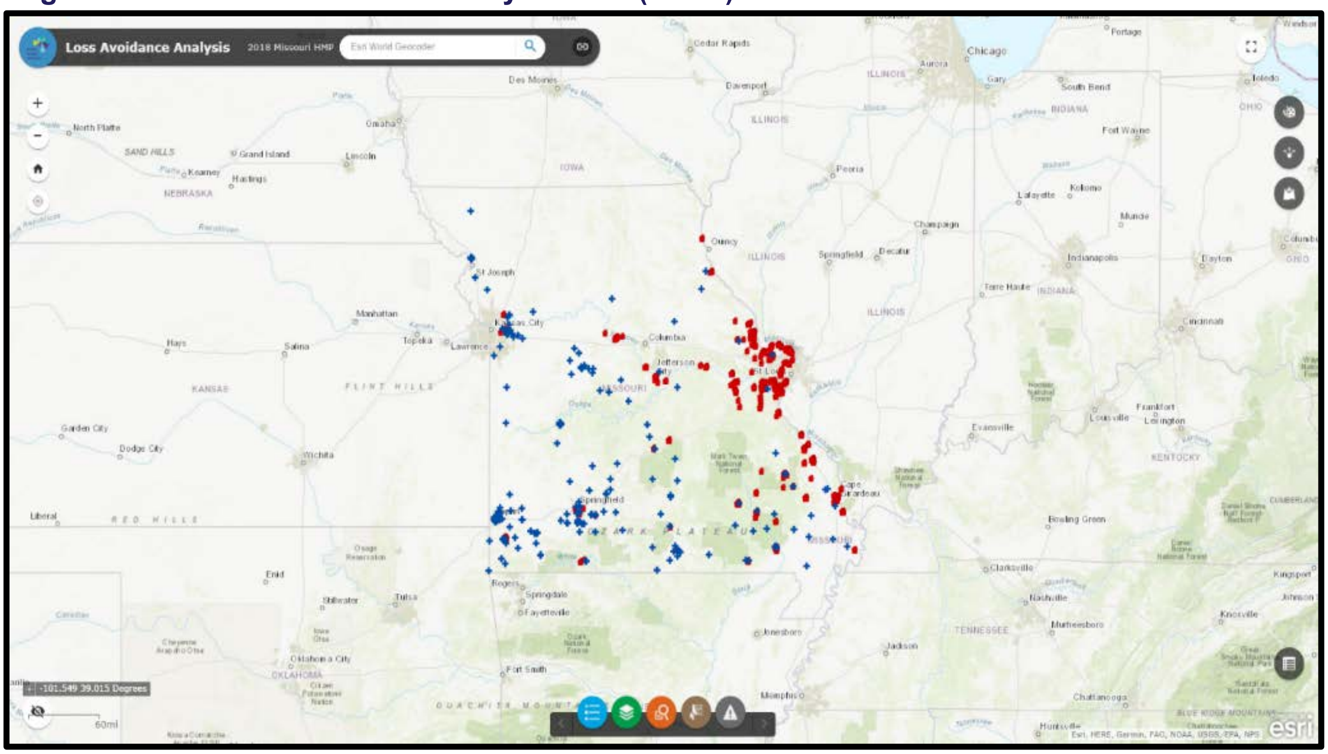
For the 2018 State Plan Update, SEMA has developed a web-based, loss avoidance analysis tool (LAAT) to assist SEMA staff and local officials collect and store the data necessary to complete a loss avoidance study following a hazard event.

Loss Avoidance Analysis Tool (LAAT)

The web-based, loss avoidance analysis tool (LAAT) is a database of the structural data necessary to complete Phase 1 of a loss avoidance study and is a data collection tool for the storm event data necessary to complete Phase 2 of a loss avoidance study. The LAAT website can be accessed here: http://bit.ly/SEMA_LossAvoidance. A User Guide has been prepared for the LAAT website and is included as Appendix E.

Step 1: Initial Project Selection – For all completed mitigation projects within the State, the LAAT database has been populated with project details as included in the approved grant application and project closeout documents. This includes actual project costs, construction completion dates, first floor elevations, and structure information. Additionally, the FEMA Corps was in the process of improving the latitude and longitude data for each acquisition site, at the time of the 2018 State Mitigation Plan Update. Once completed, this data will be incorporated into the LAAT. Figure 7.5 presents the LAAT website showing the tornado safe room locations in blue and residential buyout locations in red.

Figure 7.5. Loss Avoidance Analysis Tool (LAAT) Website



Each mitigation project has also been spatially located based upon the street address or latitude/longitude, as either obtained from the project grant application or field located with GPS. Efforts to map completed buyouts prior to 2002 have proven difficult because communities have combined parcels and lots into combined open spaces, streets and addresses no longer exist (as a result of the buyouts), and legal property descriptions are not accurate enough to pinpoint precise locations.

Those mitigation projects with limited structural or location data are included in the LAAT database, but will not move forward to Phase 2 and be utilized in a loss avoidance study.

The LAAT database may be updated at any time to include additional project information. For future mitigation projects, the structure data necessary to complete Phase 1 of a loss avoidance study will be entered by SEMA staff upon project completion and closeout.

Step 2: Project Effectiveness Analysis – Because a loss avoidance study measures benefits of a completed project based upon an actual event, the local official will be tasked with completing the storm event data collection form following a hazard event within their community or SEMA staff can add this information easily to any reports resulting from disaster declarations. The user can spatially select those mitigation projects within the hazard event area and do a simple export to show the calculated loss avoidance. **Figure 7.6** displays the Operational Tools available on the website. **Figure 7.7** shows the Add Data Tool options. Users can either upload a project area shapefile or simple draw an area of interest to use for the analysis as shown in **Figure 7.8**, respectively. The user can also share the data from the analysis with others as shown in **Figure 7.9**.

Figure 7.6. LAAT Website – Operational Tools

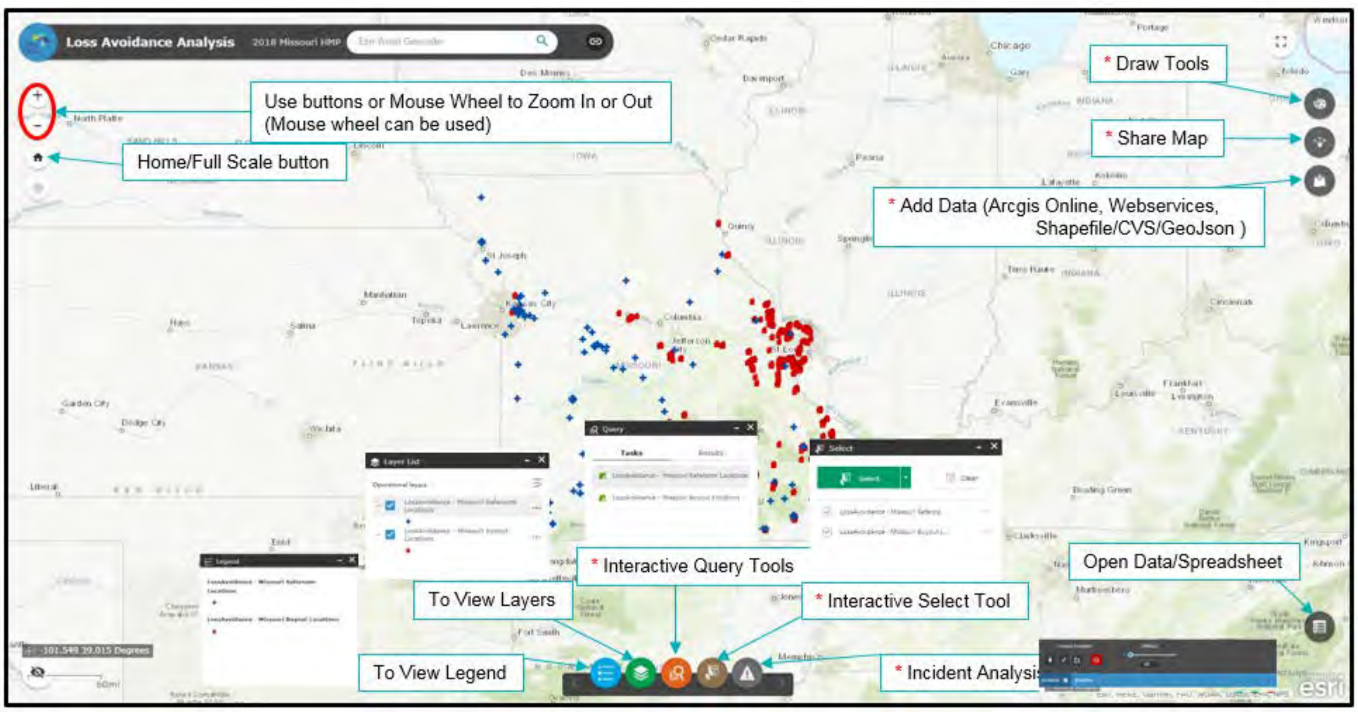
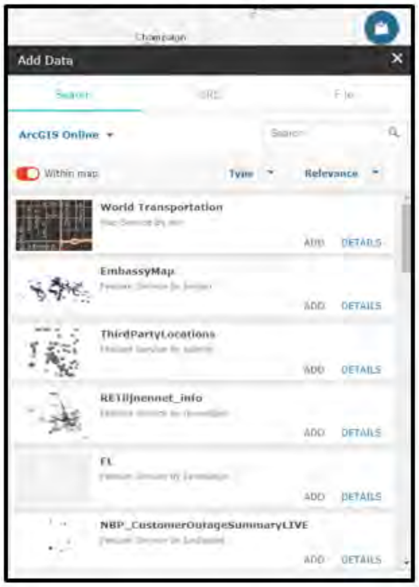


Figure 7.7. LAAT Website – "Add Data" Tool

1) From ArcGIS Online



2) From another Public Location/Agency

Add Data from following:

- ArcGIS Server Web Service
- WMS OGC Web Service
- KML
- GeoRSS File
- CSV File

3) Project and/or Personal Data

Add Data from Local Computer by Drag/Drop or Browse to Location.

Files Include:

- Shapefile
- CSV
- GPX
- GeoJson

Figure 7.8. LAAT Website – "Draw" Tool

Select Shape (Point, Line, Polygon, or Text)

Options for Shape

Approximate Measurement tool based on shape chosen

Options to set drawing

Figure 7.9.   LAAT Website – "Share" Tool

Step 3: Loss Estimation Analysis - This final phase consists of estimating losses avoided based on the effectiveness of the mitigation project during the MP_C storm events. The two major tasks in Phase 3 are (1) calculating losses avoided and (2) calculating the return on investment. This can now be done "on the fly" with the LAT by utilizing the Query Tool as shown in **Figure 7.10**.

This information and the results of completed loss avoidance studies will be incorporated into mitigation success stories to aid in the assessment of the current and future goals, objectives, and actions by simply exporting the data in the needed format using the Incident Analysis Tool shown in **Figure 7.11**.

Figure 7.10.   LAAT Website – "Query" Tool

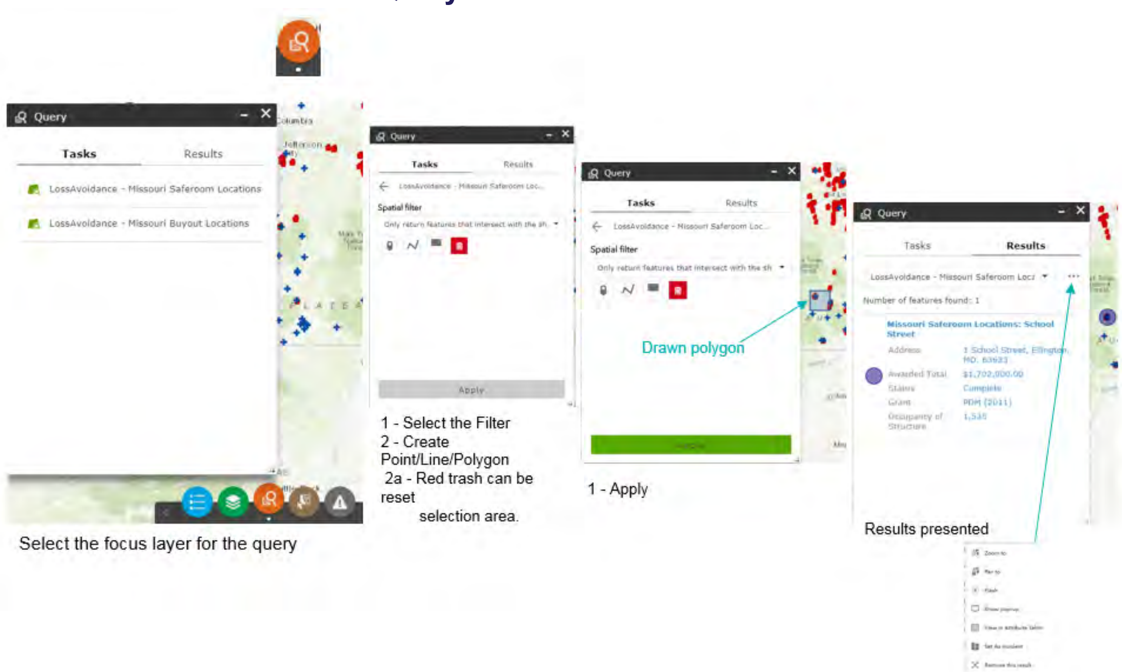
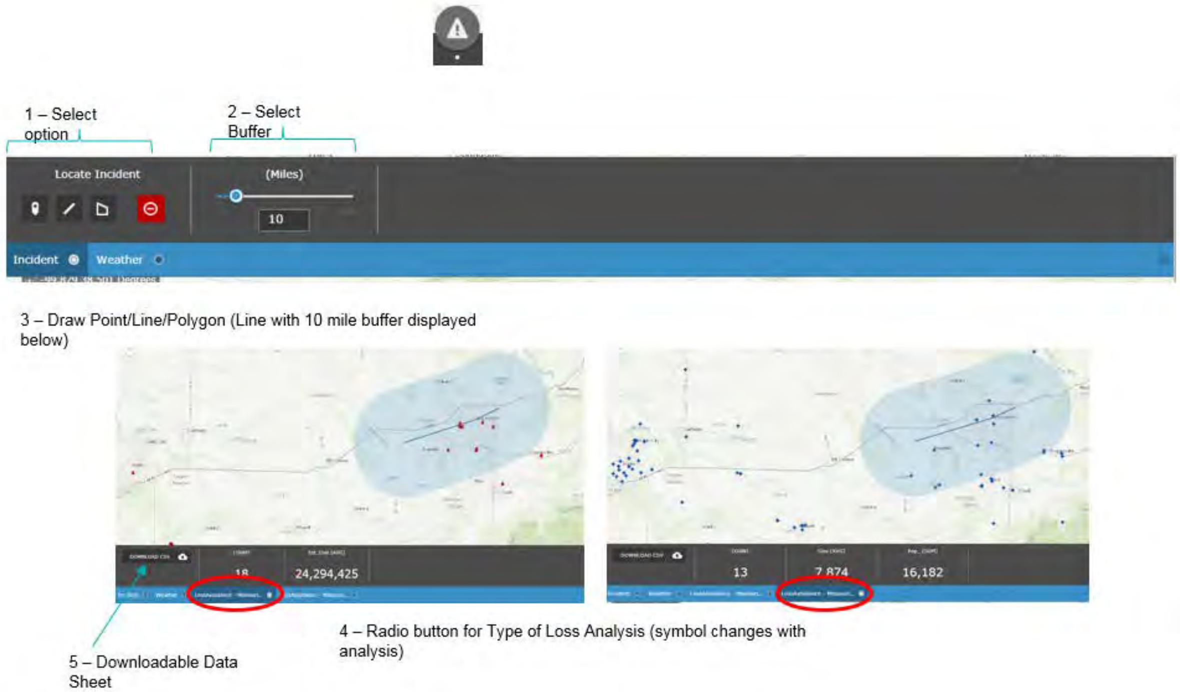
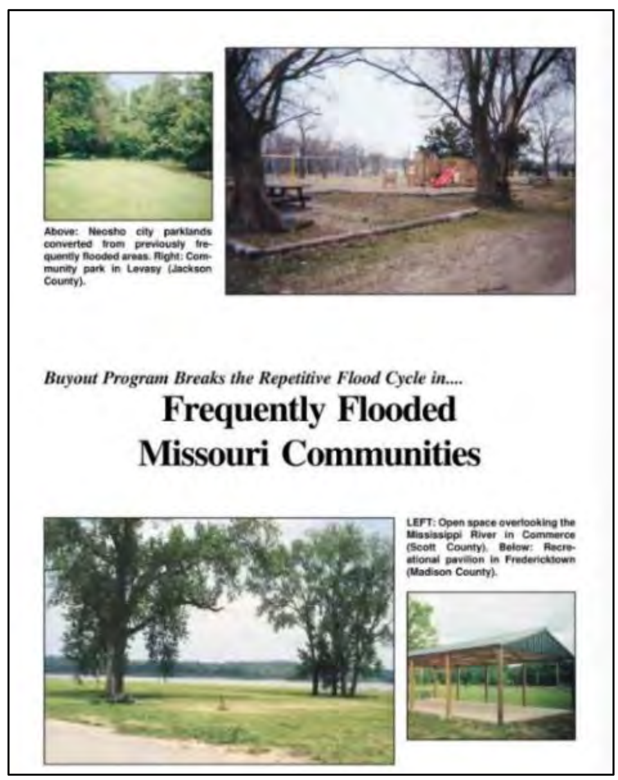


Figure 7.11. LAAT Website – "Incident Analysis" Tool



1999 Loss Avoidance Studies

To demonstrate the success of the buyout programs that occurred after the flooding in 1993, 1994, and 1995, SEMA published the acquisition success story in the 1999 publication *Stemming the Tide of Flood Losses*. This loss avoidance study demonstrated the effectiveness of the buyout program in 22 Missouri communities.



2009 Loss Avoidance Studies

Between 2007 through 2009, there were 13 presidential and emergency disaster declarations issued for Missouri (See **Table 7.8**).

Table 7.8. Major Disaster and Emergency Declarations in Missouri, 2007-2009

Declaration Date	Disaster No.	Incident Type
June 11, 2007	DR 1708	Severe Storms and Flooding
September 21, 2007	DR 1728	Severe Storms and Flooding
December 12, 2007	EM 3281	Severe Winter Storms
December 27, 2007	DR 1736	Severe Winter Storms
February 5, 2008	DR 1742	Severe Storms, Tornadoes, and Flooding
March 12, 2008	DR 1748	Severe Winter Storms and Flooding
March 19, 2008	DR 1749	Severe Storms and Flooding
May 23, 2008	DR 1760	Severe Storms and Tornadoes
June 25, 2008	DR 1773	Severe Storms and Flooding
November 12, 2008	DR 1809	Severe Storms, Flooding, and a Tornado
January 30, 2009	EM 3303	Severe Winter Storms
February 17, 2009	DR 1822	Severe Winter Storms
June 19, 2009	DR 1847	Severe Storms, Tornadoes, and Flooding

Source: Federal Emergency Management Agency

Following the spring and summer floods of 2008 (DR-1749 and DR-1773), FEMA partnered with the State of Missouri to complete a Loss Avoidance Study to assess the effectiveness of the acquisition/demolition projects in eastern Missouri along the Mississippi River and its tributaries. The report "*Loss Avoidance Study: Eastern Missouri, Building Acquisition Part One: General Overview and Part Two: Detailed Methodology*" provides detailed documentation of the methodology implemented and results.

For this study, FEMA employed the loss avoidance methodology, as previously described:

1) **Initial Project Selection** – The initial project list covered eight counties, nine communities, 20 residential acquisition projects, and 2,049 properties. The properties included 1,091 residential buildings and 958 vacant lots. The communities were located in eastern Missouri and include the Cities of Arnold, La Grange, Cape Girardeau, St. Charles, Hannibal, Winfield, Piedmont, and Marble Hill, and the County of St. Charles. Data collection efforts for the projects resulted in the elimination of several buildings from the study due to the lack of flood impact from the 2008 storm events, the lack of available structure location data, and incomplete acquisition/demolition activities. A total of 885 buildings proceeded to Phase 2 of the loss avoidance study. The vacant lots, which were acquired to create continuous open space areas, were not analyzed in Phase 2, but were included in the final return on investment computations as a project cost.

2) **Project Effectiveness Analysis** – For this loss avoidance study, a flood inundation analysis was conducted. The flood depth that would have occurred inside each building, had the building not been acquired, was calculated. Flood depths were calculated using both stream gage stage data and discharge data.

Cross sections from the Flood Insurance Studies (FIS) for the project area were digitized in a GIS environment. Stream gage stage data was input at the cross section corresponding to the gage location, and it was noted which recurrence intervals the stage fell between using the FIS or USACE flood profiles. Water surface elevations (WSEs) at the remaining cross sections along the stream profile were then interpolated through hand calculations using the appropriate recurrence intervals as lower and upper bounds. The water surface elevations were input into GIS and converted to a water surface layer.

Where stream gage data was not available, discharge data was used. The lower and upper bounding recurrence intervals were determined from the discharge tables within the FIS reports. The elevation corresponding to the recurrence interval was found on the FIS flood profile for each cross section, and a water surface layer was created.

Once flood surfaces were digitally created for the 2008 storm events affecting the communities, the flood depth at each building location (measured from the WSE to the ground) was extracted and exported in table format. Ground-surface elevations were derived from USGS digital elevation models (DEMs). The flood depth *inside* each building was then determined by adjusting the flood depth based on the first-floor elevation.

3) **Loss Estimation Analysis** – As previously noted, all buildings included in the study are residential structures. Therefore, the loss estimation analysis included physical damage (building and contents) and loss of function (displacement expense and disruption of residents). Loss of business income, lost wages, and loss of public service damages were not calculated.

Physical damages to the buildings and contents were based upon the flood depths determined in Phase 2 and computed using FEMA's Benefit Cost Analysis (BCA) Version 4 software, the U.S. Army Corps of Engineer's generic building damage curves, and the Federal Insurance Administration mobile home damage curves.

Displacement cost was estimated based upon the repair time and utilized default values for one-time displacement and monthly rental costs. For disruption, FEMA BCA Version 4 software guidance provides a national average wage. The time of disruption was calculated using the estimate that each adult occupant is disrupted 40 hours plus 8 hours for every 1% of building damage.

The losses avoided for the spring and summer 2008 events were calculated for each individual building. The cumulative amount of losses avoided was then calculated for both the Mitigation Project Absent (MPA) and Mitigation Project Complete (MPC) scenarios. The total losses in the MPC scenario were then subtracted from the total losses in the MPA scenario to determine the total losses avoided. It should be noted, no losses were calculated for the MPC scenario because the buildings no longer existed and thus no damages could be incurred. The total losses avoided for the communities were valued at $93.6 million.

Calculating the return on investment (ROI) is the final task of Phase 3. The ROI is calculated by dividing the losses avoided by the total investment for the project made by all parties involved. For this study, the project cost was valued at $44.2 million, resulting in a return on investment of 212-percent. **Table 7.9** presents the lost estimation results.

Table 7.9. Eastern Missouri Loss Avoidance Study Results

Aggregate Return on Mitigation Investment										
Analysis Information			Results by Loss Category				Total Losses Avoided	Project Investment	Project ROI	Community ROI
Community	Disaster, Project Number, and Event	Number of Buildings Included in Analysis	Building Damage	Contents Damage	Displacement Cost	Disruption Cost				
Arnold	995-0002 (spring)	79	$3,175,228	$2,878,203	$724,396	$880,433	$8,010,297	$7,054,582	85%	77%
	FMA-PJ-07MO-1997002 (spring)	1	$48,198	$28,934	$8,910	$12,205	$94,246	$104,435	90%	
	FMA-PJ-07MO-1998002 (spring)	3	$48,890	$29,378	$2,411	$15,752	$96,430	$328,901	29%	
	FMA-PJ-07MO-1999001 (spring)	8	$25,508	$18,603	$0	$10,171	$54,280	$675,885	8%	
La Grange	995-0027 (summer)	11	$481,105	$296,642	$124,431	$447,850	$1,265,024	$243,811	519%	519%
Cape Girardeau	1054-0001 (spring)	79	$380,568	$238,370	$34,488	$190,280	$843,706	$2,803,431	30%	49%
	1054-0001 (summer)	79	$871,664	$547,830	$131,176	$453,818	$1,830,644	$2,803,431	69%	
	1403-0004 (spring)	2	$0	$0	$0	$0	$0	$60,629	0%	
	1403-0004 (summer)	2	$1,036	$884	$0	$2,832	$4,863	$60,629	8%	
St. Charles County	995-0001 (summer)	467	$27,889,023	$18,899,004	$8,028,505	$8,911,969	$55,752,634	$22,572,245	247%	247%
City of St. Charles	995-0027 (summer)	9	$0	$0	$0	$0	$0	$423,247	0%	
Hannibal	995-0004 (summer)	90	$8,704,530	$5,898,533	$1,677,624	$2,224,599	$13,314,238	$2,220,253	600%	600%
Winfield	995-0015 (summer)	49	$2,984,398	$2,349,148	$838,307	$1,338,120	$6,215,974	$1,387,803	448%	448%
Piedmont	995-0045 (spring)	15	$786,451	$608,444	$175,855	$600,524	$1,886,998	$387,547	487%	304%
	1006-0007 (spring)	19	$791,189	$577,325	$191,006	$487,771	$1,817,425	$724,121	251%	
	1023-0005 (spring)	2	$190,473	$155,464	$42,612	$64,007	$371,325	$47,708	778%	
	1054-0008 (spring)	10	$474,638	$358,478	$107,885	$245,035	$1,039,470	$446,518	233%	
	1403-0008 (spring)	10	$195,868	$113,477	$33,684	$138,653	$481,680	$490,375	98%	
	FMA-PJ-07MO-1997003 (spring)	10	$834,854	$739,287	$185,758	$420,962	$1,740,581	$365,773	476%	
	FMA-PJ-07MO-1998003 (spring)	6	$320,542	$296,898	$74,559	$193,182	$718,302	$189,425	378%	
Marble Hill	1403-0011 (spring)	28	$0	$0	$0	$0	$0	$782,707	0%	0%
		TOTAL	$45,974,342	$34,999,291	$10,179,708	$18,838,259	$93,638,111	$44,153,438		212%

Source: FEMA Loss Avoidance Study: Eastern Missouri, Building Acquisition Part Two: Detailed Methodology, page 5-19.

SEMA continues to provide success stories to FEMA and to organizations like the Association of State Floodplain Managers to educate the public about the effectiveness of mitigation.

2017 Loss Avoidance Study

On May 9, 2011 the Federal Emergency Management Agency (FEMA) announced that federal disaster aid would be made available to Missouri to supplement assistance from state and local governments in areas struck by severe storms, tornadoes, straight-line winds and associated flooding during the period of April 19, 2011 through May 11, 2011. This disaster declaration was designated as DR-1980 and provided federal funding for Hazard Mitigation Grant Programs (HMGP) that were administered by the Missouri State Emergency Management Agency (SEMA).

After this event the state prioritized a program to acquire and remove properties that were subject to repetitive flooding utilizing the HMGP program. As a part of DR-1980 the state acquired and demolished approximately 40 properties with the resulting land dedicated to open space in perpetuity. This Loss Avoidance Study (LAS) looked at the acquisition projects that were implemented by cities, villages and one county in this HMGP. Those projects included: Taney County, City of Branson, Village of Dutchtown, and City of Doniphan.

The Flood Acquisition Loss Avoidance Calculator developed for FEMA was utilized to determine the avoided costs for the properties in these projects. This model assumes that the structure would have remained and would have been flooded in subsequent events. Determining the flood elevation for subsequent flood events turned out to be critical in assessing future losses and was the most difficult data point to acquire. In some cases, a site visit was necessary to acquire high water marks and in some cases the necessary data could be acquired from the agency that administers the National Flood Insurance Program (NFJP) for that jurisdiction. If sufficient data was not available to estimate future losses, those properties were excluded from the study.

The result of this study showed the following for the buyout projects:

Table 7.10. DR-1980 Loss Avoidance Study Results

Acquiring Agency	Structure Cost (present value)	Avoided Losses		Total Avoided Losses	Loss Avoidance Ratio L_R		
		2015 (DR 4250)	2017 (DR 4317)		After 2015 Flood	After 2017 Flood	Total
Taney County	$1,289,154	$1,321,699	$1,164,712	$2,486,411	1.03	0.90	1.93
City of Branson	$694,991	$459,854	$336,592	$796,446	0.66	0.48	1.15
Village of Dutchtown	$1,133,285	$2,012,408	$826,849	$2,839,257	1.78	0.73	2.51
City of Doniphan	$194,754	$0	$782,335	$782,335	0.00	4.02	4.02
Total	**$3,312,184**	**$3,793,961**	**$3,110,488**	**$6,904,449**	**1.15**	**0.94**	**2.08**

Source: FEMA Loss Avoidance Study: DR-1980 Missouri Acquisition Projects, Executive Summary Table calculations corrected for inclusion in 2018 State Plan Update.

This indicates that the Loss Avoidance Ratio (L_R), utilizing the FEMA calculator was greater than one for these projects, following the two flood events, and therefore provided the state of Missouri with significant cost savings through avoided losses in subsequent flood events.

2018 Loss Avoidance Studies

For the 2018 State Plan Update, the new loss avoidance analysis tool (LAAT) was utilized to calculate the losses avoided for residential acquisition projects in 12 counties with recent disaster declarations DR-4250 and DR-4317. This coarse computation assumed the acquired and demolished residential structures formerly located within the 1-percent annual chance floodplain would have remained and would have been substantially damaged in the disaster declaration events.

A refined loss avoidance example computation for Taney County, as well as step-by-step instructions for the LAAT, are presented in Appendix E.

Figure 7.12. Counties Impacted by DR-4250 and DR-4317

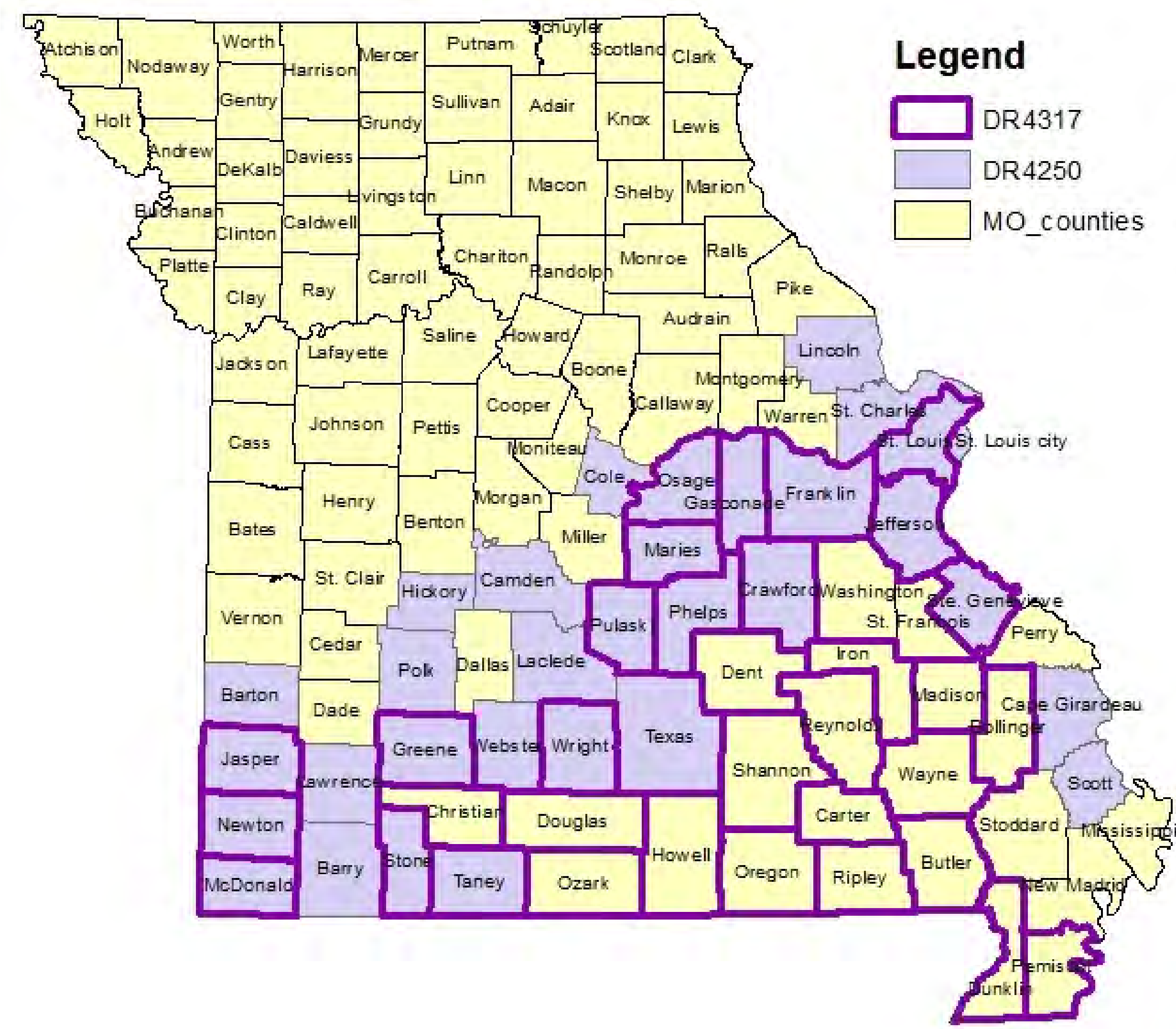


Table 7.11. Loss Avoidance Results for All Missouri Buyouts, DR-4250 and DR-4317

Community	Total # of Acquired Structures	Total # of Acquired Structures Located within the SFHA	Total Project Investment	Avoided Loss DR 4250		Avoided Loss DR 4317		Total Avoided Loss	Loss Ratio DR 4250	Loss Ratio DR 4317	Total Loss Ratio
				Structure Damage	Contents Damage	Structure Damage	Contents Damage				
Franklin	156	101	$4,103,010	$4,321,697	$2,160,849	$4,321,697	$2,160,849	$12,965,091	1.58	1.58	**3.16**
Gasconade	6	2	$556,074	$48,354	$24,177	$48,354	$24,177	$145,062	0.13	0.13	**0.26**
Greene	18	9	$1,128,880	$431,477	$215,739	$431,477	$215,739	$1,294,431	0.57	0.57	**1.15**
Jasper	3	2	$126,341	$84,228	$42,114	$84,228	$42,114	$252,684	1.00	1.00	**2.00**
Jefferson	517	147	$9,338,333	$3,080,801	$1,540,401	$3,080,801	$1,540,401	$9,242,403	0.49	0.49	**0.99**
Montgomery	77	4	$328,281	$96,708	$48,354	$96,708	$48,354	$290,124	0.44	0.44	**0.88**
Newton	68	53	$1,791,146	$1,375,476	$687,738	$1,375,476	$687,738	$4,126,428	1.15	1.15	**2.30**
Pulaski	19	8	$505,225	$212,728	$106,364	$212,728	$106,364	$638,184	0.63	0.63	**1.26**
St. Charles	1456	570	$15,459,051	$12,614,507	$6,307,254	$10,352	$5,176	$18,937,289	1.22	0.00	**1.22**
St. Louis	676	402.5	$19,598,189	$16,348,990	$8,174,495	$16,322,430	$8,161,215	$49,007,130	1.25	1.25	**2.50**
Ste. Genevieve	81	33	$1,038,091	$390,012	$195,006	$390,012	$195,006	$1,170,036	0.56	0.56	**1.13**
Taney	23	21	$3,379,541	$3,376,649	$1,688,325	$3,325,269	$1,662,635	$10,052,877	1.50	1.48	**2.97**
Grand Total	**3100**	**1353**	**$74,073,874**	**$42,381,627**	**$21,190,814**	**$29,699,532**	**$14,849,766**	**$108,121,739**	**0.86**	**0.60**	**1.46**

7.5. Effective Use of Available Mitigation Funding

Requirement §201.5(b)(3): The enhanced plan must demonstrate that the state effectively uses existing mitigation programs to achieve its mitigation goals.

This section identifies some general and specific hazard mitigation projects. They are examples of the types of projects that have made, and continue to make, Missouri's hazard mitigation program effective and successful. These projects, and others like them, have been approved in the past based on their ability to achieve some, or all, of the State's mitigation goals and objectives. Because of this demonstrated success, similar projects are likely to be approved in the future.

As a result of the successes achieved through past and present mitigation funding sources and through public-private partnerships, SEMA remains committed to continuing its efforts to encourage leveraging available funds and establishing partnerships for project leadership, implementation, and maintenance. The following table (**Table 7.12**) reiterate the effectiveness of actions funded through SEMA and how they relate to the State's mitigation goals and the Emergency Management Accreditation Program's (EMAP) mitigation standards.

Table 7.12. Missouri Mitigation Action Categories Strategy Overview

Action Category	Priority	Responsible Agency for Implementation	Hazards Addressed	Link to Local Plans, Actions, and Assistance	Protected by the Action
M1—State and Local Hazard Mitigation Plans	High	SEMA/RPCs/ local jurisdictions	All	Continued use of RPCs	Life Safety and Property
M2—NFIP Floodplain Management and Community Rating System	High	SEMA/local jurisdictions	Flood	Community assistance visits, workshops	Life Safety and Property
M3—Risk Communication	High	SEMA and other agencies	All	Vulnerability assessment data provided for local plans	Life Safety and Property
M4—Voluntary Property Acquisitions (Flood Buyout)	High	SEMA/local jurisdictions	Flood	Projects identified in local plans	Life Safety and Property
M5—Voluntary Elevation, Relocation, Floodproofing	High	SEMA/local jurisdictions	Flood	Projects identified in local plans	Life Safety and Property
M6—Tornado Safe rooms	High	SEMA/local jurisdictions	Tornado	Projects identified in local plans	Life Safety
M7—Earthquake/High Wind Structural Mitigation Projects	Medium	SEMA/MoDOT	Earthquake Tornado	Projects identified in local plans	Life Safety
M8—Earthquake/High Wind Nonstructural Mitigation Projects	Medium	SEMA/local jurisdictions	Earthquake Tornado	Projects identified in local plans	Life Safety and Property

Action Category	Priority	Responsible Agency for Implementation	Hazards Addressed	Link to Local Plans, Actions, and Assistance	Protected by the Action
M9—Structural/ Infrastructure Mitigation Projects (including Public Assistance projects)	Medium	SEMA/MoDOT/ local jurisdictions	Flood	Projects identified in local plans	Life Safety and Property
M10—Response and Recovery Facility Mitigation Projects	Medium	SEMA and other agencies	Multiple	Vulnerability assessment data provided for local plans	Life Safety and Property
M11—State Owned/Operated Facility Mitigation Projects	Medium	SEMA and other agencies	Multiple	Vulnerability assessment data provided for local plans	Life Safety and Property
M12—Buried Electric Service Lines	Low	Local jurisdictions/ certain utility providers	Multiple	Projects identified in local plans	Life Safety and Property
M13—State 5% Initiative Projects	Low	SEMA/local jurisdictions	Multiple	Projects identified in local plans, difficult to measure cost-effectiveness	Life Safety and Property
M14—Technical Assistance	Low	SEMA and other agencies	Multiple	Needs identified in local plan capability assessments	Life Safety and Property

Table 7.13. Mitigation Action Categories and Goals Crosswalk

Objectives	M1	M2	M3	M4	M5	M6	M7	M8	M9	M10	M11	M12	M13	M14
	Goal 1: Improve the Protection of Human Life, Health, and Safety													
Objective 1	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Objective 2	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Objective 3	✓	✓	✓			✓	✓	✓		✓	✓		✓	✓
Objective 4	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Objective 5	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Goal 2: Improve the Protection of Continuity of Government and Essential Services													
Objective 1	✓	✓	✓			✓	✓	✓	✓	✓	✓	✓	✓	✓
Objective 2	✓	✓	✓			✓	✓	✓	✓	✓	✓	✓	✓	✓
Objective 3	✓	✓	✓			✓	✓	✓	✓	✓	✓	✓	✓	✓
Objective 4	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Objective 5	✓	✓	✓			✓	✓	✓	✓	✓	✓	✓	✓	✓
	Goal 3: Improve the Protection of Public and Private Property													
Objective 1	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Objective 2	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Objective 3	✓	✓	✓			✓	✓	✓		✓	✓		✓	✓
Objective 4	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Objective 5	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Goal 4: Improve the Protection of Community Tranquility													
Objective 1	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Objective 2	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Objective 3	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Objective 4	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Objective 5	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

Table 7.13 provides specific types and numbers of projects and funding amounts from 2002-2017. For reference, the corresponding Mitigation Action Category is also provided. For additional details on funding by year, see Section 4.2.

Note, mitigation action categories M3 Risk Communication, M10 Response and Recovery Facility Mitigation Projects, and M11 State Owned/Operated Facility Mitigation Projects were added with this 2018 plan update and therefore do not have corresponding historic project types at this time.

Table 7.14. Summary of Mitigation Actions Implemented and Estimated Funding Amounts, 2002–2012 and 2013-2017

Project Type	Action Category	2002-2012 Number of Projects	2002-2012 Estimated Funding Amount	2013-2017 Number of Projects	2013-2017 Estimated Funding Amount
State and Local Hazard Mitigation Plans	M1	258	$7,885,551	5	$1,096,856
Flood Buyouts	M4	67	$47,337,218	18	$8,458,688
Flood Elevations	M5	3	$488,573	---	
Tornado Safe Rooms	M6	133	$159,925,978	62	$68,575,060
Tornado Safe Rooms - Multipurpose	M6	1	$686,493	---	
Bridge Replacements	M9	1	$449,787	---	
Low Water Crossings	M9	8	$888,246	2	$432,896
Streambank Stabilizations	M9	2	$92,267	---	
Basin	M9	1	$1,333,333	---	
Culvert	M9	2	$553,625	---	
Water Supply Interconnects	M9	1	$66,701	---	
Buried Electric Lines	M12	10	$11,959,530	---	
State 5% Initiative Projects	M13	12	$1,753,866	10	$598,378

This provides documentation of the State's ability to make use of funding available from FEMA HMA grant programs to implement the State's mitigation strategy. There have been instances in the past when the total amount for HMA grants could not be fully obligated. In all instances, the State forwarded applications and supplements to exhaust all available funding options. However, due to circumstances beyond the State's control, such as project cost underruns, loss of local match, local withdrawal of projects, or decrease in scope due to the voluntary nature of some projects, funds could not be fully obligated. In these instances, the availability of funds was not known until after the application periods had expired. Therefore, the State was not at liberty to forward additional applications to make use of any remaining funds. With the 2018 State Plan Update, a new mitigation action was added to pursue mitigation of state owned/operated facilities which have been identified through the refined risk assessments as at risk. As this mitigation action is implemented in the coming years, SEMA may seek to identify potential mitigation projects, such as strapping/bracing or other non-structural measures for those state owned/operated facilities identified within the high shake zones. With small projects identified early, SEMA could potentially be poised to utilize all available funding.

The following activities illustrate the types of projects that have been approved as part of the State's mitigation program. This list is not all-inclusive; however, it does demonstrate the effective use of available mitigation funding and how SEMA has used FEMA and non-FEMA funding to support mitigation in Missouri.

Local Hazard Mitigation Plan Development (M1)

There are 105 FEMA-approved local hazard mitigation plans in Missouri, representing 103 county level plans; two regional plans representing a total of 10 counties; one multi-jurisdictional plan representing two counties, and one plan for the Missouri electric cooperatives. Dent County is the only county without a current approved Hazard Mitigation Plan and they are currently in the process of developing a plan.

Mitigation funds have been used to help communities throughout the State develop hazard mitigation plans. As part of this process, these communities have developed public-private partnerships that have expanded their work into other mitigation-related activities. As a result of planning activities, communities are now more aware of the benefits of an active mitigation program and have instituted mitigation projects with their own funds.

The local mitigation planning project supports all of the goals of this plan by contributing to the development of local plans that complement the State plan and serving as the foundation for FEMA HMA grant eligibility (see **Table 7.13** and **Table 7.14**. Historically, local hazard mitigation plans in Missouri have been funded through the Hazard Mitigation Grant Program and the Pre-Disaster Mitigation program with local matching funds and/or in-kind services.

Preparation/Updating of Floodplain Maps (M2 and M14)

Funds from a variety of programs have been used to develop flood maps for previously unmapped areas and to revise/update older existing maps. This initiative will enable more communities in the State to join the National Flood Insurance Program (NFIP). As a result, more individuals, families, and businesses will be able to get insurance to cover future flood-related losses.

In Missouri, SEMA is participating in FEMA's Risk MAP program and as of early 2018, 79 counties have a countywide digital flood insurance map. Thirty-four counties are model based on LiDAR topography 1-meter digital elevation Model (DEM) and 45 counties are model based on USGS 10-meter DEM. The remaining 33 counties not digital are still paper (non-digital and community based not countywide) except for Schuyler County, that is not digital and does not have any existing paper floodplain maps. As of early 2018, 22 of the 33 PIR counties are under Data Development for mapping updates. LiDAR was collected in 2018 for the remaining 11 PIR counties and are scheduled for Data Development in 2019. The SEMA 5-Year Business Plan addresses the remaining forty 45 counties not final on LiDAR and mapping updates are planned for 2019-2022.

The Missouri Risk MAP effort supports all of the goals and objectives of this plan as indicated in **Table 7.13** and **Table 7.14**. The program also supports the State's mitigation strategy for ensuring continued effective use of resources by demonstrating how partnerships with other State and local agencies are used to leverage funding. In Missouri, three cities, two counties, and SEMA participate in FEMA's Cooperating Technical Partners (CTP) Program. CTP partnerships are established with NFIP participants that have both the interest and capability to become more active in the FEMA flood hazard mapping program by collaborating to maintain up-to-date flood hazard maps and other flood hazard information.

Acquisition of Primary Residences in Flood-Prone Areas (M4 & M5)

The State has previously, and most likely will continue to, make the acquisition of primary residences in flood-prone areas a top priority. Hazard Mitigation Grant Program funds from previous Missouri disasters have been used to fund this extremely successful program. The Missouri Community Buyout Program was recognized as a model for the nation following the devastating 1993 floods.

This program removed families and insurable buildings from harm's way. By doing so, it eliminated the threat of flooding and the associated financial and emotional hardship on those families that participated in the program; reduced the cost of future disasters to the federal, state, and local government; and provided the participating community with open space to develop parks for the entire community to enjoy. It also has reduced impacts on local first responders, who have fewer life safety emergencies to handle during floods.

Since the 1993 flood, this buyout program has continued to demonstrate how Missouri has effectively used available mitigation funding programs and packaged these mitigation funds with funds from non-FEMA sources. FEMA funds have been matched, as appropriate, with Community Development Block Grants (including supplemental appropriations for Unmet Needs), State general revenue, and local government funds.

Through the Silver Jackets program, SEMA has proposed, and was awarded funding in late 2017, to develop a Missouri Flood Buyout Strategy to guide the selection process for distribution of mitigation grant funding for acquisition/demolition projects. The developed buyout strategy will identify a variety of selection factors, in addition to historic and potential flood damage, such as impacts to water quality, water quantity, local economy, and housing. The strategy will rank the identified factors and allow the state to better reduce risk through identifying and prioritizing the most flood prone, highest risk properties for buyouts across the state.

The buyout program supports the goals and objectives of this plan as indicated in Table 7.13 and Table 7.14. The program also supports the State's mitigation strategy for ensuring continued effective use of resources by demonstrating how partnerships with other State and local agencies can be used to leverage funding.

Acquisition of Severe Repetitive Loss (SRL) Properties (M4)

Over the history of the SRL property acquisition program, the State of Missouri has mitigated 358 SRL properties with total paid NFIP claims of over $37 million in 15 counties. In St. Charles and St. Louis Counties, more than 100 SRL properties have been mitigated in each. **Table 7.15** below shows the number of mitigated SRL properties by community.

Table 7.15. Mitigated Severe Repetitive Loss Properties by County

County	Community Name	Number of Mitigated Severe Repetitive Loss Properties	Number of Paid NFIP Claims	Total Payments	Average Payment*
Callaway County	Jefferson City	1	8	$111,651.57	$13,956.45
Cape Girardeau County	Cape Girardeau	3	16	$152,595.41	$9,470.55
Clay County	Mosby	1	7	$101,580.90	$14,511.56
Holt County	Big Lake	29	98	$4,018,198.51	$42,882.89
Holt County	Holt County	1	4	$205,709.70	$51,427.43
Jefferson County	Arnold	13	84	$1,527,891.60	$18,891.25
Jefferson County	Crystal City	2	12	$153,980.61	$13,250.75
Jefferson County	Jefferson County	19	126	$1,842,684.21	$14,298.76
Lincoln County	Lincoln County	7	42	$426,893.12	$10,982.17
Lincoln County	Old Monroe	1	5	$51,588.36	$10,317.67
Lincoln County	Winfield	1	6	$101,115.66	$16,852.61
Pemiscot County	Pemiscot County	1	7	$121,667.82	$17,381.12
Pike County	Pike County	2	28	$252,008.55	$9,308.77
Platte County	Platte County	1	3	$162,865.48	$54,288.49
Pulaski County	Waynesville	1	4	$99,013.79	$24,753.45
St. Charles County	Portage des Sioux	8	48	$606,879.83	$13,517.75
St. Charles County	St. Charles County	122	951	$13,888,890.01	$14,972.41
St. Charles County	St. Peters	1	14	$246,233.69	$17,588.12
St. Charles County	West Alton	34	229	$3,110,577.88	$14,739.75
St. Francois County	Bonne Terre	1	4	$71,653.66	$17,913.42
St. Louis County	Brentwood	5	32	$407,994.98	$14,626.98
St. Louis County	Chesterfield	1	7	$41,283.27	$5,897.61
St. Louis County	Fenton	10	64	$738,449.98	$11,685.79
St. Louis County	Maryland Heights	1	5	$118,455.62	$23,691.12
St. Louis County	St. Louis County	41	245	$3,737,531.21	$15,658.80
St. Louis County	Sunset Hills	2	11	$110,590.02	$11,160.15
St. Louis County	University City	12	116	$1,299,460.48	$12,129.51
St. Louis County	Valley Park	31	178	$2,647,257.43	$15,351.62
Ste. Genevieve County	Ste. Genevieve	4	20	$233,796.40	$12,330.25
Taney County	Branson	2	4	$612,051.94	$153,012.99

*Average payment is calculated as the mean of all properties' average payments within each community.

Source: SEMA

Tornado Safe rooms (M6)

In Missouri, only flood mitigation projects are prioritized ahead of projects that mitigate tornadoes and high winds. Between 2013 and 2017, there were 62 tornado safe room projects funded in Missouri, primarily with PDM funding. **Table 7.16** presents a summary of the status of each project between 2012 and 2017. Tornado safe rooms have proven to protect people from tornadoes and high winds when built to FEMA construction standards. Projects include safe rooms in homes that protect individual families as well as large-scale school and community safe rooms, which often meet multiple community objectives (e.g., serving as both a school gymnasium and a safe room).

The funding of tornado safe rooms supports the goals and objectives of this plan as indicated in Table 7.8. The program also supports the State's mitigation strategy for ensuring continued effective use of resources by demonstrating how partnerships with other State and local agencies can be used to leverage funding.

Table 7.16. Tornado Safe Room Projects, 2013-2017

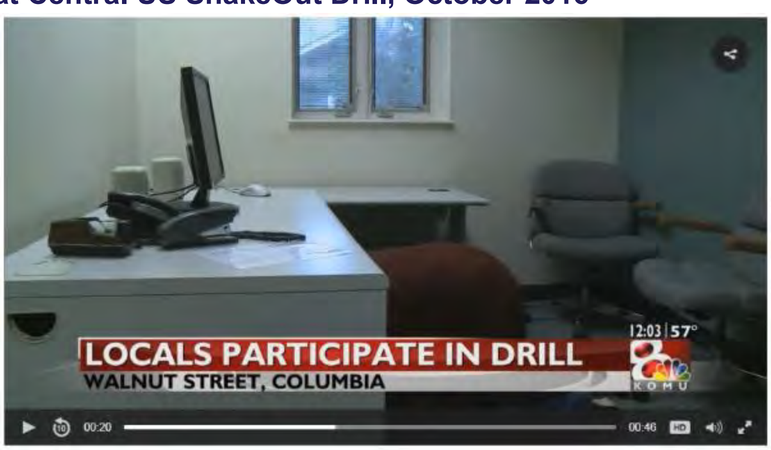
Year	No. of Approved Projects	No. of Completed Projects	No. of Pending/Ongoing Projects
2013	41	40	1
2014	6	6	0
2015	1	1	0
2016	7		7
2017	7	1	6
Total	**62**	**48**	**14**

Earthquake/High Wind Nonstructural Mitigation Projects (M8)

During February and March 2010, hundreds of Missourians took advantage of free earthquake public awareness events offered by SEMA and DNR's Division of Geology and Land Survey (DGLS). Free events were offered in St. Louis, Leasburg, Malden, Kennett, Piedmont, Jefferson City, Sikeston and Festus. At these public events, school children, residents and business planners asked questions and collected earthquake safety and mitigation information to protect their families and their property before a catastrophic earthquake occurs.

As noted earlier, SEMA regularly participates in the annual Great ShakeOut earthquake drills. These exercises are designed to promote awareness and increase earthquake preparedness nationwide. The Great Central U.S. ShakeOut is a multi-state drill spanning much of the central United States. Of the 719 participants registered to participate in the upcoming 2018 ShakeOut exercise, 202 are from Missouri.

Figure 7.13. Great Central US ShakeOut Drill, October 2016

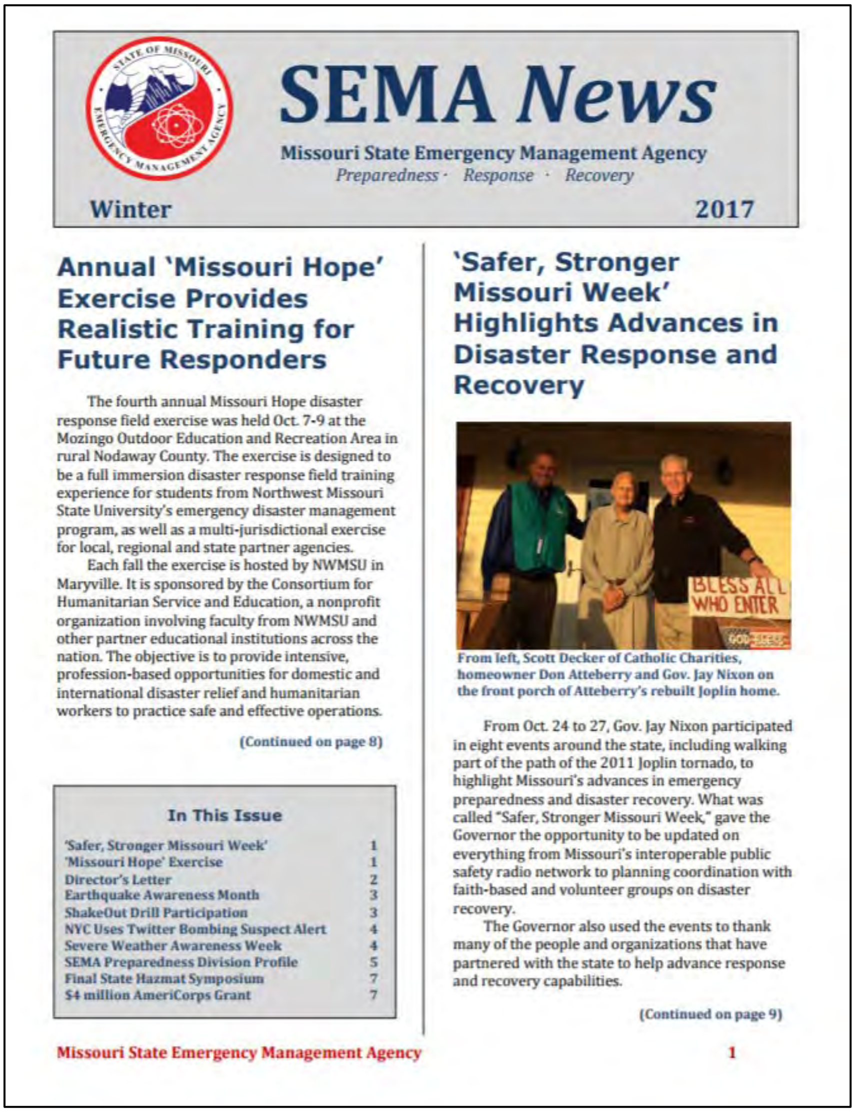


Source: KOMU, October 20,2016

Public Outreach (M13 and M14)

SEMA also makes a considerable effort to educate the public, local officials, government officials, schools, private associations, and businesses about the value and importance of mitigation programs (see **Figure 7.14**). SEMA offers mitigation workshops, participates in public forums, provides one-on-one counseling, presents at conferences, provides written materials, develops guidebooks and manuals, publishes success stories, sends out press releases, offers information on the Internet, and provides training materials to local emergency managers, earthquake program partners, floodplain managers, and businesses.

Figure 7.14. SEMA Newsletter



SEMA News

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Winter 2017

Annual 'Missouri Hope' Exercise Provides Realistic Training for Future Responders

The fourth annual Missouri Hope disaster response field exercise was held Oct. 7-9 at the Mozingo Outdoor Education and Recreation Area in rural Nodaway County. The exercise is designed to be a full immersion disaster response field training experience for students from Northwest Missouri State University's emergency disaster management program, as well as a multi-jurisdictional exercise for local, regional and state partner agencies.

Each fall the exercise is hosted by NWMSU in Maryville. It is sponsored by the Consortium for Humanitarian Service and Education, a nonprofit organization involving faculty from NWMSU and other partner educational institutions across the nation. The objective is to provide intensive, profession-based opportunities for domestic and international disaster relief and humanitarian workers to practice safe and effective operations.

(Continued on page 8)

In This Issue

'Safer, Stronger Missouri Week' Highlights Advances in Disaster Response and Recovery

From left, Scott Decker of Catholic Charities, homeowner Don Atteberry and Gov. Jay Nixon on the front porch of Atteberry's rebuilt Joplin home.

From Oct. 24 to 27, Gov. Jay Nixon participated in eight events around the state, including walking part of the path of the 2011 Joplin tornado, to highlight Missouri's advances in emergency preparedness and disaster recovery. What was called "Safer, Stronger Missouri Week," gave the Governor the opportunity to be updated on everything from Missouri's interoperable public safety radio network to planning coordination with faith-based and volunteer groups on disaster recovery.

The Governor also used the events to thank many of the people and organizations that have partnered with the state to help advance response and recovery capabilities.

(Continued on page 9)

Missouri State Emergency Management Agency 1

Specifically, SEMA staffs a mitigation booth and frequently makes presentations at the annual Emergency Management conference. In addition, to promote the concept and value of mitigation, SEMA issues press releases after FEMA makes HMA grant awards to notify the public of the mitigation project being funded, SEMA also publishes a quarterly newsletter that serves as a forum for emergency management news, including mitigation as well as an Annual Report and Blue Book report that document and share activities.

SEMA's public outreach efforts support all the goals of this plan, as increased public awareness is an objective under every goal (see **Table 7.13** and Section 4.1 Hazard Mitigation Goals and Objectives). These efforts also support the State's mitigation strategy for ensuring continued effective use of resources through a wide array of partnerships (common partnerships for public outreach include public and private radio and television stations, public and private school organizations, and service organizations (e.g., Lions, Rotary, and Elks clubs) and volunteer organizations (American Red Cross).

Annual Hazard Mitigation Assistance Grants Application Assistance (M14)

As documented in Section 4.2.5 *Review and Progress of Mitigation Actions*, Missouri has successfully secured funding for local mitigation plans and projects and State mitigation planning funds from the annual, nationally competitive Pre-Disaster Mitigation (PDM) grant program since 2002. One of the reasons for this success is the hands on technical assistance that SEMA provides to sub-applicants in their grant applications and benefit-cost analyses. This has been provided through annual contractor supported Hazard Mitigation Assistance grant workshops. These two-day workshops consist of HMA grants and BCA training. The BCA training was offered in 2013 and 2015. In addition to this training, the SEMA mitigation website provides links to FEMA's online BCA training as well as the BCA software.

This assistance supports all the goals of this plan by educating eligible State, local, and nonprofit entities in how they can secure funding for mitigation planning and projects. It also supports the State's mitigation strategy for ensuring continued effective use of resources by educating subapplicants about the process (as well as the State goals and objectives) to maximize the amount of PDM funding granted to Missouri. Projects are screened during the application process to determine if they align with local and State mitigation goals.

Other Mitigation Actions

From time to time, other types of mitigation projects have been warranted if proven to be cost-effective solutions to problems. For example, based on documented damage to power lines, it became possible to bury those lines from the street to the meter on residences as a cost-effective mitigation measure to the adverse effects of severe weather (M12). These projects have been required to fulfill all the requirements for flood mitigation projects and possibly have had other additional requirements depending on the nature of the project.

Other actions implemented or obligated include flood elevations (M5), culvert/bridge replacements (M9), detention basins (M9), low water crossings (M9), electrical service line burials (M12), high wind retrofits (M7), generators (M13), and sirens (M8). The Missouri Department of Transportation designs new bridges and retrofits old bridges, including several in St. Louis, to resist seismic impacts (M7 and M9). To see how these actions meet the goals and objectives of the State, see Table 7.13. More information about these activities can be found in Section 4.2 Mitigation Actions.

7.5.1. Mitigation Success

The State mitigation program encourages and motivates State and local government agencies, as well as the private sector and the general public, to mitigate hazards and establishes priorities for hazard mitigation programs in all areas of the State. To establish these priorities, the Hazard Mitigation Planning Team reviewed existing State statutes, ongoing mitigation initiatives, proposed mitigation initiatives/projects, and completed mitigation projects. The review of completed mitigation projects focused on the projects' overall success and contribution toward meeting the goals and objectives of the State and applicable local mitigation program.

Following are some examples of successful mitigation programs and projects. This list is not all-inclusive, but does include the efforts that have been deemed the most successful and/or beneficial to the overall mitigation program.

The State Hazard Mitigation Program

The State, through SEMA, has instituted an effective and comprehensive all-hazard mitigation program. Through the wise use of available federal Hazard Mitigation Assistance grants and State funds (e.g., Hazard Mitigation Grant Program, Public Assistance, Unmet Needs, Pre-Disaster Mitigation, Flood Mitigation Assistance, Community Development Block Grants, Department of Natural Resources Stormwater Grants, Natural Resources Conservation Service, etc.) the State has been able to successfully mitigate many areas against the devastating effects of future disasters.

Hazard mitigation planning is a vital component of the State's disaster resistant community effort. SEMA mitigation staff schedule and conduct various trainings and workshops throughout the year to increase local knowledge and understanding of mitigation planning. A successful example of this is the Hazard Mitigation Plan Outline Workshops. Each year since 2015, three on-site planning workshops have been provided throughout the state focused specifically on use of the Plan Outline. This Plan Outline provides a framework/format for development of local hazard mitigation plan updates. It is organized with headings and subheadings to present meaningful information as well as ensure compliance with the local hazard mitigation planning requirements. Additional details are provided in Section 4.6.3.

History and a working relationship with State partners such as the State Historic Preservation Office and the Missouri Department of Conservations are indicators of SEMA's commitment to be able to prepare environmental documentation. Historically, SEMA has performed or reviewed all benefit-cost analyses for hazard mitigation grant applications and has successfully trained local jurisdictions to complete them. All current mitigation staff members have received formal FEMA benefit-cost training and use the software on a regular basis to keep knowledge and skills current.

During the 1993 Midwest floods, an interagency hazard mitigation team (IHMT) was formed. This team was composed of representatives from FEMA, SEMA, and various State agencies/departments (Governor's Office, Department of Economic Development, Department of Natural Resources, Department of Transportation, and others). The 1993, 1994, and 1995 buyout projects were selected, coordinated, and managed by a small committee appointed by the governor for this specific purpose. The wisdom in this approach can be found in the results as six months after hazard mitigation funding became available, all projects were approved.

This IHMT would later become the Hazard Mitigation Project Coordinating Group, then the State Hazard Mitigation Planning Team (SHMPT), and now the current State Risk Management Team (SRMT). While the name of this entity changed, its purpose remains the same. Following a significant disaster, hazard mitigation projects are coordinated through the representatives of the SRMT. This coordination is primarily with representatives from the Department of Economic Development Community Development Block Grant section, the Missouri Department of Transportation, the Department of Natural Resources Historic Preservation office, and the U.S. Army Corps of Engineers. Other state and federal agencies are added to this group as the situation and mitigation issue dictates.

Ongoing since the 2008 floods, SEMA has participated in the Silver Jackets Program. This coordination program is an Interagency Flood Risk Management Team that consists of regional, state, USACE and FEMA partners and promotes the motto "Many Agencies, One Solution, Reducing Risk." The name Silver Jackets comes from the different colored jackets which various agencies wear when responding to disasters, such as, USACE personnel wear red and FEMA personnel wear blue. The "Silver Jackets" represents a unified interagency team. SEMA is currently working with the Silver Jackets Program to develop a Missouri Flood Buyout Strategy to guide the selection process for distribution of mitigation grant funding for acquisition/demolition projects. The strategy planning sessions kickoff in 2018.

The mitigation process and the State's mitigation initiatives are ongoing. SEMA's mitigation staff in conjunction with other State and local agencies, continue to look for new opportunities and funding sources. The staff also continues to look at expanding existing mitigation initiatives and developing new ones. The primary focus for the use of disaster-related Hazard Mitigation Grant Program funds has been the flood buyout program and more recently the tornado safe room construction program.

The State also has an effective and proactive floodplain management program. Personnel from the Floodplain Management Section of SEMA are continually conducting assistance visits, trainings, and site inspections in communities throughout the State. These efforts ensure that local government, private enterprises, and the citizens of the State are aware of the benefits of participating in the National Flood Insurance Program, among other things.

As a result of the State's mitigation program, local governments and private industries have formed partnerships to make the State and their communities and residents safer and more prepared for the next potential disaster. Their actions will help ensure that future disasters have less of an impact on lives, property, and infrastructure in their communities and the State.

Missouri Community Buyout Program

In the aftermath of the summer of 1993 flood, the State launched an unprecedented statewide hazard mitigation effort in the form of the Community Buyout Program. This was a voluntary program designed to acquire residential properties in the floodplain and move residents out of harm's way. The buyout program utilized a mix of federal funds, including funds from the Hazard Mitigation Grant Program, Public Assistance, and Missouri Community Development Block Grants. Then-Governor Mel Carnahan conservatively estimated the buyout program would save Missouri an estimated $200 million in flood fighting costs, Individual Assistance, and flood insurance claims over the next 20 years.

But, no one could predict Missouri would have the opportunity to test the buyout's effectiveness as quickly as it did when the spring 1995 flood, the third worst flood on record in many places, struck. Due to the buyout program, there were some 2,000 families no longer living in the floodplain. Removing these flood prone properties from harm's way saved millions in disaster assistance and emergency protective measures statewide.

Participating buyout communities were able to focus their efforts on the flood response. They did not have to use their limited resources on evacuating residents or sandbagging structures to save private property in the floodplain. Likewise, claims for flood insurance and applications for assistance, such as Small Business Administration and Individual and Family Grant (IFG) Program loans, were minimized.

The flood of 1995 was significantly equal to the flood of 1993 in the majority of communities that undertook a flood buyout program after the 1993 flood. The cost of human suffering was dramatically reduced in 1995, however, thanks to the buyout program and the associated demolition of about two-thirds of the flood-prone homes after the flood of 1993. This meant that fewer people were in harm's way during the flood of 1995, thanks to Missouri's highly successful buyout program. Flood insurance claims payments on flood buyout properties, totaled more than $22.6 million for the 1993 and 1995 flood events. As a result of the buyout program these claims will never be paid out again.

The flood of May 2007 (DR 1708) drew parallels to the 1993 flood, causing significant damage along the Missouri River, and generated more success stories for the buyout program. In one example, 17 properties had been acquired in the City of Tracy for approximately $450,000. In some areas of Tracy, recent water levels exceeded those of the 1993 flood. Had they not been removed, those 17 homes would have been inundated with flood waters and cost the city and homeowners hundreds of thousands of dollars. Additionally, the spring and summer floods of 2008 (DR-1749 and DR-1773) impacted eastern Missouri. The loss avoidance study conducted by FEMA following these flood events, as presented in Section 7.4.2, demonstrates the cost-effectiveness of the buyout program with losses avoided valued at $96.3 million and a return on investment of 21.2 percent.

Floods occurring in the winter of 2015/2016 (DR-4250 and EM-3374) were also devastating to the State. A highly unusual heavy rainfall event from December 26 through 29 dropped 7.5-10 inches of rain along a 60-mile wide corridor extending from just south of Joplin to St. Louis. Rivers and streams reacted quickly to the post-Christmas rainfall event, and flash flooding was widespread with hundreds of water rescues reported, especially over the southern half of the state. There were 27 flood fatalities reported in 2015. This was more than the combined number for the previous 7 years and represented the highest number since 1993, the highest number on record for the State. A loss avoidance analysis was conducted for this flood event, as presented in Section 7.4.2.

Table 7.17 presents the number of structures acquired and demolished by County with each associated mitigation project.

Table 7.17. Missouri's Community Buyout Program Success

County	Mitigation Project Identifier	Year	Number of Properties
Bollinger	DR-1403-0011-R	2002	26
	DR-1736-0002-R	2007	4
Boone	DR-0995-0016-R	1993	7
	DR-0995-0021-R	1993	4
Buchanan	DR-0995-0035-R	1993	37
	DR-1635-0010-R	2006	1
Butler	DR-1403-0005-R	2002	36
	DR-1676-0021-R	2007	10
	FMA-PJ-07-MO-2006-002	2006	3
Callaway	DR-0995-0003-R	1993	6
	DR-1054-0001-R	1995	2
Cape Girardeau	DR-1054-0001-R	1995	107
	DR-1403-0004-R	2002	2
	DR-1980-0074-R	2011	11
	FMA-PJ-07-MO-2013-005	2013	1
Carroll	DR-0995-0011-R	1993	96
	DR-1253-0005-R	1998	6
Cass	DR-1463-0004-R	2003	4
	DR-1463-0005-R	2003	22
Christian	RFC-PJ-07-MO-2009-001	2009	1
Marion	DR-0995-0004-R	1993	144
	DR-0995-0030-R	1993	37
	DR-1736-0003-R	2007	15
Mississippi	DR-1980-0079-R	2011	19
Moniteau	FMA-PJ-07MO-1997001	1997	7
Montgomery	DR-0995-0005-R	1993	61
	DR-0995-0037-R	1993	16
Newton	DR-0995-0036-R	1993	60
	DR-1403-0002-R	2002	7
	DR-1412-0009-R	2002	1
Nodaway	DR-0995-0038-R	1993	1
Perry	DR-0995-0013-R	1993	32
Phelps	DR-0995-0040-R	1993	25
Platte	DR-0995-0018-R	1993	1
	DR-0995-0031-R	1993	17
	FMA-PJ-07-MO-2016-005	2016	1
Pulaski	DR-1006-0002-R	1993	19
Ray	DR-1253-0002-R	1998	3
Reynolds	DR-1403-0012-R	2002	26
	DR-1412-0005-R	2002	28

County	Mitigation Project Identifier	Year	Number of Properties
Clark	DR-0995-0014-R	1993	43
	DR-0995-0025-R	1993	7
Clay	DR-0995-0026-R	1993	57
	DR-1023-0001-R	1994	11
	DR-1253-0001-R	1998	5
	DR-1253-0004-R	1998	7
	DR-4238-0018-R	2015	1
	FMA-PJ-07-MO-2013-002	2013	2
	FMA-PJ-07-MO-2016-007	2016	4
Cole	DR-0995-0003-R	1993	161
	DR-1412-0010-R	2002	1
Daviess	DR-0995-0041-R	1993	271
Franklin	DR-0995-0033-R	1993	5
	DR-0995-0034-R	1993	34
	DR-0995-0039-R	1993	2
	DR-1023-0002-R	1994	4
	DR-1253-0010-R	1998	19
	DR-1256-0003-R	1998	2
	DR-1328-0001-R	2000	17
	DR-1412-0001-R	2002	11
	DR-1676-0012-R	2007	21
	DR-1708-0001-R	2007	1
	FMA-PJ-07-MO-2013-004	2013	3
	FMA-PJ-07-MO-2016-006	2016	37
Gasconade	DR-0995-0037-R	1993	6
Greene	DR-1253-0012-R	1998	2
	DR-1256-0005-R	1998	1
	DR-1328-0002-R	2000	2
Ripley	DR-1676-0018-R	2007	20
	DR-1980-0036-R	2011	1
	FMA-PJ-07-MO-2013-001	2013	1
Scott	DR-1054-0002-R	1995	29
St. Charles	DR-0995-0001-R	1993	1407
	DR-0995-0017-R	1993	9
	DR-1054-0003-R	1995	8
	DR-1728-0001-R	2007	7
	FMA-PJ-07MO-1997004	1997	1
	FMA-PJ-07MO-1998004	1998	1
	FMA-PJ-07-MO-2008-001	2008	9
	FMA-PJ-07-MO-2013-003	2013	3
	FMA-PJ-07-MO-2014-003	2014	3
	FMA-PJ-07-MO-2014-004	2014	2
	FMA-PJ-07-MO-2014-005	2014	1
	FMA-PJ-07-MO-2015-002	2015	2
	FMA-PJ-07-MO-2016-009	2016	2
	SRL-PJ-07-MO-2008-001	2008	1
St. Clair	DR-0995-0001-R	1993	2
	DR-1023-0003-R	1994	1
St. Francois	DR-1403-0007-R	2002	7
St. Louis	DR-0995-0001-R	1993	1
	DR-0995-0007-R	1993	550
	DR-0995-0008-R	1993	19
	DR-0995-0009-R	1993	9
	DR-1023-0003-R	1994	3
	DR-1403-0006-R	2002	1
	DR-1676-0019-R	2007	6

County	Mitigation Project Identifier	Year	Number of Properties
	DR-1412-0004-R	2002	6
	DR-1760-0001-R	2008	5
	FMA-PJ-07-MO-2006-001	2006	2
Harrison	DR-0995-0037-R	1993	1
Howard	DR-0995-0022-R	1993	73
Howell	DR-1006-0003-R	1993	2
	DR-1403-0003-R	2002	6
	DR-1412-0008-R	2002	3
Iron	DR-1403-0014-R	2002	7
	DR-1412-0011-R	2002	5
	DR-5270-0002-R	1999	6
Jackson	DR-0995-0028-R	1993	5
	DR-1253-0003-R	1998	12
	DR-5256-0002-R	1998	26
Jasper	DR-1980-0077-R	2011	3
Jefferson	DR-0995-0002-R	1993	211
	DR-0995-0012-R	1993	220
	DR-0995-0019-R	1993	19
	DR-0995-0020-R	1993	25
	DR-0995-0042-R	1993	1
	DR-1463-0001-R	2003	3
	DR-1736-0004-R	2007	13
	FMA-PJ-07MO-1997002	1997	1
	FMA-PJ-07MO-1998002	1998	3
	FMA-PJ-07MO-1998005	1998	3
	DR-1749-0007-R	2008	24
	DR-1773-0003-R	2008	2
	DR-1773-0004-R	2008	12
	DR-1822-0027-R	2009	3
	DR-5256-0003-R	1998	1
	DR-5256-0009-R	1998	1
	FMA-PJ-07-MO-2004-001	2004	4
	FMA-PJ-07-MO-2014-001	2014	11
	FMA-PJ-07-MO-2014-002	2014	3
	FMA-PJ-07-MO-2015-001	2015	1
	FMA-PJ-07-MO-2016-001	2016	8
	FMA-PJ-07-MO-2016-003	2016	1
	FMA-PJ-07-MO-2016-004	2016	1
	FMA-PJ-07-MO-2016-008	2016	3
	FMA-PJ-07-MO-2016-010	2016	1
	PDMC-PJ-07-MO-2005-003	2005	2
	PDMC-PJ-07-MO-2009-004	2009	5
	PDMC-PJ-07-MO-2009-006	2009	2
	PDMC-PJ-07-MO-2011-006	2011	1
	RFC-PJ-07-MO-2008-001	2008	1
Ste. Genevieve	DR-0995-0006-R	1993	40
	DR-0995-0010-R	1993	41
Stoddard	DR-0995-0010-R	1993	2
Stone	DR-0995-0008-R	1993	1
Taney	DR-1054-0002-R	1995	2

County	Mitigation Project Identifier	Year	Number of Properties
	FMA-PJ-07MO-1999001	1999	6
	FMA-PJ-07MO-2000001	2000	4
	FMA-PJ-07MO-2001001	2001	5
	FMA-PJ-07-MO-2005-001	2005	1
	FMA-PJ-07-MO-2016-002	2016	2
Lewis	DR-0995-0023-R	1993	2
	DR-0995-0027-R	1993	12
	DR-1708-0005-R	2007	8
Lincoln	DR-0867-0004-R	1990	89
	DR-0995-0015-R	1993	45
	DR-0995-0029-R	1993	376
	PDMC-PJ-07-MO-2005-005	2005	15
Madison	DR-1006-0001-R	1993	27
	DR-1253-0007-R	1998	2
	DR-1253-0008-R	1998	26
	DR-1256-0002-R	1998	16
	DR-1270-0001-R	1999	7
	DR-1270-0002-R	1999	1
	DR-1403-0013-R	2002	20
	DR-1403-0015-R	2002	8
	DR-5270-0003-R	1999	5
	DR-5270-0004-R	1999	3
	DR-5270-0006-R	1999	8

County	Mitigation Project Identifier	Year	Number of Properties
	DR-1412-0007-R	2002	7
	DR-1980-0002-R	2011	9
	DR-1980-0003-R	2011	5
Texas	PDMC-PJ-07-MO-2003-004	2003	3
	PDMC-PJ-07-MO-2005-019	2005	1
Warren	DR-0995-0024-R	1993	20
	DR-0995-0032-R	1993	14
Wayne	DR-0995-0045-R	1993	9
	DR-1006-0007-R	1993	19
	DR-1023-0005-R	1994	2
	DR-1054-0008-R	1995	10
	DR-1403-0008-R	2002	12
	DR-1676-0010-R	2004	9
	DR-1676-0015-R	2004	18
	DR-1749-0009-R	2008	4
	FMA-PJ-07MO-1997003	1997	10
	FMA-PJ-07MO-1998003	1998	6
	RFC-PJ-07-MO-2009-002	2009	1
Webster	DR-1676-0013-F	2007	1
	PDMC-PJ-07-MO-2005-025	2005	1
TOTAL			**5,432**

Source: State Emergency Management Agency

Since the 1993 floods, over 5,430 primary residences have been acquired through the buyout program. This voluntary program has allowed families in flood-prone areas to relocate out of harm's way and reduced disaster-related costs. The acquired properties were placed in public ownership with deed restrictions to ensure that future use of these lands will not put the lives of Missouri residents at risk from flood disasters. The document *Past Mitigation Projects* contains Community Buyout Program statistics through fiscal year 2009.

Some communities have continued this program by using local funds to acquire flood-prone properties. This is a clear example of the positive impact of advertising mitigation success stories. Because of the success of this program, the acquisition of flood-prone structures continues to be a priority for the use of hazard mitigation funds available to the State.

For additional information on the tremendous success of the Missouri Buyout Program, refer to the SEMA and the FEMA library for following documents:

- Loss Avoidance Study: Eastern Missouri, Building Acquisition Part One: General Overview and Part Two: Detailed Methodology"
- Stemming the Tide of Flood Losses
- Missouri Flood Mitigation Project
- Success Stories from the Missouri Buyout Program

As previously mentioned, through the Silver Jackets program, SEMA has proposed, and was awarded funding in late 2017, to develop a Missouri Flood Buyout Strategy to guide the selection process for distribution of mitigation grant funding for acquisition/demolition projects. The developed buyout strategy will identify a variety of selection factors, in addition to historic and potential flood damage, such as impacts to water quality, water quantity, local economy, and housing. The strategy will rank the identified factors and allow the state to better reduce risk through identifying and prioritizing the most flood prone, highest risk properties for buyouts across the state.

Safe Room Construction Program

As of early 2018, 195 tornado safe room projects have been completed or are in progress utilizing FEMA Hazard Mitigation Assistance grants totaling over $228 Million. Since the 2013 State Mitigation Plan, four out of the four Presidential Disaster Declarations in Missouri included devastating tornadoes. The State of Missouri is committed to setting a standard in the State for safe room construction, ensuring that all funded safe rooms are constructed in accordance with FEMA design standards. The newly developed Loss Avoidance Assistance Tool described in Section 7.4.2 has functionality to assess the effectiveness of the safe room program.

In the summer of 2016, SEMA's Mitigation Management Section closed out two community safe room projects: Fordland School District in Webster County and Orchard Farm School District in St. Charles County. During a closeout visit, mitigation staff takes photos of the completed mitigation projects (see **Figure 7.15 and Figure 7.16**) and makes sure the community has all the required paperwork easily accessible if a federal audit is conducted for the project.

Figure 7.15. Fordland School District Safe Room, Webster County

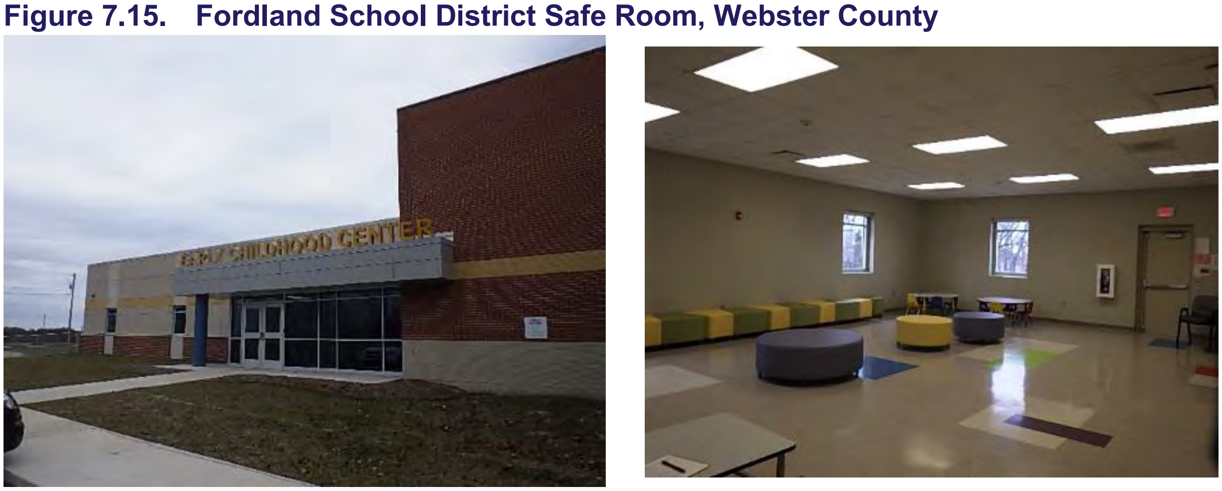


Figure 7.16. Orchard Farm School District Safe Room, St. Charles County

Both the Fordland School District and Orchard Farm School District safe rooms were approved for funding in 2014 through HMGP funding from DR-4144.

In the spring of 2017, SEMA's Mitigation Management Section closed out a community safe room project in Nodaway County at the Maryville R-II School District High School (see **Figure 7.17**.). This project was approved for funding in 2015 through HMGP funding from DR-4200.

Figure 7.17. Maryville School District High School, Nodaway County

Another specific example of the success of this program is the monolithic dome safe room for the Niangua R-V School District in Webster County. This dome-shaped safe room doubles as a preschool classroom and is the first of its kind approved for FEMA funding. This safe room, funded out of the FY2006 appropriation of the PDM grant program will hold approximately 400 people and meets FEMA's criteria for the design and construction of community safe rooms. The new dome-shaped building cost just over $300,000. Monolithic domes are known not only for their safety, but also for their energy efficiency. A dome can cost as much as 50 percent less to heat and cool than a traditional structure of the same size. Also, because of the materials used in their construction, they are also fire-safe.

Local Mitigation Planning Program

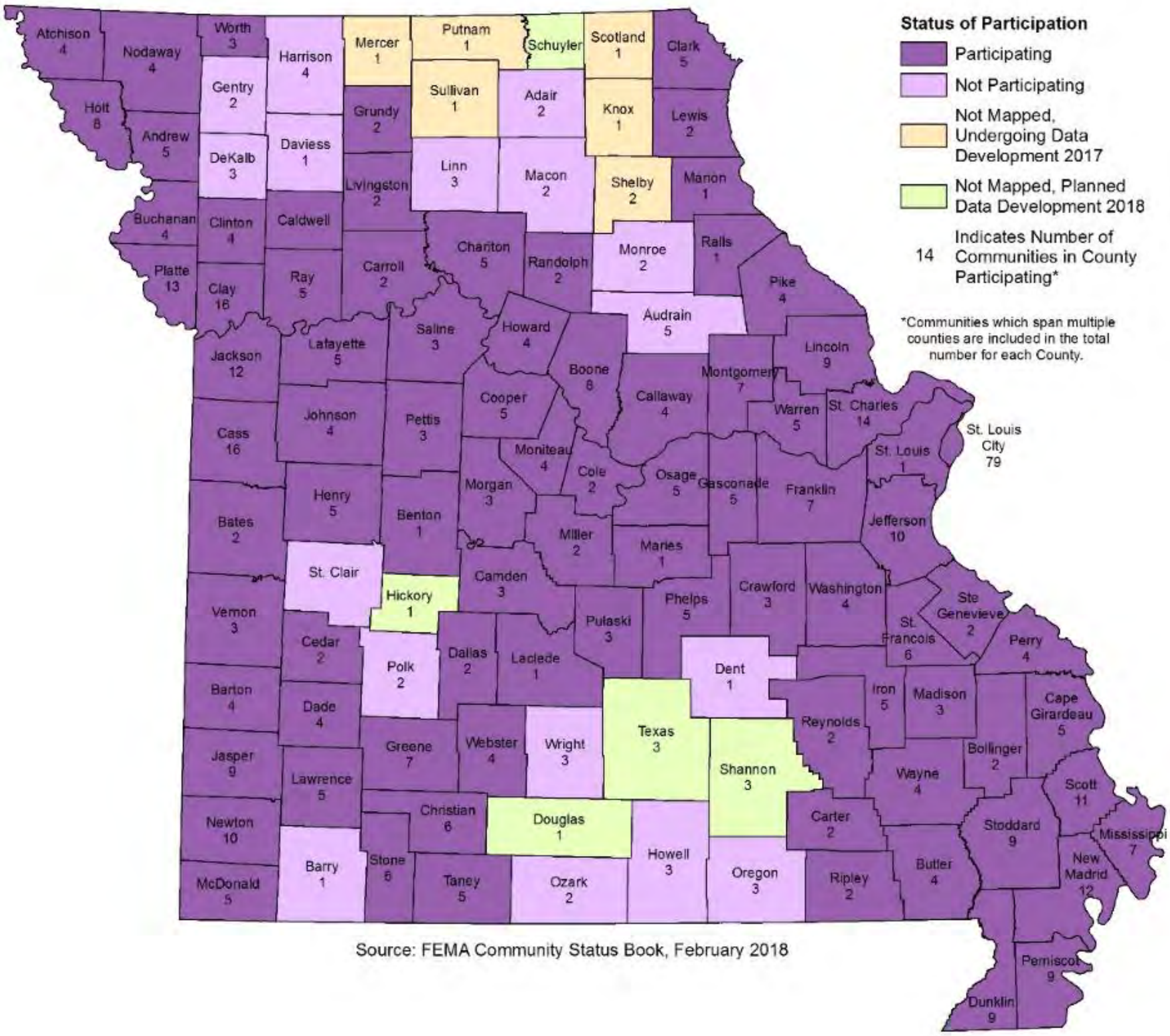
This project was established to develop local hazard mitigation plans that meet the requirements of the Disaster Mitigation Act of 2000. Funding for local hazard mitigation plans has come primarily from Hazard Mitigation Grant Program funds and Pre-Disaster Mitigation funds. This effort showcases the coordination between the State and the Regional Planning Commissions and Councils of Government throughout the State, the represented local communities, business and industry, as well as concerned private citizens. Currently in 2018, there are 105 FEMA-approved local hazard mitigation plans in Missouri, representing 103 county level plans; two regional plans representing a total of 10 counties; one multi-jurisdictional plan representing two counties, and one plan for the Missouri electric cooperatives. Dent County is the only county without a current approved Hazard Mitigation Plan and they are currently in the process of developing a plan. The success of this effort is documented in more detail in Chapter 5 Coordination of Local Mitigation Planning.

National Flood Insurance Program

In Missouri, the National Flood Insurance Program (NFIP) has shown remarkable progress over time. When SEMA took responsibility for administration of the State's floodplain management program in 1995, there were 523 jurisdictions in the National Flood Insurance Program. As of February 2018, there were 673 participating jurisdictions: 672 communities in the regular program and 1 community in the emergency program. All the participating communities have established local floodplain management ordinances to help them administer the program.

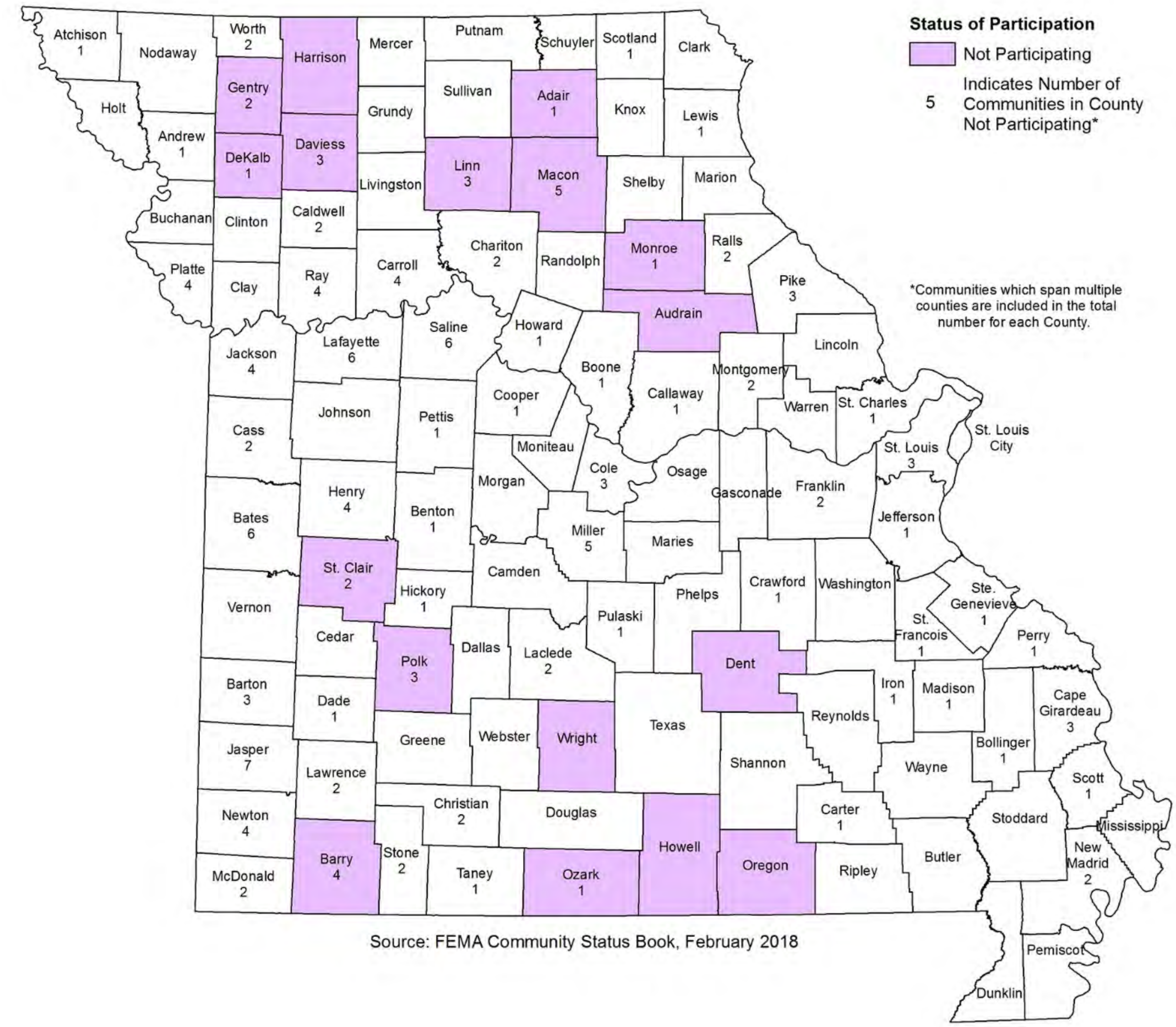
There are 163 jurisdictions in Missouri that are not in the National Flood Insurance Program (NFIP) that have hazard areas identified. Through the Risk MAP program and current Paper Inventory Reduction (PIR) program, SEMA will have a total of 100 counties, or 88% of the State, with updated and identified flood hazard areas by 2019. With the identification of new flood hazard areas, communities are learning of their flood risk and opportunities to join the NFIP. The locations of participating and nonparticipating communities are mapped by county in **Figure 7.18** and **Figure 7.19**, respectively.

Figure 7.18. Missouri Communities Participating in NFIP



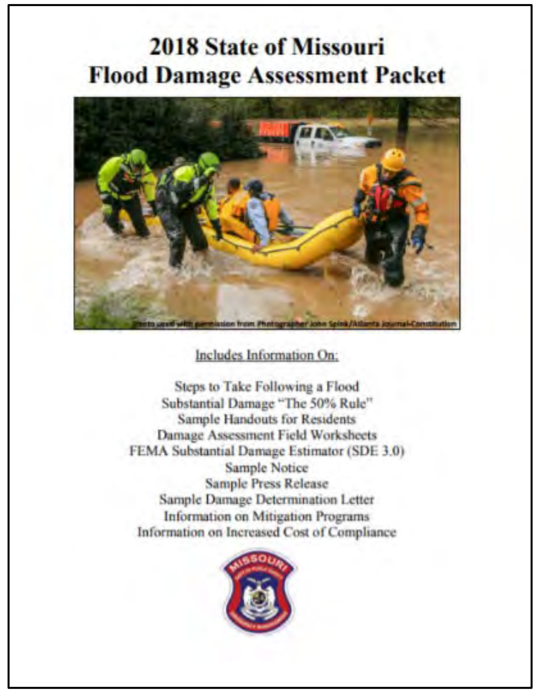
Source: FEMA Community Status Book, February 2018

Figure 7.19. Missouri Communities Not Participating in NFIP



Floodplain Management Outreach

The devastating flood event of December 2015 (DR-4250) forced numerous evacuations and resulted in 27 flood fatalities. The State faced massive cleanup efforts that would last for months. Because of excellent outreach efforts following this flood event, many communities that were affected by a later flooding event in June of 2017 (DR-4317) were off and running with substantial damage evaluations immediately after the waters receded, expediting the recovery process for dozens of affected communities. Outreach efforts included notification to local floodplain managers in NFIP communities accompanied with a 23-page "Missouri Flood Damage Assessment Packet". The packet included information on:


2018 State of Missouri
Flood Damage Assessment Packet

Includes Information On:

Steps to Take Following a Flood
Substantial Damage "The 50% Rule"
Sample Handouts for Residents
Damage Assessment Field Worksheets
FEMA Substantial Damage Estimator (SDE 3.0)
Sample Notice
Sample Press Release
Sample Damage Determination Letter
Information on Mitigation Programs
Information on Increased Cost of Compliance

- Steps to take following a flood
- Substantial Damage "The 50% Rule"
- Sample handouts for residents
- Damage Assessment Field Worksheets (various samples)
- FEMA Substantial Damage Estimator (SDE 2.2.2)
- Sample Notice
- Sample Press Release
- Sample Damage Determination Letter
- Information on Mitigation Grant Programs
- Information on Increased Cost of Compliance

This outreach process is an ongoing effort. The packet was updated recently for use in 2018.

MoDNR Stormwater Improvements

In 2001, the Missouri Department of Natural Resources (MoDNR) awarded more than $9.9 million to 46 Missouri communities for stormwater improvements. Of these 46 communities, 7 of them had populations of 3,000 or less. Funding for these grants came from bond issues approved by Missouri voters in 1988 and 1998 for improvements to stormwater, wastewater treatment, and public drinking water systems.

Types of projects approved by DNR included, but were not limited to:

- Drainage modifications to prevent pooling water, reduce streambank erosion, reduce localized flooding, and improve discharge water quality
- Buyout and demolition of flood-prone homes
- Replacement of undersized drainage systems to prevent flooding of houses and streets
- Channel stabilization and drainage improvement
- Modification of existing detention basin outlet for better storage capacity and to help avert downstream flooding
- Development of city- and county-wide stormwater management plans
- Construction of stormwater collection and control systems
- Combinations of biostabilization measures and upstream detention to alleviate existing erosion and to prevent future channel degradation based on anticipated future development conditions
- Construction of new storm sewer systems

CDBG Disaster Supplemental Funding

The State of Missouri received two separate CDBG Disaster Supplemental Appropriations related to the weather-related events of 2008.

1) The Supplemental Appropriations Act of 2008 provided $300 million of CDBG supplemental funds for necessary expenses related to disaster relief, long-term recovery, and restoration of infrastructure in areas covered by a declaration of major disaster under Title IV of the Stafford Act. Missouri received $11,032,438 from this appropriation, and was limited to activities covered under Disaster Declarations 1760 and 1773.
2) The Consolidated Security, Disaster Assistance, and Continuing Appropriations Act (PL-110-329 and hereafter identified as the Second 2008 Act) appropriates over $6 billion in CDBG funds for necessary expenses related to disaster relief, long-term recovery, and restoration of infrastructure, housing and economic revitalization in areas affected by hurricanes, flooding and other natural disasters that occurred during 2008, for which the President declared a major disaster under title IV of the Robert T. Stafford Disaster Relief and Emergency Assistance Act. The allocation awarded to Missouri from this Supplemental Appropriation is $92,605,490. Of this allocation, an amount not less than $10,372,631 must be used for affordable rental housing. All but 8 Missouri counties were covered by at least one disaster declaration during 2008.

Missouri has awarded 99 percent (net of state administration) of the 1st supplemental appropriation on projects specifically related to disaster events 1760 and 1773, as required by the Act. These projects consist of mostly infrastructure restoration projects, plus some commercial and residential buyout.

By April 2010, Missouri had formally awarded approximately half (net of state administration) of the 2nd supplemental appropriation on projects in the disaster affected areas, as required by the Second 2008 Act. These projects consist of infrastructure restoration, job training, and economic revitalization in the disaster declared areas. Applications are still under review, and 100 percent of the appropriation will be awarded for eligible projects in the disaster declared areas.

In addition, Missouri used existing CDBG funding (recaptured funds and program income) to address flooding events in early 2008 for which no supplemental appropriation was yet available. A total of 13 projects were awarded for levee repair and acquisition of flood affected homes; the amount awarded was $2.8 million. This is in addition to the supplemental funding.

In 2012 CDBG received a supplemental for 2011 events. Section 239 of the Department of Housing and Urban Development Appropriations Act, 2012 (Public Law 112-55, approved November 18, 2011) makes available up to $400 million, to remain available until expended, in CDBG funds for necessary expenses related to disaster relief, long-term recovery, restoration of infrastructure and housing, and economic revitalization in the most impacted and distressed areas resulting from a major disaster declared in 2011 pursuant to the Robert T. Stafford Disaster Relief and Emergency Assistance Act of 1974.

The State of Missouri Department of Economic Development (DED) has been awarded $8,719,059 from this appropriation. The federal disaster declarations that are specific to this supplemental appropriation are 1980 and 4012. Only areas included in one of these disaster declarations are eligible to apply for and receive CDBG assistance from this Disaster Appropriation.

Reservoirs, Levees, and Flood Walls

During the Great Flood of 1993, flood damage reduction structures prevented an estimated $19.1 billion in potential additional damage, according to the May 26, 1994, *Draft Report of the Interagency Floodplain Management Review Committee*. Of that, it is estimated that at least $11.5 billion damage was prevented along the Missouri River: $7.4 billion was attributed to management of floodwater stored in reservoirs and $4.1 billion was attributed to levees. Reservoirs, levees, and flood walls prevented damage of approximately $5.6 billion in Kansas City.

Another study, conducted by a former U.S. Army Corps of Engineers (Corps) District engineer, estimated flood damage in the St. Louis district of the Corps at $1.4 billion. At the same time, the study estimated damage prevented by federal flood damage reduction efforts at $5.4 billion. Thus, an 80 percent reduction in potential damage was achieved in the St. Louis Corps district.

Missouri Bridges Constructed to Withstand Earthquakes

The Missouri Department of Transportation (MoDOT) began designing bridges to resist seismic hazards in 1990. However, many of the nearly 2,000 bridge structures in earthquake-prone portions of the State were not designed to resist seismic induced forces. Several structures in St. Louis that were designed and constructed before 1990 have been retrofitted to resist seismic induced forces.

Construction of the retrofit of Poplar Street Bridge in St. Louis, Missouri was completed in late 2002 at a cost of $6.2 million. This 2,165-foot bridge carries more than 130,000 vehicles per day across the Mississippi River.

Figure 7.20. Pier 1 Retrofits on the Poplar Street Bridge, St. Louis, Missouri

Source: Seismic Retrofit of the Popular Street Bridge, Mark R. Capron

National Oceanic and Atmospheric Administration Weather Radio All Hazards

The National Oceanic and Atmospheric Administration (NOAA) Weather Radio All Hazards (NWR) is an all-hazards public warning system that broadcasts forecasts, warnings, and emergency information 24 hours a day. The National Weather Service has responsibility for the NWR. Tone alert radios receive the broadcasts and can be programmed to sound when severe weather watches, warnings, or other critical information is broadcast. They are designed to automatically sound when warnings are issued.

The NWR project increased the number of NOAA weather warning transmitters in Missouri from 10 in 1998 to 34 in 2007 and continued to increase to 240 in 2018 (See **Table 7.18**). Every county in the State is covered by a NOAA Weather Radio transmitter. However, due to hills and other issues that cause signal blockage, there are areas that cannot pick up a strong signal. Approximately 95 percent of the State can receive NWR broadcasts (see **Figure 7.21**). This success story is a result of the cooperative efforts of State, federal, and local government; private citizens; business and industry; and the State's electric cooperatives.

The expanded severe weather warning coverage provided by these transmitters benefits everyone in the State. By providing early warnings for severe weather, these transmitters enable people in the affected areas to take cover and protect themselves from severe weather.

Table 7.18. Missouri NOAA Weather Radio Stations

County	Site Number	Site Location	Call Sign	Frequency
Adair	29001	La Plata	WXM39	162.525
Adair	29001	Lancaster	WXM36	162.550
Andrew	29003	Cameron	KZZ85	162.475
Andrew	29003	Maryville	KZZ37	162.425
Andrew	29003	Saint Joseph	KEC77	162.400
Atchison	29005	Maryville	KZZ37	162.425
Atchison	29005	Shubert	KWN41	162.500
Audrain	29007	Bellflower	WNG728	162.450
Audrain	29007	Columbia	WXL45	162.400
Barry	29009	Avilla	WXJ61	162.425
Barry	29009	Branson	KZZ43	162.550
Barry	29009	Cassville	WNG608	162.500
Barry	29009	Springdale	WNG694	162.400
Barry	29009	Springfield	WXL46	162.400
Barton	29011	Avilla	WXJ61	162.425
Barton	29011	El Dorado Springs	KZZ30	162.475
Bates	29013	Clinton	KZZ39	162.500
Bates	29013	El Dorado Springs	KZZ30	162.475
Bates	29013	Parker	WZ2512	162.525
Benton	29015	Clinton	KZZ39	162.500
Benton	29015	El Dorado Springs	KZZ30	162.475
Benton	29015	Eldon	WZ2548	162.550
Bollinger	29017	Cape Girardeau	KXI93	162.550
Bollinger	29017	Fredericktown	WWG49	162.500
Boone	29019	Columbia	WXL45	162.400
Boone	29019	Jamestown	KWN55	162.425
Buchanan	29021	Cameron	KZZ85	162.475
Buchanan	29021	Saint Joseph	KEC77	162.400
Butler	29023	Bloomfield	WXL47	162.400
Butler	29023	Doniphan	WWG48	162.450
Butler	29023	Piedmont	KXI66	162.425
Caldwell	29025	Cameron	KZZ85	162.475
Caldwell	29025	Carrollton	KZZ34	162.450

County	Site Number	Site Location	Call Sign	Frequency
Caldwell	29025	Trenton	KZZ38	162.500
Callaway	29027	Bellflower	WNG728	162.450
Callaway	29027	Columbia	WXL45	162.400
Camden	29029	Eldon	WZ2548	162.550
Cape Girardeau	29031	Cape Girardeau	KXI93	162.550
Carroll	29033	Carrollton	KZZ34	162.450
Carter	29035	Doniphan	WWG48	162.450
Carter	29035	Piedmont	KXI66	162.425
Cass	29037	Clinton	KZZ39	162.500
Cass	29037	Kansas City	KID77	162.550
Cass	29037	Parker	WZ2512	162.525
Cedar	29039	Avilla	WXJ61	162.425
Cedar	29039	El Dorado Springs	KZZ30	162.475
Chariton	29041	Carrollton	KZZ34	162.450
Chariton	29041	La Plata	WXM39	162.525
Christian	29043	Branson	KZZ43	162.550
Christian	29043	Springfield	WXL46	162.400
City of St. Louis	29510	St. Louis	KDO89	162.550
Clark	29045	Medill	WXL99	162.450
Clay	29047	Cameron	KZZ85	162.475
Clay	29047	Kansas City	KID77	162.550
Clinton	29049	Cameron	KZZ85	162.475
Clinton	29049	Saint Joseph	KEC77	162.400
Cole	29051	Columbia	WXL45	162.400
Cole	29051	Eldon	WZ2548	162.550
Cole	29051	Jamestown	KWN55	162.425
Cooper	29053	Carrollton	KZZ34	162.450
Cooper	29053	Columbia	WXL45	162.400
Cooper	29053	Jamestown	KWN55	162.425
Crawford	29055	Bourbon	WWF75	162.525
Dade	29057	Avilla	WXJ61	162.425
Dade	29057	El Dorado Springs	KZZ30	162.475
Dade	29057	Springfield	WXL46	162.400
Dallas	29059	Eldon	WZ2548	162.550
Dallas	29059	Springfield	WXL46	162.400
Daviess	29061	Cameron	KZZ85	162.475
Daviess	29061	Trenton	KZZ38	162.500
DeKalb	29063	Cameron	KZZ85	162.475

County	Site Number	Site Location	Call Sign	Frequency
DeKalb	29063	Saint Joseph	KEC77	162.400
Dent	29065	Summersville	WWF76	162.475
Douglas	29067	Gainesville	KZZ82	162.425
Douglas	29067	Springfield	WXL46	162.400
Douglas	29067	Summersville	WWF76	162.475
Douglas	29067	West Plains	KXI38	162.525
Dunklin	29069	Bloomfield	WXL47	162.400
Dunklin	29069	Jonesboro	WXJ51	162.550
Dunklin	29069	Wardell	WWG47	162.525
Franklin	29071	Bellflower	WNG728	162.450
Franklin	29071	Bourbon	WWF75	162.525
Franklin	29071	St. Louis	KDO89	162.550
Gasconade	29073	Bellflower	WNG728	162.450
Gasconade	29073	Bourbon	WWF75	162.525
Gasconade	29073	Columbia	WXL45	162.400
Gentry	29075	Cameron	KZZ85	162.475
Gentry	29075	Maryville	KZZ37	162.425
Greene	29077	Springfield	WXL46	162.400
Grundy	29079	Trenton	KZZ38	162.500
Harrison	29081	Maryville	KZZ37	162.425
Harrison	29081	Trenton	KZZ38	162.500
Henry	29083	Clinton	KZZ39	162.500
Hickory	29085	El Dorado Springs	KZZ30	162.475
Hickory	29085	Eldon	WZ2548	162.550
Hickory	29085	Hermitage	WXM81	162.450
Holt	29087	Maryville	KZZ37	162.425
Holt	29087	Saint Joseph	KEC77	162.400
Holt	29087	Shubert	KWN41	162.500
Howard	29089	Carrollton	KZZ34	162.450
Howard	29089	Columbia	WXL45	162.400
Howard	29089	Jamestown	KWN55	162.425
Howell	29091	Alton	KXI35	162.500
Howell	29091	Summersville	WWF76	162.475
Howell	29091	West Plains	KXI38	162.525
Iron	29093	Fredericktown	WWG49	162.500
Jackson	29095	Kansas City	KID77	162.550
Jasper	29097	Avilla	WXJ61	162.425
Jasper	29097	Joplin	WZ2545	162.550

County	Site Number	Site Location	Call Sign	Frequency
Jasper	29097	Neosho	KJY82	162.450
Jefferson	29099	St. Louis	KDO89	162.550
Johnson	29101	Clinton	KZZ39	162.500
Johnson	29101	Kansas City	KID77	162.550
Knox	29103	La Plata	WXM39	162.525
Knox	29103	Medill	WXL99	162.450
Laclede	29105	Eldon	WZ2548	162.550
Laclede	29105	Springfield	WXL46	162.400
Lafayette	29107	Carrollton	KZZ34	162.450
Lafayette	29107	Kansas City	KID77	162.550
Lawrence	29109	Avilla	WXJ61	162.425
Lawrence	29109	Cassville	WNG608	162.500
Lawrence	29109	Springfield	WXL46	162.400
Lewis	29111	Hannibal	WXK82	162.475
Lewis	29111	Medill	WXL99	162.450
Lincoln	29113	Bellflower	WNG728	162.450
Lincoln	29113	St. Louis	KDO89	162.550
Linn	29115	Carrollton	KZZ34	162.450
Linn	29115	La Plata	WXM39	162.525
Linn	29115	Trenton	KZZ38	162.500
Livingston	29117	Carrollton	KZZ34	162.450
Livingston	29117	Trenton	KZZ38	162.500
Macon	29121	Carrollton	KZZ34	162.450
Macon	29121	La Plata	WXM39	162.525
Madison	29123	Fredericktown	WWG49	162.500
Maries	29125	Eldon	WZ2548	162.550
Marion	29127	Hannibal	WXK82	162.475
McDonald	29119	Avilla	WXJ61	162.425
McDonald	29119	Cassville	WNG608	162.500
McDonald	29119	Grove	WWH38	162.525
McDonald	29119	Neosho	KJY82	162.450
McDonald	29119	Springdale	WNG694	162.400
Mercer	29129	Trenton	KZZ38	162.500
Miller	29131	Eldon	WZ2548	162.550
Mississippi	29133	Bloomfield	WXL47	162.400
Mississippi	29133	Cape Girardeau	KXI93	162.550
Mississippi	29133	Mayfield	KIH46	162.475
Moniteau	29135	Columbia	WXL45	162.400

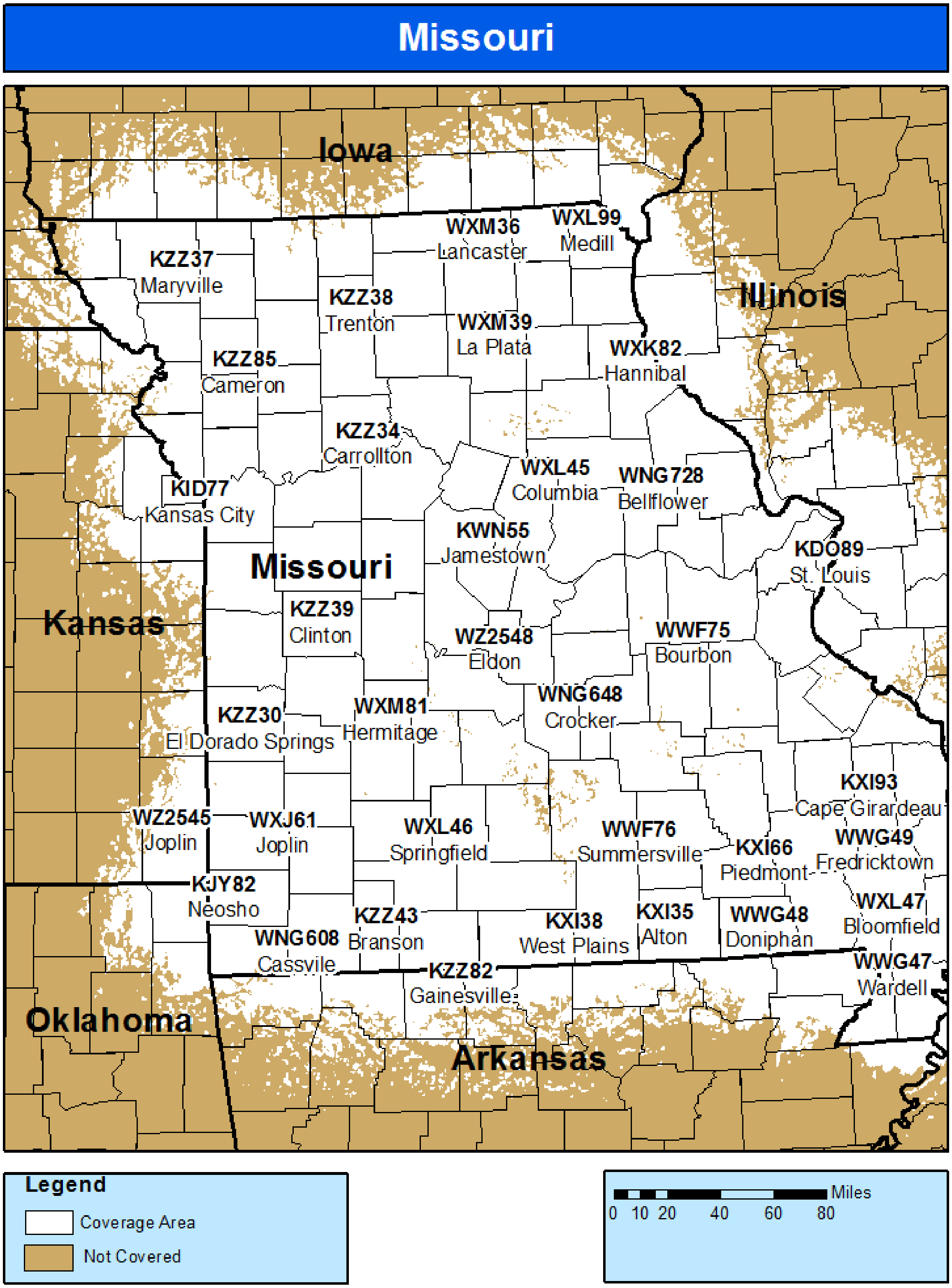
County	Site Number	Site Location	Call Sign	Frequency
Moniteau	29135	Eldon	WZ2548	162.550
Moniteau	29135	Jamestown	KWN55	162.425
Monroe	29137	Bellflower	WNG728	162.450
Monroe	29137	Hannibal	WXK82	162.475
Montgomery	29139	Bellflower	WNG728	162.450
Montgomery	29139	Columbia	WXL45	162.400
Morgan	29141	Eldon	WZ2548	162.550
New Madrid	29143	Bloomfield	WXL47	162.400
New Madrid	29143	Wardell	WWG47	162.525
Newton	29145	Avilla	WXJ61	162.425
Newton	29145	Cassville	WNG608	162.500
Newton	29145	Grove	WWH38	162.525
Newton	29145	Neosho	KJY82	162.450
Nodaway	29147	Maryville	KZZ37	162.425
Oregon	29149	Alton	KXI35	162.500
Oregon	29149	Summersville	WWF76	162.475
Oregon	29149	West Plains	KXI38	162.525
Osage	29151	Bellflower	WNG728	162.450
Osage	29151	Columbia	WXL45	162.400
Osage	29151	Eldon	WZ2548	162.550
Ozark	29153	Gainesville	KZZ82	162.425
Ozark	29153	West Plains	KXI38	162.525
Pemiscot	29155	Dyersburg	WWH30	162.500
Pemiscot	29155	Jonesboro	WXJ51	162.550
Pemiscot	29155	Wardell	WWG47	162.525
Perry	29157	Cape Girardeau	KXI93	162.550
Perry	29157	Chester	KXI42	162.450
Perry	29157	Fredericktown	WWG49	162.500
Pettis	29159	Carrollton	KZZ34	162.450
Pettis	29159	Clinton	KZZ39	162.500
Phelps	29161	Bourbon	WWF75	162.525
Phelps	29161	Crocker	WNG648	162.500
Pike	29163	Bellflower	WNG728	162.450
Pike	29163	Hannibal	WXK82	162.475
Platte	29165	Kansas City	KID77	162.550
Platte	29165	Saint Joseph	KEC77	162.400
Polk	29167	El Dorado Springs	KZZ30	162.475
Polk	29167	Springfield	WXL46	162.400

County	Site Number	Site Location	Call Sign	Frequency
Pulaski	29169	Crocker	WNG648	162.500
Pulaski	29169	Eldon	WZ2548	162.550
Putnam	29171	Lake Rathbun	WXN91	162.425
Putnam	29171	Lancaster	WXM36	162.550
Putnam	29171	Trenton	KZZ38	162.500
Ralls	29173	Hannibal	WXK82	162.475
Randolph	29175	Carrollton	KZZ34	162.450
Randolph	29175	La Plata	WXM39	162.525
Ray	29177	Cameron	KZZ85	162.475
Ray	29177	Carrollton	KZZ34	162.450
Ray	29177	Kansas City	KID77	162.550
Reynolds	29179	Fredericktown	WWG49	162.500
Reynolds	29179	Piedmont	KXI66	162.425
Ripley	29181	Doniphan	WWG48	162.450
Ripley	29181	Piedmont	KXI66	162.425
Saline	29195	Carrollton	KZZ34	162.450
Schuyler	29197	Lancaster	WXM36	162.550
Scotland	29199	Lancaster	WXM36	162.550
Scotland	29199	Medill	WXL99	162.450
Scott	29201	Bloomfield	WXL47	162.400
Scott	29201	Cape Girardeau	KXI93	162.550
Shannon	29203	Alton	KXI35	162.500
Shannon	29203	Summersville	WWF76	162.475
Shelby	29205	Hannibal	WXK82	162.475
Shelby	29205	La Plata	WXM39	162.525
St. Charles	29183	Bellflower	WNG728	162.450
St. Charles	29183	St. Louis	KDO89	162.550
St. Clair	29185	Clinton	KZZ39	162.500
St. Clair	29185	El Dorado Springs	KZZ30	162.475
St. Francois	29187	Fredericktown	WWG49	162.500
St. Louis	29189	St. Louis	KDO89	162.550
Ste. Genevieve	29186	Fredericktown	WWG49	162.500
Stoddard	29207	Bloomfield	WXL47	162.400
Stone	29209	Avilla	WXJ61	162.425
Stone	29209	Branson	KZZ43	162.550
Stone	29209	Springfield	WXL46	162.400
Sullivan	29211	La Plata	WXM39	162.525
Sullivan	29211	Lancaster	WXM36	162.550

County	Site Number	Site Location	Call Sign	Frequency
Sullivan	29211	Trenton	KZZ38	162.500
Taney	29213	Branson	KZZ43	162.550
Taney	29213	Gainesville	KZZ82	162.425
Taney	29213	Springfield	WXL46	162.400
Texas	29215	Summersville	WWF76	162.475
Vernon	29217	El Dorado Springs	KZZ30	162.475
Vernon	29217	Parker	WZ2512	162.525
Warren	29219	Bellflower	WNG728	162.450
Warren	29219	St. Louis	KDO89	162.550
Washington	29221	Bourbon	WWF75	162.525
Wayne	29223	Bloomfield	WXL47	162.400
Wayne	29223	Doniphan	WWG48	162.450
Wayne	29223	Fredericktown	WWG49	162.500
Wayne	29223	Piedmont	KXI66	162.425
Webster	29225	Springfield	WXL46	162.400
Worth	29227	Maryville	KZZ37	162.425
Wright	29229	Springfield	WXL46	162.400

Source: National Weather Service

Figure 7.21. Missouri's NOAA Weather Radio Coverage



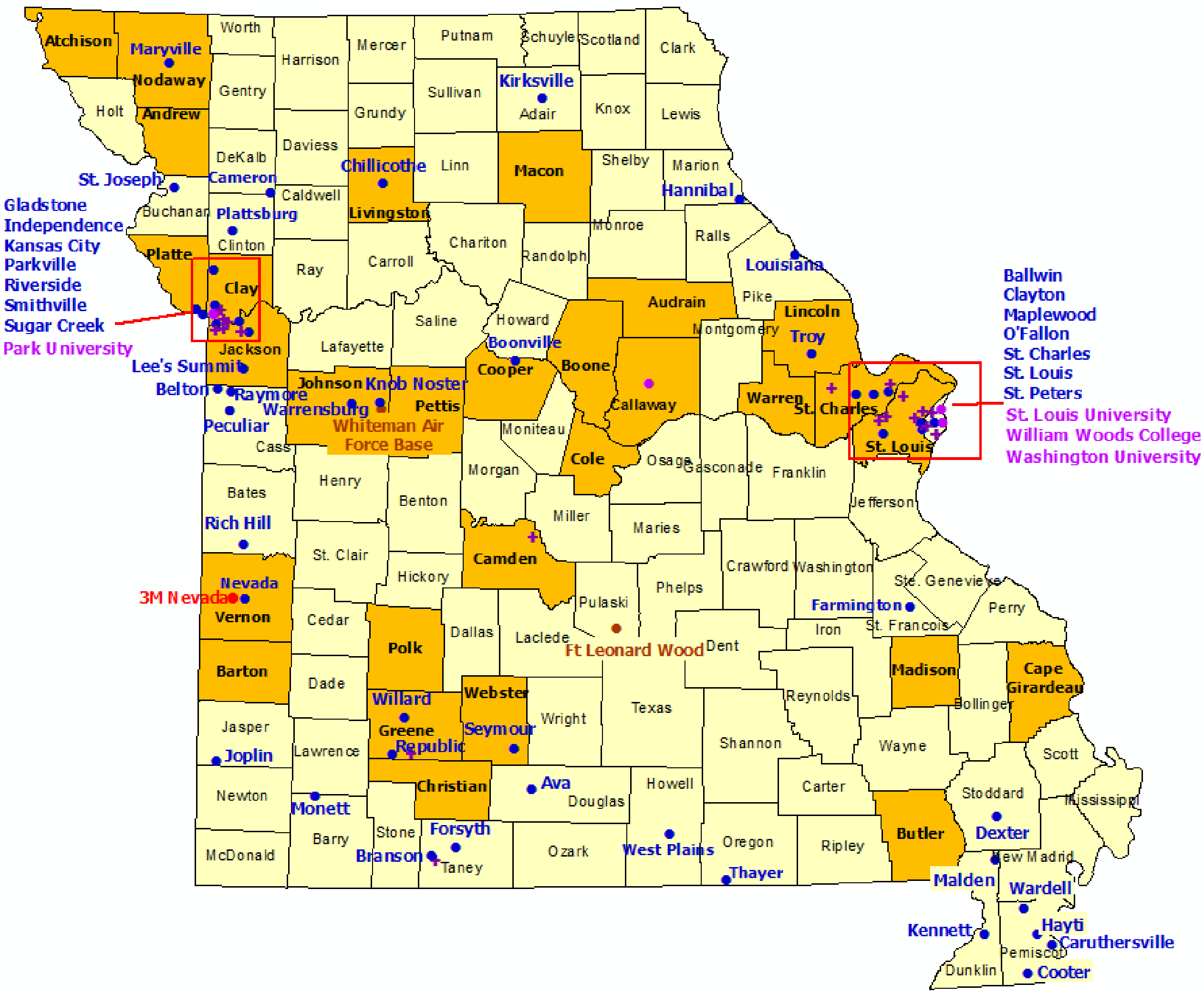
National Oceanic and Atmospheric Administration (NOAA) StormReady Program

Missouri has consistently made progress in preparing its communities for severe weather. Storm Ready sites have increased from 28 in 2004 to 86 in 2018:

- 2004 - 7 counties, 20 communities, and 1 commercial site in the StormReady program.
- 2007 - 16 counties, 25 communities, 1 commercial site (there are only 5 nationwide), and 1 university.
- 2010 - 16 counties, 34 communities, 2 commercial sites, 1 university, and 2 supporters.
- 2018 - 29 Counties, 50 Communities, 2 Government/Military Sites, 4 Universities, 1 Commercial Site 22 Supporters

Missouri's 84 StormReady® Designated communities are presented in **Figure 7.22**.

Figure 7.22. Missouri's StormReady Designations



Source: National Weather Service StormReady® Program, http://www.weather.gov/stormready/mo-sr

Disaster Resistant Community Program

Although the program has ended, the State of Missouri's Disaster Resistant Community program, in conjunction with the former FEMA Project Impact program was labeled a great success. Through this initiative, the civic and political leaders of eight communities developed and instituted sound mitigation actions in their respective communities. While only eight communities are formally recognized as "Disaster Resistant Communities," the Hazard Mitigation Planning initiative promotes similar strategies as communities develop partnerships and a strategy with an ultimate goal of being resistant to the impacts of disasters. As discussed previously, Dent County is the only county without a current approved Hazard Mitigation Plan and they are currently in the process of developing a plan.

Other Mitigation Projects

The following success stories highlight the potential for future loss reduction and how mitigation projects have been successful in meeting multiple community objectives and effectively leveraging partnerships.

Brush Creek Community Partners

When the Brush Creek Flood Control and Beautification Project was initiated in the 1980s, the decision was made for what is also known as the Federal Project to be constructed between Tracy Avenue and Roanoke Parkway. Since the completion of this phase in 1996, concern about the reach from Roanoke west into Kansas have intensified. The concrete that lines the channel has broken up, the banks are eroding and trees have fallen into the creek. The City of Kansas City, Johnson County, Kansas and the U.S. Army Corps of Engineers have collaborated to examine conditions in the entire 29 square mile watershed in order develop a comprehensive plan to improve flood risk management and water quality while balancing economic, environmental and social benefits. The Bi-State Reach between Roanoke and just into Johnson County is the first of a few specific areas being examined in the study.

MoDNR Dam Safety Program – New Technology Used to Create Dam Inundation Maps

The Missouri DNR's Water Resources Center has developed a procedure for creating dam inundation maps by augmenting field surveys with highly sophisticated imaging and geospatial software and equipment. These systems include high resolution LiDAR elevation data, HEC-RAS software, HEC-GeoRAS, and Digital Elevation Model (DEM) data.

City of Neosho

This city has successfully developed a stormwater utility and has used the funds to create detention basins and improve the aesthetics of the downtown area. These efforts were spurred by participation in an earlier flood buyout program, where the success of mitigation was apparent to the residents and leaders of this community.

Kansas City

Kansas City used its own tax revenue to elevate a low bridge that had been overtopped by a flash flood in 1998 that killed eight people. The Prospect Bridge was elevated in conjunction with creek stabilization and open space improvements using "No Adverse Impact" principles of floodplain management. The very weekend the bridge was dedicated in October 2004, the area experienced heavy rains that could have resulted in flooding if the bridge had not been replaced.

City of Piedmont

This city has an annual creek cleanup, in cooperation with the Department of Conservation and the Natural Resource Conservation Service. This is an example of a true community cooperative effort that involves these agencies as well as local volunteers, including local boy scouts. The cleanup helps reduce flooding by reducing channel clogging debris. The aesthetics of the community are improved and the environmental benefits include improved habitat for fish.

Hannibal

The Mississippi River has always been a threat to Hannibal; and after eight close calls over three decades, local businessmen, banks, and city government raised the $850,000 local share for a $5.8

million flood wall. The wall, which was constructed between the town and the river, was completed barely one year before the 1993 flood. The U.S. Corps of Engineers estimated that the wall prevented $14.5 million in damage to downtown Hannibal, more than two times what it cost.

Other areas of Hannibal did not fare so well. Because of the large number of homes that were damaged, the State was quick to initiate a buyout program. The program proved to be successful when, in 1995, another flood struck Hannibal. This time though, no one was forced from their homes, and no homes were ruined. The people and their homes had been moved out of harm's way. In all, 116 homes were purchased in Hannibal through the buyout program, and the land, once a problem, is now an asset, serving a variety of recreational, even revenue generating, purposes.

City of St. Joseph Manufactured Home Park Shelter Ordinance

The City of St. Joseph, Missouri, established an ordinance that requires manufactured home communities to provide storm safe rooms for their residents. All storm safe rooms are required to meet local Americans with Disabilities Act requirements and the design criteria set forth by FEMA 361, Design and Construction Guidance for Community Shelters. For details, contact the City of St. Joseph Building Codes Department.

Kansas City Area Northland Habitat for Humanity Safe room Initiative

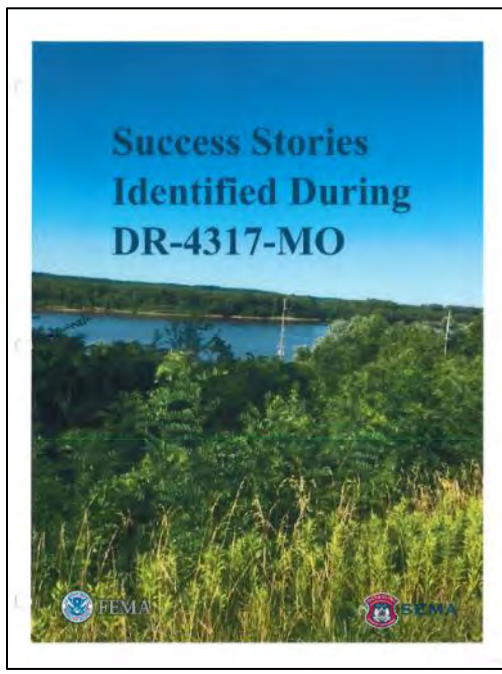
The Habitat for Humanity Northland coordinated the construction of safe rooms in 10 of their homes. All safe rooms were constructed to meet criteria set forth by FEMA 320, Taking Shelter From the Storm: Building a Safe room Inside Your House. For details on the Habitat for Humanity safe room projects, contact your local Habitat for Humanity chapter.

Additional Projects

Listed below are more examples of the types of mitigation projects that have been undertaken by communities throughout the State. These projects were cost-effective based on the FEMA benefit-cost analysis module, and they provided a benefit to their communities by decreasing the impact of related disasters.

Success Stories Identified During DR-4317-MO

Mitigation success stories following the June flood event of 2017 are highlighted in the joint FEMA-SEMA publication "Success Stories Identified During DR-4317-MO". Many of these stories such as floodplain management outreach, home buyout, and stream restoration are shared throughout Section0.



City of Cassville – Flat Creek stream cleaning and restoration. Sediment accumulation along Flat Creek in Cassville contributed to massive flooding during the August flood event of 2015. The event left homes and businesses flooded, as well as, six ballfields, several trash receptacles and a walking trail. The City utilized funds from their Parks and Stormwater tax to cover the cost to restore the carrying capacity of the stream. In coordination with MoDNR and the USACE, the project included dredging 2,000 feet of upstream creek bed, widening the creek 50 feet, increasing the depth another five feet, and removing small trees and debris.

Following the 2017 flood event (DR-4317), homes and businesses that were damaged in the 2015 flood were not affected, and only two of the six ballfields sustained damage.

City of Richmond—Drop box installation ($2,434), to alleviate flooding caused by stormwater runoff, which exceeded capacity of old drainage system.

Moniteau County—Culvert replacement at four locations ($8,731), to replace and upgrade culverts at four locations.

Platte County—Culvert upgrade at two locations ($20,371), to upgrade culverts where capacity was not sufficient to handle run off from heavy rain events.

Platte County—Sewer upgrade ($11,927), to replace storm sewer in residential area, which was no longer collecting stormwater.

City of Blue Springs—Sewer upgrade ($177,455), to increase capacity of sanitary sewer system in residential area, which would overflow during heavy rain events.

City of Grain Valley—Culvert upgrade ($91,000), to increase capacity of stormwater culvert in residential area, which would overflow during heavy rain events.

City of Grain Valley—Manhole repairs ($32,979), to clean, repair, and seal 48 manholes to prevent infiltration of stormwater into the sanitary sewer system.

City of Lee's Summit—Sewer upgrade ($669,000), to increase capacity of sanitary sewer system in residential area, which would overflow during heavy rain events.

City of Greenwood—Sewer upgrade ($288,233), to replace existing storm sewer system in residential area, which had deteriorated to 10 percent of capacity.

City of Savannah—Sewer improvements ($336,837), to install improved drainage system in commercial and residential area, which overflowed during heavy rain events.

7.6. Commitment to a Comprehensive Mitigation Program

Requirement §201.5(b)(4)(i-vi):	**The enhanced plan must demonstrate that the state is committed to a comprehensive state mitigation program, which might include any of the following:** (i) A commitment to support local mitigation planning by providing workshops and training, state planning grants, or coordinated capability development of local officials, including emergency management and floodplain management certifications. (ii) A statewide program of hazard mitigation through the development of legislative initiatives, mitigation councils, formation of public/private partnerships, and/or other executive actions that promote hazard mitigation. (iii) The state provides a portion of the non-federal match for HMGP and/or other mitigation projects. (iv) To the extent allowed by state law, the state requires or encourages local governments to use a current version of a nationally applicable model building code or standard that addresses natural hazards as a basis for design and construction of state sponsored mitigation projects. (v) A comprehensive, multiyear plan to mitigate the risks posed to the existing buildings that have been identified as necessary for post-disaster response and recovery operations. (vi) A comprehensive description of how the state integrates mitigation into its post-disaster recovery operations.

Throughout the 2018 plan SEMA and State mitigation planning partners have documented their commitment to a comprehensive mitigation program. The State's desire is for this plan to be a resource to other planning partners.

Support for Local Mitigation Planning

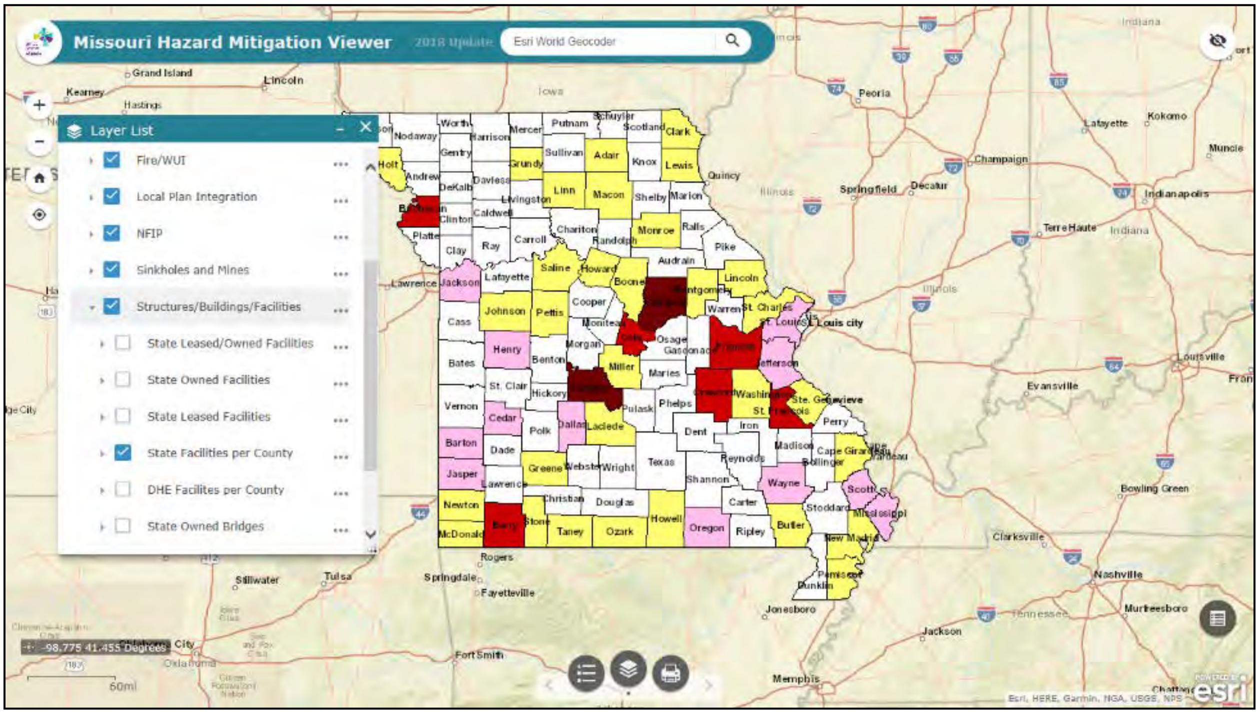
- SEMA has demonstrated its commitment to support local mitigation planning and capability development of local officials throughout this 2018 Plan Update including the successful deployment of the Local Mitigation Plan Outline. Workshops and training are provided for local officials for floodplain management certification, local mitigation planning, hazard mitigation grants, and benefit cost-analysis. The Missouri Certified Emergency Manager Program (MoCEM) is sponsored and administered by the Missouri Emergency Preparedness Association (MEPA) with cooperation and support of the State Emergency Management Agency (SEMA). Certified Floodplain Manger (CFM) training is also supported by SEMA with trainings offered three times each year, as well as, administration of the exam.
    - See also Sections 4.5.1, 7.1.4, 7.2.4, and 7.3.1

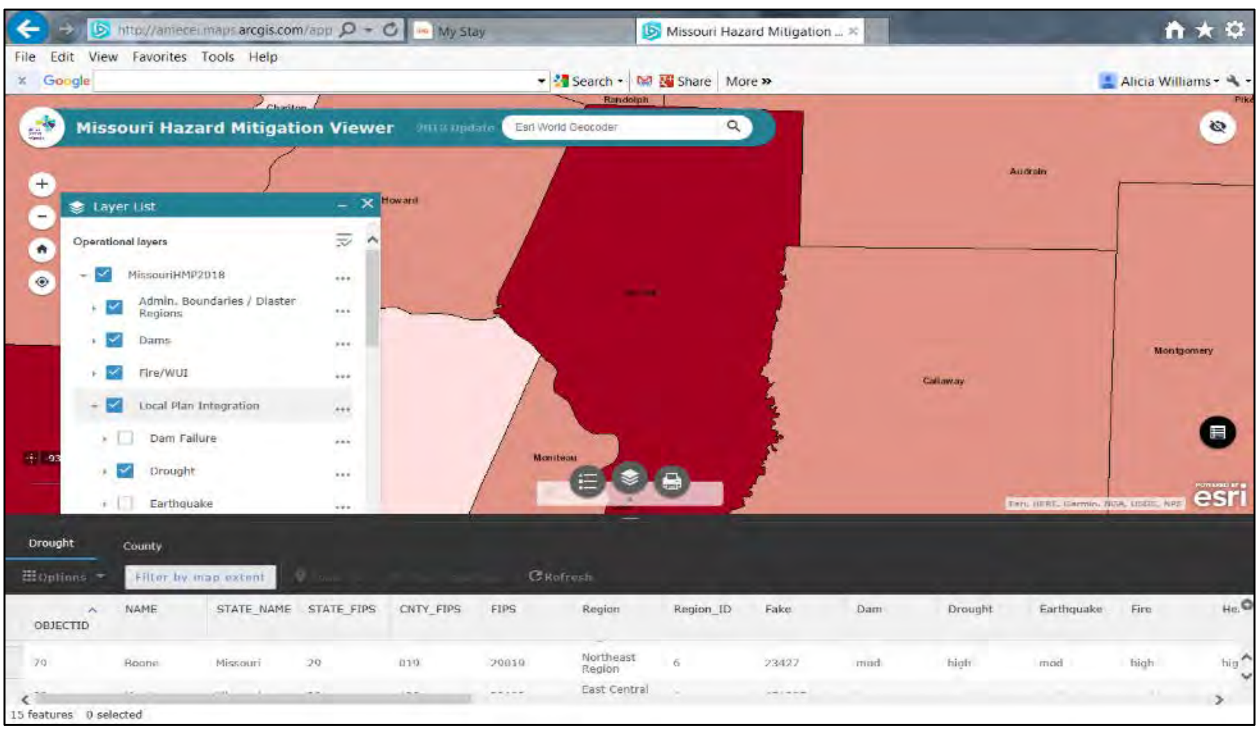
With the 2018 Plan Update, SEMA is pleased to provide online access to all of the risk assessment data and associated mapping for all 115 counties in the State (including the independent City of St. Louis). Through a web-based Missouri Hazard Mitigation Viewer, local planners or other interested parties can obtain all State Plan datasets. This effort removes a barrier for local mitigation planners to performing all the needed local risk assessments by providing the data developed during the 2018 State Plan

Update. Functionality will combine all data layers developed or provided by SEMA planners and partners (State and Local) into one central location. The Missouri Hazard Mitigation Viewer includes a Map Viewer with a legend of clearly labeled features, a north arrow, a base map that is either aerial imagery or a street map, risk assessment data symbolized the same as in the 2018 State Plan for easy reference, search and query capabilities, zoom levels to county level data and capable of downloadable PDF format maps. **Figure 7.23** and **Figure 7.24** present the Missouri Hazard Mitigation Viewer.

Figure 7.23. Missouri Hazard Mitigation Viewer

Figure 7.24. Missouri Hazard Mitigation Viewer





Legislative Initiatives, Mitigation Councils, Public/Private Partnerships, Executive Actions

The State of Missouri has demonstrated the use of legislative initiatives, mitigation councils, public/private partnerships, and executive actions in implementing the State's Mitigation Strategy. Below are a few highlights:

- State Statute RSMO 310.200-207 is one example of the State's commitment to mitigation. This statute applies to 47 southeast counties in Missouri that are required to adopt an ordinance requiring new public construction/alteration to comply with seismic design and construction of the BOCA code or UBC.
- Executive Order 97-09 was signed by the lieutenant governor in July 1997 authorizing SEMA to issue floodplain permits for any state-owned or leased development in a special flood hazard area.
- State Risk Management Team (SRMT) is a State Mitigation Council that meets regularly to complete reviews and updates to this Mitigation Plan.
- With the creation of the Flood Recovery Task Force after the 2008 flooding, the Missouri Governor emphasized the need for mitigation planning in the aftermath and recovery from devastating floods.
    - See also Table 4.21, Missouri State Statutes and Executive Orders

State Funds for Mitigation

The State of Missouri partially funds the floodplain management budget. In the past, the State of Missouri has provided funding to match mitigation assistance grants. However, this funding has not been available for the past three years due to budget constraints.

Building Design and Construction

For State-sponsored mitigation projects, SEMA requires sub-applicants to adhere to all applicable building code requirements. In addition, for safe room construction projects, SEMA requires adherence to FEMA's Design and Construction Guidance. As indicated previously, all public buildings constructed in the 47 southeastern counties designated as earthquake-prone are required to be constructed in accordance with seismic design and construction.

- See also Sections 4.2.1, 4.2.4, and 7.2.3

Mitigation of Risks to Post-Disaster Response and Recovery Operations

Essential facilities, and the associated services and functions, are the most significant components in the protection of the health, safety, and well-being of Missouri and our communities at risk. Essential facilities are those facilities that should be functional after a hazard event and are necessary for post disaster response and recovery operations. To prevent interruptions in essential services, it was important for SEMA to (1) identify essential facilities for response and recovery; (2) identify potential mitigation measures to reduce the vulnerabilities of the essential facilities including utilities, essential systems, and essential equipment; and (3) identify potential funding sources. This process, as outlined below, will be completed within the next 5-years.

Step 1: Identification of Post-Disaster Response and Recovery Facilities

Facilities identified by the Missouri State Emergency Management Agency (SEMA) as essential facilities for response and recovery at the local level include schools, as potential shelters, fire departments and medical facilities.

These essential facilities were first identified through FEMA's HAZUS-multi hazard risk assessment tool and then compared to the 2016 HSIP data to create a complete and updated list. It was determined that the HSIP data was more complete and comprehensive than the default data in HAZUS.

Essential facility subtypes and counts identified within the earthquake study region include:

- Fire Departments - 521
- Educational Facilities – 2,079
  - College/University - 79
  - Private - 567
  - Public – 1,423
  - Supplemental College - 10
- Medical – 386
  - Medical Hospital - 69
  - Nursing Homes - 276
  - Urgent Care – 41

Detailed information on the earthquake analysis and specific facility names are provided in Section 3.3.4, Section 3.5, and Appendix C within the *Missouri Earthquake Risk Assessment Enhancements: Essential Facilities Analysis* Report. **Figure 7.25, Figure 7.26**, and **Figure 7.27** present the location of fire departments, education facilities, and medical facilities within areas of probable earthquake damage. These maps, along with specific facility information for those facilities with a greater than 50-percent complete damage probability, are available within Appendix C and on the Missouri Hazard Mitigation Viewer.

Figure 7.25. Fire Departments within Areas of Probably Earthquake Damage

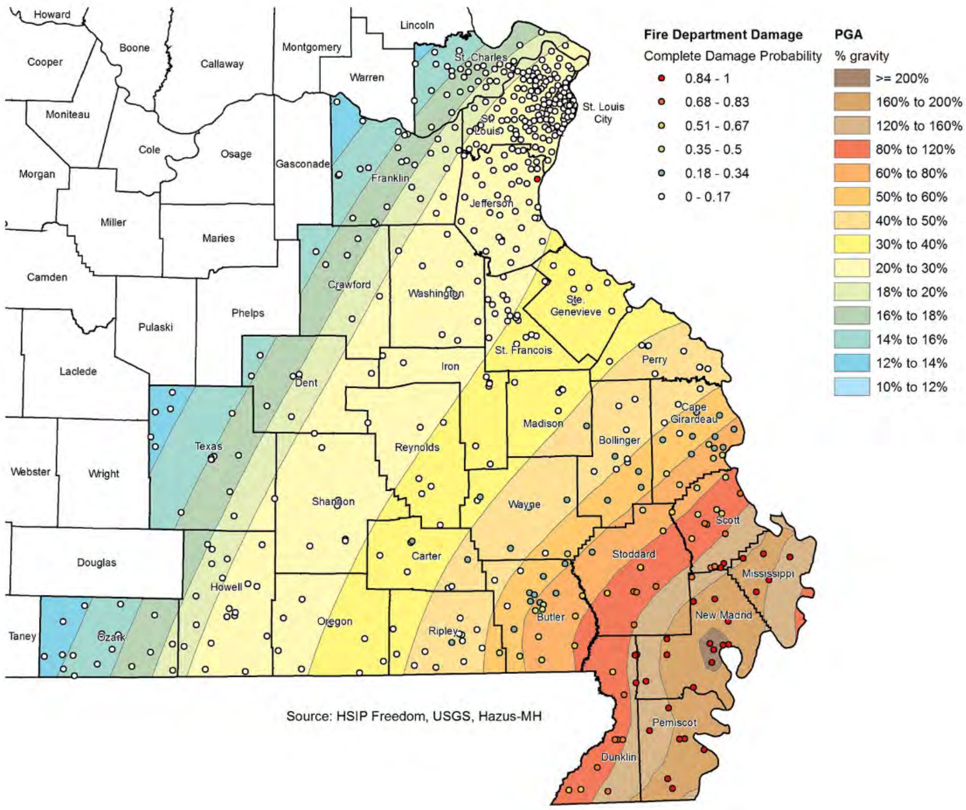


Figure 7.26. Educational Facilties within Areas of Probably Earthquake Damage

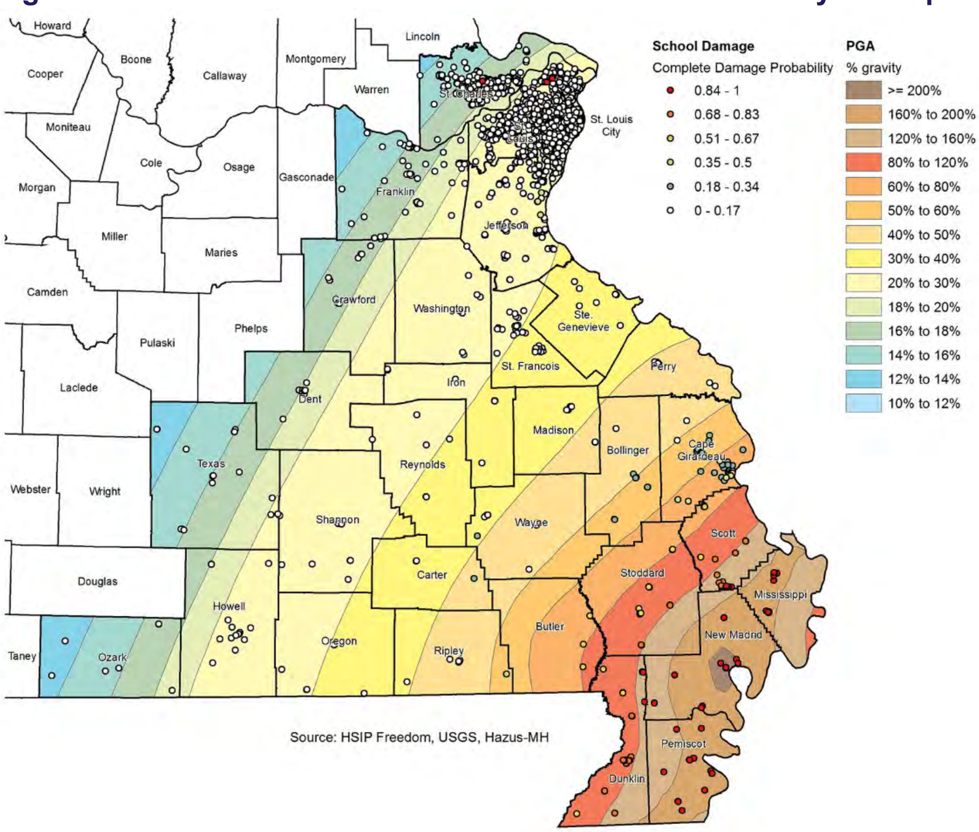
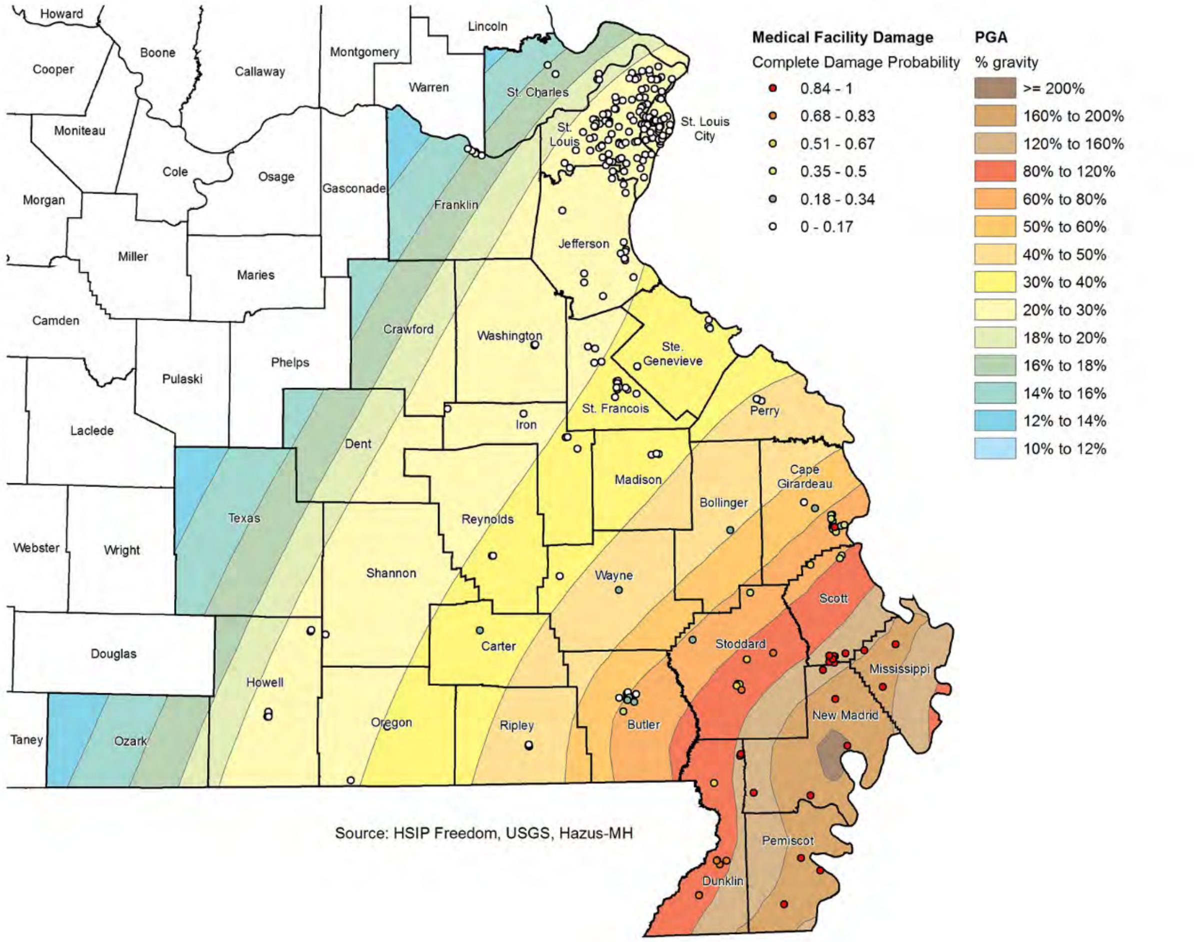


Figure 7.27. Medical Facilities within Areas of Probably Earthquake Damage



For the flood hazard, essential facility subtypes and counts within the identified special flood hazard area include:

Fire Departments - 47

Education Facilities – 46

- College/University - 6
- Private - 5
- Public – 35

Medical – 12

- Medical Hospital - 1
- Public Health Department - 7
- Urgent Care – 1

Detailed information on the flood analysis is provided in Section 3.3.1 and Section 3.5. **Figure 7.28**, **Figure 7.29** and **Figure 7.30** present the location of fire departments, education facilities, and medical facilities within the special flood hazard areas. These maps, along with specific facility information, are available within Appendix C and on the Missouri Hazard Mitigation Viewer.

Figure 7.28. Fire Departments within the Special Flood Hazard Area

7 Enhanced Plan

Figure 7.29. Educational Facilities within the Special Flood Hazard Area

Figure 7.30. Medical Facilities within the Special Flood Hazard Area

Step 2 - Identification of Mitigation Measures

For critical facilities identified within the earthquake study region, mitigation measures will be identified over the next five years through the following recommended actions:

1. **Support Local Jurisdictions in Conducting Rapid Visual Screening of Buildings for Potential Seismic Hazards using procedures specified in ATC 21 (FEMA 154)**
   Rapid Visual Screening of Building for Potential Seismic Hazards (RVS) is a pre-disaster procedure that can be implemented quickly and inexpensively to develop a list of potentially hazardous buildings without the cost of a detailed seismic analysis of individual buildings. The fire, medical, and education facilities identified in the enhanced earthquake analysis could be targeted for RVS to identify buildings that may warrant further detailed seismic analysis.
   a. Continue to hold and/or expand training workshops for Rapid Visual Screening of Buildings for Potential Seismic Hazards & Rapid Observation of Vulnerability & Estimation of Risk (ROVER)

2. **Support Local Jurisdictions in Conducting Detailed Seismic Safety Inspections of High Risk Facilities**
   Fire, medical, and education facilities with a high probability of damage/low post-earthquake functionality should be further evaluated for seismic hazard and retrofit potential.

   Specific Fire Department assessment

   Fire department facilities with a high probability of damage/low post-earthquake functionality should be further evaluated for seismic hazard and retrofit potential. This should include assessment of engine bay doors that might be compromised.

   Specific Medical care facilities assessment

   Medical care facilities with a high probability of damage/low post-earthquake functionality should be further evaluated for seismic hazard and retrofit potential. This should include non-structural seismic safety retrofits such as bracing or securing sensitive medical equipment and reduction of toppling hazards such as shelves and light fixtures that can cause injury and reduce facility functionality.

   Specific Education Facilities assessment

   Education Facilities with a high probability of damage/low post-earthquake functionality should be further evaluated for seismic hazard and retrofit potential. This should include non-structural seismic safety retrofits such as bracing bookshelves and reduction of other toppling hazards that can cause injury and reduce facility functionality. Facilities designated as potential shelters should be given priority for detailed assessments.

3. **Expand current process for evaluation and prioritization of mitigation actions (see Section 7.2.1) to incorporate and score mitigation projects identified through the Detailed Seismic Safety Inspections**

4. **Hold Training on ATC 20 Post Earthquake Safety Evaluation of Buildings**
   Following an earthquake disaster there is an immediate need for damage inspections throughout the affected areas. People need to be kept from using unsafe buildings, and safe shelter must be provided for those left homeless. It is essential that qualified building inspectors quickly identify structures that are safe for re-entry and those that must be avoided. Regular building inspection officials may become overloaded instantly and require additional help. Under such emergency conditions, qualified volunteer inspectors, including architects, engineers, and building inspectors

are needed from unaffected regions and certain other qualified design and construction professionals can provide help with the post-earthquake safety evaluations. These volunteers will typically be activated through a pre-existing agreement with state and local emergency management officials. Training using the procedures outlined in ATC 20 should be implemented to bolster this capacity. Attendees of this course would receive inspector qualification training, experience to become a team member for inspecting earthquake damaged buildings, and a field manual to guide their future work.

5. **Encourage Local Jurisdictions to Use Results to plan for post-earthquake shelter planning and preparedness**
   Post-earthquake shelter planning should look at alternate facilities and consider options for relocating people out of the hardest hit areas.

For critical facilities identified within the special flood hazard areas, mitigation measures will be identified over the next five years through the following recommended actions:

1. **Support Local Jurisdictions in Conducting Site Specific Flood Vulnerability Assessments of Buildings for Potential Flood Hazard**
   Identification of specific vulnerabilities at a particular critical facility to flooding may be accomplished by reviewing the facility siting conditions; past flooding issues; location of critical utilities, essential systems, and essential equipment; and emergency management plans.
   a. Develop training workshops for conducting site-specific Flood Vulnerability Assessments
   b. Determine if evacuation plans are in place for critical facilities with vulnerable populations.

2. **Support Local Jurisdictions in developing detailed mitigation projects based upon site specific flood vulnerability assessment. Mitigation projects may include the following:**
   a. <u>Elevate</u> major components of essential systems and equipment that are located below the base flood elevation (BFE).
   b. <u>Dry floodproof</u> around individual pieces of equipment or areas that contain essential equipment to prevent floodwaters from coming into contact with critical equipment.
   c. Install <u>back-up generators</u> for pumping and lift stations in sanitary sewer systems along with other measures (e.g., alarms, meters, remote controls, and switchgear upgrades).
   d. Identify alternate methods for supply critical services to support <u>redundancy</u>.
   e. Install/upgrade stormwater pumping stations.
   f. Install flood telemetry systems in sewage lift stations.
   g. Install earthen dikes around flood-threatened critical facilities.
   h. <u>Anchoring</u> of hazardous materials and/or buoyant materials containers.

   Continue to hold training workshops for “How to Identify Mitigation Actions Using Flood Risk Data and Products”. The User Guide for the workshop, see Appendix B, presents the process for development of mitigation actions for protection of essential services using Flood Risk Data.

3. **Review existing local hazard mitigation plans with mitigation actions which address emergency services or actions that protect people and property during and immediately after a disaster or hazard event to identify potential projects addressing response and recovery facilities.**

4. **Expand current process for evaluation and prioritization of mitigation actions (see Section 7.2.1) to incorporate and score mitigation projects identified through the Detailed Seismic Safety Inspections.**

Step 3 - Identification of Funding Sources

Funding sources for training workshops include:

- National Earthquake Hazards Reduction Program (NEHRP) Earthquake State Assistance Program
- National Earthquake Technical Assistance Program (NETAP)
- Emergency Management Performance Grants Program (EMPG)
- FEMA Community Engagement and Risk Communication (CERC) program

Additional sources of federal and state funding and technical resources are presented in Appendix D.

Step 4 - Next Steps

1. Review current training schedule and identify opportunities for future training workshops for earthquake mitigation - Rapid Visual Screening of Buildings for Potential Seismic Hazards & Rapid Observation of Vulnerability & Estimation of Risk (ROVER).
2. Begin process to develop training workshop for conducting site-specific Flood Vulnerability Assessments.
3. Coordinate with SRMT to expand current process for evaluation and prioritization of mitigation actions to incorporate and score mitigation projects which address critical facilities.
4. Encourage local jurisdictions to incorporate mitigation measures identified through the detailed vulnerability assessments into the local hazard mitigation plans and long-term recovery plans.
5. Expand critical facilities to include police stations; emergency operations centers; communication and data centers; essential government buildings; and other critical facilities and their contents, machinery, and equipment therein, that serve the community or affect the safety, health, or welfare of the surrounding population.
    - See also Sections 4.2.1, 4.2.3, and 4.2.5.

Integration of Mitigation into Post-Disaster Recovery

FEMA's Public Assistance (PA) Program provides assistance to the State of Missouri, local governments, and certain types of private nonprofit (PNP) organizations so that our communities can quickly respond to and recover from declared disasters or emergencies. Through the PA Program, FEMA provides supplemental Federal disaster grant assistance for debris removal, emergency protective measures, and the restoration of disaster-damaged, publicly owned facilities and the facilities of certain PNP organizations. The PA Program also encourages protection of these damaged facilities from future events by providing assistance for hazard mitigation measures.

In review of the PA Program implementation in Missouri, obligated federal funding for PA projects resulting from declared disasters between the years 1998 and 2018 were identified. This corresponds to disaster declarations DR-1253 through DR-4317.

Disaster Declarations DR-1253 through DR-1980

PA projects fall into two categories: emergency work (A – debris removal; B – emergency protective measures) and permanent work (C – roads/bridges; D – water control facilities; E – buildings/equipment; F – utilities; and G – parks, recreational, and other facilities). The top ten counties for the total number of Public Assistance projects includes: Jasper, Sullivan, St. Louis, Barry, Miller, New Madrid, Texas, Scott, Webster, and Shannon counties. **Table 7.19** presents the total number of PA projects by county by PA project type. Open projects still under pre-obligation processing are not represented.

As previously noted, hazard mitigation measures may be integrated into the permanent restoration of damaged facilities (PA project types C, D, E, F, and G) to protect the facilities from future damage. Permanent work to restore roads and bridges is the most frequent project type. The top ten counties for the total number of PA permanent work projects includes: Sullivan, Miller, Shannon, Webster, Texas, Barry, Reynolds, Harrison, Grundy, Douglas, and New Madrid.

Table 7.19. Missouri Public Assistance Project Summary, DR-1253 through DR-1980

County	Total # of PA Projects	Public Assistance Project Types						
		A - Debris Removal	B - Protective Measures	C - Roads and Bridges	D - Water Control Facilities	E - Public Buildings	F - Public Utilities	G - Recreational or Other
Adair	177	6	20	108	1	12	25	5
Andrew	53	8	15	29		1		
Atchison	109	24	38	38	2	3	4	
Audrain	62	4	7	41	4	3	1	2
Barry	258	47	31	166		6	4	4
Barton	90	8	27	47			7	1
Bates	69	9	32	16	1	1	7	3
Benton	27	4	19	2		2		
Bollinger	112	14	7	76		8	3	4
Boone	131	4	79	8		36	3	1
Buchanan	31	7	16	3		3	1	1
Butler	206	21	49	115		6	15	
Caldwell	86	3	17	65			1	

County	Total # of PA Projects	Public Assistance Project Types						
		A - Debris Removal	B - Protective Measures	C - Roads and Bridges	D - Water Control Facilities	E - Public Buildings	F - Public Utilities	G - Recreational or Other
Callaway	71	9	31	11		8	4	8
Camden	75	8	23	36		4	2	2
Cape Girardeau	217	38	60	60	17	18	10	14
Carroll	215	29	47	124	1	2	12	
Carter	103	5	10	84		3		1
Cass	121	32	42	32	1	5	8	1
Cedar	162	41	37	57	1	19	4	3
Chariton	152	18	33	93			4	4
Christian	121	24	41	45		3	5	3
Clark	77	7	23	44	1	1		1
Clay	45	17	16	2		6	2	2
Clinton	87	11	15	53		3	2	3
Cole	116	34	61	4		15		2
Cooper	12		10	2				
Crawford	68	8	9	47			4	
Dade	210	29	20	153		4	2	2
Dallas	155	17	28	100		7	1	2
Daviess	134	3	1	121		3	6	
DeKalb	57	4	9	44				
Dent	51	6	3	39		1	1	1
Douglas	187	7	5	170		2	3	
Dunklin	156	29	48	41	2	14	15	7
Franklin	183	15	22	95	6	12	24	9
Gasconade	41	6	10	20		1	3	1
Gentry	51	6	6	37			2	
Greene	181	48	85	19		15	10	4
Grundy	189	6	7	169	1	2	4	
Harrison	184	4	2	159			18	1
Henry	60	5	41	14				
Hickory	28	3	18	5		2		
Holt	187	39	49	80		10	8	1
Howard	113	12	14	70	1	6	4	6
Howell	136	12	17	82	2	10	9	4
Iron	81	8	13	49		1	5	5
Jackson	179	85	58	7		19	5	5
Jasper	353	79	157	12		54	14	37

County	Total # of PA Projects	Public Assistance Project Types						
		A - Debris Removal	B - Protective Measures	C - Roads and Bridges	D - Water Control Facilities	E - Public Buildings	F - Public Utilities	G - Recreational or Other
Jefferson	108	21	31	20	1	16	10	9
Johnson	70	17	30	16		6	1	
Knox	48	3	3	38		2	1	1
Laclede	156	9	31	104		5	4	3
Lafayette	177	38	45	82		4	3	5
Lawrence	214	67	45	71		20	8	3
Lewis	116	15	31	53	1	5	7	4
Lincoln	130	21	68	24		12	3	2
Linn	132	5	21	94	2	2	8	
Livingston	132	3	25	89	1	5	8	1
Macon	71	7	18	39		1	5	1
Madison	113	15	21	60	1	5	9	2
Maries	72	9	15	46		2		
Marion	120	14	35	67		1		3
McDonald	115	11	35	39		9	13	8
Mercer	140	3		135			2	
Miller	257	15	26	206		5	3	2
Mississippi	177	26	33	85	6	17	8	2
Moniteau	16	5	9			1	1	
Monroe	88	10	20	43	1	5	8	1
Montgomery	41	8	27	3		3		
Morgan	42	10	24	5		2	1	
New Madrid	253	31	57	112	2	25	16	10
Newton	138	33	49	31		15	5	5
Nodaway	191	30	18	135			8	
Oregon	108	9	11	75		4	6	3
Osage	35	5	15	14		1		
Ozark	162	7	8	145		1		1
Pemiscot	194	22	46	54		41	14	17
Perry	52	7	24	12		5	2	2
Pettis	59	6	30	9		12		2
Phelps	91	9	15	60		1	5	1
Pike	126	25	27	60	1	9	2	2
Platte	50	10	15	10		5	4	6
Polk	149	23	47	60		11	4	4
Pulaski	133	14	27	75		4	10	3

County	Total # of PA Projects	Public Assistance Project Types						
		A - Debris Removal	B - Protective Measures	C - Roads and Bridges	D - Water Control Facilities	E - Public Buildings	F - Public Utilities	G - Recreational or Other
Putnam	161	3	15	125		4	13	1
Ralls	52	3	10	32		4	3	
Randolph	87	12	30	33		3	6	3
Ray	198	26	39	122	1	4	2	4
Reynolds	205	12	14	167		4	7	1
Ripley	65	9	12	38		3		3
Saline	72	7	26	33		3	3	
Schuyler	31	3	2	18			8	
Scotland	78	4	3	63		1	7	
Scott	244	51	75	81		20	7	10
Shannon	233	13	10	177	2	6	10	15
Shelby	114	9	15	72		7	11	
St. Charles	54	15	33	3		2		1
St. Clair	35	3	19	12			1	
St. Francois	66	12	24	12		2	10	6
St. Louis	263	131	105	8		13	1	5
St. Louis (city)	22	3	11	2		4	1	1
Ste. Genevieve	56	11	20	20	2	2	1	
Stoddard	227	55	52	112		4	2	2
Stone	100	12	32	41		1	6	8
Sullivan	313	9	18	266	3		16	1
Taney	160	26	59	32		10	16	17
Texas	251	36	21	185		1	4	4
Vernon	190	2	31	143	6	4	2	2
Warren	14	4	9			1		
Washington	50	7	11	28			4	
Wayne	157	14	21	102	2	8	9	1
Webster	234	17	14	194		5	1	3
Worth	38	4	5	25		1	3	
Wright	72	10	8	48		2	4	
TOTAL	**14087**	**1949**	**3154**	**7259**	**73**	**712**	**599**	**341**

Source: FEMA; https://www.fema.gov/openfema-dataset-public-assistance-funded-projects-details-v1

FEMA uses the Project Worksheet (PW) (FEMA Form 90-91) to document details of the project, including a detailed description of the disaster-related damage, dimensions, and the associated scope of work (SOW) and costs. For those projects with a total cost below the established minimum project threshold, as established by FEMA each fiscal year ($125,500 for 2018), the project is termed small and may be developed by the individual applicant and is subject to a validation process by FEMA. Once FEMA obligates a Small Project, FEMA does not adjust the approved amount of an individual Small Project. The federal cost share is also funded in full, based on the cost estimate, at the time of obligation. For those projects with a total cost greater the established minimum project threshold, the project is termed a large project and is funded based on documented actual costs for eligible work.

In Missouri, communities have been funded for over 8,000 small PA projects with an average cost of $13,366 and just over 600 large PA projects with an average cost of $249,539. **Table 7.20** presents the number of PA projects, both large and small, per county, and the average project cost. The top ten counties for the total number of large PA projects are Webster, Shannon, Jasper, Lawrence, Barry, Dallas, Mississippi, Butler, Greene, and Reynolds. The top ten counties for the total number of small PA projects are Sullivan, Miller, Texas, Grundy, Shannon, Harrison, Douglas, Reynolds, Barry, and Dade.

Table 7.21 through **Table 7.25** present a summary of the project types within each category of PA Project. From these summary tables, the following project types are the most common as well as receive the most funding:

- Repair of damaged public buildings (E) – 452 projects for a total of $106,359,692
- Repair of damaged roadways (C) – 4,889 projects for a total of $101,680,463
- Repair of electrical distribution systems (F) – 200 projects for a total of $64,621,635
- Repair of damaged culverts (C) – 1,047 projects for a total of $16,332,860
- Repair of damaged bridges (C) – 419 projects for a total of $15,351,698
- Repair of sanitary sewer systems (F) – 181 projects for a total of $12,618,246
- Repair of damaged low water crossings (C) – 258 projects for a total of $6,006,182
- Repair of water distribution systems (F) – 132 projects for a total of $4,859,452
- Repair of erosion to ditches/channels (C) – 136 projects for a total of $4,458,272
- Repair of ponds/basins/reservoirs (D) – 17 projects for a total of $1,645,784
- Repair of damaged roadway embankments/shoulders (C) – 86 projects for a total of $1,080,753

Incorporation of mitigation measures into each of these PA projects is encouraged. Mitigation measures must be cost effective, meeting one of the following criteria: (1) not exceeding 15% of the total eligible repair cost; (2) not exceeding 100% of the total eligible repair cost of a pre-approved mitigation measure, as provided in FEMA Guidance document FP-104-009-2 Public Assistance Program and Policy Guide, Appendix J; or (3) cost effectiveness is demonstrated through an acceptable benefit-cost analysis methodology, as provided in FEMA's BCA software. Assuming SEMA was able to assist the local jurisdictions with incorporation of mitigation measures costing a minimum of 15% of the total project cost of all the PA projects noted above, the total cost for mitigation would be $50,252,256. The federal share, assumed to be 75% of the mitigation cost, would be $37,689,192. This investment of approximately $37.7M dollars would then save the State of Missouri approximately $226M in future disaster costs, based upon a savings of $6 per every $1 spent.

Table 7.20. Missouri Public Assistance Project Summary – Total and Average Costs for PA C-G, DR-1253 through DR-1980

County	Total # of PA Projects C-G	Total of Project Amounts for PA Projects C-G	Large Projects		Small Projects	
			Number	Average Cost	Number	Average Cost
Adair	151	$3,001,615	6	$105,867	145	$14,184
Andrew	30	$1,367,965	1	$669,862	29	$7,710
Atchison	47	$3,325,126	2	$32,276	45	$17,743
Audrain	51	$664,801	1	$122,461	50	$8,583
Barry	180	$9,525,366	17	$285,525	163	$20,850
Barton	55	$2,767,903	3	$300,808	52	$22,559
Bates	28	$742,125	1	$52,155	27	$13,356
Benton	4	$291,817	---	---	4	$5,786
Bollinger	91	$3,119,075	10	$134,214	81	$15,192
Boone	48	$4,083,996	7	$130,379	41	$7,328
Buchanan	8	$2,143,419	1	$100,000	7	$14,937
Butler	136	$6,599,643	14	$128,853	122	$13,820
Caldwell	66	$1,295,150	---	---	66	$18,019
Callaway	31	$1,319,577	2	$167,062	29	$9,186
Camden	44	$1,384,813	2	$66,703	42	$13,389
Cape Girardeau	119	$5,811,134	7	$240,175	112	$10,585
Carroll	139	$3,716,731	8	$72,319	131	$19,144
Carter	88	$2,515,371	8	$85,608	80	$21,283
Cass	47	$3,245,469	6	$192,200	41	$12,424
Cedar	84	$6,438,679	12	$229,153	72	$16,679
Chariton	101	$1,928,446	---	---	101	$15,947
Christian	56	$6,352,338	7	$139,708	49	$14,144
Clark	47	$1,643,792	1	$88,186	46	$16,781
Clay	12	$2,596,178	2	$67,881	10	$11,190
Clinton	61	$1,346,197	3	$83,262	58	$12,452
Cole	21	$2,464,774	---	---	21	$2,573
Cooper	2	$195,020	---	---	2	$22,487
Crawford	51	$1,421,771	6	$72,500	45	$18,831
Dade	161	$3,380,203	2	$141,785	159	$16,815
Dallas	110	$4,885,569	17	$117,245	93	$16,860
Daviess	130	$1,243,430	---	---	130	$9,319
DeKalb	44	$464,701	1	$93,367	43	$6,320
Dent	42	$1,267,182	1	$48,003	41	$25,499
Douglas	175	$2,416,252	1	$425,835	174	$10,377
Dunklin	79	$16,925,219	9	$1,304,417	70	$6,677

County	Total # of PA Projects C-G	Total of Project Amounts for PA Projects C-G	Large Projects		Small Projects	
			Number	Average Cost	Number	Average Cost
Franklin	146	$3,305,824	12	$77,646	134	$10,235
Gasconade	25	$406,607	1	$57,048	24	$10,534
Gentry	39	$524,015	---	---	39	$10,346
Greene	48	$69,939,991	14	$2,519,120	34	$15,339
Grundy	176	$2,404,979	---	---	176	$12,785
Harrison	178	$2,454,995	3	$237,501	175	$9,594
Henry	14	$250,281	---	---	14	$6,861
Hickory	7	$145,756	---	---	7	$9,540
Holt	99	$2,622,737	1	$61,274	98	$13,472
Howard	87	$2,177,473	6	$243,506	81	$7,501
Howell	107	$5,062,098	5	$282,799	102	$19,175
Iron	60	$1,565,320	5	$96,571	55	$16,936
Jackson	36	$43,675,759	5	$1,314,246	31	$6,139
Jasper	117	$178,723,942	34	$2,626,967	83	$11,361
Jefferson	56	$2,302,208	5	$117,795	51	$11,136
Johnson	23	$1,800,127	---	---	23	$10,967
Knox	42	$451,591	1	$151,523	41	$6,667
Laclede	116	$5,377,931	8	$122,706	108	$25,015
Lafayette	94	$3,413,263	8	$108,713	86	$20,577
Lawrence	102	$11,431,996	19	$330,185	83	$12,971
Lewis	70	$2,398,076	1	$63,193	69	$14,746
Lincoln	41	$1,960,304	3	$94,947	38	$8,337
Linn	106	$3,345,855	4	$423,460	102	$12,929
Livingston	104	$1,543,442	1	$73,841	103	$13,192
Macon	46	$2,192,980	3	$249,338	43	$24,659
Madison	77	$3,879,385	8	$231,197	69	$11,543
Maries	48	$936,509	---	---	48	$14,810
Marion	71	$7,483,032	2	$152,510	69	$14,585
McDonald	69	$3,211,626	8	$212,162	61	$13,319
Mercer	137	$1,921,625	1	$67,825	136	$13,545
Miller	216	$4,959,253	7	$110,098	209	$16,520
Mississippi	118	$13,771,606	16	$566,977	102	$23,340
Moniteau	2	$344,879	1	$70,658	1	$1,000
Monroe	58	$2,543,671	3	$621,067	55	$8,624
Montgomery	6	$622,179	1	$215,932	5	$2,346
Morgan	8	$332,767	---	---	8	$10,804
New Madrid	165	$5,997,506	10	$170,760	155	$11,489

County	Total # of PA Projects C-G	Total of Project Amounts for PA Projects C-G	Large Projects		Small Projects	
			Number	Average Cost	Number	Average Cost
Newton	56	$4,130,260	3	$215,243	53	$8,950
Nodaway	143	$3,248,866	8	$191,185	135	$9,314
Oregon	88	$2,641,434	4	$150,087	84	$11,030
Osage	15	$476,584	1	$125,242	14	$16,027
Ozark	147	$5,028,013	6	$438,330	141	$10,785
Pemiscot	126	$16,327,621	11	$1,027,500	115	$6,953
Perry	21	$2,607,256	---	---	21	$11,182
Pettis	23	$829,860	---	---	23	$7,765
Phelps	67	$2,869,692	9	$123,184	58	$22,074
Pike	74	$2,200,035	6	$67,611	68	$15,715
Platte	25	$984,468	1	$276,876	24	$9,071
Polk	79	$2,905,310	10	$109,446	69	$9,781
Pulaski	92	$3,740,304	4	$240,251	88	$19,644
Putnam	143	$1,595,779	---	---	143	$10,428
Ralls	39	$756,498	1	$76,176	38	$15,915
Randolph	45	$720,041	---	---	45	$9,672
Ray	133	$2,933,044	1	$66,582	132	$11,957
Reynolds	179	$5,170,814	13	$82,571	166	$20,620
Ripley	44	$1,880,595	3	$79,440	41	$24,089
Saline	39	$841,196	1	$136,193	38	$12,613
Schuyler	26	$408,057	---	---	26	$15,145
Scotland	71	$928,491	1	$79,300	70	$11,123
Scott	118	$6,733,030	5	$556,713	113	$10,666
Shannon	210	$4,187,389	35	$59,679	175	$10,703
Shelby	90	$1,143,984	---	---	90	$10,211
St. Charles	6	$2,600,965	---	---	6	$20,800
St. Clair	13	$454,586	1	$142,761	12	$11,187
St. Francois	30	$1,487,260	4	$157,164	26	$9,349
St. Louis	27	$9,525,001	1	$182,692	26	$5,872
St. Louis (city)	8	$1,948,863	4	$200,457	4	$12,145
Ste. Genevieve	25	$1,605,352	5	$83,624	20	$13,094
Stoddard	120	$4,808,482	6	$133,212	114	$16,465
Stone	56	$1,817,590	7	$75,259	49	$14,796
Sullivan	286	$4,461,558	7	$93,575	279	$12,938
Taney	75	$4,078,523	10	$159,246	65	$12,936
Texas	194	$4,931,701	6	$74,312	188	$21,022
Vernon	157	$3,157,449	4	$61,098	153	$18,292

County	Total # of PA Projects C-G	Total of Project Amounts for PA Projects C-G	Large Projects		Small Projects	
			Number	Average Cost	Number	Average Cost
Warren	1	$165,445	---	---	1	$1,000
Washington	32	$1,888,963	5	$160,749	27	$31,601
Wayne	122	$3,164,653	9	$72,849	113	$18,838
Webster	203	$8,550,066	75	$65,913	128	$17,276
Worth	29	$496,251	---	---	29	$13,289
Wright	54	$1,021,629	1	$73,238	53	$12,843
TOTAL	**8,984**	**$638,825,392**	**622**	**$249,539 Average**	**8,362**	**$13,366 Average**

Source: FEMA; https://www.fema.gov/openfema-dataset-public-assistance-funded-projects-details-v1

Table 7.21. PA Projects – Category C – Roads and Bridges, DR-1253 through DR-1980

PA Application Description	Number of Projects	Total Cost of Projects	Minimum of 15% 406 Funding
Repair to Damaged Roadways	4,889	$101,680,463	$15,252,069
Repair to Damaged Culverts	1,047	$16,332,860	$2,449,929
Repair to Damaged Bridges	419	$15,351,698	$2,302,755
Low Water Crossing Repair	258	$6,006,182	$900,927
Ditch/Channel Erosion	136	$4,458,272	$668,741
Embankment/Shoulder Erosion	86	$1,080,753	$162,113
Street Sign Damage	17	$147,437	$22,116
Sidewalk Damage	16	$120,413	$18,062
Miscellaneous Stormwater System Damage	16	$140,529	$21,079
Other Damage	25	$801,085	---
Not Defined	350	$8,784,845	---
TOTAL	7,259	$154,904,537	$21,797,791

Table 7.22. PA Projects – Category D – Water Control Facilities, DR-1253 through DR-1980

PA Application Description	Number of Projects	Total Cost of Projects	Minimum of 15% 406 Funding
Channel/Drainage Ditch Repair	18	$369,063	$55,359
Pond/Basin/Reservoir Repair	17	$1,645,784	$246,868
Repair to Damaged Culverts	9	$95,307	$14,296
Dam/Embankment Repair	5	$52,792	$7,919
Spillway Repair	5	$38,249	$5,737
Levee Repair	3	$93,022	$13,953
Lift/Pump Stations Damage	2	$21,358	$3,204
Repair to Damaged Roadways	2	$17,609	$2,641
Storm Drainage Tunnel Damage	1	$98,590	$14,789

PA Application Description	Number of Projects	Total Cost of Projects	Minimum of 15% 406 Funding
Harbor Damage	1	$34,154	$5,123
Water Main Damage	1	$26,690	$4,004
Retaining Wall Damage	1	$20,875	$3,131
Public Building Damage	1	$1,000	$150
Other/Not Defined	7	$152,090	$22,814
TOTAL	**73**	**$2,666,581**	**$399,987**

Table 7.23. PA Projects – Category E – Public Buildings, DR-1253 through DR-1980

PA Application Description	Number of Projects	Total Cost of Projects	Minimum of 15% 406 Funding
Repair to Damaged Buildings	452	$106,359,692	$15,953,954
Repair to Damaged Basements	4	$12,999	$1,950
Equipment/Bldg Contents Damage	118	$1,643,769	---
Vehicle Damage	83	$364,526	---
Repair to Damaged Communication Tower/Antenna	14	$83,217	$12,483
Pump Stations/Lift Stations Damage	9	$95,432	$14,315
Wastewater/Sewage Plant Damage	6	$46,938	$7,041
Traffic Lights/Signs/Flagpole Damage	6	$20,524	$3,079
Fencing Damage	4	$10,092	---
Other/Not Defined	16	$41,607	$6,241
TOTAL	**712**	**$108,678,796**	**$15,999,061**

Table 7.24. PA Projects – Category F – Public Utilities, DR-1253 through DR-1980

PA Application Description	Number of Projects	Total Cost of Projects	Minimum of 15% 406 Funding
Electrical Distribution	200	$64,621,635	$9,693,245
Sanitary Sewer Repairs	181	$12,618,246	$1,892,737
Water Distribution	132	$4,859,452	$728,918
Stormwater System	18	$195,603	$29,340
Communications	10	$191,534	$28,730
Gas Utility Repairs	8	$174,939	$26,241
Fence Damage	3	$8,937	$1,341
Repair to Damaged Roadways	2	$45,024	$6,754
Other/Not Defined	45	$1,460,932	$219,140
TOTAL	**599**	**$84,176,303**	**$12,626,445**

Table 7.25. PA Projects – Category G – Recreational or Other, DR-1253 through DR-1980

PA Application Description	Number of Projects	Total Cost of Projects	Minimum of 15% 406 Funding
Repair to Damaged Park Facilities/Buildings	51	$837,906	$125,686
Fencing Damage	42	$258,325	---
Athletic Field Damages	25	$260,881	---
Repair to Damaged Park Grounds/Landscape	21	$4,264,022	---
Parking Lot/Sidewalks Damage	18	$459,938	---
Repair to Damaged Roadways	17	$179,741	$26,961
Stormwater System Repairs	14	$134,650	$20,198
Electrical Repairs	14	$474,423	$71,163
Trail Repair	7	$41,103	---
Pedestrian Bridge Repair	5	$75,411	$11,312
Other/Not Defined	127	$1,844,961	$276,744
TOTAL	**341**	**$8,831,362**	**$532,064**

Focusing on the most common and most costly project types, the following are recommendations for inclusion of mitigation measures into the PA process:

General

- The top ten counties for the number of PA projects, both total and permanent, as well as the top ten counties for large and small projects are provided. Recommend coordination with these jurisdictions to gain input on lessons learned and advice for other jurisdictions. A panel discussion at an EMA or M*f*SMA conference is a potential action.
- Example computations assumed mitigation measures would cost only 15% of the total project cost. To encourage mitigation measures which are either on the approved list or demonstrate cost effectiveness above 100% of the project cost, include technical staff from a variety of disciplines on the PA Team, as well as, benefit-cost analyst.

Public Buildings

- As noted in the previous section, *Mitigation of Risks to Post-Disaster Response and Recovery Operations,* critical facilities susceptible to earthquake and flooding have been identified. Conducting detailed vulnerability assessments at the specific sites will identify mitigation measures that could be incorporated either pre-disaster or following a presidential disaster declaration through the PA process.
  - As noted in the previous section, provide training workshops for local jurisdictions to conduct the detailed vulnerability assessments and include identified mitigation measures in their local hazard mitigation plans and long-term recovery plans.

- Flooded basements of public buildings were a common repair need with equipment and contents subsequently severely damaged. Instruction on dry and wet floodproofing of buildings is recommended.
- Staff the PA Team with a structural engineer to assist with identification of structural mitigation measures such as anchoring to foundations, footings, superstructure, and roofing.
- Partner with organizations, such as the Regional Planning Commissions and the Missouri Municipal League, to communicate and educate staff and members about the risk in their communities through workshops and presentations in their jurisdictions and/or organizational meetings such as annual conferences and newsletters.
- Work closely with the Office of Administration (OA) to identify actions measures to remedy and mitigate State Owned Facilities at risk.

Roads and Bridges

- Washed out roadways and erosion of shoulders and embankments were common repair needs. Include geotextile fabric in the repair design.
- For the repair of this type of damage to be eligible, the local jurisdiction must demonstrate that the damage was directly caused by the incident. Original roadway design drawings and/or maintenance records and photographs will assist in demonstration of damage to the roadway and cause.
- Work with MoDOT State Officials to assist in efforts to replace undersized bridges and culverts.
- Work with MoDOT State Officials to assist in efforts to provide signage for Low Water Crossings in areas identified as at risk.

Electrical Distribution Systems

- Damage to electrical systems can be mitigated by moving the equipment outside the hazard area, or above the flood hazard area, and also by creating a redundant system. Creating redundancies will require local emergency planning based on a comprehensive understanding of system capacity. Funding for this type of local emergency planning will assist jurisdictions in identifying needs for a redundant system and prepare the jurisdiction with mitigation measures for future implementation.
- Continued coordination with the Missouri Department of Energy and implementation of the Comprehensive State Energy Plan.
- Working with Utility Service providers to communicate risk and potentially incentivize property owners to raise at-risk equipment through their Rebate, Incentives and Financing programs already in place, similar to ones for installing energy efficient equipment.

Drainage Structures – Culverts, Bridges, Channels, and Ponds/Basins/Reservoirs

- Mitigation actions for drainage structures, including culverts, require a watershed hydrology study to determine downstream impacts and address NFIP regulations.
    - *Staff the PA Team with water resources engineer or MoDOT Liaison Engineer*
    - *Coordinate with local jurisdiction to determine if there are any historical drainage complaints within the immediate area*
- Design erosion control and bank stabilization techniques, including the incorporation of green infrastructure.
    - *Staff PA Team with water resources engineer or MoDOT Liaison Engineer*

Sanitary Sewer Systems

- Similar to the electrical systems, damage to the sanitary sewer can be mitigated by moving the equipment outside the hazard area, or above the flood hazard area, and also by utilizing submersible or watertight equipment. Staff PA Team with wastewater engineer to assist with project identification.

Sanitary Sewer Systems

- Similar to the electrical systems, damage to the sanitary sewer can be mitigated by moving the equipment outside

Disaster Declarations DR-4130 through DR-4317

For an additional detailed review of the PA Program implementation in Missouri along with 406 mitigation funding, federal funding for PA projects resulting from declared disasters between the years 2013 and May 2018 were identified. This corresponds to disaster declarations DR-4130 through DR-4317. **Table 7.26** presents, by PA project type, the total number of projects, total project costs, and the percentage of mitigation funding.

Table 7.26. PA Projects – Category C through G, DR-4130 through DR-4317

PA Project Type	Number of Projects	Number of Projects with 406 Mitigation Funding	Percent of Projects with 406 Mitigation Funding	Total Cost of Projects	Total Cost of 406 Mitigation Funding	Percent of Cost as 406 Mitigation Funding
C - Roads and Bridges	2,243	303	13.5%	$147,475,528	$2,633,037	1.8%
D - Water Control Facilities	41	8	19.5%	$2,124,930	$210,103	9.9%
E - Public Buildings	139	16	11.5%	$17,000,940	$4,254,936	25.0%
F - Public Utilities	256	38	14.8%	$44,478,945	$2,803,356	6.3%
G - Recreational or Other	240	33	13.8%	$12,830,224	$349,233	2.7%
TOTAL	**2,919**	**398**	**13.6%**	**$223,910,568**	**$10,250,665**	**4.6%**

From this summary table, it can be noted that 406 mitigation funding is utilized in conjunction with approximately 14% of all Public Assistance projects, ranging from 12% of all public building projects to 20% of all water control facilities projects. The total funding for 406-mitigation of over $10 million accounts for 5% of the total PA project costs, ranging from 2% of road and bridge projects to 25% of public building projects. This investment of approximately $10.2 million dollars saves the State of Missouri approximately $61.2 million in future disaster costs, based upon a savings of $6 per every $1 spent. The category of roads and bridges have the greatest number of projects and greatest total project costs, yet the least percentage of mitigation funding. This should be one area of focus for future funding and mitigation measures.

Taking a closer look at the individual disaster events, **Table 7.27** presents the mitigation policies applied to each disaster and project type. From this summary table, it can be noted that the primary determination of cost-effectiveness of mitigation funding is selecting pre-approved mitigation measures followed by the 15% policy. The use of a separate benefit-cost analysis methodology, such as FEMA's BCA software, was rarely used. This indicates an opportunity to further educate state and local staff on use of the BCA software and its capabilities. Mitigation funding was not utilized for building codes and standards and for a limited number of construction practices as related to roads and bridges.

Table 7.27. Mitigation Policies – Category C through G, DR-4130 through DR-4317

Disaster	Total Number of Projects which include Mitigation Funding	Total Cost of 406 Mitigation Funding	Mitigation Policy Applied to Project				
			List of Pre-Approved	Not Exceeding 15%	Benefit Cost Analysis	Codes and Standards	Construction Practices
DR – 4130 – Severe Storms, Straight-line Winds, Tornadoes, and Flooding							
C - Roads and Bridges	27	$83,855	18	3	---	---	4
D - Water Control Facilities	1	$400	---	---	---	---	---
E - Public Buildings	---	---	---	---	---	---	---
F - Public Utilities	1	$5,842	1	---	---	---	---
G - Recreational or Other	1	-$98	1	---	---	---	---
TOTAL	**30**	**$89,999**	**20**	**3**	**---**	**---**	**4**
DR - 4144 – Severe Storms, Straight-line Winds, and Flooding							
C - Roads and Bridges	13	$95,459	8	1	---	2	---
D - Water Control Facilities	---	---	---	---	---	---	---
E - Public Buildings	1	$244	1	---	---	---	---
F - Public Utilities	3	$9,449	1	---	---	---	---
G - Recreational or Other	1	$440	1	---	---	---	---
TOTAL	**18**	**$105,592**	**11**	**1**	---	**2**	---
DR - 4200 – Severe Storms, Straight-line Winds, Tornadoes, and Flooding							
C - Roads and Bridges	21	$77,440	15	4	---	---	---
D - Water Control Facilities	---	---	---	---	---	---	---
E - Public Buildings	1	$846	---	1	---	---	---
F - Public Utilities	2	$1,877	1	---	---	---	---
G - Recreational or Other	1	$2,817	1	---	---	---	---
TOTAL	**25**	**$82,980**	**17**	**5**	---	---	---
DR-4238 – Severe Storms, Straight-line Winds, Tornadoes, and Flooding							
C - Roads and Bridges	118	$992,238	73	8	1	---	---
D - Water Control Facilities	3	$24,130	3	---	---	---	---
E - Public Buildings	4	$1,326,940	1	1	---	---	---
F - Public Utilities	8	$45,864	1	4	---	---	---
G - Recreational or Other	3	$3,736	1	---	---	---	---
TOTAL	**136**	**$2,392,908**	**79**	**13**	1	---	---
DR – 4250 - Severe Storms, Straight-line Winds, Tornadoes, and Flooding							
C - Roads and Bridges	64	$526,109	50	4	1	---	---
D - Water Control Facilities	1	$125,000	1	---	---	---	---
E - Public Buildings	6	$2,700,061	2	2	---	---	---

Disaster	Total Number of Projects which include Mitigation Funding	Total Cost of 406 Mitigation Funding	Mitigation Policy Applied to Project				
			List of Pre-Approved	Not Exceeding 15%	Benefit Cost Analysis	Codes and Standards	Construction Practices
F - Public Utilities	16	$2,565,029	10	2	2	---	---
G - Recreational or Other	20	$256,350	9	2	---	---	---
TOTAL	**107**	**$6,172,549**	**72**	**10**	**3**	**---**	**---**
DR - 4317 - Severe Storms, Straight-line Winds, Tornadoes, and Flooding							
C - Roads and Bridges	60	$857,936	30	7	2	---	---
D - Water Control Facilities	3	$60,573	2	---	---	---	---
E - Public Buildings	4	$226,845	---	---	---	---	---
F - Public Utilities	8	$175,294	4	1	---	---	---
G - Recreational or Other	7	$85,989	2	---	---	---	---
TOTAL	**82**	**$1,406,637**	**38**	**8**	**2**	---	---

In addition to the approved funding for mitigation measures within PA projects, there are several mitigation funding requests that were not funded for the noted disaster events (see **Table 7.28**). Approximately 17-percent of the requested mitigation proposals were either ineligible, declined or not implemented due to several reasons including:

- Mitigation measure not cost-effective
- Mitigation measure not cost effective under the 100 percent rule
- Applicant declined because of lack of funds for local share
- Applicant would like technical assistance for mitigation measures
- The proposed new repair / construction is of Codes and Standards
- The proposed repair / restoration of the damaged section is of Codes and Standards
- Applicant performed mitigation prior to the incident period
- Applicant did not separate mitigation from pre-existing conditions
- Mitigation is no longer proposed for this project due to the historic nature of the structure

It is possible that some of these unfunded project requests could be reassessed for future funding potential.

Table 7.28. PA Projects without Mitigation Measures, DR-4130 through DR-4317

PA Project Type	Number of PA Projects	Number of PA Projects with 406 Mitigation Proposals	Number of Approved 406 Mitigation Measures	Number of Ineligible 406 Mitigation Measures	Percent of Ineligible Proposed Projects 406 Mitigation Funding
C - Roads and Bridges	2,243	362	303	59	16.3%
D - Water Control Facilities	41	10	8	2	20.0%
E - Public Buildings	139	19	16	3	15.8%

PA Project Type	Number of PA Projects	Number of PA Projects with 406 Mitigation Proposals	Number of Approved 406 Mitigation Measures	Number of Ineligible 406 Mitigation Measures	Percent of Ineligible Proposed Projects 406 Mitigation Funding
F - Public Utilities	256	57	38	19	33.3%
G - Recreational or Other	240	34	33	1	2.9%
TOTAL	**2,919**	**482**	**398**	**84**	**17.4%**

Additional project details for the ineligible/not-implemented mitigation proposals to the PA projects are presented in Appendix F.

In recognition of the need to integrate and maximize mitigation into Post-Disaster Recovery, SEMA has developed a Notice of Interest database specifically targeting projects for 406 mitigation funding in coordination with local jurisdictions. SEMA is further working collaboratively with FEMA R-VII to maximize mitigation through development of a pilot program to initiate mitigation project identification and inclusion earlier in the Public Assistance process. Efforts to develop this pilot program are currently underway and include preparation of Memorandums of Understanding between SEMA, and FEMA V-II, The Nature Conservancy, and Wood E&IS to address identified needs and activities such as:

- Providing technical assistance for identification and design of potential mitigation measures
- Performing benefit-cost analysis of proposed mitigation measures
- Providing technical assistance for review of environmental and historic preservation requirements
- Providing education and outreach to local jurisdiction to understand the PA process and the incorporation of 406 mitigation

SEMA is also working collaboratively with FEMA R-VII through presentations and speaking engagements on maximizing mitigation at the Emergency Management Institute in March 2018 and at the State Hazard Mitigation Officer Workshop in April 2018.

Comprehensive State Mitigation Program

The overall effectiveness of the State's mitigation program is demonstrated in Section 7.5 Effective Use of Available Mitigation Funding and in Section 7.3 Program Management Capability.

Missouri has been in the forefront in mitigation nationally, demonstrated by being one of the first States to develop a FEMA approved 'enhanced' State mitigation plan in 2004. In 2004, the plan demonstrated a commitment to address the "data limitation" noted in the risk assessment and hazard analysis and the lack of approved local hazard mitigation plans through the establishment of mitigation action category M1—State and Local Hazard Mitigation Plans. In 2018, there are 105 FEMA-approved local hazard mitigation plans in Missouri, representing 103 county level plans; two regional plans representing a total of 10 counties; one multi-jurisdictional plan representing two counties, and one plan for the Missouri electric cooperatives. Dent County is the only county without a current approved Hazard Mitigation Plan and they are currently in the process of developing a plan.

Demonstration of Missouri's commitment to mitigation is integrated into each section of this plan, and represented in this plan as a whole. Some examples of the evidence of the State's commitment to mitigation can be referenced in:

- Section 2.1.1 *Evolution of the State Hazard Mitigation Plan* and Section 4.5 *State Capability Assessment* for organizations within the State that have consistently promoted mitigation:

- Governor's Task Force on Flood Plain Management
- Long-Term Recovery and Unmet Needs Groups
- Structural Assessment and Visual Evaluation Coalition
- Missouri Seismic Safety Commission
- Regional Planning Commissions/Councils of Government
- State Hazard Mitigation Planning Team (formerly the Hazard Mitigation Project Coordinating Group)

➢ Section 3.3 *Hazard Profiles and Risk Assessment* for a demonstration of additional commitment in vulnerability assessment. Missouri is one of the few states to have completed countywide Hazus flood and earthquake loss estimations for every county in the State. In 2018, highlights to the risk assessments include:

- The risk assessments for all counties were updated utilizing the newly released version of Hazus. For counties which have Risk MAP products available, the depth grids for those communities were utilized as part of the Hazus analysis. For counties with new floodplains developed since 2010 for which there are no Risk MAP products, depth grids were created utilizing the updated DFIRM data. The MSDIS structure inventory was used to supplement HAZUS as the source for numbers and types of at-risk structures.
- The vulnerability analysis of state-owned facilities continued to be expanded in this 2018 State Plan Update and the results have been provided to the Office of Administration, Department of Higher Education, Department of Transportation, and Missouri Department of Conservation. For those facilities for which GIS data was provided, the State agencies have been provided with the results indicating specific facilities potentially at risk to inundation from failure of state-regulated dams, flooding from a 100-year flood event, and levee failure; location relative to sinkholes and potential wildfires; and damage from an earthquake event with a 2% probability of exceedance in 50 years. Results were provided in both GIS (geodatabase) and Excel spreadsheet formats.

➢ Section 4 Comprehensive State Hazard Mitigation Program for an outline of the mitigation objectives identified to raise the level of mitigation commitment:

- Objective 1.3—Supports the development of sensible enabling legislation, programs, and capabilities of federal, state, and local governments and public-private partnerships engaged in mitigation activities
- Objective 2.5—Encourages federal, state, and local officials; educational institutions; private associations; and private business entities that provide essential services to incorporate mitigation into other plans
- Objective 3.2—Strengthens cooperation with SEMA's mitigation partners and helps educate them about mitigating the loss of property
- Objective 4.2—Considers sustainability issues (ecologically sound, economically viable, socially just, and humane) when developing or reviewing mitigation projects and plans

- Section 5 Coordination of Local Mitigation Planning provides evidence of Missouri's commitment to the local mitigation planning efforts. In this chapter, the Sate provides specific methodology for locals to employ to determine vulnerability to dam and levee failure.

SEMA's true commitment to a comprehensive State mitigation program may be best demonstrated through the agency's efforts to meet the Emergency Management Accreditation Program (EMAP) standards. Mitigation and state mitigation planning programs are critical elements of the EMAP standard for mitigation. Section 2.3.3 *Integration with EMAP Standards* documents how the EMAP mitigation standards are met and interlaced throughout the 2018 Mitigation Plan. The fact that SEMA has worked diligently to meet the EMAP standards and continues to receive reaccreditation is testimony to the importance that SEMA places on mitigation and emergency management, in general. The figure below presents a recent press release from EMAP congratulating Missouri with the high honor of reaccreditation (see **Figure 7.31**).

Figure 7.31. Media Release from EMAP

EMAP
Emergency Management Accreditation Program

Media Release
For immediate release: October 26, 2017
Contact: Nicole Ishmael, emap@emap.org

Highest Honor for Emergency Management Awarded to Ten Programs

Falls Church, VA. – Congratulations to the following Emergency Management Programs that have earned accreditation by the Emergency Management Accreditation Program (EMAP): Michigan State University; Rhode Island; Idaho; Tufts University; Ramsey County, Mn.; Walla Walla District of the United States Army Corps of Engineers; and FEMA Region VI. In addition, Missouri, Mississippi, City of Boston, Ma.; have achieved reaccreditation.

Appendix A1

Missouri Hazard Mitigation Viewer

User Guide

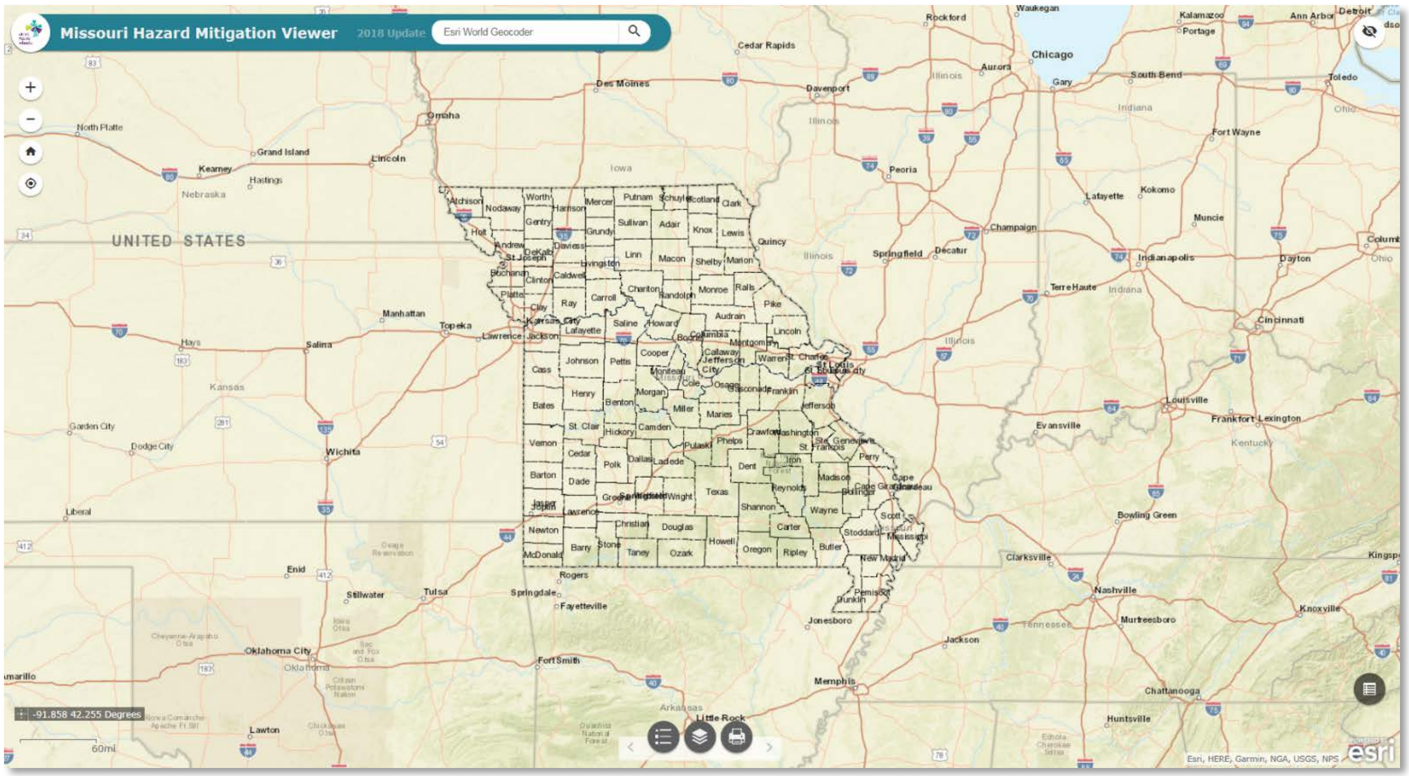
Missouri Hazard Mitigation Viewer User Guide

Introduction

With the 2018 Hazard Mitigation Plan Update, SEMA is pleased to provide online access to the risk assessment data and associated mapping for the 114 counties in the State, including the independent City of St. Louis. Through the web-based **Missouri Hazard Mitigation Viewer**, local planners or other interested parties can obtain all State Plan datasets. This effort removes from local mitigation planners a barrier to performing all the needed local risk assessments by providing the data developed during the 2018 State Plan Update.

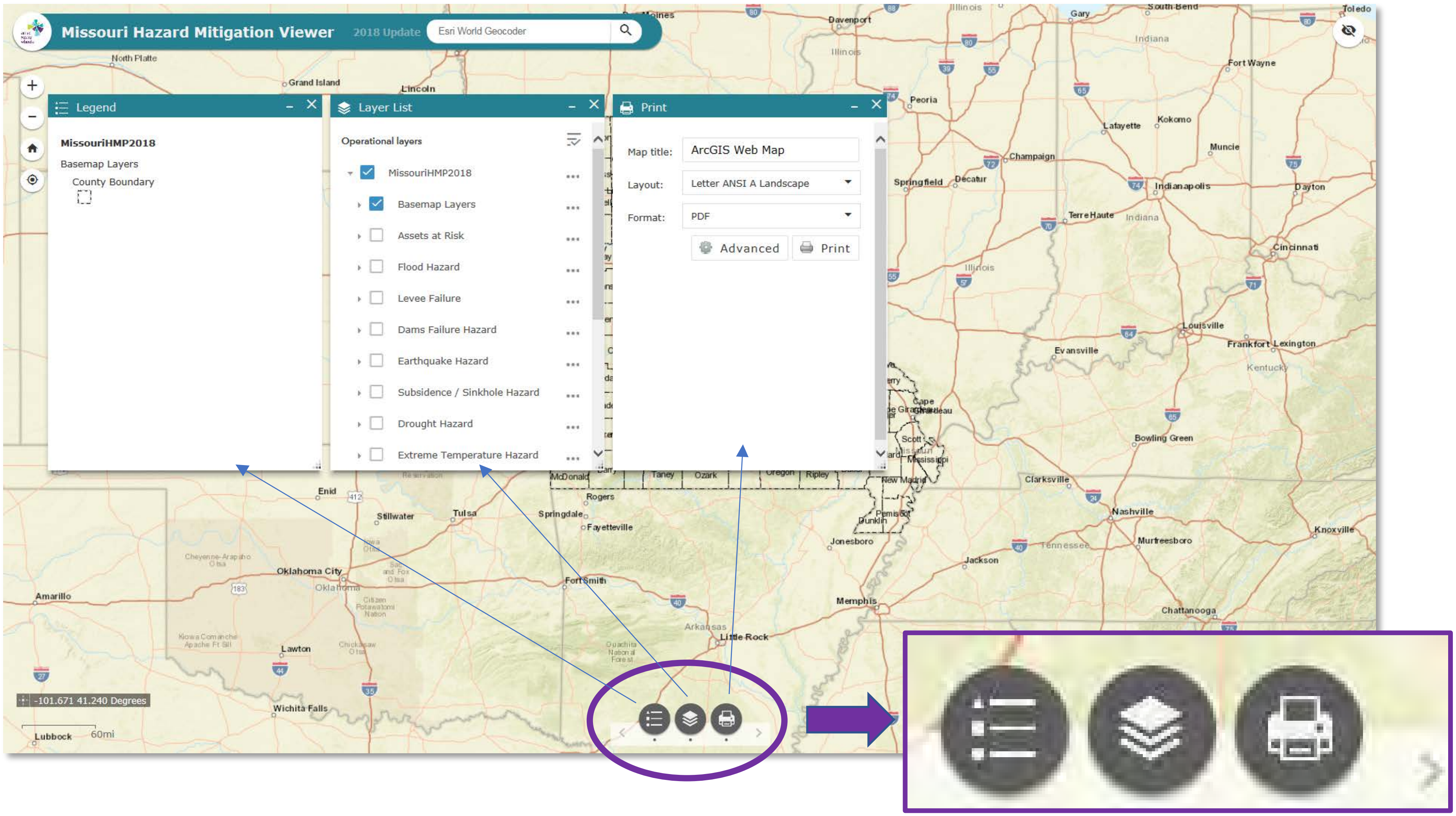
Table of Contents

Functionality will consolidate all data layers developed or provided by SEMA planners and partners (State and Local) into one central location. The Missouri Hazard Mitigation Viewer includes a Map Viewer with a legend of clearly labeled features, a north arrow, a base map that is either aerial imagery or a street map, risk assessment data symbolized the same as in the 2018 State Plan for easy reference, search and query capabilities, ability to zoom to county level data and capability to download PDF format maps. The Missouri Hazard Mitigation Viewer can be found at this link: http://bit.ly/MoHazardMitigationPlanViewer2018. Figure 1 below shows how the page looks when you first open it.

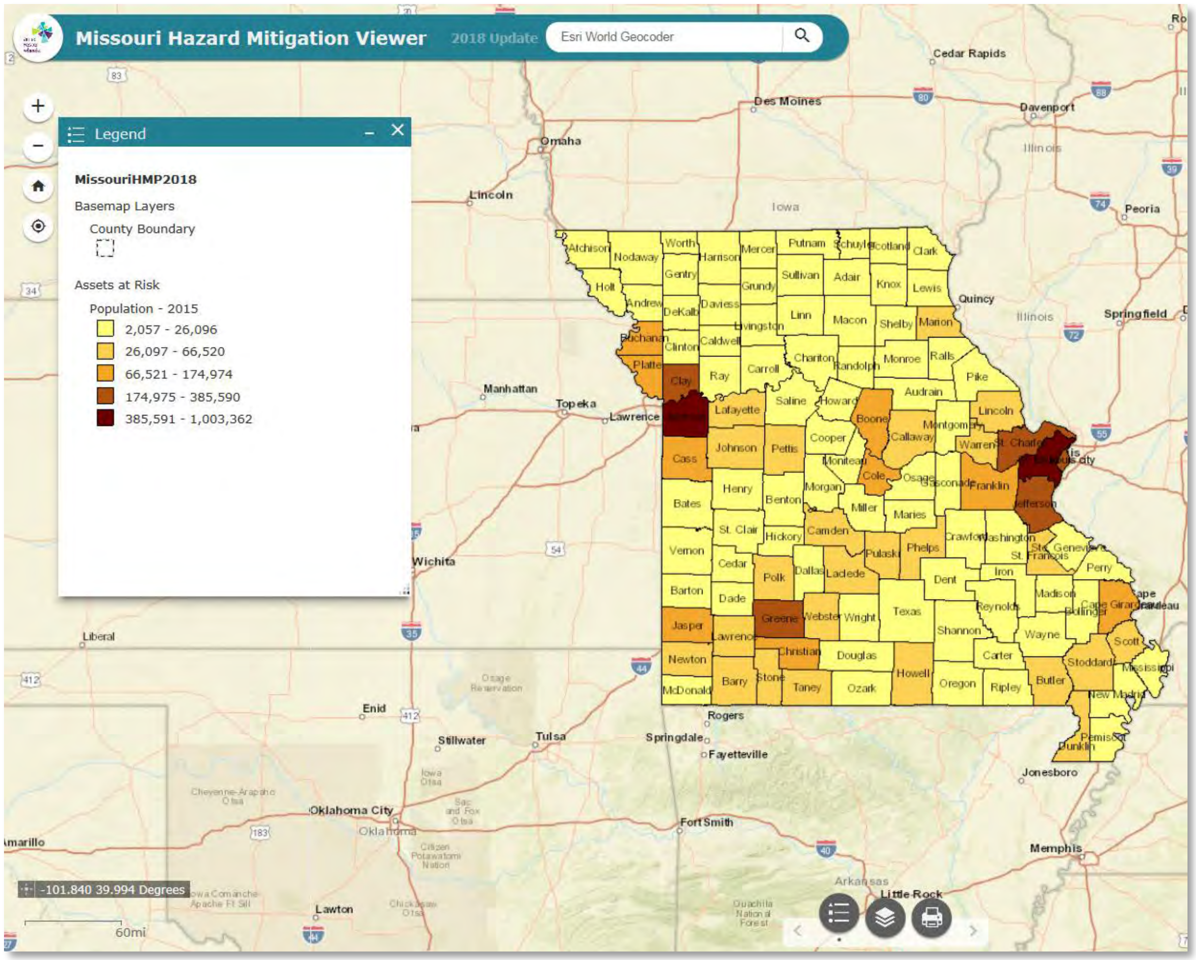


User Guide Instructions

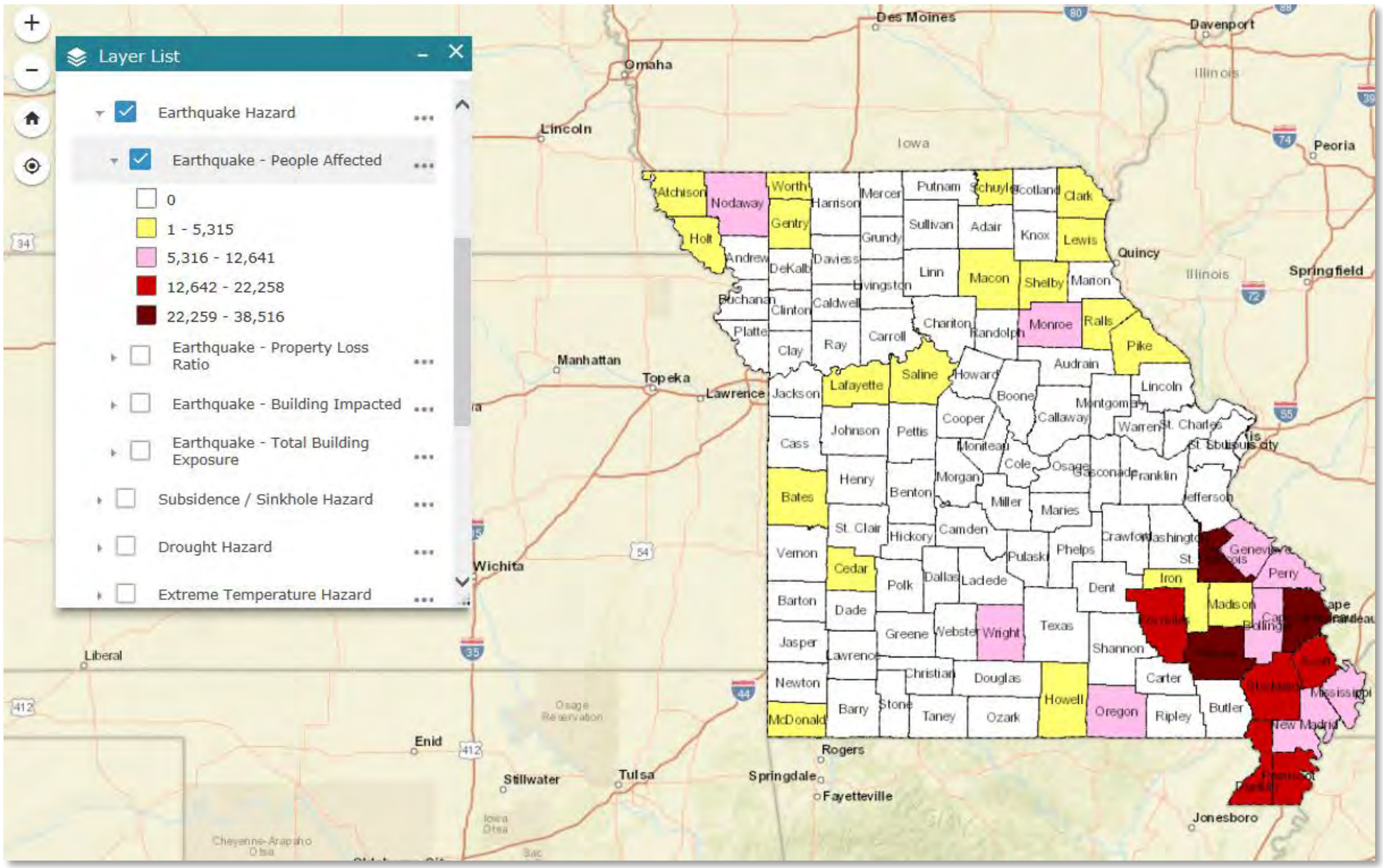
By clicking on the three buttons at the bottom center of the page, three windows will open as shown in Figure 2 below. From left to right, these buttons: Legend, Layer List, and Print.



The Legend window shows the symbology or the colors of the layers that are turned on or active as shown in the example below. These layers match the pdfs shown in the 2018 Hazard Mitigation Plan.



The Layer List button activates the window where the Operational Layers can be turned on/off or made active/inactive. There are two levels of Operational Layers that will need to be turned on as shown in the example below. Both levels are defaulted off except the county basemap layer. The Earthquake Hazard example below shows the People Affected by Earthquake active and three inactive layers; Property Loss, Buildings Impacted and Total Building Exposure.



In the upper left corner of the Viewer, are the buttons which control zoom.

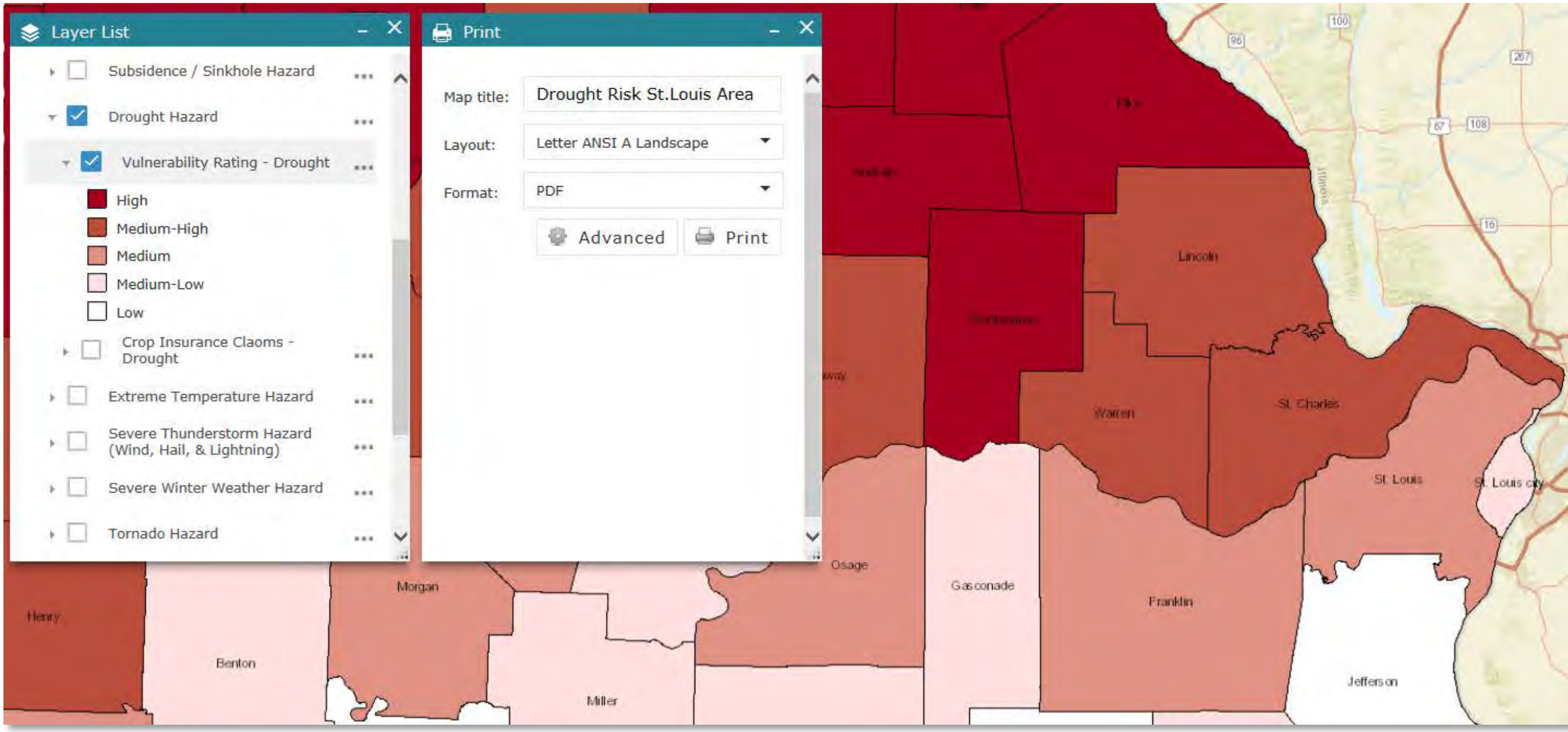
The plus sign zooms in.

The minus sign zooms out.

The Home or house icon returns the map to full scale and centers it on the user's screen display.

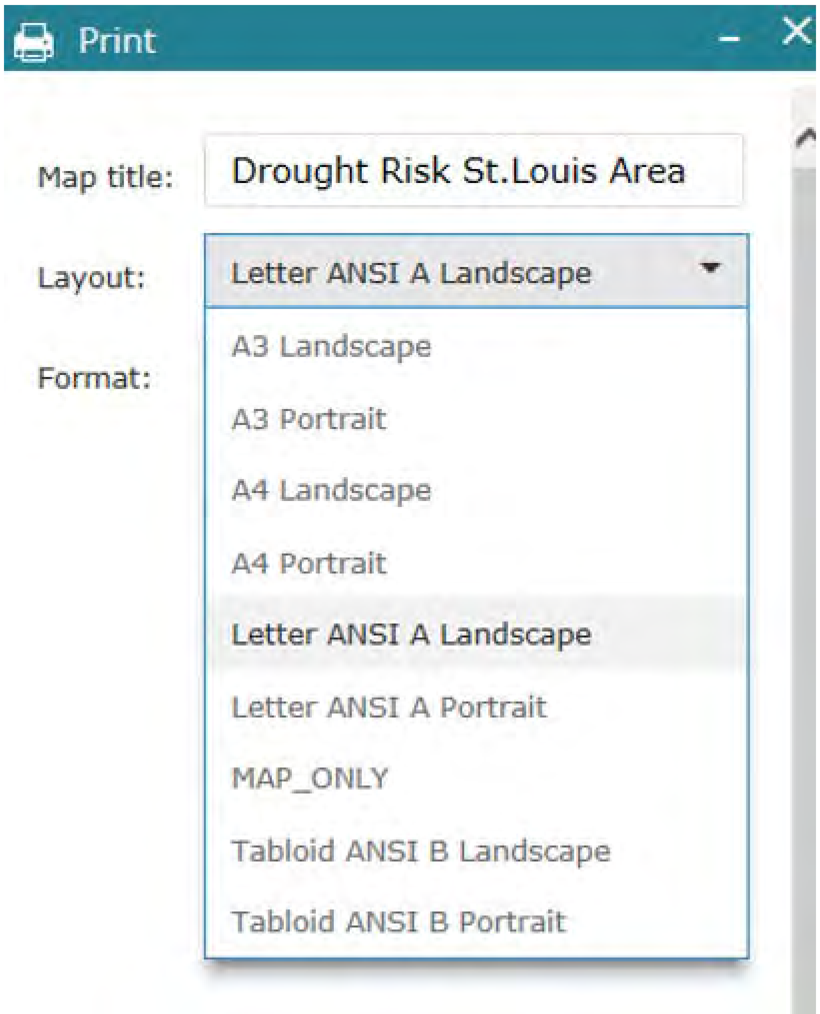
In the upper right corner of the Viewer, is the Overview button. Clicking on this icon opens a wide-angle map showing where the current selection is located inside the wider view. This is a toggle button. To close out the Overview map, tap the icon again and it will close.

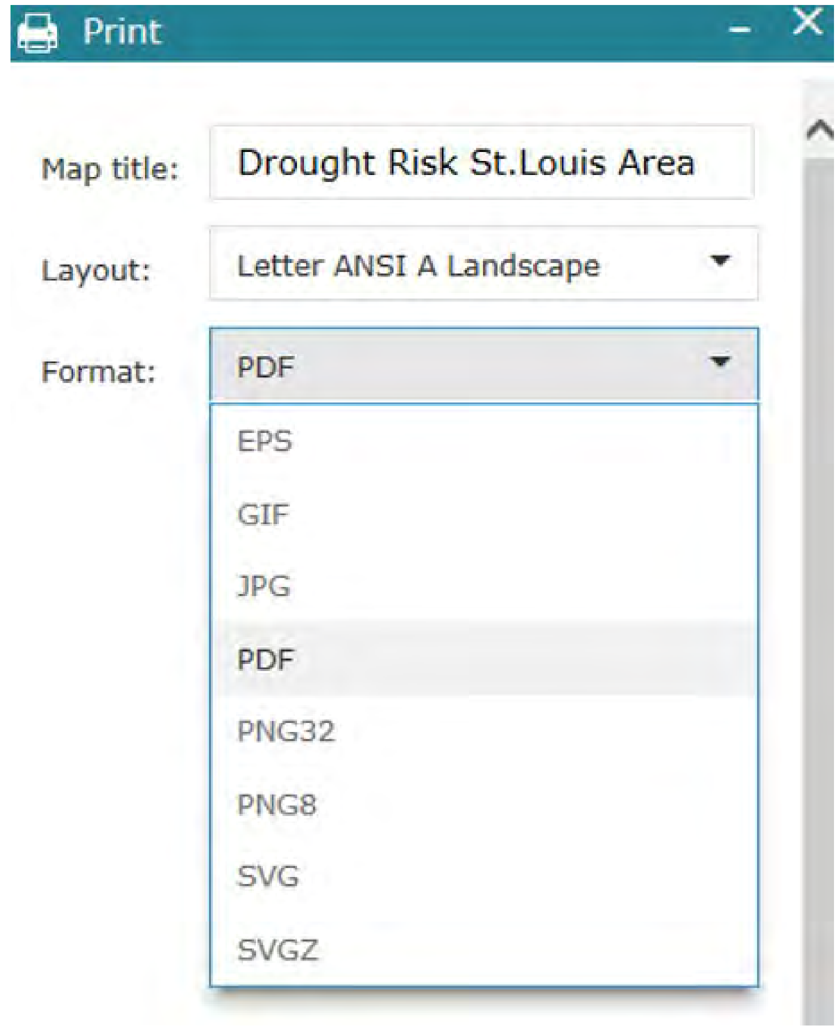
The Print function allows the user to create and customized maps. The map title can be customized.



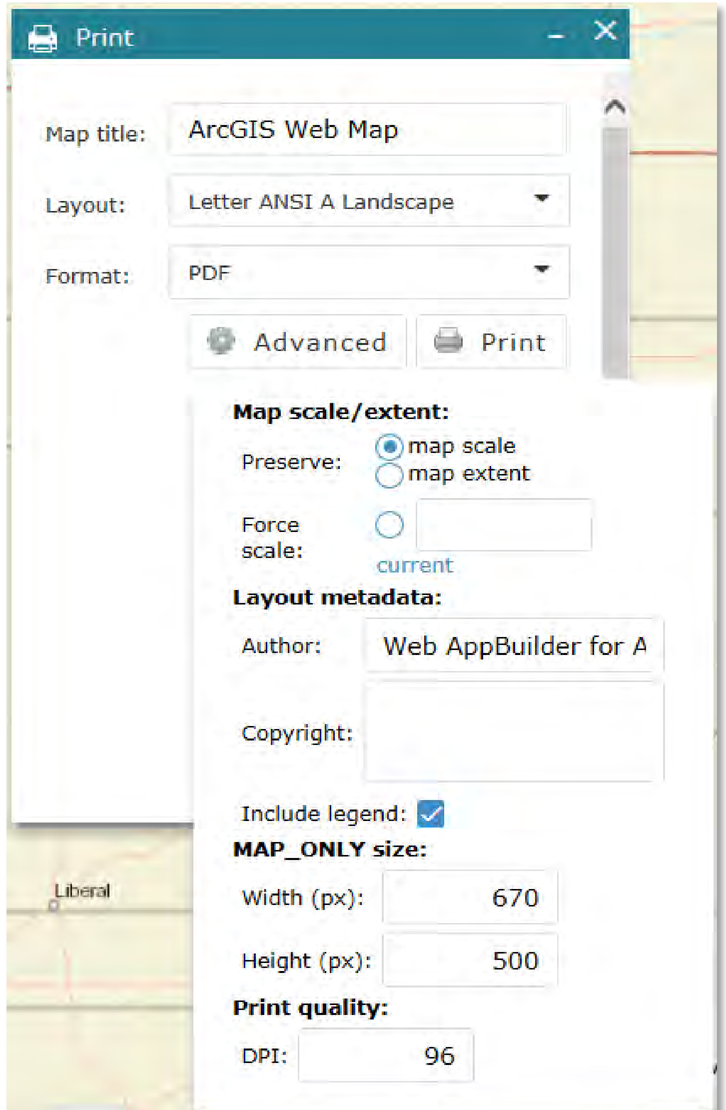
The dropdown list under Layout provides options for standard sizes of maps.

The dropdown menu under Format provides options for standard types of digital files.

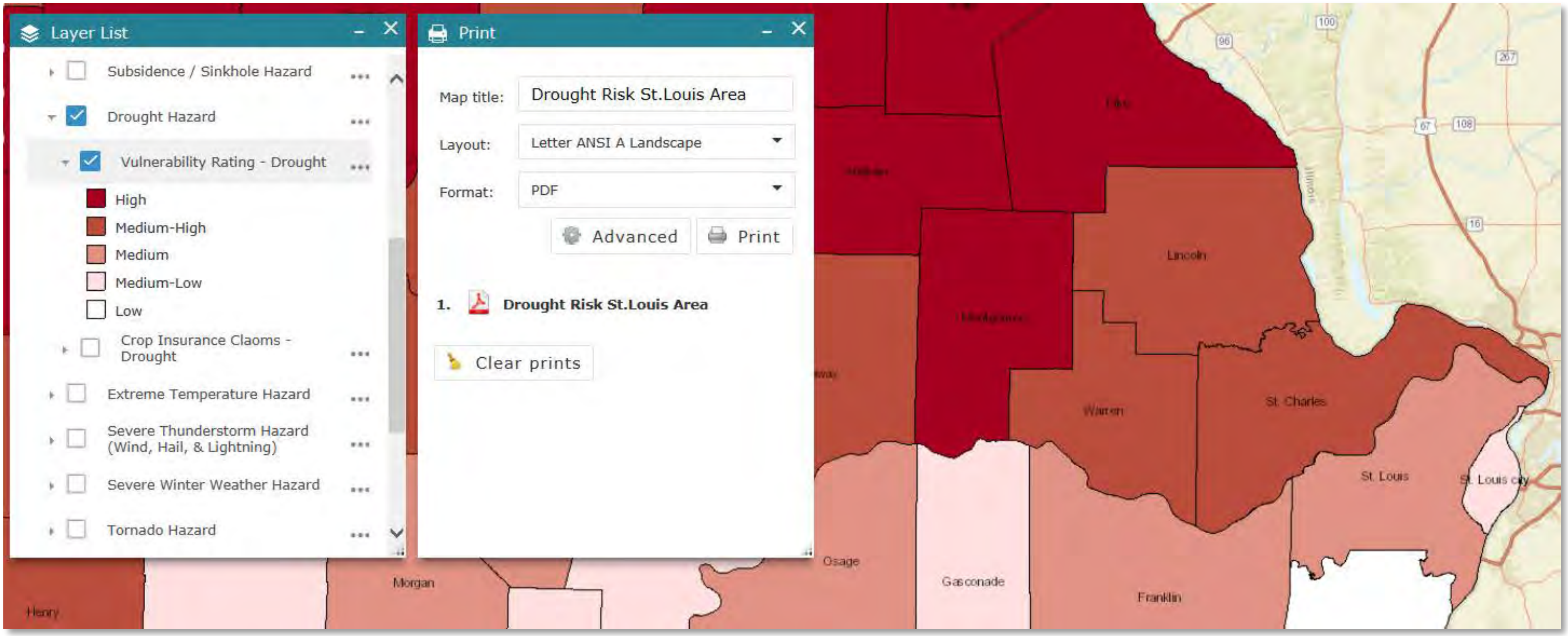




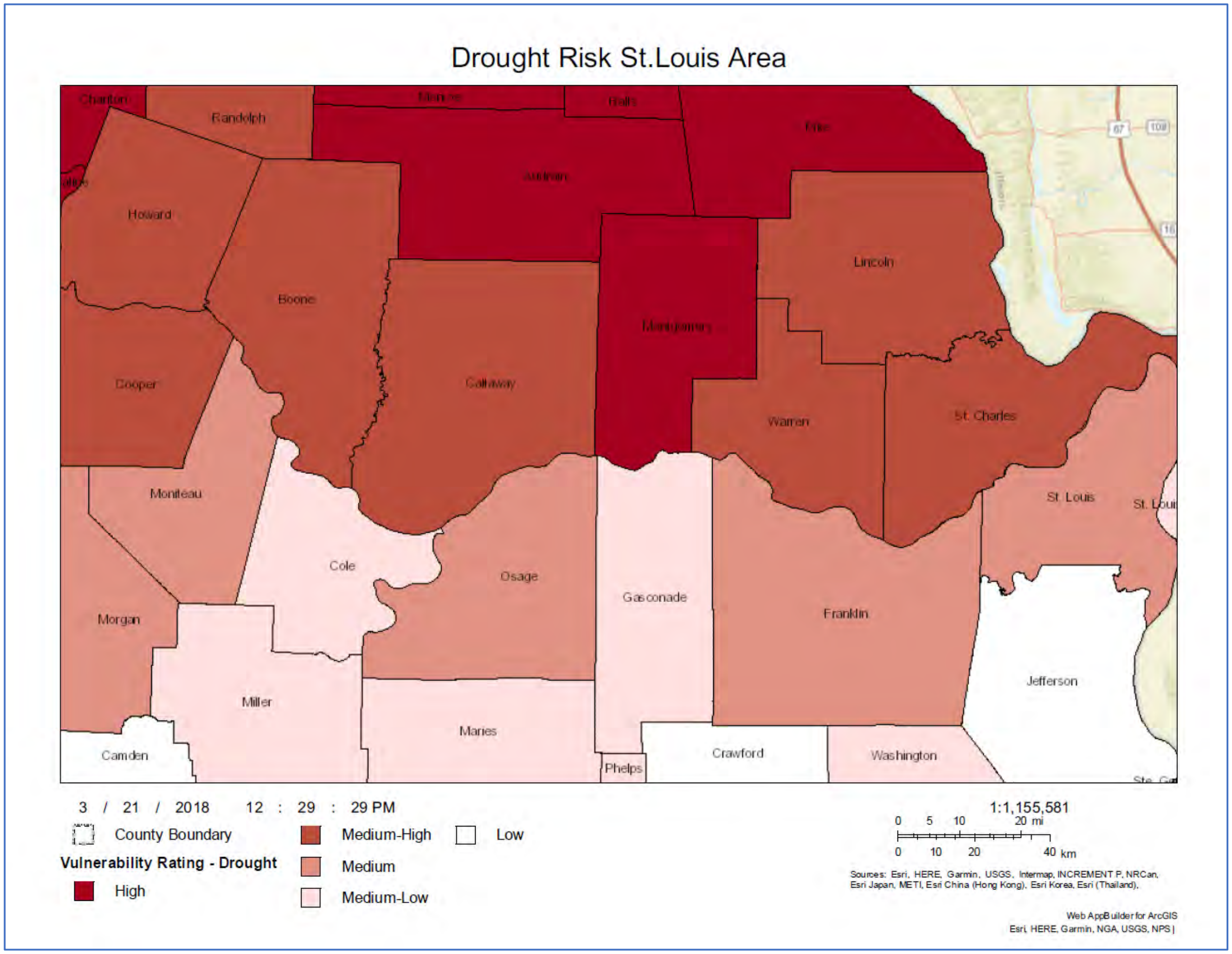
Options for scale, metadata, map only size and print quality can be found under the Advanced Button.



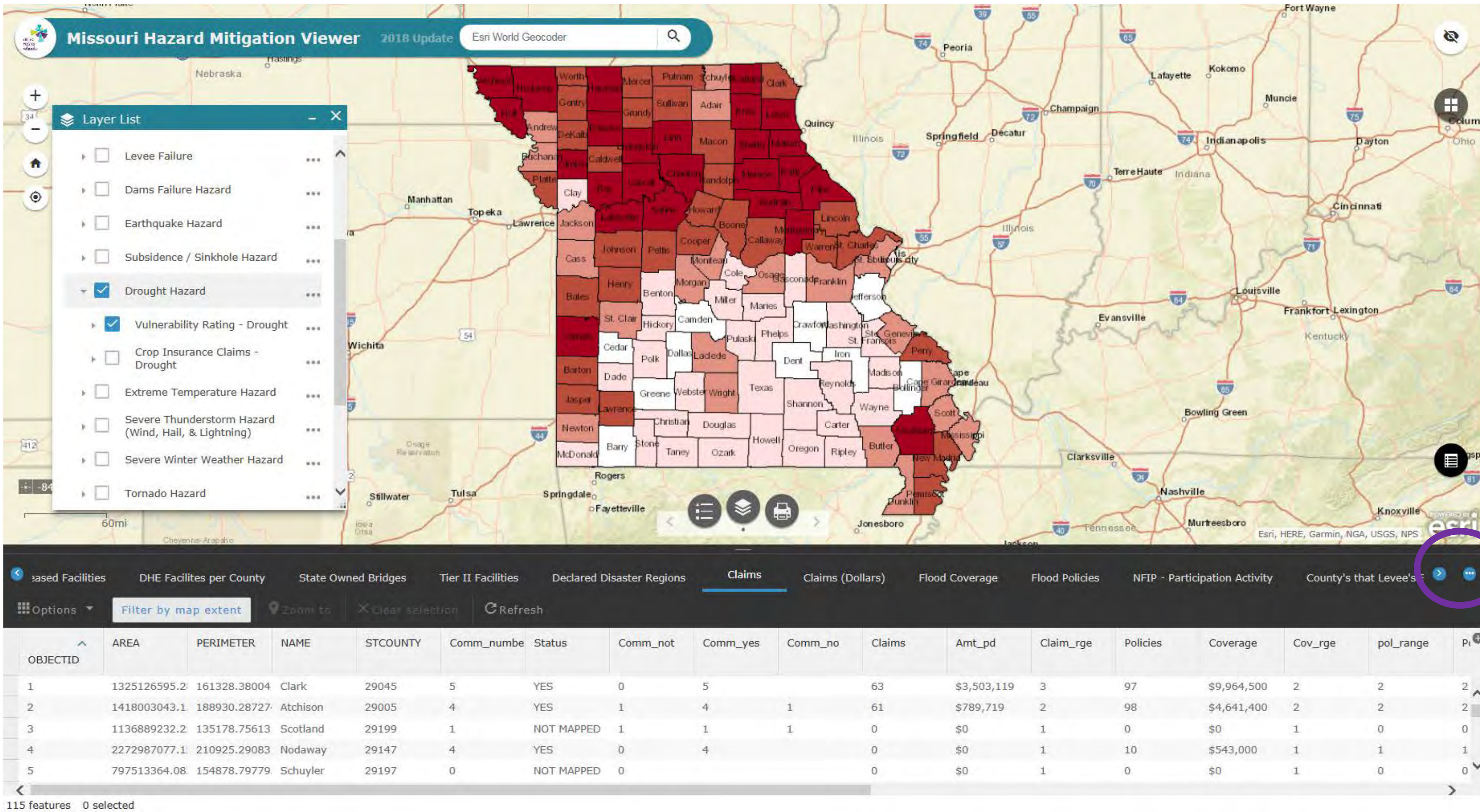
Clicking on the Print Button will create the custom map in the digital format.



Clicking on the map name, in this example Drought Risk St. Louis Area, will open the digital file created which can be saved to the user's computer or printed. This opens automatically in a new internet tab. To close it out, close the tab. The Mitigation Viewer tab will still be open to the last selection.

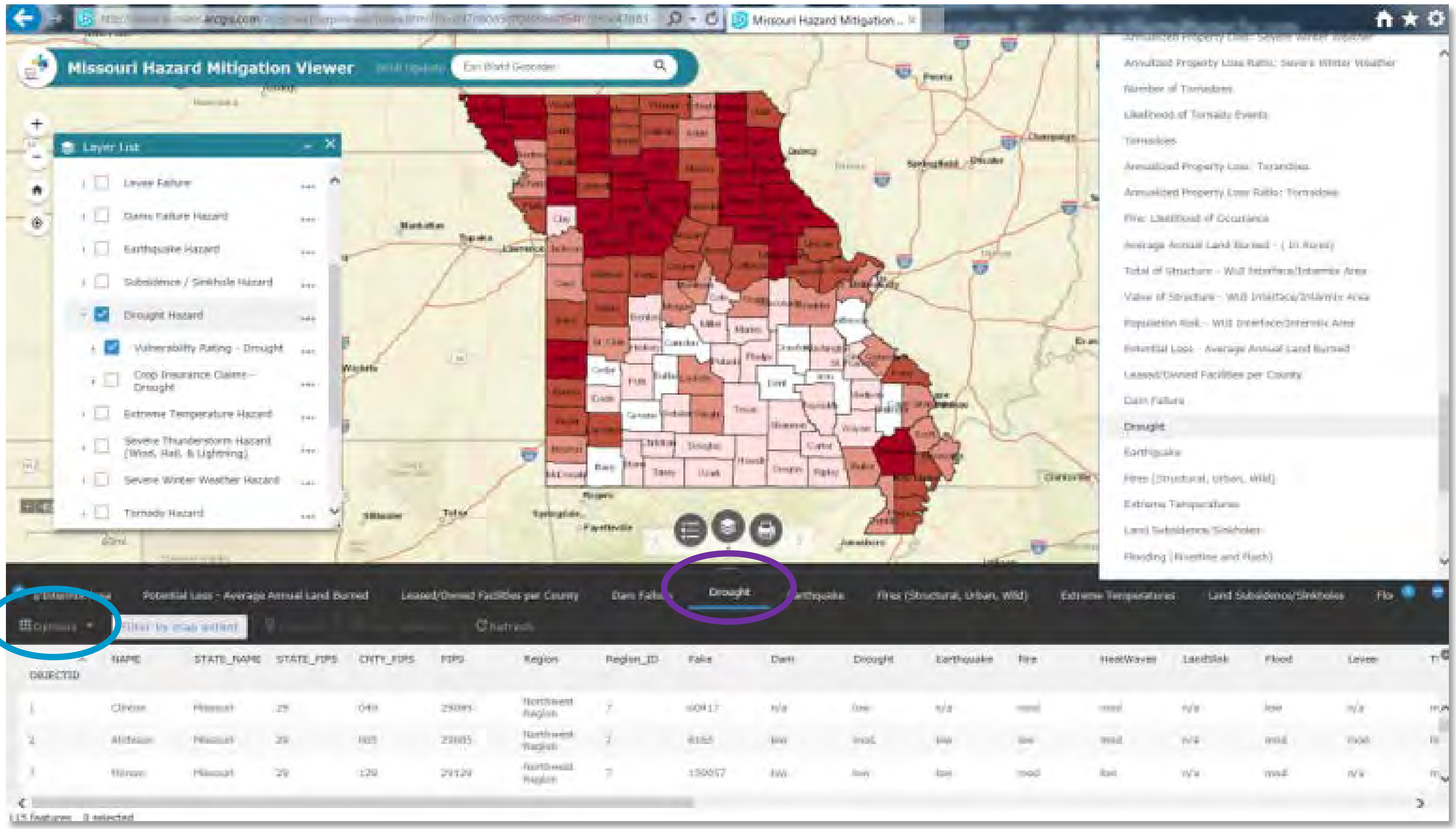


In the bottom right corner of the Viewer is the **Attributes** button. This is also a toggle button. Click once to open the attributes table, tap again to close it. The attributes table for the active map will display at the bottom of the screen.

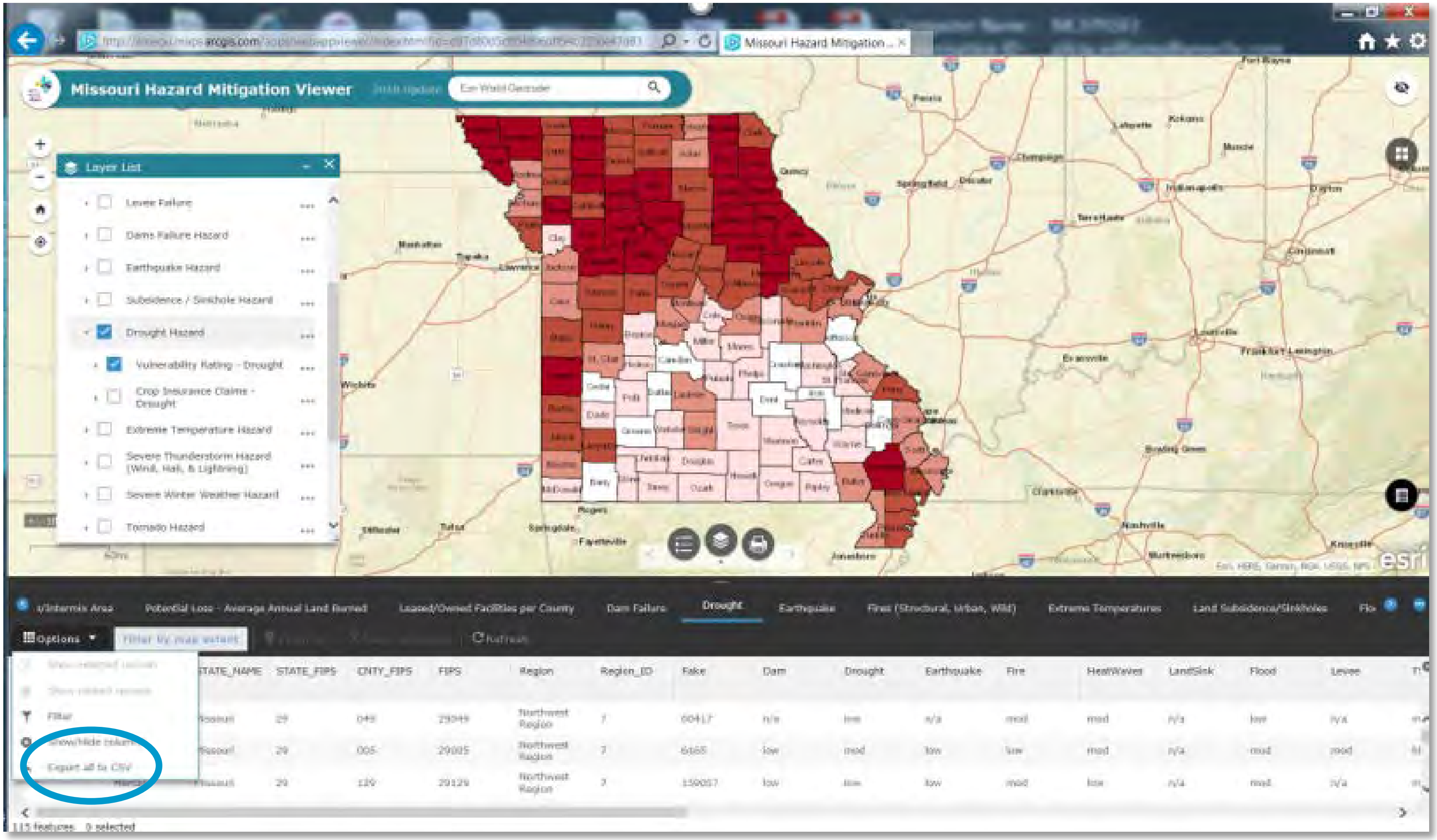


This data can be exported into a CSV format file that can then be used by many different formats. To export, the attributes table much be active as shown above. Click the blue button on the upper right hand of the attribute table, circled in purple above.

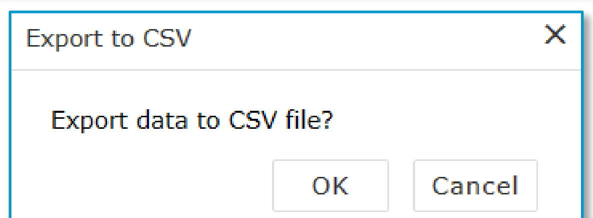
A window will appear on the right side that shows the various tables available for download. Highlight the table needed by clicking on it as shown below. That Attribute table will be zoomed to and shown as noted on the dark bar inside the purple circle.



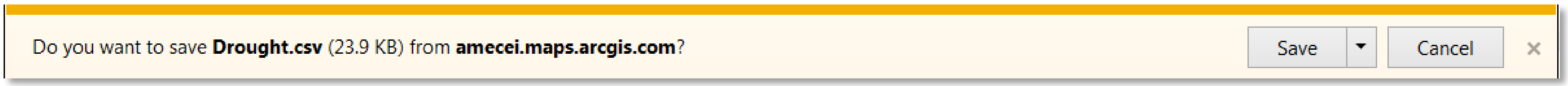
Click on the Options tab, circled in teal in the graphic above.

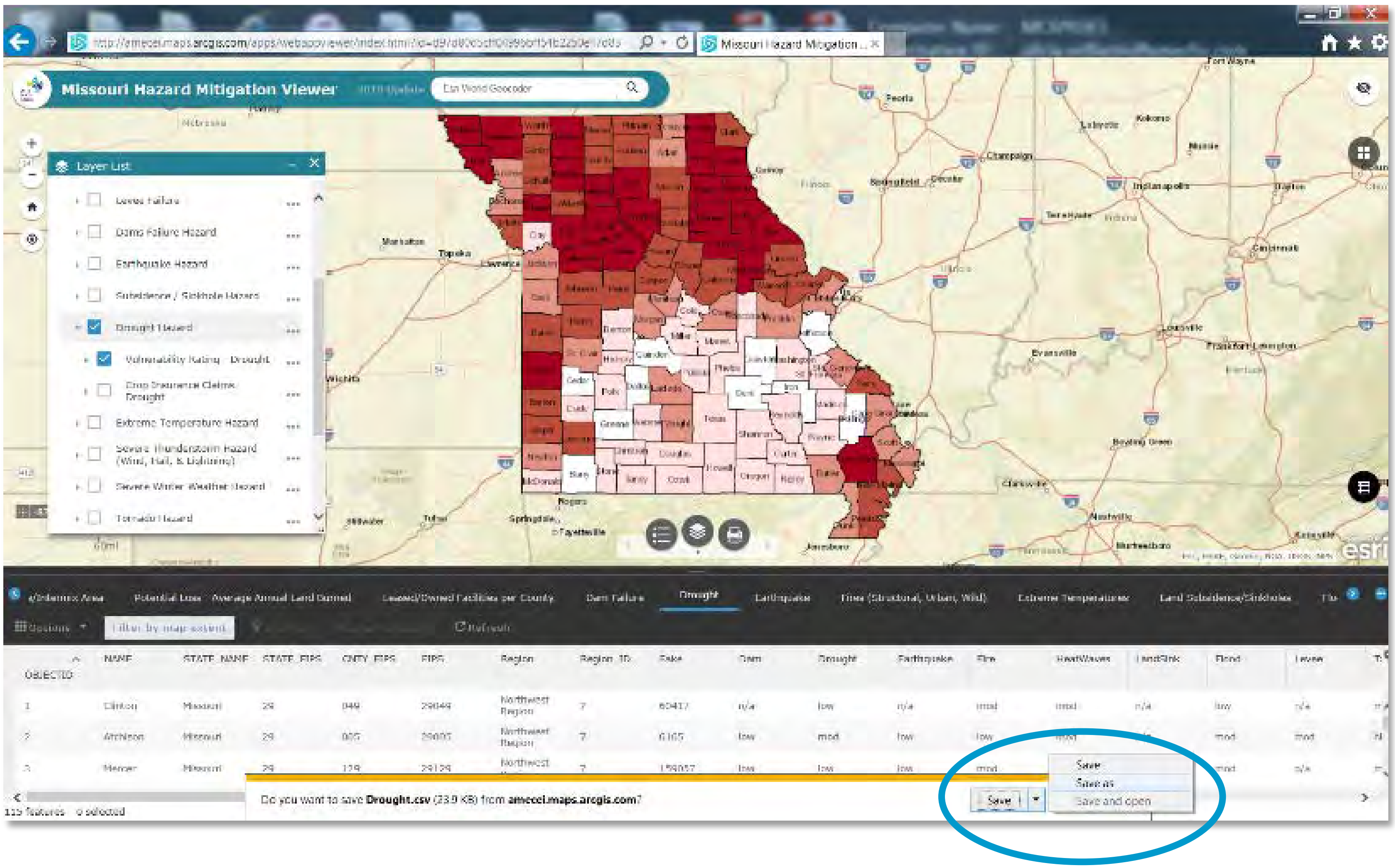


Choose the **Export to CSV option**. A small window will open. Click “Ok”.

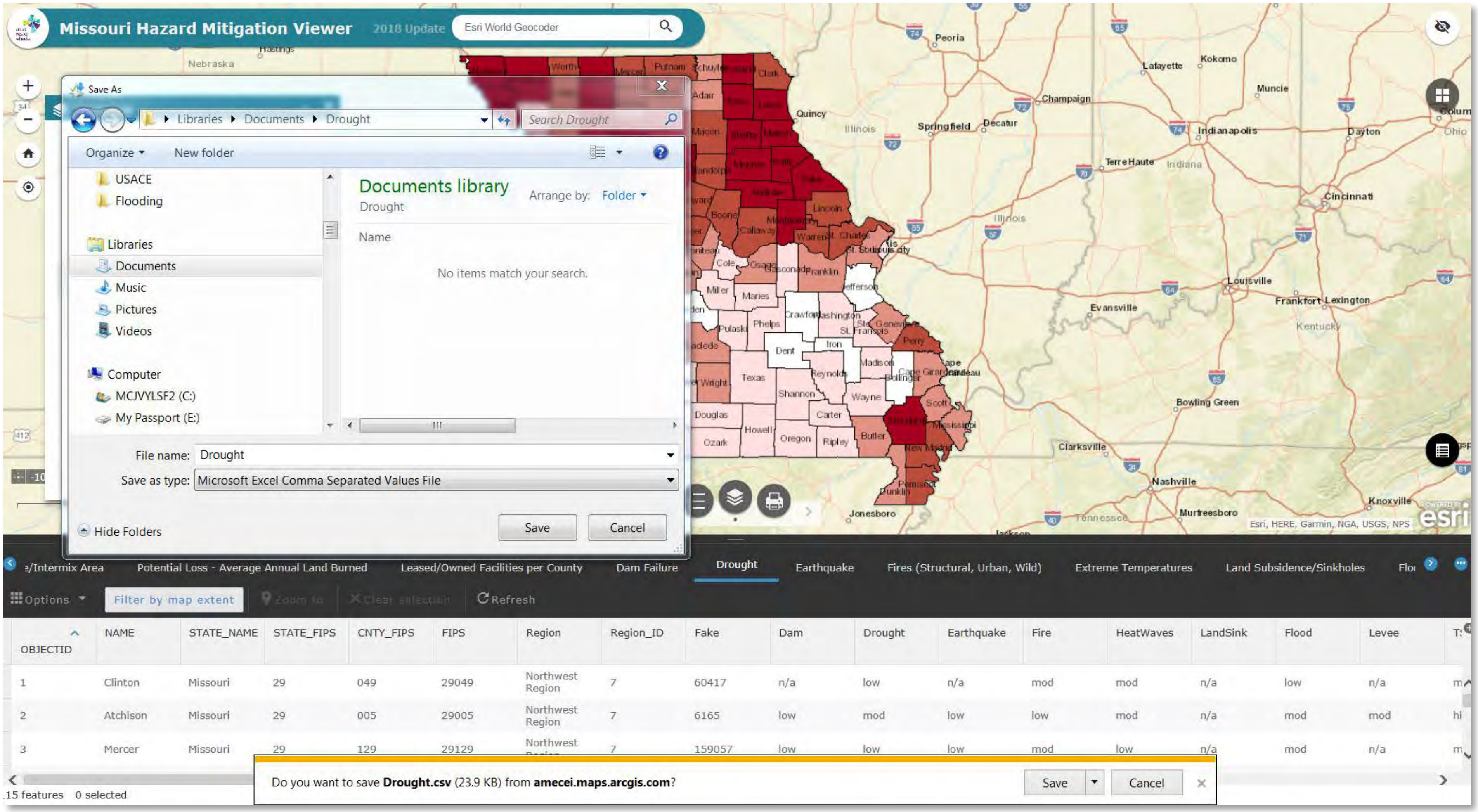


At the bottom of the page, a small banner will appear asking if you want to save the file. Using the dropdown arrow next to the word “Save, choose “Save as”.

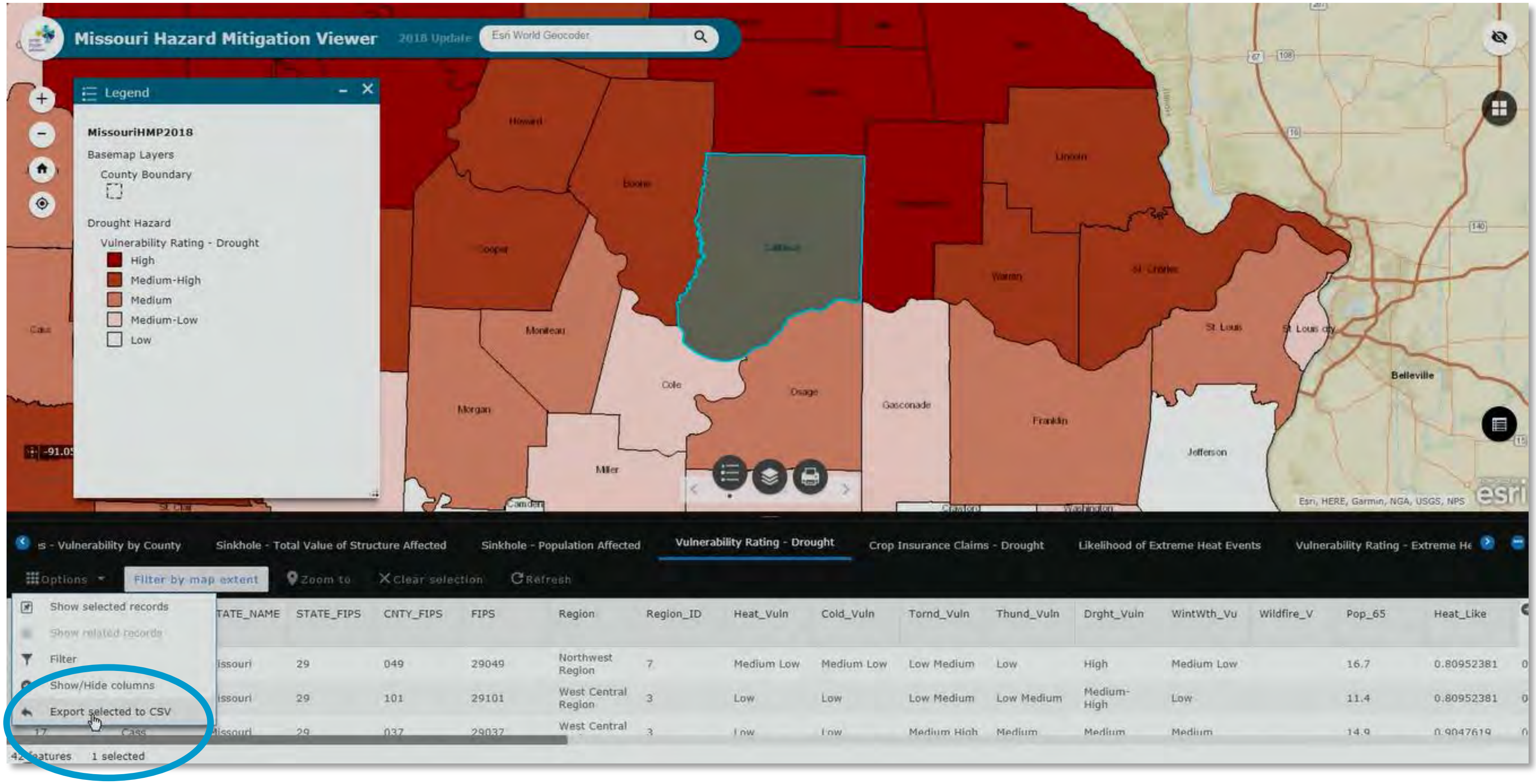




Navigate to the folder on the user's computer where the file should be stored, customize the name and click the Save button at the bottom of the window.



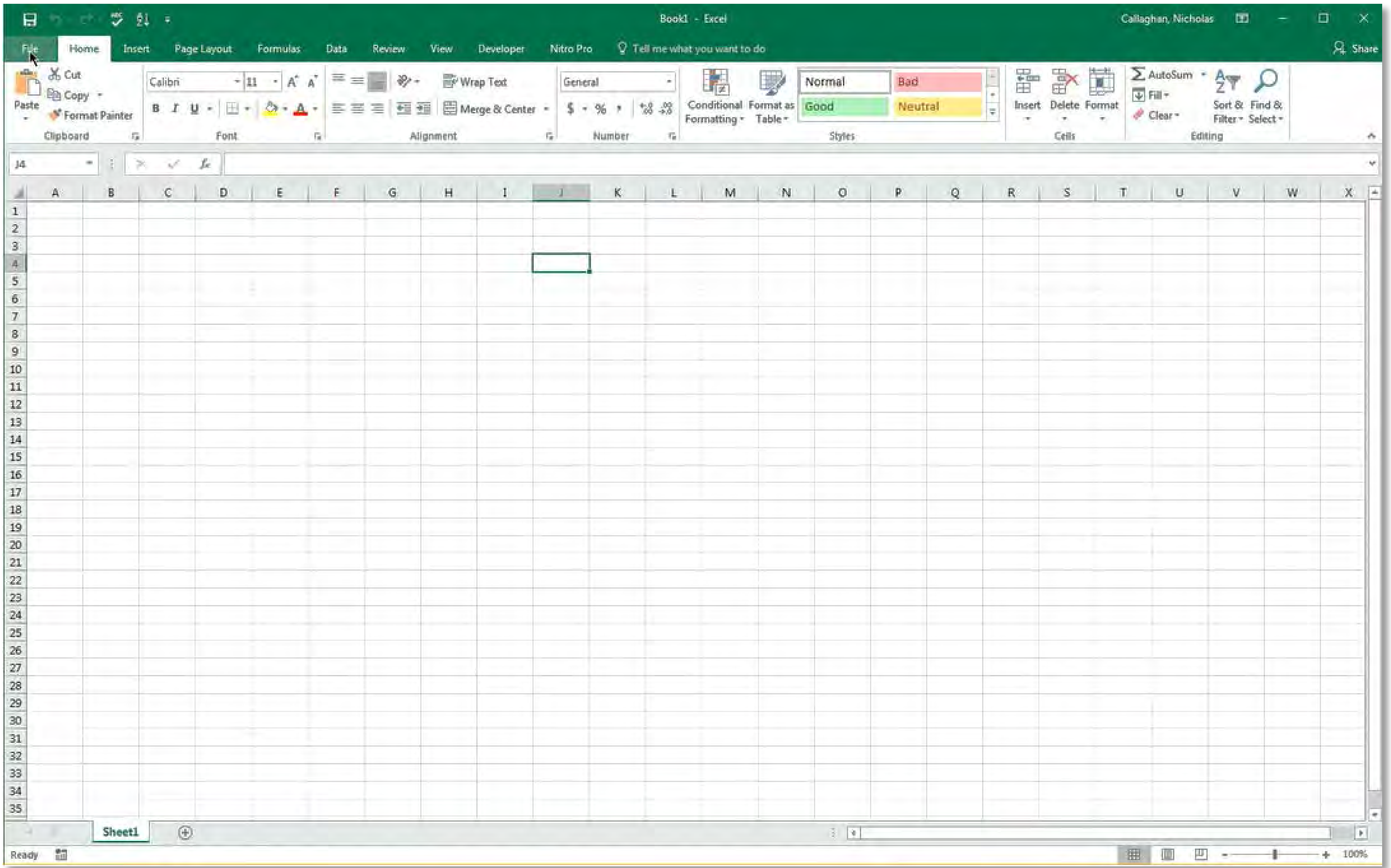
A single county or group of counties may be selected for export as well.



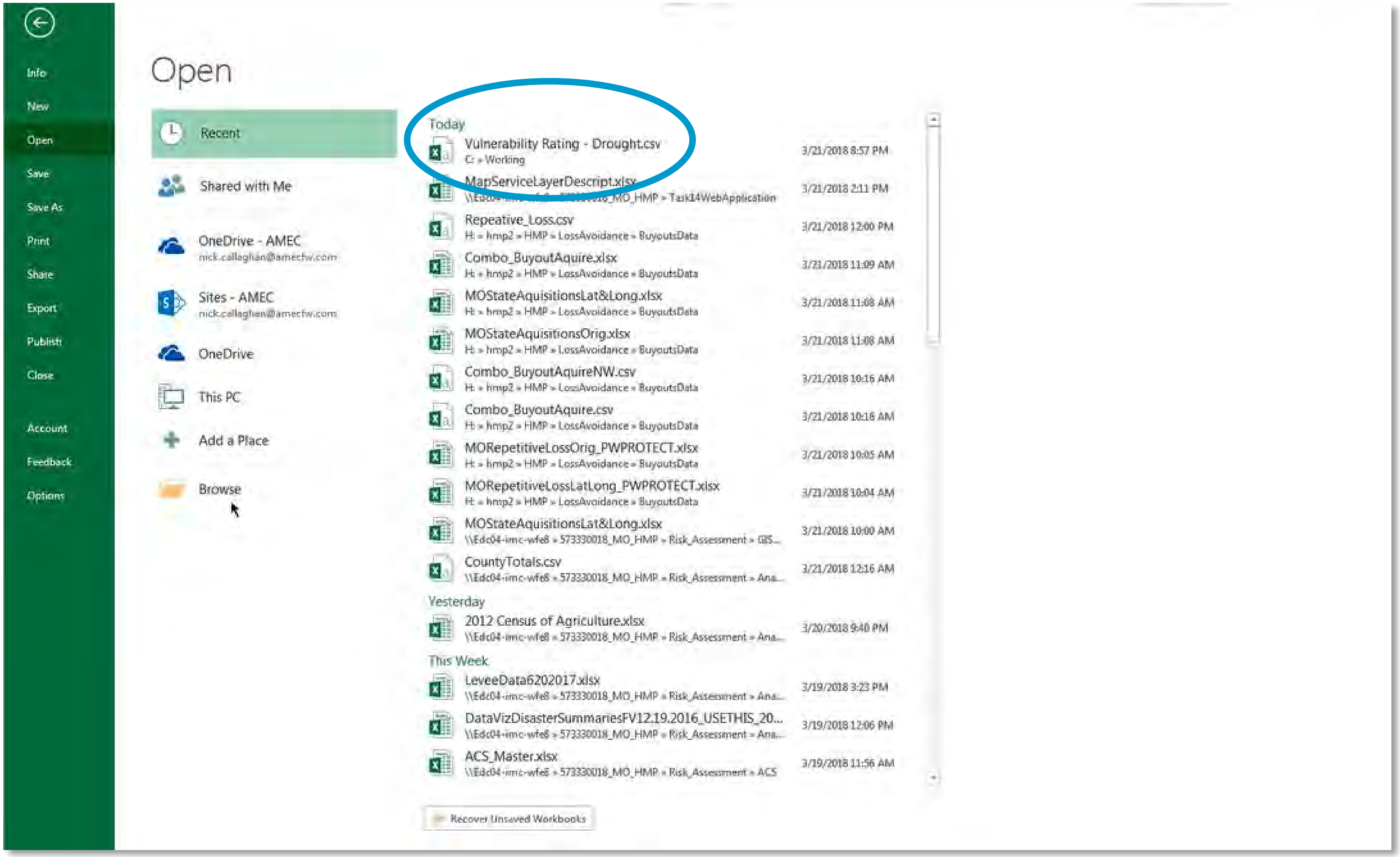
CSV Files in Excel

Downloaded CSV files can be opened in several formats as shown in detail below. To Open a CSV in Excel:

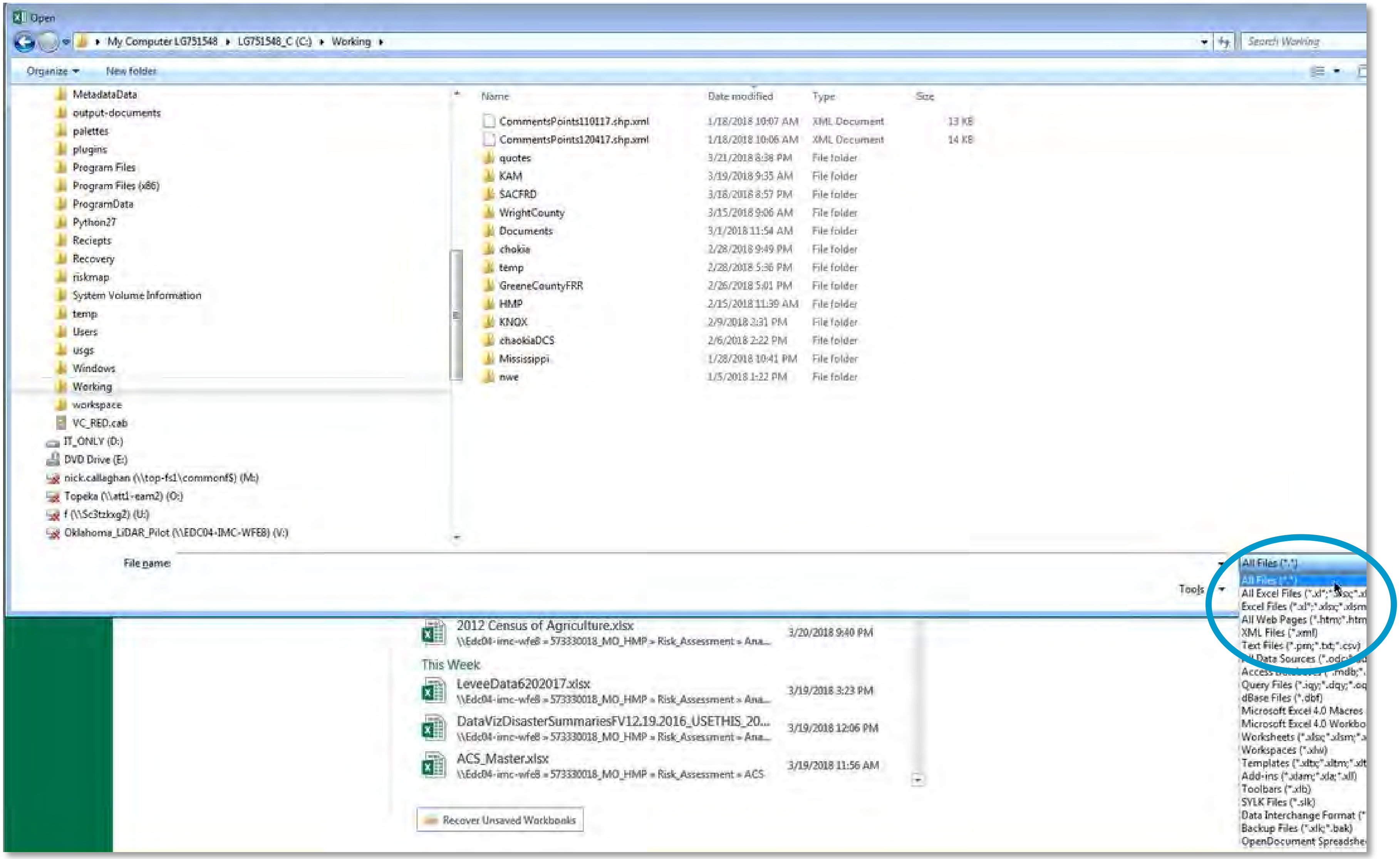
1) Open a blank Excel file.



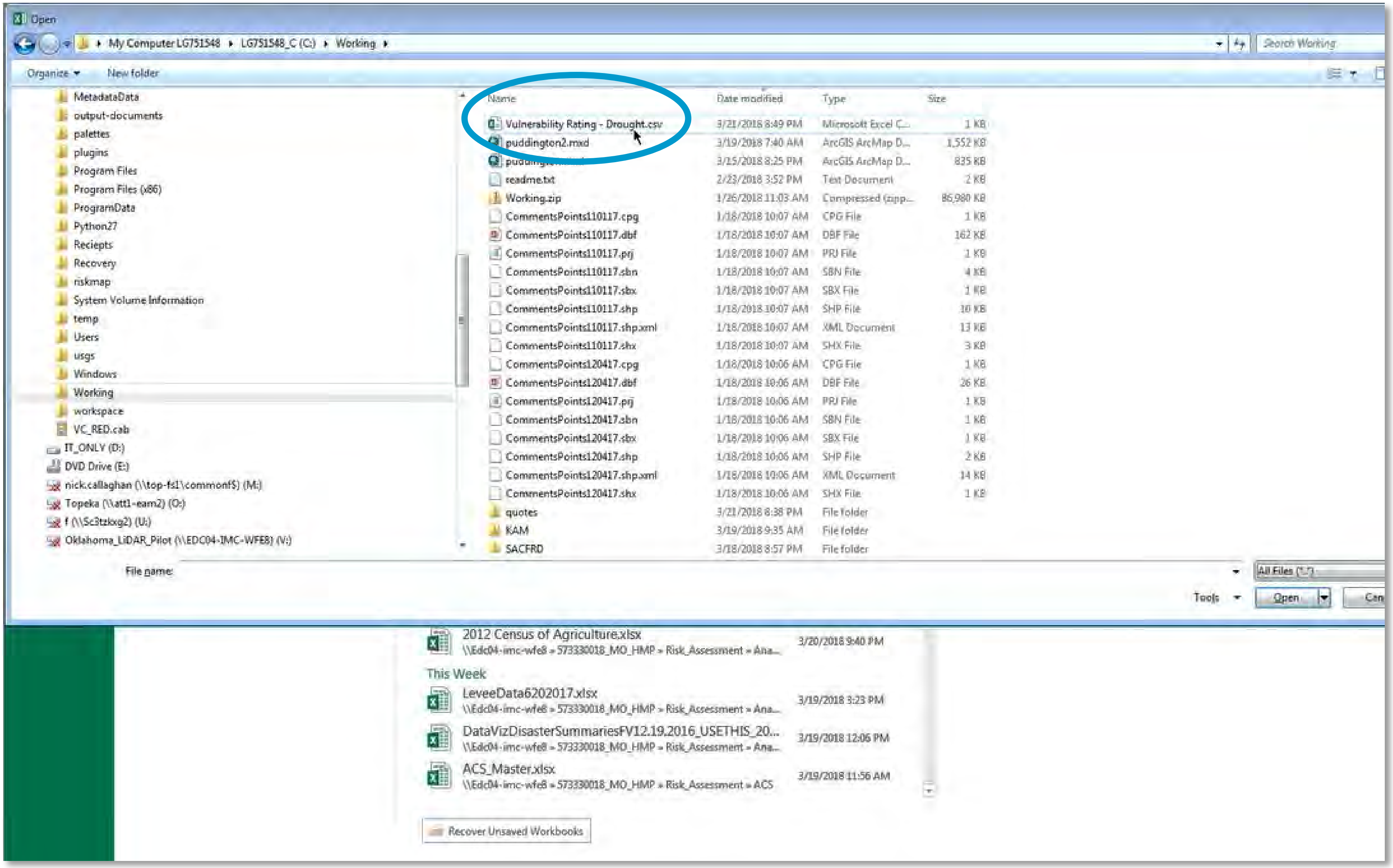
2) Click File and Browse to the CSV file



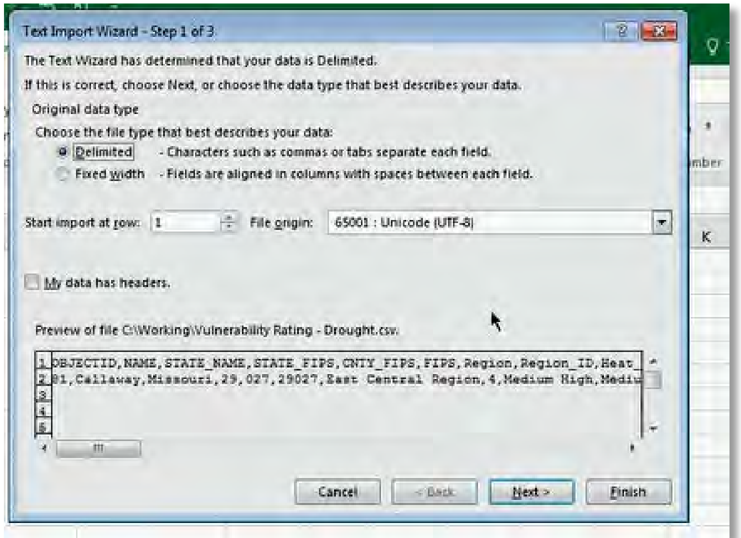
3) Navigate to the saved CSV location. Using the dropdown arrow for file types in the bottom right side of the window, choose "All Files (*.*).



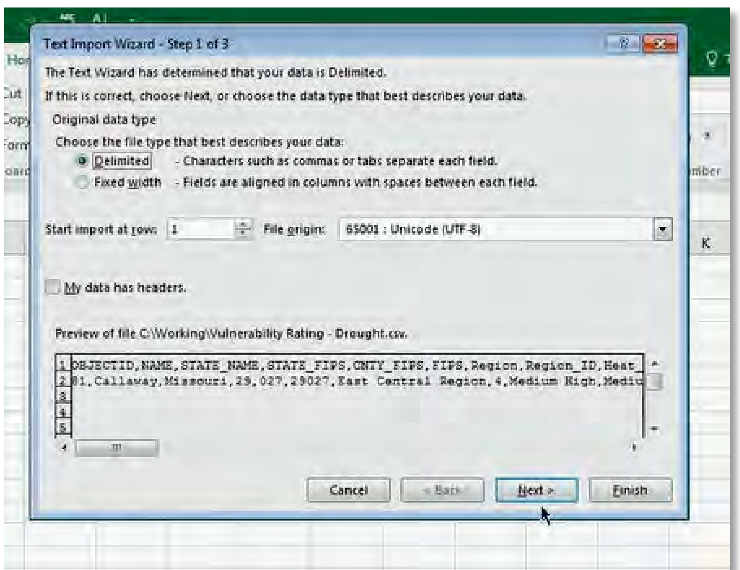
4) Click on the CSV file in the File Name window.



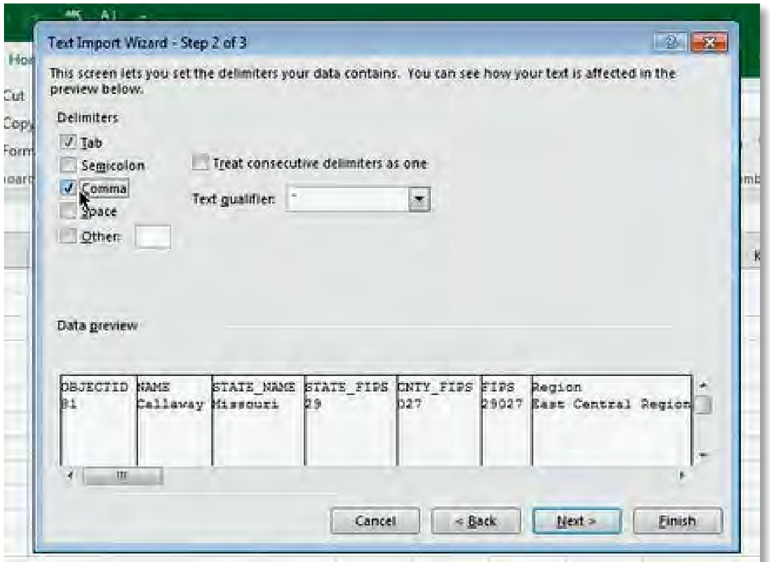
5) A Text Import Wizard window will open showing Step 1 of 3. Choose the "Delimited" radio button in the upper middle of the window.



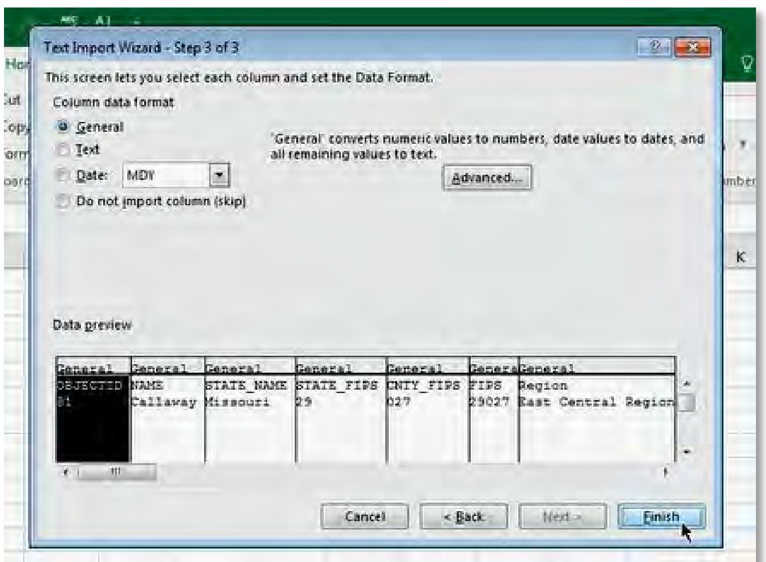
6) Then click "Next" at the bottom right.



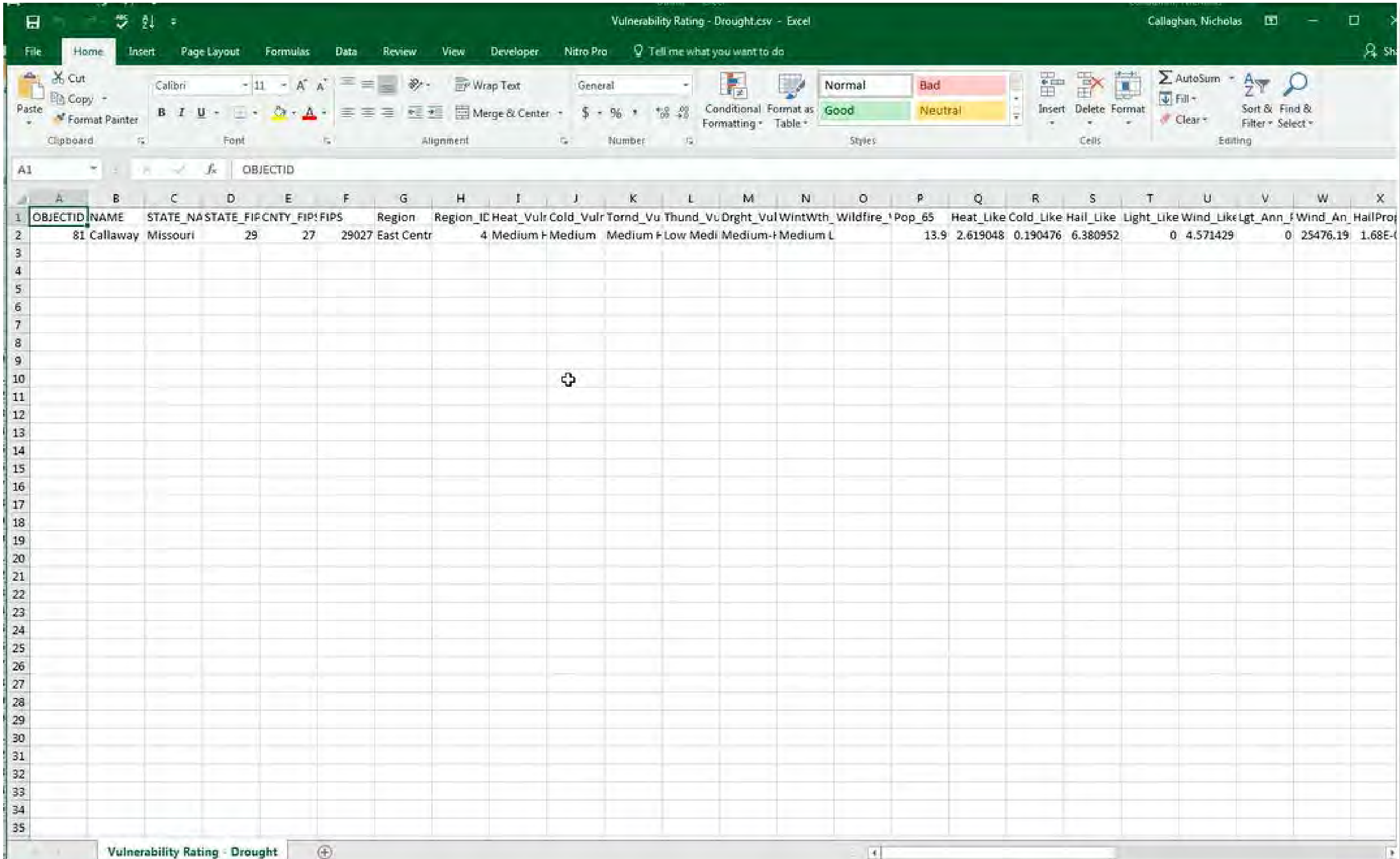
7) The Step 2 of 3 Text Import Wizard Window will open. Select the “Tab” and “Comma” check boxes on the left. Then click “Next” at the bottom.



8) The Step 3 of 3 Text Import Wizard window will open. Click the “General” radio button on the left. Then click “Finish” at the bottom.



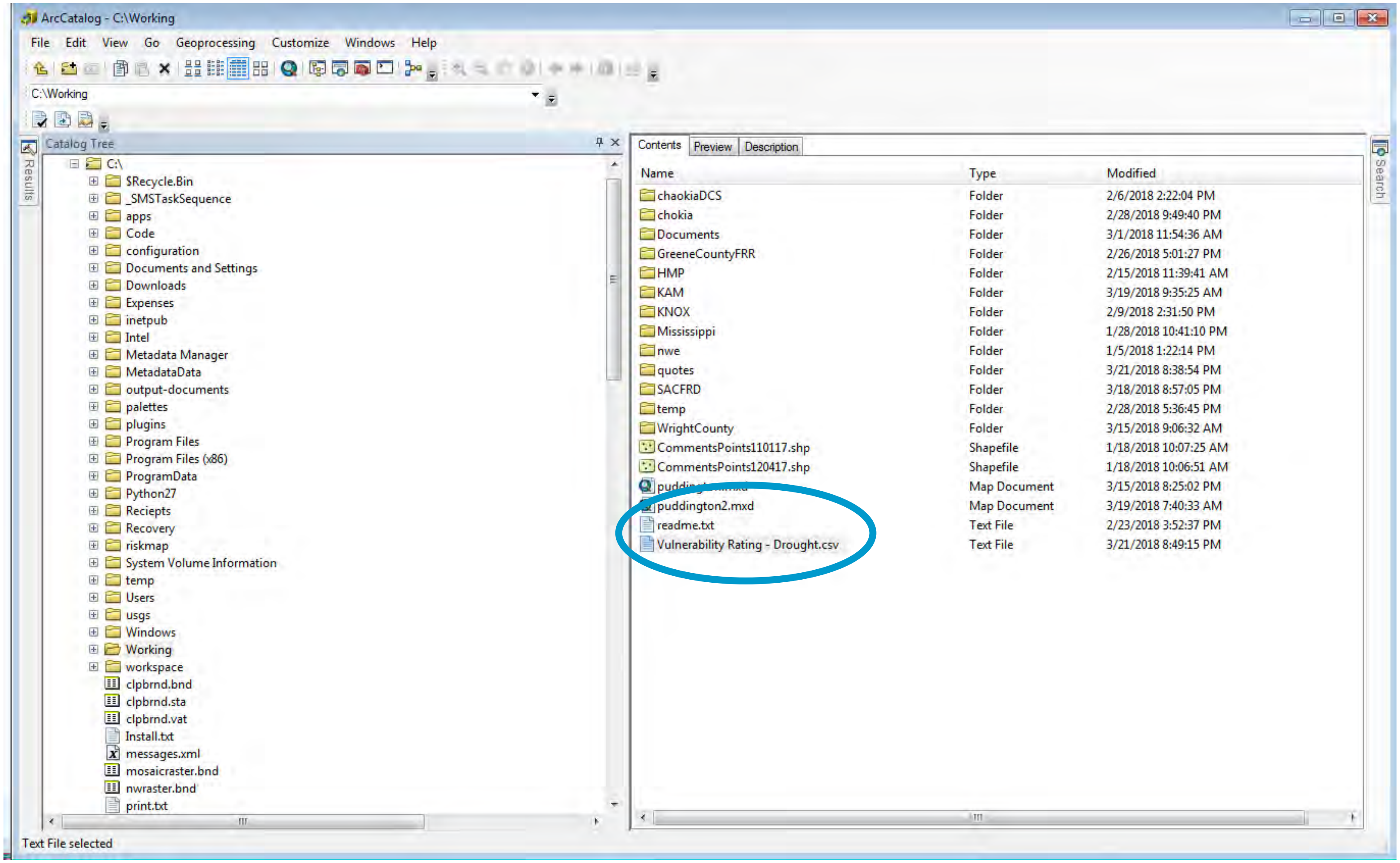
9) The Text Import Wizard window will shut and the data will appear in the Excel spreadsheet.



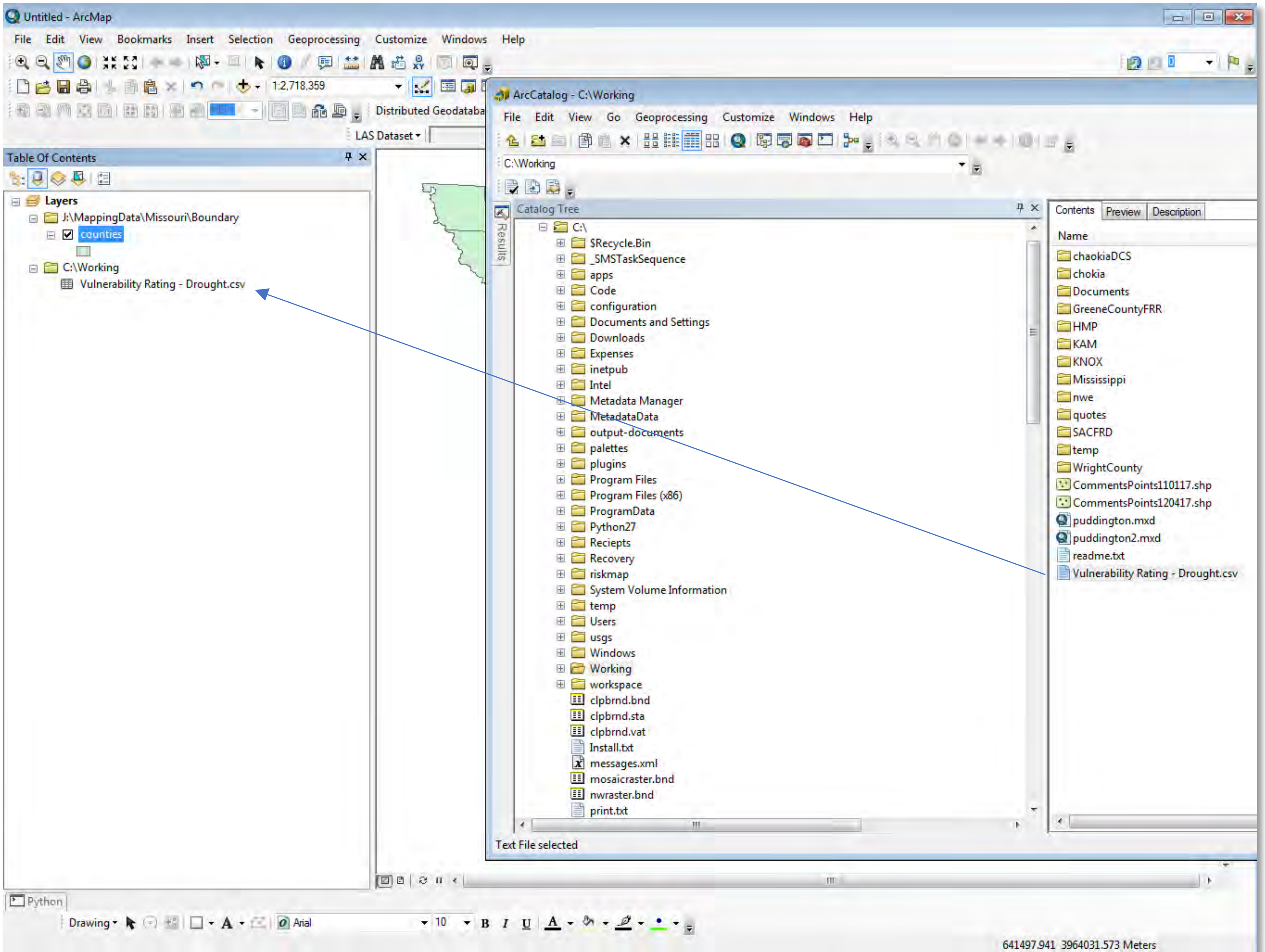
CSV Files in ArcGIS

To Open a CSV file in ArcGIS

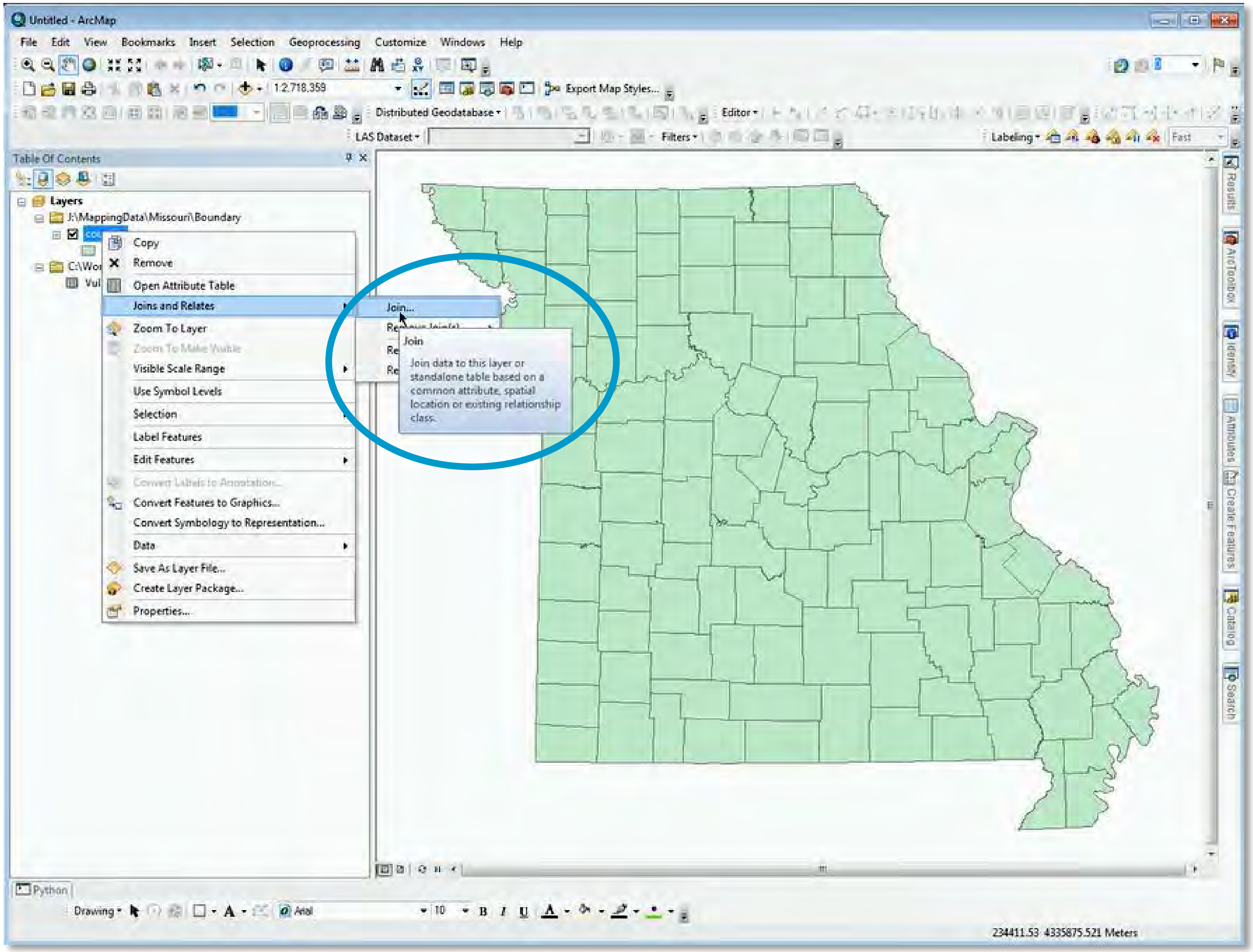
1) Open ArcMAP and then ArcCatalog. Navigate to the stored CSV file location in ArcCatalog.



2) Drag the CSV file from Catalog into ArcMAP. Also add to the ArcMap a county boundary shapefile.



3) Join the CSV file to the County Shapefile by right clicking on the County shapefile in the Table of contents window to open the options window, choosing "**Joins and Relates** "and then "**Join**".



4) A Join Data window will open. Choose the following options utilizing the drop-down arrows:

a) Join attributes from a table

b) Choose the field of the County

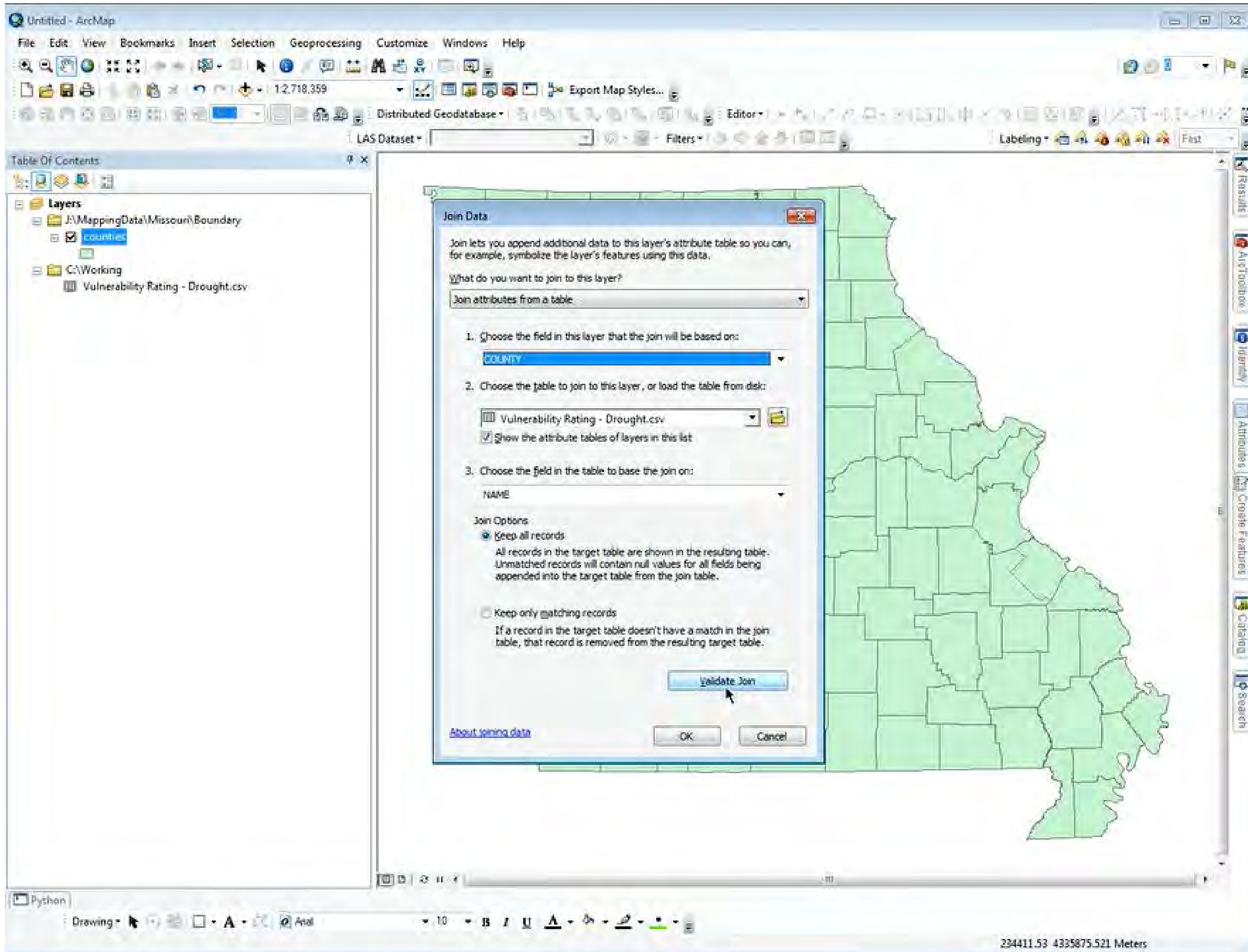
c) Choose the CSV file name

d) Choose the field with the County name in it

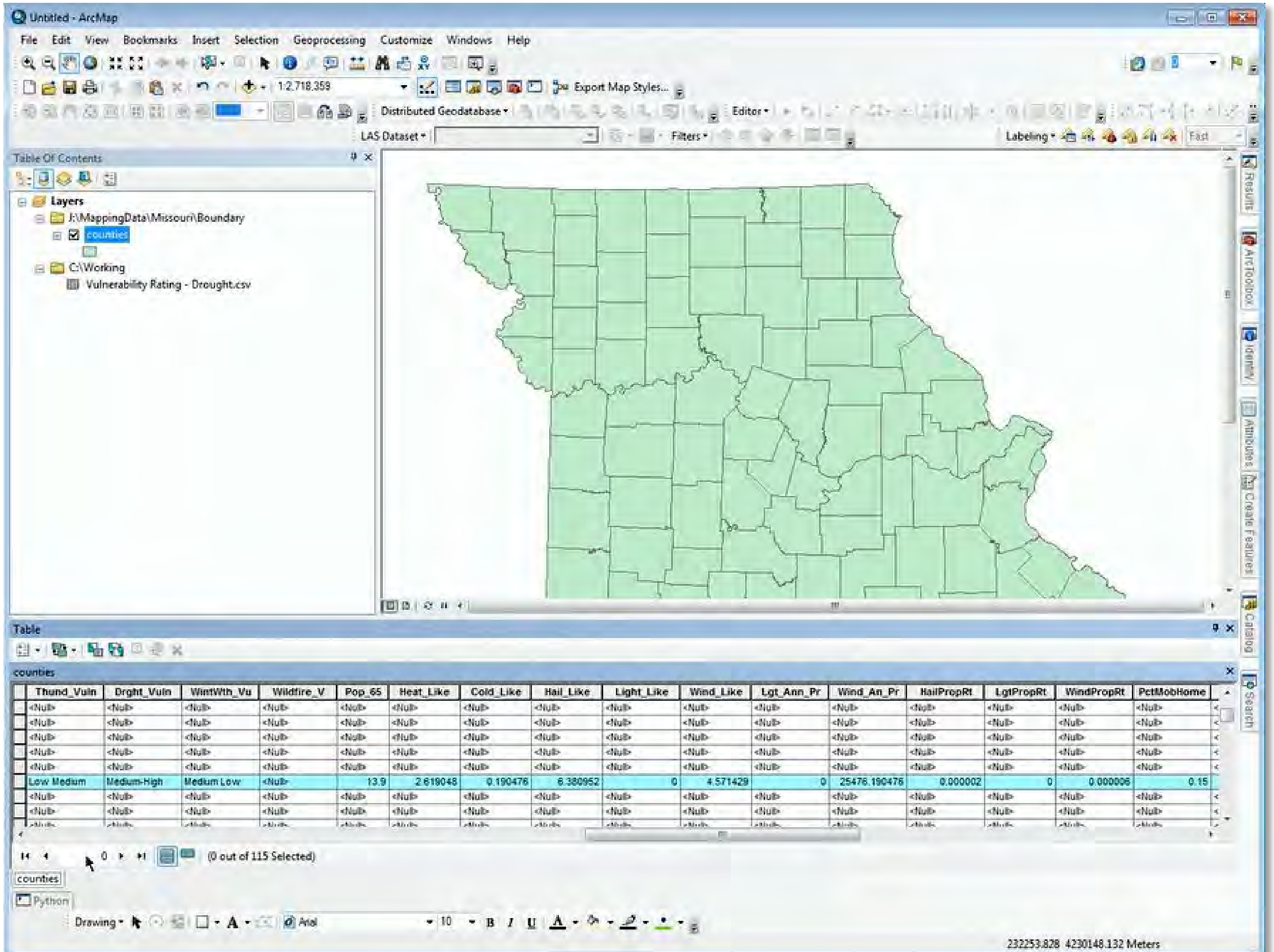
e) Choose "Keep all records"

f) Choose "Validate Join"

g) Click "Ok" at the bottom.



5) The data in the CSV file will now appear appended to the right of the County file attributes. For counties with no data in the CSV file, the attributes are <Null>.



Data Key

To assist the user in analyzing the data exported and the data displayed in the Plan Document, the following Data Key has been prepared which shows the Data Category, the attribute field names, a description of the attribute fields, the methodology or source used, the Table Number, the Figure Number and the Page Numbers using this attribute in the Plan Document.

Category	Attribute Field	Description	Methodology/Source	Table No.	Figure No.	Page Nos.
General Data	NAME	County Name				
	STATE_NAME	State Name				
	STATE_FIPS	Federal Information Processing Standard number (FIPS) for the State				
	CNTY_SEAT	County Seat				
	CNTY_FIPS	Federal Information Processing Standard number (FIPS) for the County				
	FIPS	Concatenated State and County FIPS number				
	Region	Statewide Regional Coordinators Program Jurisdictions				
	Region_ID	Statewide Regional Coordinators Program Jurisdiction Number				
Assetts at Risk	Total_Pop	Total Population (2015)	U.S. Census Bureau	3.5	3.1	3.11
	NC_Pop	Numerical Change in Population, 2010-2015	U.S. Census Bureau	3.5	3.2	3.11
	PC_Pop	Percent Change in Population, 2010-2015	U.S. Census Bureau	3.5	3.3	3.11
	NC_HU	Numerical Change in Housing Units, 2010-2015	U.S. Census Bureau	3.13	3.4	3.22
	PC_HU	Percent Change in Housing Units, 2010-2015	U.S. Census Bureau	3.14	3.5	3.23
	NC_PopDen	Numerical Change in Population Density, 2010-2015	U.S. Census Bureau	3.15	3.6	3.27
	PC_PopDen	Percent Change in Population Density, 2010-2015	U.S. Census Bureau	3.15	3.7	3.28
	SOVI	Social Vulnerability Rating Index	Hazards and Vulnerability Research Institute	3.19	3.8	3.3
	PctMobHome	Percentage of Mobile Homes	U.S. Census Bureau	3.91	3.164	3.296
	ARENatural	Missouri Dept of Conservation Facility Name	Missouri Department of Conservation (MDC)	3.18	---	3.290
	AREAMINDI	Missouri Dept of Conservation Facility Type	MDC	3.18	---	3.290
	Site_Name	Dept of Higher Education Facility Name	Department of Higher Education (DHE)	3.18	3.220	3.590
	Facility_N	Dept of Higher Education Facility Building	DHE	3.18	3.220	3.590
	Type	MoDOT Facility Type	Missouri Department of Transportation (MoDOT)	3.18	3.221	3.591
	Name	MoDOT Facility Name	MoDOT	3.18	3.221	3.591
	FEATURE_INTERSECTED	State Owned Bridges Stream Crossing	MoDOT	3.18	3.221	3.591
	STRUCTURE_NUMBER	State Owned Bridges Structure Number	MoDOT	3.18	3.221	3.591
	Owned	Number of State Owned Facilities	Office of Administration, DHE, MDC, MoDOT	3.172	3.218	3.592
	Department	State Owned Facility Department	Office of Administration, DHE, MDC, MoDOT	3.172	3.218	3.593
	Site_Sit	State Owned Facility Name	Office of Administration, DHE, MDC, MoDOT	3.172	3.218	3.593
	Leased	Number of State Leased Facilities	Office of Administration, DHE, MDC, MoDOT	3.172	3.220	3.593
	DHE	Number of Department of Higher Education (DHE) Facilities	DHE	3.170	3.220	3.592
	St_Bridges	Number of State Owned Bridges	MoDOT	3.170	3.221	3.592
	Dam_Facs	Number of State-Owned Facilities in Inundation Zones of USACE dams	Office of Administration, FEMA, Army Corps of Engineers (USACE)	3.184	3.608	3.606
	FloodCount	Number of State-owned Facilities in the 100-year Floodplain	Office of Administration, FEMA, Army Corps of Engineers (USACE)	3.174	3.222	3.597
	Tier_II	Number of State-owned facilities within 0.5 miles of Tier II Hazardous Materials Facilities	Office of Administration, Missouri Emergency Response Commission	3.199	3.229	3.623
	Fac_Count	Number of State-owned facilities within 0.5 miles of Tier II Hazardous Materials Facilities	Office of Administration, Missouri Emergency Response Commission	3.199	3.229	3.623
	EHS_Count	Number of Facilities Reporting Storage of Extremely Hazardous Substances (EHS)	Office of Administration, Missouri Emergency Response Commission	3.199	3.229	3.623
Flood Hazard	Claims	Number of Claims in County	Federal Emergency Management Agency (FEMA)	3.32	3.107	3.106
	Amt_pd	Amount paid	FEMA	3.32	3.107	3.106
	Policies	Number of policies	FEMA	3.32	3.107	3.106
	Coverage	Total coverage of policies	FEMA	3.32	3.107	3.106
	Particip	NFIP Participation	FEMA			
	NAICS_Desc	Educational facility description	Homeland Security Infrastructure Program (HSIP)			
	Level	Educational facility level	HSIP			
	Name	Educational facility name	HSIP			
	Type	Fire station type	HSIP			
	Name	Fire station name	HSIP			
	NAICSDESCR	Medical facility description	HSIP			
	Name	Medical facility Name	HSIP			
Levee Failure	NFHL_XPL	Levee shown on national flood hazard layer (NFHL)	FEMA, USACE	3.38	3.64	3.130
	NLD	Levee in National levee database (NLD)	FEMA, USACE	3.38	3.64	3.130
	NLI_Struct	National Levee Inventory structures affected	FEMA, USACE		3.69	3.141
	NLI_PopAff	National Levee Inventory population affected	FEMA, USACE		3.68	3.140
	NFHLStrVal	NFHL Structure value affected	FEMA, USACE	3.43		3.140
Dam Failure Hazard	TotalDam	Total number of dams in county	Missouri Department of Natural Resources (MoDNR), USACE		3.71	3.150
	HighHazard	Number of high hazard dams	MoDNR, USACE		3.72	3.151
	Signif_Haz	Number of dams with significant hazard	MoDNR, USACE		3.73	3.151
	Low_Haz	Number of low hazard dams	MoDNR, USACE		3.74	3.152
	Unrated	Number of dams with hazard unrated	MoDNR, USACE	3.47		3.159
	St_TotInd	Number of structures affected by state dams	Office of Administration, MoDNR, USACE		3.82	3.185
	Fed_TotInu	Number of structures affected by USACE dams	Office of Administration, MoDNR, USACE		3.84	3.186
	StReg_Class1	Number of class 1 state regulated dams	MoDNR, USACE		3.76	3.154
	StReg_Class2	Number of class 2 state regulated dams	MoDNR, USACE		3.77	3.154
	StReg_Class3	Number of class 3 state regulated dams	MoDNR, USACE		3.78	3.155
	Num_St_strt	Number of structures affected by state regulated dams	Office of Administration, MoDNR, USACE	3.53	3.82	3.173
	Num_USACE_Num	Number of structures affected by USACE regulated dams	Office of Administration, MoDNR, USACE	3.54	3.84	3.178
	StateInundation_Value	Value of structures affected by state dams	Office of Administration, MoDNR, USACE	3.53	3.83	3.173
	USACEInundation_Val	Value of structures affected by USACE dams	Office of Administration, MoDNR, USACE	3.53	3.85	3.173
	StatePeopleAffect	Population affected by State Dams	Office of Administration, MoDNR, USACE	3.53	3.86	3.173
	USACEPeopleAffect	Population affected by USACE Dams	Office of Administration, MoDNR, USACE	3.53	3.87	3.173
	Dam	Hazard rating for Dam Failure	Statistical analysis of multiple datasets, rating values based on natural breaks		3.72	3.151
	Drought	Hazard rating for Drought	Statistical analysis of multiple datasets, rating values based on natural breaks	3.73	3.113	3.247
	Earthquake	Hazard rating for Earthquake	Statistical analysis of multiple datasets, rating values based on natural breaks		3.92	3.209
	Fire	Hazard rating for Fire	Statistical analysis of multiple datasets, rating values based on natural breaks	3.121	3.172	3.394

Category	Attribute Field	Description	Methodology/Source	Table No.	Figure No.	Page Nos.
Earthquakes & Hazard Ratings	Heatwaves	Hazard rating for Heatwaves	Statistical analysis of multiple datasets, rating values based on natural breaks	3.81	3.199	3.267
	LandSink	Hazard rating for Sinkholes	Statistical analysis of multiple datasets, rating values based on natural breaks	3.66	3.105	3.227
	Flood	Hazard rating for Flooding	Statistical analysis of multiple datasets, rating values based on natural breaks		3.68	3.140
	Levee	Hazard rating for Levee Failure	Statistical analysis of multiple datasets, rating values based on natural breaks	3.43	3.69	3.141
	Tstorm	Hazard rating for Thunderstorms	Statistical analysis of multiple datasets, rating values based on natural breaks	3.94	3.13	3.312
	Tornado	Hazard rating for Tornado	Statistical analysis of multiple datasets, rating values based on natural breaks	3.117	3.166	3.81
	Lightning	Hazard rating for Lightning	Statistical analysis of multiple datasets, rating values based on natural breaks	3.94	3.13	3.312
	EQ_Pimpact	Number of people affected by earthquake hazard	US Census Bureau, HAZUS V. 3.2	3.61		3.210
	EQ_Bimpact	Number of buildings affected by earthquake hazard	US Census Bureau, HAZUS V. 3.2	3.61		3.210
	EQ_LossE	Earthquake total building exposure	US Census Bureau, HAZUS V. 3.2	3.61		3.210
	EQLossR	Earthquake property loss ratio	losses to buildings annualized over eight earthquake return periods (100, 250, 500, 750, 1,000, 1,500, 2,000, and 2,500 years)	3.6	3.91	3.205
	FD_Pimpact	Number of people affected by fire hazard	MSDIS Structure Inventory, HAZUS	3.122	3.177	3.400
	FD_Bimpact	Number of buildings affected by fire hazard	avg acres burned each year and the avg value of structures per acre in WUI areas	3.122	3.175	3.400
	FD_LossR	Fire property loss ratio	avg acres burned each year and the avg value of structures per acre in WUI areas	3.123	3.178	3.416
	T_Pimpact	Number of people affected by tornado hazard	National Center for Environmental Information (NCEI), HAZUS, US Census Bureau	3.116		3.379
	T_Bimpact	Number of buildings affected by tornado hazard	National Center for Environmental Information (NCEI), HAZUS, US Census Bureau	3.116		3.379
	T_LossR	Tornado property loss ratio	National Center for Environmental Information (NCEI), HAZUS, US Census Bureau	3.117	3.167	3.810
	WinStorm	Hazard rating for Winter Storms	Statistical analysis of multiple datasets, rating values based on natural breaks	3.106	3.145	3.343
Subsidence/Sinkhole Hazard	Num_Snkhls	Number of Sinkholes by County	MoDNR, Missouri Geological Survey (MGS)	3.65	3.103	3.223
	Num_Mine	Number of Mines by County	MoDNR, MGS	3.65	3.103	3.223
	SnkDsgnFac	Sinkholes Vulnerability by County	# of structures within sinkhole areas, rating values based on natural breaks	3.66	3.105	3.228
	MneDsgnFct	Mines Vulnerability by County	# of structures within sinkhole areas, rating values based on natural breaks	3.66	3.105	3.228
	Pop_Affect	Total Population Affected by Sinkholes	MSDIS, MoDNR, MGS	3.67	3.108	3.230
	TotVal_Str	Total Value of Structures Affected by Sinkholes	MSDIS, MoDNR, MGS	3.67	3.107	3.230
	StrtInSink	Number of Structures Affected by Sinkholes	MSDIS, MoDNR, MGS	3.67		3.230
Drought & Extreme Weather Hazards	Heat_Vuln	Ranking for Vulnerability to Heat (Low, Medium Low, Medium, Medium High, High)	Statistical analysis of multiple datasets, rating values based on natural breaks	3.81	3.199	3.267
	Cold_Vuln	Ranking for Vulnerability to Cold (Low, Medium Low, Medium, Medium High, High)	Statistical analysis of multiple datasets, rating values based on natural breaks	3.81	3.121	3.267
	Tornd_Vuln	Ranking for Vulnerability to Tornado (Low, Medium Low, Medium, Medium High, High)	Statistical analysis of multiple datasets, rating values based on natural breaks	3.117	3.166	3.810
	Thund_Vuln	Ranking for Vulnerability to Thunder (Low, Medium Low, Medium, Medium High, High)	Statistical analysis of multiple datasets, rating values based on natural breaks	3.94	3.13	3.312
	Drght_Vuln	Ranking for Vulnerability to Drought (Low, Medium Low, Medium, Medium High, High)	Statistical analysis of multiple datasets, rating values based on natural breaks	3.73	3.113	3.247
	WintWth_Vu	Ranking for Vulnerability to Winter Weather (Low, Medium Low, Medium, Medium High, High)	Statistical analysis of multiple datasets, rating values based on natural breaks	3.106	3.145	3.343
	Wildfire_V	Ranking for Vulnerability to Wildfire (Low, Medium Low, Medium, Medium High, High)	Statistical analysis of multiple datasets, rating values based on natural breaks	3.121	3.172	3.394
	Pop_65	Vulnerability Population Over Age 65	percentage of population over 65 data from the U.S. Census	3.80	---	3.265
	Heat_Like	Likelihood of Occurrence of a Heat Event	# Events/Period of Record: 21 years	3.81	3.118	3.267
	Cold_Like	Likelihood of Occurrence of a Cold Event	# Events/Period of Record: 21 years	3.81	3.12	3.267
	Hail_Like	Likelihood of Occurrence of a Hail Event	# Events/Period of Record: 21 years	3.92	3.128	3.299
	Light_Like	Likelihood of Occurrence of a Lightning Event	# Events/Period of Record: 21 years	3.92	3.129	3.299
	Wind_Like	Likelihood of Occurrence of a High Wind Event (40 MPH and higher)	# Events/Period of Record: 21 years	3.92	3.127	3.299
	Lgt_Ann_Pr	Annualized Property Loss due to Lightning Damage	# Events/Period of Record: 21 years	3.93	3.13	3.306
	Wind_An_Pr	Annualized Property Loss due to High Wind Damage	# Events/Period of Record: 21 years	3.93	3.131	3.306
	HailPropRt	Annualized Property Loss Ratio for Hail	# Events/Period of Record: 21 years	3.92	3.128	3.299
	LgtPropRt	Annualized Property Loss Ratio for Lightning	# Events/Period of Record: 21 years	3.93	3.129	3.299
	WindPropRt	Annualized Property Loss Ratio for High Wind	# Events/Period of Record: 21 years	3.92	3.127	3.299
	WinWtrLike	Likelihood of Severe Winter Weather Events	# Events/Period of Record: 21 years	3.106	3.144	3.343
	WW_AnnProp	Annualized Property Loss due to Severe Winter Weather Damage	# Events/Period of Record: 21 years	3.107	3.146	3.349
	WW_PropRt	Annualized Property Loss Ratio for Severe Winter Weather	# Events/Period of Record: 21 years	3.107	3.147	3.349
	Torn_Event	Number of Historic Tornado Events	# Events/Period of Record: 21 years	---	3.15	3.359
	Torn_Like	Likelihood of Occurrence for Tornado Events	# Events/Period of Record: 21 years	3.117	3.165	3.810
	Torn_An_PR	Annualized Property Loss due to Tornado Damage	# Events/Period of Record: 21 years	3.117	3.167	3.810
	Torn_Pr_Rt	Annualized Property Loss Ratio for Tornadoes	# Events/Period of Record: 21 years	3.117	3.168	3.810
	Hail_An_Pr	Annualized Property Loss due to Hail Damage	# Events/Period of Record: 21 years	3.92	3.132	3.299
	Drght_Crop	Average Annualized Crop Claims	2012 Agricultural Census	3.73	3.114	3.247
Wildfire Hazard	WldFr04_12	Number of Wildfires 2004-2012	MDC Data	3.121		3.394
	Brnd04_12	Average Acres Burned 2004-2012	MDC Data	3.121	3.173	3.394
	WldFr13_16	Number of Wildfires 2013-2016	MDC Data	3.121		3.394
	Brnd13_16	Average Acres Burned 2013-2016	MDC Data	3.121	3.173	3.394
	WldFr04_16	Number of Wildfires 2004-2016	MDC Data	3.121		3.394
	Occr_13yr	Likelihood of Occurrence	(#/year)	3.121	3.172	3.394
	Brnd_Tot	Total Acres Burned	MDC Data	3.121		3.394
	Av_Brnd	Average Annual Acreage Burned	MDC Data	3.121	3.173	3.394
	Struct_Tot	Number of Structures Vulnerable to Wildfire	MSDIS Structure Inventory, HAZUS	3.122	3.175	3.400
	Struct_Val	Total Structure Value Within WUI	MSDIS Structure Inventory, HAZUS	3.122	3.176	3.414
	Pop_Risk	Population Vulnerable to Wildfire	MSDIS Structure Inventory, HAZUS	3.122	3.177	3.414
	Potnt_Loss	Potential Loss Average Annual Land Burned	avg acres burned each year and the avg value of structures per acre in WUI areas	3.123	3.178	3.416
Hazardous Materials Incidents	Tier_II	Number of State-owned facilities within 0.5 miles of Tier II Hazardous Materials Facilities	Office of Administration, Missouri Emergency Response Commission	3.199	3.229	3.623

Appendix A2

Vulnerability Analysis Data Matrix

Hazard	Natural or Human-caused / Technological	Hazard Sub-type	Category of Analysis	Statistical Analysis Factors	Tables	Figures (blue indicates Wood E&IS-created map) For Color scheme's please refere to the Request form.	Data Sources
Drought	Natural	Meteorological	Statistical Analysis Data Presentation	1. # of Average Annual Drought Impacts (Drought Impact Reporter) 2. Crop Exposure (2012 USDA Census of Agriculture 3. Annualized Crop Claims (USDA RMA 2007-2016) 4. SOVI (University of South Carolina)	**Vulnerability Summary by County** County Raw data for all factors Assigned rating for each factor	Drought Regions and susceptibility 2012 Drought graphics from drought report 2012 NASS Crop Condition Graphics Statewide Drought Monitor time series (2000-2016) Drought Impact Distribution Annualized Crop Claims $ Annualized Crop Loss Ratio Drought Vulnerability Summary	Missouri Drought Plan USDA Risk Management Agency USDA Census of Agriculture 2012 Central US Drought Assessment report NIDIS drought portal and drought monitor time series analysis Drought Impact Reporter Select NASS Crop Condition Graphics for MO 2012 State Water Plan-2003 Social Vulnerability Index MODOT data Palmer Drought Severity Index
Extreme Temperature	Natural	Meteorological	Statistical Analysis Data Presentation	1. Likelihood of Occurrence (NCDC events / years 1993-2016) 2. SOVI (University of South Carolina) 3. Population (2015 ACS) 4. % population age 65 and up (2015 ACS)	**Vulnerability Summary by County** County Raw data for all factors Assigned rating for each factor **Chart on months with highest number of heat events and months with highest number of cold events from NCDC or NOAA.** **Line graph of hyperthermia deaths in Missouri per year 1980-2012** **Pie chart of hyperthermia deaths by jurisdiction 2000-2012 (Jackson County, St Louis County, St Louis City, Other)** **Bar chart of hyperthermia deaths by age 2000-2012** **Crop claims by County (USDA RMA -2007-2016)**	Extreme Heat Likelihood % Population 65 and up by County (or reference map if in exp/dev section) Extreme Heat Vulnerability Summary	Missouri Department of Health and Senior Services National Climatic Data Center - Storm Events Database USDA Risk Management Agency Social Vulnerability Index 2015 ACS
Fires (structural, urban	Human-caused	Other	Statistical Analysis Data Presentation	Structural / Urban Fire 1. Likelihood of Occurrence-structure fire (NFIRS) 2. Building Exposure Value (HAZUS) 3. Annualized Property Loss (NFIRS) 4. Housing Density (2015 ACS) 5. # of Deaths / Injuries (NFIRS) 6. SOVI Wildfire See Tab 2 - Perform GIS Analysis utilizing SOVI data	**Vulnerability Summary by County for Structural / Urban Fire** County Raw data for all factors Assigned rating for each factor	Structural / Urban Fire Likelihood Annualized Property Loss $ Annualized Property Loss Ratio Historical Deaths / Injuries Structural / Urban Fire Vulnerability Summary	HAZUS - Building Values National Fire Incident Reporting System Social Vulnerability Index
Severe Thunderstorms	Natural	Meteorological	Statistical Analysis Data Presentation	1. Likelihood of Occurrence (NCDC events / yrs.) 2. Building Exposure Value (HAZUS) 3. Annualized Property Loss (NCDC / HAZUS)-hail, wind, and lightning 4. SOVI 5. Housing Density (2015 ACS) 6. # Mobiles Homes (2010 Census)	**Vulnerability Summary by County** County Raw data for all factors Assigned rating for each factor **Summary of Additional Data for Vulnerability Analysis** **Annualized Crop claims by County (USDA RMA -2007-2016)**	Severe Thunderstorm Likelihood Annualized Combined Property Loss $ Annualized Combined Property Loss Ratio Severe Thunderstorm Vulnerability Summary # of Mobile homes by County	National Climatic Data Center - Storm Events Database HAZUS - Building Values USDA Risk Management Agency Social Vulnerability Index 2015 ACS--housing density and # of mobile homes
Severe Winter Weather	Natural	Meteorological	Statistical Analysis Data Presentation	1. Likelihood of Occurrence (NCDC events / yrs.) 2. Building Exposure Value (HAZUS) 3. Annualized Property Loss (NCDC / HAZUS) 4. SOVI (University of South Carolina) 5. Housing Density (2015 ACS)	**Vulnerability Summary by County** County Raw data for all factors Assigned rating for each factor **Annualized Crop claims by County (USDA RMA -2007-2016)** **Additional Vulnerability / Winter Storm Cost Data**	Severe Winter Storm Likelihood Annualized Property Loss $ Annualized Property Loss Ratio Severe Winter Storm Vulnerability Summary	National Climatic Data Center - Storm Events Database HAZUS - Building Values USDA Risk Management Agency Social Vulnerability Index 2015 ACS--housing density Homeless Populations by County Snow and Ice Removal Costs (MoDOT) Public Assistance Funding for Severe Winter Storms (SEMA)
Tornadoes	Natural	Meteorological	Statistical Analysis Data Presentation	1. Likelihood of Occurrence (NCDC events / yrs.) 2. Building Exposure Value (HAZUS) 3. Annualized Property Loss (NCDC / HAZUS) 4. SOVI 5. Population Density (2015 ACS) 6. # Mobile Homes	**Vulnerability Summary by County** County Raw data for all factors Assigned rating for each factor	Number of Tornadoes per County (1950-2016) Tornado Likelihood Annualized Property Loss $ Annualized Property Loss Ratio Tornado Vulnerability Summary # of Mobile homes by County	National Climatic Data Center - Storm Events Database HAZUS - Building Values Social Vulnerability Index 2015 ACS--population density and # of mobile homes

Hazard	Natural or Human-caused / Technological	Hazard Sub-type	Category of Analysis	Summary of GIS Analysis	Tables	Figures (blue indicates Wood E&IS-created map) For Color scheme's please refere to the Request form.	Data Sources
Dam Failure	Natural	Flood-Related	GIS Analysis Data Presentation	GIS analysis of Inundation maps against HAZUS/MSDIS exposure data -State-regulated High Hazard dams -Federal dams to determine types, numbers, and values of buildings at risk Estimate population at risk based on # of residential properties in inundation areas X average household size. Proportional division will be used to calculate the exposure in census blocks not entirely covered by the dam inundation area.	**Numbers and Types of Dams by County** **Results of Inundation Area Analysis by County**	**NID Dams by Hazard Class-(4 maps-Total, High, SIgnificant, Low)** State Regulated Dams by Hazard Class (4 maps - Total, Class 1, Class 2, Class 3) Number of Buildings at Risk Estimated Values of Buildings at Risk Estimated Losses of Buildings at Risk Estimated Population at Risk	National Inventory of Dams MO DNR dam inventory Inundation Areas – State Regulated Dams, Missouri DNR Inundation Areas – Federal Dams, USACE HAZUS - values of buildings at risk MSDIS - # and type of buildings at risk 2015 ACS - Average household size to determine population at risk
Earthquake	Natural	Geologic	GIS/Scenario Analysis Data Presentation	HAZUS MH 3.2 - 2% annual chance in 50 years probabilistic scenario	**Annualized Loss Summary by County** **Loss Estimation for 2% Probability in 50 Years Earthquake (Regional)** **Loss Estimation for 2% Probability in 50 Years Earthquake (County)** **Social Impact Estimates by County**	Annualized Loss – direct economic loss to buildings per county (HAZUS) Peak Ground Acceleration for 2% probability in 50 years earthquake Economic Loss to Buildings for 2% / 50 years – by census Tract Economic Loss to Buildings for 2% / 50 Years--by census Tract – zoomed to critical counties, St Louis magnified as graphic Loss ratio 2% probability of exceedance in 50 years earthquake – by census block *All maps will highlight the counties in the New Madrid Seismic Zone as critical counties	CUSEC website and data (soils, liquefaction) Mid-America Earthquake Center at University of Illinois USGS Center for Earthquake Research and Information – New Madrid Seismic Zone Earthquake Probabilities MODNR – soils, groundwater depth Other information sources: CAPSTONE 14 2014 exercise 2011 NLE exercise documents HAZUS MH 3.2 Missouri Threat and Hazard Identification and Risk Assessment
Flooding (Riverine & Flash)	Natural	Flood-Related	GIS/Scenario Analysis Scenario Analysis Data Presentation	HAZUS MH 3.2 - 1% Annual Chance flood loss scenario. All counties will be updated utilizing the newly released version of HAZUS. For counties which have RiskMAP products available, the depth grids for those communities will be utilized as part of the HAZUS analysis. For counties with new floodplains developed since 2010 for which there are no RiskMAP products, depth grids will be created utilizing the updated DFIRM data. MSDIS structure inventory will supplement HAZUS as source for # of at-risk/Exposed structures.	**Top 10 Counties for Flood Insurance Dollars Paid** **Repetitive Loss Properties** **Severe Repetitive Loss Properties** **Top Ten Counties by Type of Loss (HAZUS Results)** **Total Direct Building Loss and Income Loss (HAZUS Results)** **Buildings At Risk by Type (MSDIS Results)** **Displaced People and Shelter Needs** **Agriculture Losses**	Counties with DFIRM vs counties with HAZUS-MH only Map of DFIRM and HAZUS-MH base flood scenarios Example of DFIRM data compared to HAZUS-MH data (Crawford County) Example of HAZUS depth grid output Example of HAZUS floodplain boundaries with Census block overlaid Dollars paid for flood insurance by county (1978 – 2016) Number of flood loss claims by county (1978 – 2016) Repetitive loss properties by county (1978 – 2016) Building and income loss by county (HAZUS) Building loss ratio by county (HAZUS) Displaced people by county (HAZUS) Number of Buildings at risk by county (MSDIS)	HAZUS NFHL - DFIRMs MSDIS Structure Inventory Presidential Disaster Declaration Costs –PA & IA program costs Flood Insurance Administration Policy and Loss Statistics Flood Insurance Administration Repetitive Loss and Severe Repetitive Loss Property Data National Flood Insurance Program – Community Status Book USDA Risk Management Agency crop loss (2007-2016) SEMA, Missouri Flood History and Flood Deaths, Disaster Costs MoDOT – scour critical bridges Missouri Threat and Hazard Identification and Risk Assessment USGS Flood Hazard Data National Weather Service Hydrologic Data
Land Subsidence / Sinkholes	Natural	Geologic	GIS Analysis Data Presentation	The sinkhole hazard layer will be used in conjunction with the MSDIS structure file, and potentially layers locating specific infrastructure, to determine structures that fall within sinkhole areas as well as structures that are within a buffered distance of sinkholes. The number of mines and caves per county will be reported through data presentation as available from the Department of Natural Resources.	**Structures Vulnerable to Sinkholes in Missouri**	Number of sinkholes per county Number of structures "In" and Proximal to Sinkholes per county Major cave bearing areas in Missouri Number of Mines per county	MSDIS Structure Inventory MSDIS Sinkhole location map MSDIS Caves map MSDIS Mines Map Missouri Department of Natural Resources, Division of Geology and Land Survey SEMA Sinkhole Location Policy Paper HAZUS
Levee Failure	Natural	Flood-Related	GIS Analysis Data Presentation	GIS analysis of levee protected areas in National Flood Hazard Layer and National Levee Database against HAZUS/MSDIS exposure data Estimate population at risk based on # of residential properties in protected areas X average household size. Proportional division will be used to calculate the exposure in census blocks not entirely covered by the relevant Protected by Levee area.	**Known Levees in Missouri Table** **Results of Levee Failure analysis**	Levee locations in Missouri (levee lines from USACE National Levee Inventory Database) Estimated Number of Buildings at Risk to Levee Failure Estimated Losses as a result of Levee Failure Population exposure per county	NFHL – DFIRMs USACE National Levee Inventory database HAZUS - values of buildings at risk MSDIS - # and type of buildings at risk Average household size to determine population at risk in residential building types
Wildfire	Natural	Other	GIS Analysis Data Presentation	GIS layers available from SILVIS Lab at University of Wisconsin - Madison to quantify the population and buildings at risk within wildfire risk zones	**Data Presentation for wildfire including:** County Likelihood of Occurrence-wildfire (MDC and MT Natl Forest) Annualized acreage burned by Wildfire **Results of WU-Interface / WU-Intermix Analysis** **Missouri Structural Fire Statistics Table – year, total fires, total dollar loss, fire related injuries and deaths** **Statewide Forest and Grassland Fires by Cause table – updated**	Wildfire Likelihood Annualized Acreage Burned WUI Interface / Intermix Estimated Number of Buildings at Risk Estimated Losses as a result of Wildfire Estimated Population at Risk Missouri Department of Conservation Forestry Regions Map Missouri fire and mutual aid regions map Mark Twain National Forests map	Department of Conservation historical wildfire data HAZUS MSDIS Structure Inventory 2015 American Community Survey SILVIS Lab – WU-Interface / Intermix layers Mark Twain National Forest historical wildfire data

Hazard	Natural or Human-caused / Technological	Hazard Sub-type	Category of Analysis	Summary of Analysis	Tables	Figures	Data Sources
CBRNE Attack	Human-Caused / Technological	Civil Defense	Scenario Analysis Data Presentation	EMCAPS scenarios for 1. Chemical 2. Biological 3. IED-ammonium nitrate 4. Radiological IED	• Chemical attack casualties table including: • Biological attack casualties table including: • IED attack casualties table including: • Radiological dispersion device casualties table including:	None Identified	• Johns Hopkins University Electronic Mass Casualty Assessment and Planning Scenarios • CBRNE material stockpiles in MO • Terrorist incident tracking data • Explosives incidents in Missouri (United States Bomb Center) • US Bomb data (National Counter-Terrorism Center) • Population Dense Facilities • Missouri Threat and Hazard Identification and Risk Assessment
Civil Disorder	Human-Caused / Technological	Civil Defense	Data Presentation	Data presentation of past civil disorder events to provide a basis for potential future events	• Locations of correctional facilities	• Correctional Institutions and Probation and Parole Offices	• Adult Institutions - Missouri Department of Corrections • Media outlets/reputable internet search results • Crime data - Federal Bureau of Investigation • Mass casualty gun violence data • Population Dense Facilities • Hate Map Hate Group List – Southern Poverty Law Center • Missouri Threat and Hazard Identification and Risk Assessment
Cyber Disruption	Human-Caused / Technological	Civil Defense	Data Presentation	Data presentation of known cyber disruption events to provide a basis for potential future events	Previous Cyber Disruption Events--bulleted, not in a table	•Monthly Attacks collected by Hackmageddon (2014-2016) •Motifvations Behind Attacks 2014 vs. 2016 •Top 10 Attack Techniques (2014-2016)	• Hackmageddon • Symantec 2016 Internet Security Threat Report • State of Information Technology in Missouri, Annual Report • Missouri Threat and Hazard Identification and Risk Assessment (THIRA) – 2016
Hazardous Materials	Human-Caused / Technological	Accident	Data Presentation	Data Presentation and narrative description	• Number of Tier II Chemical Facilities per County • Previous Haz-Mat Incidents by County • Pipeline Miles per county (gas miles and liquid miles)-PHMSA • EPA Priority Sites • Potential costs of HAZ-MAT Spill remediation	• Bar chart of incidents reported to MEERTS taken from MO DNR (2000-2015) • Map of the number of incidents per county overlaid with regions covered by each response office (FY2015) • Locations of Tier II Chemical Facilities • Locations of Gas and Petroleum Pipelines (PHMSA)	• Missouri Department of Natural Resources Environmental Emergency Response Tracking System • State of Missouri contract for Hazardous Substance Cleanup and Disposal Services • Pipeline and Hazardous Materials Safety Administration Pipeline Locations Pipeline Incidents • Environmental Protection Agency Superfund Sites • Methamphetamine Incidents-Missouri Highway Patrol • Tier II Chemical Facilities – Missouri DNR • Missouri Highway Freight and Rail Freight Maps - MoDOT • Missouri Hazardous Substance Cleanup and Disposal Services Contract
Mass Transportation Accidents	Human-Caused / Technological	Accident	Data Presentation	Data Presentation and narrative description	• Costs of a traffic crash including: • Annual loss estimates for mass transportation accidents	None Identified	• Federal Transit Administration • Federal Highway Administration • Transport routes and water and land transportation hubs - MoDOT • Airport data and air incidents - Federal Aviation Administration • Transportation fatality data - American Public Transportation Association National Transit Database • State of Missouri THIRA
Nuclear Power Plants	Human-Caused / Technological	Accident	Data Presentation	Data Presentation and narrative description	Fire Department Radiological Capabilities	• Emergency Planning Zones • Contamination Zones	• Radiological Emergency Preparedness Plans for Nuclear Power Plants • 2015 American Community Survey – population data • MSDIS – Nuclear Site Contamination Zones • Nuclear Regulatory Commission – University Reactors • Missouri Threat and Hazard Identification and Risk Assessment
Public Health Emergencies / Environmental Issues	Human-Caused / Technological	Health	Data Presentation	Data Presentation and narrative description focusing on the following public health considerations 1. Pandemic Influenza 2. Smallpox 3. St. Louis Encephalitis 4. Meningitis 5. Lyme Disease 6. West Nile Virus 7. SARS 8. Zika Virus 9. Ebola Virus 10. Tuberculosis 11. Air Pollution 12. Water Pollution	• Estimated vaccination coverage table comparing US and Missouri – same as 2010 and 2013, updated for 2017/18 • Pandemic influenza vulnerability table using MO DHSS Planning Assumptions • Potential GDP Losses by Industry from Pandemic Flu and the Potential for U.S. Economic Recession • Reportable Diseases by County (MO-DHSS) • Table with various county level-data of identified populations vulnerable to Public Health Emergencies including:	• Potential number of hospitalizations due to pandemic influenza per county	• Missouri Department of Health and Senior Services Adult Care Homes / beds Pandemic Disease Assumptions, 2011 Missouri's Pandemic Influenza Response Plan • University of Missouri Office of Social and Economic Data Analysis (OSEDA) Missouri Kids Count Data Book • US National Immunization Survey and Pandemic Flu data - CDC • Homeless Populations Missouri Housing Development Commission • Prevalence of Non-residents / Tourists • US Census Data – County Populations • Missouri Hospital Association's Hospital Industry Data Institute – Hospital Charges and Collections • Missouri Department of Natural Resources - Missouri Water Quality Report • Animal health and crop disease data • Missouri Air Pollution Data • Missouri Threat and Hazard Identification and Risk Assessment • Top toxic chem producers / releases in MO – EPA
Special Events	Human-Caused / Technological	Civil Defense	Scenario Analysis Data Presentation	EMCAPS scenario for IED - ammonium nitrate fuel oil in crowded stadium	IED attack casualties table from the EMCAPS scenario	None Identified	• John's Hopkins University Electronic Mass Casualty Assessment and Planning Scenario Tool • Missouri Threat and Hazard Identification and Risk Assessment
Terrorism	Human-Caused / Technological	Civil Defense	Scenario Analysis Data Presentation	EMCAPS scenario for Chemical Attack - mustard gas in crowded stadium	• Terrorist Attack impacts table from the EMCAPS scenario	• MO emergency response regions map • Identified hate groups map	• Johns Hopkins University Electronic Mass Casualty Assessment and Planning Scenarios • Southern Poverty Law Center • News outlets/online sources (various) • Population Dense Facilities • Missouri Threat and Hazard Identification and Risk Assessment (THIRA)

Utilities (Interruptions and Systems Failures)	Human-Caused / Technological	Civil Defense / Acc	Data Presentation	Descriptions along with the presentation of data on causes of utility interruptions and system failures including the following: • Electrical power • Natural gas • Public water (potable and wastewater treatment) • Communications systems Causes of utility interruption that will be discussed include: • Cascading impacts of other primary hazards (thunderstorm, winter storm, flooding, tornado, cyber disruption, terrorism, etc.) • Space Weather / geomagnetic storms • Lack of Maintenance • Human Error • System Overload / Failure	• Natural Gas Pipeline Miles by System--added • Public Water Intakes/Wells and Wastewater Treatment Facilities by County--added • Power Outages in Missouri (2000-2014)--added • FEMA Standard Values for Loss of Service for Utilities • Vulnerability Summary Table (Loss of Use Estimates) • EMAP Consequence Analysis	• Missouri Electric Service Area Map • Missouri Electrical Transmission Cooperatives in Missouri • Missouri Natural Gas Pipeline Map • Missouri Communications Networks Map-not available (LB) • Electric loss of service per county--covered in table, no map • Drinking water loss of service per county--covered in table, no map • Wastewater treatment loss of service per county--covered in table, no map	• FEMA Loss of Use Estimates, What is a Benefit?: Guidance on Benefit-Cost Analysis of Hazard Mitigation Project • Population Data from 2015 ACS • Missouri Public Service Commission • Utility Subscription / Power Outage Statistics - Missouri Rural Electric Cooperatives and Private Power • Pipeline and Hazardous Materials Safety Administration • Water and Wastewater Utilities – EPA • Energy Information Administration • Missouri Threat and Hazard Identification and Risk Assessment

Appendix B

How to Identify Mitigation Actions Using Flood Risk Data and Products

User Guide

Show Me ...

User Guide

How to Identify Mitigation Actions Using Flood Risk Data and Products

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USER GUIDE:

How to Identify Mitigation Actions Using Flood Risk Data and Products

Table of Contents

USER GUIDE:

How to Identify Mitigation Actions Using Flood Risk Data and Products

I. Workshop and User Guide Overview

- The Missouri State Emergency Management Agency (SEMA) works in partnership with FEMA, through a cooperative agreement, to perform program management activities, technical mapping-related activities and community engagement and risk communication (CERC) activities associated with the Risk MAP Program. The CERC Workshop “How to Identify Mitigation Actions Using Flood Risk Data and Products” was developed and facilitated to help to build risk awareness and understanding, as well as ownership of flood risk and risk data at the local level; and help to strengthen and encourage communities to take responsibility for progressing risk reduction actions that will result in a more resilient community.
- This User Guide was prepared as an accompanying resource to the CERC Workshop to provide an overview of the Workshop topics and to outline the utilization of Flood Risk Data to identify mitigation actions. It may be used independent of the workshops as a resource as well.

II. Additional Guidance Documents

- The following additional guidance documents are recommended to provide a further understanding of mitigation, mitigation actions, Risk MAP Products and application of GIS.
- Emergency Management Institute (EMI) Independent Study Course IS-922: *Applications of GIS for Emergency Management*
- Federal Emergency Management Agency (FEMA). 2014. *Risk MAP Flood Risk Products* (Fact Sheet) Department of Homeland Security. Washington, D.C.
- Federal Emergency Management Agency (FEMA). 2013. *Mitigation Ideas: A Resource for Reducing Risk to Natural Hazards*. Department of Homeland Security. Washington, D.C.
- Federal Emergency Management Agency (FEMA). 2010. *Designing for Flood Levels Above the BFE* (Technical Fact Sheet No. 1.6) Department of Homeland Security. Washington, D.C.
- Federal Emergency Management Agency (FEMA). 2008. *Using the Hazard Mitigation Plan to Prepare Successful Mitigation Projects (FEMA 386-9)*. Department of Homeland Security. Washington, D.C.
- Federal Emergency Management Agency (FEMA). 2003. *Developing the Mitigation Plan: Identifying Mitigation Actions and Implementation (FEMA 386-3)*. Department of Homeland Security. Washington, D.C.
- Multihazard Mitigation Council. 2005. *Natural Hazard Mitigation Saves: An Independent Study to Assess the Future Savings from Mitigation Activities*. National Institute of Building Sciences. Washington, D.C.

What is Mitigation?

I. Introduction to Hazard Mitigation

- Mitigation is the effort to reduce loss of life and property by lessening the impact of disasters.
- Mitigation is taking action now, before the next disaster, to reduce human and financial consequences later. Implementation steps include:
  - Analyzing risk;
  - Reducing risk; and
  - Insuring against risk.
- Effective mitigation requires that we all understand local risks, address the hard choices, and invest in long-term community well-being.
- Without mitigation actions, we jeopardize our safety, financial security, and self-reliance.

An additional hazard mitigation definition includes: pre-impact actions that provide *passive* protection at the time of disaster impact. This definition clearly distinguishes hazard mitigation from emergency preparedness, which consists of pre-impact actions that provide the resources (personnel, plans, facilities, equipment, materials) needed to support an *active* response at the time of disaster impact. It also distinguishes hazard mitigation from recovery preparedness, which consists of pre-impact actions or policies that provide the resources needed to return the community to its normal patterns of social functioning after disaster impact occurs.

Mitigation Benefits

- A dollar spent on mitigation saves society an average of $4.00.
- Mitigation is sufficiently cost-effective to warrant federal funding on an ongoing basis both before disasters and during post-disaster recovery.
- 10 Years since Mitigation Saves, increased focus on promoting:
  - **Sustainability** - the capability to equitably meet the vital human needs of the present without compromising the ability of future generations to meet their own needs.
  - **Resilience** - is the ability to adapt to changing conditions and prepare for, withstand, and rapidly recover from disruption.
  - **Safe Growth** - is to build environments that are safe for current and future generations and to protect buildings, transportation, utilities, and the natural environment from damage.

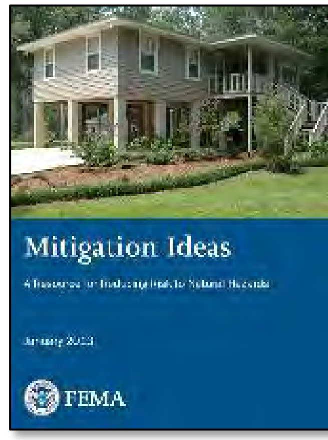
In 2005, the Multihazard Mitigation Council (MMC) conducted a widely cited study, *Natural Hazard Mitigation Saves: An Independent Study to Assess the Future Savings from Mitigation Activities*, which documented how every $1 spent on mitigation saves society an average of $4. Since that study was published, though the findings are still relevant, the building community mitigation landscape itself has changed. Mitigation Saves is the most often-quoted work on mitigation.

The study results indicate that the natural hazard mitigation activities funded by 3 FEMA grant programs between 1993-2003:

- Were cost effective and reduced future losses from earthquake, wind, and flood events;
- Resulted in significant net benefits to society as a whole (individuals, states, and communities) in terms of reduced future losses; and
- Represented significant potential savings to the federal treasury in terms of future increased tax revenues and reduced hazard-related expenditures.

Mitigation Categories

FEMA's **Mitigation Ideas Publication -** A Resource for Reducing Risk to Natural Hazards was developed to assist communities in identifying potential mitigation actions. The document is a resource to use to identify and evaluate a range of potential mitigation actions for reducing risk to natural hazards and disasters. Ideas for mitigation actions are presented for natural hazards, including: Drought, Earthquake, Erosion, Extreme temperatures, Flood, Hail, Landslide, Lightning, Sea level rise, Severe wind, Severe winter weather, Storm surge, Subsidence, Tornado, Tsunami, and Wildfire.



There are 23 suggested mitigation actions for flooding summarized into four types: (1) Local Planning and Regulations, (2) Structure and Infrastructure Projects, (3) Natural Systems Protection, and (4) Education and Awareness Programs. These mitigation actions include:

Local Planning and Regulations

- F1 – Incorporating Flood Mitigation Into Local Planning
- F2 – Form Partnerships to Support Floodplain Management
- F3 – Limit or Restrict Development in Floodplain Areas
- F4 – Adopt and Enforce Building Codes and Development Standards
- F5 – Improve Stormwater Management Planning
- F6 – Adopt Policies to Reduce Stormwater Runoff
- F7 – Improve Flood Risk Assessment
- F8 – Join or Improve Compliance with NFIP
- F9 – Manage the Floodplain Beyond Minimum Requirements
- F10 – Participate in the CRS Program
- F11 – Establish Local Funding Mechanisms for Flood Mitigation

Structure and Infrastructure Projects

- F12 – Remove Existing Structures from Flood Hazard Areas
- F13 – Improve Stormwater Drainage System Capacity
- F14 – Conduct Regular Maintenance for Drainage Systems and Flood Control Structures
- F15 – Elevate or Retrofit Structures and Utilities
- F16 – Floodproof Residential and Non-Residential Structures
- F17 – Protect Infrastructure
- F18 – Protect Critical Facilities
- F19 – Construct Flood Control Measures

Natural Systems Protection

- F20 – Protect and Restore Natural Flood Mitigation Features
- F21 – Preserve Floodplains and Open Space

Education and Awareness Programs

- F22 – Increase Awareness of Flood Risk and Safety
- F23 – Educate Property Owners about Flood Mitigation Techniques

SMART Actions

- In addition to identifying mitigation actions, we want to select actions that are SMART.
- SMART is an acronym to guide action development. It is an effective tool that provides the clarity, focus, and motivation to complete a mitigation action.

S - Specific - with clearly stated and defined project
M – Measurable - with measurable outputs defined according to criteria (quantity, quality, time)
A – Attainable - achievable and realistic
R – Relevant - aligned to the mitigation and community needs
T – Timely - within a clear time-frame

Mitigation Action Tracker

- The Mitigation Actions Tracker prototype is a web-based tool to document and report local mitigation actions influenced by Risk MAP (or non-Risk MAP) processes. Data captured will support measuring Risk MAP Action Metric performance while also providing stakeholders valuable mitigation information that can be leveraged by future planning or other risk reduction efforts.
- The web-based tool is used to:
  - Identify Areas of Mitigation Interest (AOMI) and actions
  - Document & Organize mitigation activities
  - Communicate progress on mitigation activities
  - Identify point(s) of contact for each mitigation action
- https://mat.msc.fema.gov/About.aspx

Step. 1 Understanding Your Flood Risk Assessment

II. Flood Risk Assessment Data

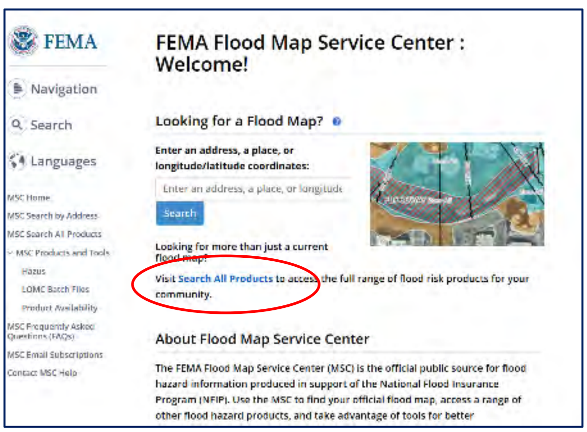
- FEMA Regulatory Products
- FEMA Non-Regulatory Products
- Other Datasets

Where to find FEMA Products

- The FEMA Flood Map Service Center (MSC) is the official online source for flood hazard information produced under the National Flood Insurance Program (NFIP). All flood mapping products, such as Flood Insurance Rate Maps (FIRMs), Flood Insurance Studies (FIS), and National Flood Hazard Layer (NFHL) geodatabases, are available for free download.
- https://msc.fema.gov/portal/

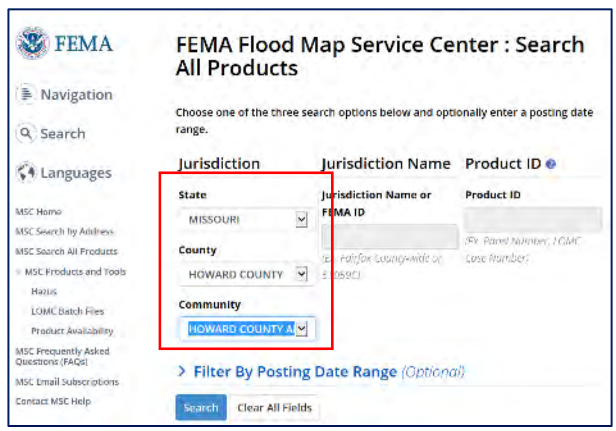
MSC Home Screen

– Select "Search All Products"



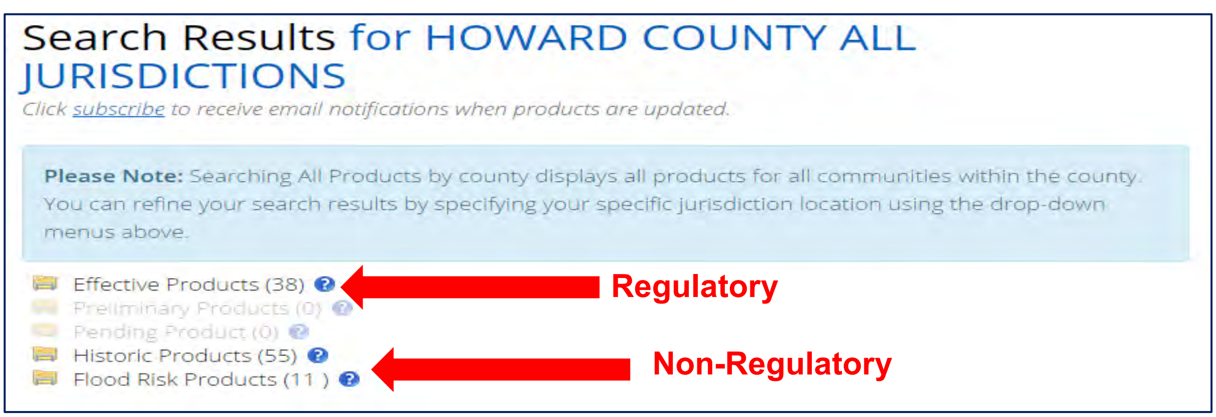
Search All Products Screen

– Select Jurisdiction by State, County, and Community



Search Results Screen

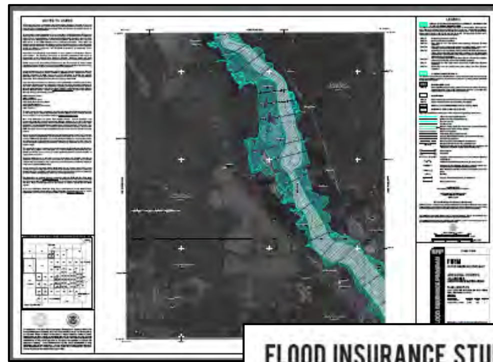
– Select FEMA Products



FEMA Regulatory Products

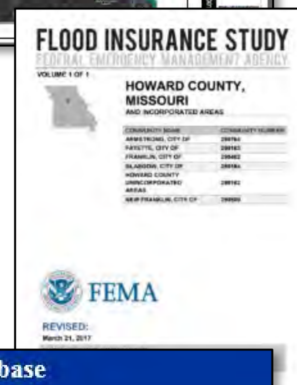
1. Flood Insurance Rate Map (FIRM)

- The official map of a community on which FEMA has delineated both the special hazard areas and the risk premium zones applicable to the community. Full FIRM panels are quite large (36" x 25.875"), so most users will prefer to print out a smaller selected portion called a FIRMette. This can be accomplished by selecting "View" once you have located your FIRM or by using the FIRMette - Desktop application.



2. Flood Insurance Study (FIS)

- A compilation and presentation of flood risk data for specific watercourses, lakes and coastal flood hazard areas within a community. The FIS report provides a detailed written account of a flood hazard mapping study and its findings.



3. FIRM Database

- The Digital Flood Insurance Rate Map (DFIRM) Database depicts flood risk information and supporting data used to develop the risk data.
- The primary risk classifications used are:
  - 1-percent-annual-chance flood event
  - 0.2-percent-annual-chance flood event
  - Areas of minimal flood risk

FEMA Non-Regulatory Products

- Flood Risk Products (FRP) go beyond the basic flood hazard information found in the official regulatory products. These products provide a more user friendly analysis of flood risks within a Risk MAP Flood Risk Project, as they are specifically geared toward communicating flood risk information to the public, rather than meeting statutory requirements under the NFIP. The three Flood Risk Product types are similar to their regulatory equivalents:
  - Flood Risk Database provides a framework for storage for the datasets,
  - Flood Risk Report is a summary of key information, and
  - Flood Risk Map is a visual depiction of select information found in the datasets.

- This training focuses on the Flood Risk Database and associated Datasets.

4. Flood Risk Database

- Flood Risk Database (FRD) is a relational database that houses the flood risk data developed during the flood risk analysis
- Parallels the Flood Insurance Rate Map Database
- This training will help you make use of this data:
  - Changes Since Last FIRM
  - Flood Depth and Analysis Grids
  - Areas of Mitigation Interest
  - Flood Risk Assessment

a) *Changes Since Last FIRM Data*

- Changes Since Last FIRM (CSLF) shows where the Special Flood Hazard Area (SFHA) has changed since the last effective FIRM.
- Polygon areas of changes to 1% and 0.2% annual chance floodplains and floodways.
- Polygons will contain attributes that indicate regulatory zone changes as well as contributing engineering factors (e.g. changes to peak discharges, modeling methodology).
- In the image to the right, SFHA decreases are indicated in green; SFHA increases are indicated in red, and no change to the SFHA is indicated in yellow.

b) *Flood Depth Grids*

- Flood Depth and Analysis Grids communicate the depth and velocity of floodwaters as well as the probability of an area being flooded over time
- Raster (grid) of water depth
- Depth is calculated as the difference (in feet) between the water surface elevation and the ground
- Produced for 10%, 4%, 2%, 1%, and 0.2% annual chance events

c) *Percent Annual Chance of Flooding Grid*

- A grid dataset that represents the percent annual chance of flooding for locations along a flooding source
- Uses Water Surface Elevation Grids for 10%, 4%, 2%, 1%, and 0.2% annual chance events to calculate Percent Annual Chance Flooding for a single grid cell

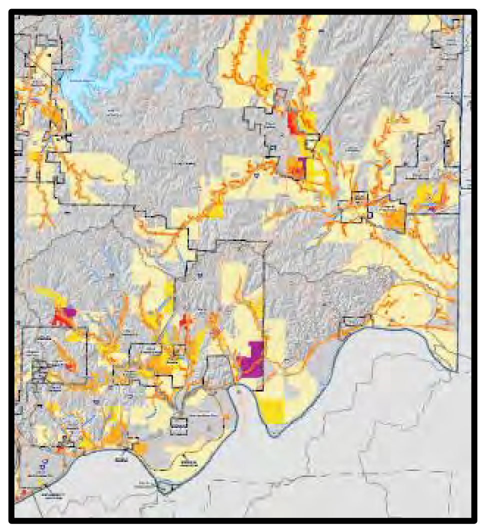
d) *Percent Chance of Flooding over a 30-year Period Grid*

- A grid dataset that represents the percent chance of flooding within a 30-year period for locations along a flooding source
- Uses PctAnnual_Grd and the equation: $1-(1-p)^{30}$

e) *Areas of Mitigation Interest*

- This data layer will include factors which contribute to flood losses and highlights flood issues and associated effects.
- Examples of information to be included in this data layer include the following items, which will be delivered in point format:
  - Risk "hot spot" areas
  - Previous flood insurance claims
  - Flood control structures
  - Significant proposed and recent development within the floodplain
  - Locations of successful mitigation projects

f) *Flood Risk Assessment*



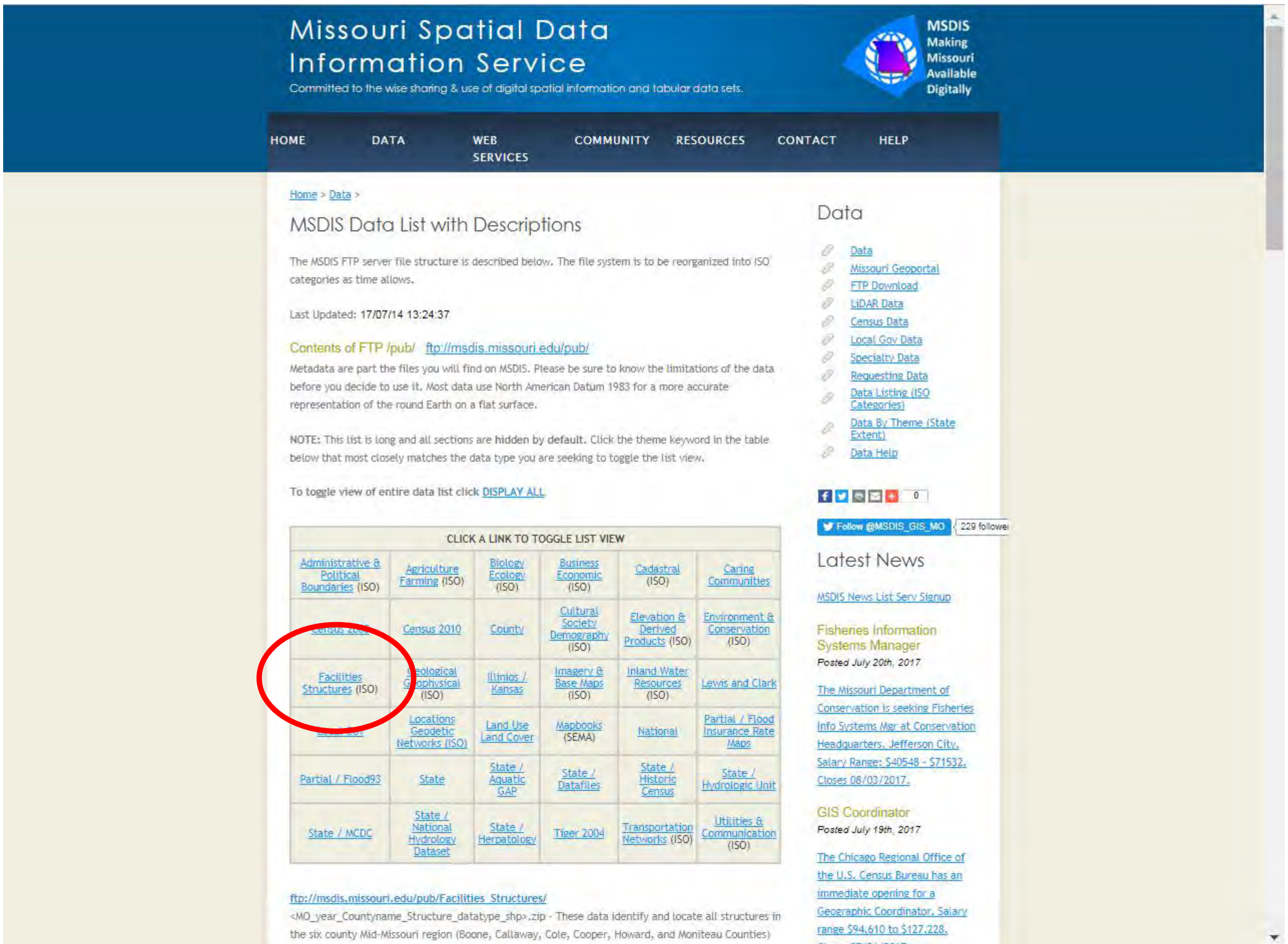
- Census block polygons of risk assessment and loss estimate results from the 2010 HAZUS flood average annualized loss study.
- Refined HAZUS loss estimates will be prepared that improve on the 2010 AAL flood loss data using depth grids created for new or revised studies.
- The 1% annual chance flood loss will be shown on the Flood Risk Map in a graph (reflecting loss values per census block aggregated at the watershed and community level); and will be shown in tabular fashion in the Flood Risk Report, also aggregated by watershed and community, for easy use in mitigation plans.

D. Structures File from MSDIS

- Missouri Spatial Data Information Service (MSDIS), hosted by the University of Missouri, a spatial data retrieval and archival system. **MSDIS** is responsible for data storage and access, standardization of both digital and tabular data, creation of the data dictionary, compilation of metadata, and statewide GIS user information networks.
- Data may be downloaded here: http://www.msdis.missouri.edu/data/datalist.html#facstruc

Data Retrieval Home Screen

- Select “Facilities Structures”



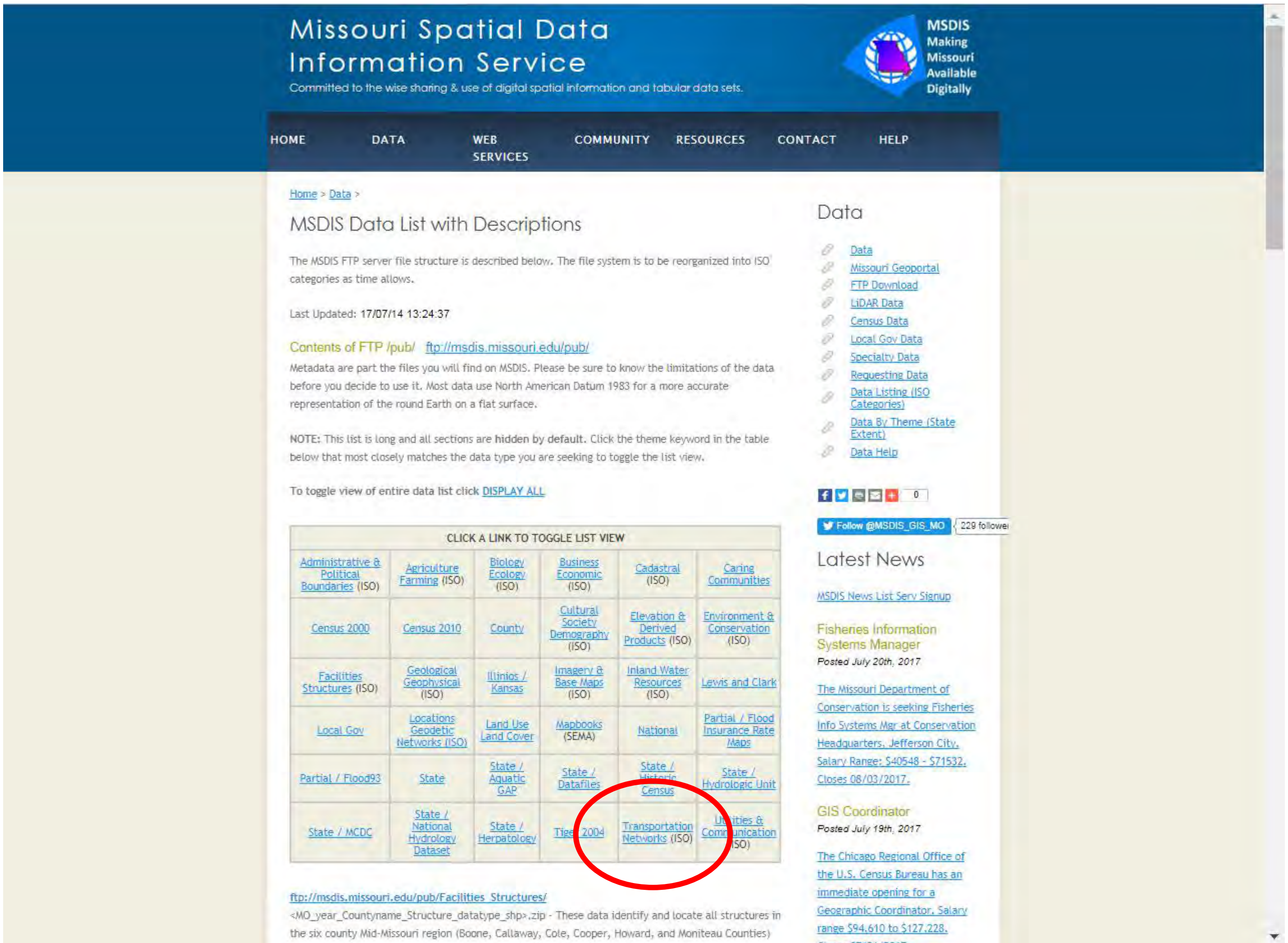
- ftp://msdis.missouri.edu/pub/Facilities_Structures/
- MO_year_Countyname_Structure_datatype_shp.zip - These data identify and locate all structures in the six county Mid-Missouri region (Boone, Callaway, Cole, Cooper, Howard, and Moniteau Counties) and validate locations and attributes for 25 different critical infrastructure building types.
- MO_year_Structure_Dexcription_shp.zip - These data identify and locate various structures at state extent.

E. Transportation Files from MODOT on MSDIS

- Missouri Department of Transportation (MoDOT) data is also available on MSDIS. Routes are represented as single linear feature, such as a city street or highway. Generally used for coarse geographic and environmental analysis. Linear referencing is used to reference specific data or events (accidents, pavement type, speed limit, signage, etc.) to locations along a route or travelway, allowing more specific analysis or modeling.
- Data may be downloaded here: http://www.msdis.missouri.edu/data/datalist.html#facstruc

Data Retrieval Home Screen

  – Select "Transportation Networks"



- ftp://msdis.missouri.edu/pub/Transportation_Networks
- MO_year_Descriptive_File_Name_shp.zip

Show Me ...

Step. 2 Using Flood Risk Assessment to Identify Mitigation Actions

I. Overview and Examples of Tools-In-Action

- With an understanding of FEMA's flood risk (Risk MAP) tools and their availability, the next step is to utilize each tool to identify mitigation actions. Following along with the mitigation categories/types as presented in FEMA's Mitigation Ideas publication, examples of tools-in-action begin with the Structure and Infrastructure Projects, further defined as:
  - Emergency Services Actions (F18);
  - Property Protection Actions (F12, F15, and F16); and
  - Structure/Infrastructure Projects (F13, F14, F17, F19).
- The graphic below was included in FEMA's Mitigation How-To Series within [How To Guide #3 Identifying Mitigation Actions and Implementation Strategies].

Mitigation actions can be grouped into six broad categories:

1. **Prevention.** Government administrative or regulatory actions or processes that influence the way land and buildings are developed and built. These actions also include public activities to reduce hazard losses. Examples include planning and zoning, building codes, capital improvement programs, open space preservation, and storm water management regulations.
2. **Property Protection.** Actions that involve the modification of existing buildings or structures to protect them from a hazard, or removal from the hazard area. Examples include acquisition, elevation, relocation, structural retrofits, storm shutters, and shatter-resistant glass.
3. **Public Education and Awareness.** Actions to inform and educate citizens, elected officials, and property owners about the hazards and potential ways to mitigate them. Such actions include outreach projects, real estate disclosure, hazard information centers, and school-age and adult education programs.
4. **Natural Resource Protection.** Actions that, in addition to minimizing hazard losses, also preserve or restore the functions of natural systems. These actions include sediment and erosion control, stream corridor restoration, watershed management, forest and vegetation management, and wetland restoration and preservation.
5. **Emergency Services.** Actions that protect people and property during and immediately after a disaster or hazard event. Services include warning systems, emergency response services, and protection of critical facilities.
6. **Structural Projects.** Actions that involve the construction of structures to reduce the impact of a hazard. Such structures include dams, levees, floodwalls, seawalls, retaining walls, and safe rooms.

- Each example will present, in tabular format, the GIS dataset needs, including federal, state, and local products, and associated instructional steps in the process to identify mitigation actions.
- A complete summary table of mitigation actions and associated datasets is provided as an appendix to the User Guide.

II. Examples of Tools-In-Action: Emergency Services

F-18 Protect Critical Facilities

A. Requiring that all critical facilities including emergency operations centers (EOC), police stations, and fire department facilities be located outside of flood-prone areas.

B. Requiring all critical facilities to meet requirements of Executive Order 11988 and be built at least 1 foot above the 500-year flood elevation.

C. Installing/upgrading stormwater pumping stations.

D. Raising electrical components of sewage lift stations above base flood elevation.

E. Raising manhole openings using concrete pillars.

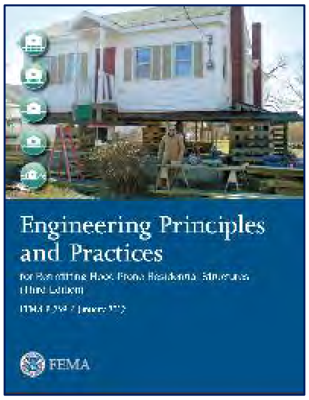
F. Installing watertight covers or inflow guards on sewer manholes.

G. Installing flood telemetry systems in sewage lift stations.

H. Installing back-up generators for pumping and lift stations in sanitary sewer systems along with other measures (e.g., alarms, meters, remote controls, and switchgear upgrades).

I. Building earthen dikes around flood-threatened critical facilities.

J. Using bioengineered bank stabilization techniques.



F-18. A Critical Facilities Outside of Flood-Prone Areas

1. Select those MSDIS structures that intersect or are located within the 0.2% Annual Chance Floodplain and/or 0.2% Annual Chance Depth Grid. Note, the 0.2% Annual Chance Grid may be converted to a polygon using the ESRI "Raster to Polygon" tool, for ease of structure selection.
2. Filter MSDIS Structure data to select critical facilities.
3. Note any critical facilities located within the mapped floodplain.
4. Utilize 0.2% floodplain boundary for future construction of critical facilities.

	FIRM Regulatory Products			Risk MAP Non-Regulatory Products						Missouri State Datasets		Local Datasets					
	1% Annual Chance Floodplain	0.5% Annual Chance Floodplain	FIRM Datasets - Profile Baselines (streams)	Depth Grids (10%, 4%, 2%, 1%, and 0.2%)	Percent Chance over 30-Year Period Grid	Percent Annual Chance Grids	Changes Since Last Firm (CSLF)	Areas of Mitigation Interest (AOMI)	Flood Risk Assessment	MSDIS - Structure Points and Data	MoDOT - Roadways	Local - Structrue Footprints	Local - Parcels	Local - Storm/Water/Sewer Infrastructure	Local - Topography	Local - Repetitive Loss Data	Aerial Photography
Mitigation Actions																	
F-18 Protect Critical Facilities																	
A. Requiring that all critical facilities including emergency operations centers (EOC), police stations, and fire department facilities be located outside of flood-prone areas.		x		x						x		x					

F-18.B Critical Facilities First Floor Elevations 1-Foot Above 500-YR

1. Select those MSDIS structures that intersect or are located within the 0.2% Annual Chance Floodplain and/or 0.2% Annual Chance Depth Grid. Note, the 0.2% Annual Chance Grid may be converted to a polygon using the ESRI "Raster to Polygon" tool, for ease of structure selection.
2. Filter MSDIS Structure data to select critical facilities.
3. Review finished floor of critical facilities and 0.2% flood elevation.

F-18.C Installing/Upgrading Stormwater Pumping Stations

1. Select those MSDIS structures that intersect or are located within the 0.2% Annual Chance Floodplain and/or 0.2% Annual Chance Depth Grid. Note, the 0.2% Annual Chance Grid may be converted to a polygon using the ESRI "Raster to Polygon" tool, for ease of structure selection.
2. Filter MSDIS Structure data to select critical facilities/stormwater pump stations.
3. Coordinate with local stormwater infrastructure, as needed.

F-18.D Raising Electrical Components of Sewage Lift Stations

See F-18 A. Review Elevation Certificates, as available, for elevations of sewer lift stations at specific structures.

F-18.E Manhole Openings Using Concrete Pillars

1. Identify sewer manholes located within the 1% Annual Chance floodplain by overlaying the local sewer infrastructure with the 1% annual chance depth grid. Note, the 1% Annual Chance Grid may be converted to a polygon using the ESRI "Raster to Polygon" tool, for ease of structure selection.

	FIRM Regulatory Products			Risk MAP Non-Regulatory Products						Missouri State Datasets		Local Datasets					
	1% Annual Chance Floodplain	0.5% Annual Chance Floodplain	FIRM Datasets - Profile Baselines (streams)	Depth Grids (10%, 4%, 2%, 1%, and 0.2%)	Percent Chance over 30-Year Period Grid	Percent Annual Chance Grids	Changes Since Last Firm (CSLF)	Areas of Mitigation Interest (AOMI)	Flood Risk Assessment	MSDIS - Structure Points and Data	MoDOT - Roadways	Local - Structrue Footprints	Local - Parcels	Local - Storm/Water/Sewer Infrastructure	Local - Topography	Local - Repetitive Loss Data	Aerial Photography
Mitigation Actions																	
F-18 Protect Critical Facilities																	
B. Requiring all critical facilities to meet requirements of Executive Order 11988 and be built 1 foot above the 500-year flood elevation.		x		x						x		x					
C. Installing/upgrading stormwater pumping stations.		x		x						x		x					
D. Raising electrical components of sewage lift stations above base flood elevation.		x		x						x		x					
E. Raising manhole openings using concrete pillars.		x		x							x						

F-18.F Installing watertight covers or inflow guards on sewer manholes.

1. Identify sewer manholes located within the 1% Annual Chance floodplain by overlaying the local sewer infrastructure with the 1% annual chance depth grid.
2. Install water tight covers or inflow guards on all manholes identified in the floodplain.

F-18.G Installing flood telemetry systems in sewage lift stations.

1. Select those MSDIS structures that intersect or are located within the 0.2% Annual Chance depth grid.
2. Filter MSDIS Structure data to select critical facilities/sanitary sewer lift stations.
3. Coordinate with local sewer infrastructure, as needed.

F-18.H Installing back-up generators for pumping and lift stations in sanitary sewer systems along with other measures.

1. Select those MSDIS structures that intersect or are located within the 0.2% Annual Chance depth grid.
2. Filter MSDIS Structure data to select critical facilities/sanitary sewer pumping and lift stations.
3. Coordinate with local sewer infrastructure, as needed.

F-18.I Building earthen dikes around flood-threatened critical facilities.

See F-18 A.

F-18.J Using bioengineered bank stabilization techniques.

See F-13A. Utilize profile baselines (streams) and aerial photography to identify areas of stream restoration.

	FIRM Regulatory Products			Risk MAP Non-Regulatory Products						Missouri State Datasets		Local Datasets					
	1% Annual Chance Floodplain	0.5% Annual Chance Floodplain	FIRM Datasets - Profile Baselines (streams)	Depth Grids (10%, 4%, 2%, 1%, and 0.2%)	Percent Chance over 30-Year Period Grid	Percent Annual Chance Grids	Changes Since Last Firm (CSLF)	Areas of Mitigation Interest (AOMI)	Flood Risk Assessment	MSDIS - Structure Points and Data	MoDOT - Roadways	Local - Structrue Footprints	Local - Parcels	Local - Storm/Water/Sewer Infrastructure	Local - Topography	Local - Repetitive Loss Data	Aerial Photography
Mitigation Actions																	
F-18 Protect Critical Facilities																	
F. Installing watertight covers or inflow guards on sewer manholes.		x		x							x			x			
G. Installing flood telemetry systems in sewage lift stations.		x		x						x		x		x			
H. Installing back-up generators for pumping and lift stations in sanitary sewer systems along with other measures (e.g., alarms, meters, remote controls, and switchgear upgrades).		x		x						x		x		x			
I. Building earthen dikes around flood-threatened critical facilities.		x		x						x		x	x				x
J. Using bioengineered bank stabilization techniques.		x		x								x	x				x

III. Examples of Tools-In-Action: Property Protection

F-12 Remove Existing Structures from Flood Hazard

A. Communities may remove structures from flood-prone areas to minimize future flood losses by acquiring and demolishing or relocating structures from voluntary property owners and reserving lands subject to repetitive flooding.

Before - floodprone structures

After - open green space

F-12.A Remove Existing Structures from Flood Hazard Areas

Acquisitions may be prioritized for a community by previous flood history, potential future flooding, and other community priorities such as linked open space and greenways.

1. Does your community have any repetitive loss properties? See State NFIP coordinator for updated information.
2. Identify structures that flood at high frequency events.
3. Convert the 10% and 4% Annual Chance Grids to polygons using the ESRI "Raster to Polygon" tool.
4. Select the MSDIS structures that intersect or are located within the 10% or 4% Annual Chance Floodplains.
5. From the identified structures, review depths of flooding at these high frequency events to identify priority acquisitions.

	FIRM Regulatory Products			Risk MAP Non-Regulatory Products						Missouri State Datasets		Local Datasets					
	1% Annual Chance Floodplain	0.5% Annual Chance Floodplain	FIRM Datasets - Profile Baselines (streams)	Depth Grids (10%, 4%, 2%, 1%, and 0.2%)	Percent Chance over 30-Year Period Grid	Percent Annual Chance Grids	Changes Since Last Firm (CSLF)	Areas of Mitigation Interest (AOMI)	Flood Risk Assessment	MSDIS - Structure Points and Data	MoDOT - Roadways	Local - Structrue Footprints	Local - Parcels	Local - Storm/Water/Sewer Infrastructure	Local - Topography	Local - Repetitive Loss Data	Aerial Photography
Mitigation Actions																	
F-12 Remove Existing Structures from Flood Hazard Areas																	
A. Communities may remove structures from flood-prone areas to minimize future flood losses by acquiring and demolishing or relocating structures from voluntary property owners and reserving lands subject to repetitive flooding.				x		x				x		x				x	

F-15 Elevate or Retrofit Structures and Utilities

A. Elevating structures so that the lowest floor, including the basement, is raised above the base flood elevation.

B. Raising utilities or other mechanical devices above expected flood levels.

C. Elevating and anchoring manufactured homes or, preferably, keeping manufactured homes out of the floodplain.

D. Relocating utilities and water heaters above base flood elevation and using tankless water heaters in limited spaces.

F-15.A Elevating structures so that the lowest floor, including the basement, is raised above the base flood elevation.

1. Select those MSDIS structures that intersect or are located within the 1% Annual Chance Floodplain and/or 1% Annual Chance Depth Grid. Note, the 1% Annual Chance Grid may be converted to a polygon using the ESRI "Raster to Polygon" tool, for ease of structure selection.
2. Sort structures by depth of flooding.

F-15.B Raising utilities or other mechanical devices above expected flood levels.

See F-15 A. Review Elevation Certificates, as available, for elevations of utilities or other mechanical devices at specific structures.

F-15.C Elevating and anchoring manufactured homes or, preferably, keeping manufactured homes out of the floodplain.

See F-15 A. Filter MSDIS Structure data to select mobile homes.

F-15.D Relocating utilities and water heaters above base flood elevation and using tankless water heaters in limited spaces.

See F-15 A. Review Elevation Certificates, as available, for elevations of utilities or water heaters at specific structures.

	FIRM Regulatory Products			Risk MAP Non-Regulatory Products						Missouri State Datasets		Local Datasets					
	1% Annual Chance Floodplain	0.5% Annual Chance Floodplain	FIRM Datasets - Profile Baselines (streams)	Depth Grids (10%, 4%, 2%, 1%, and 0.2%)	Percent Chance over 30-Year Period Grid	Percent Annual Chance Grids	Changes Since Last Firm (CSLF)	Areas of Mitigation Interest (AOMI)	Flood Risk Assessment	MSDIS - Structure Points and Data	MoDOT - Roadways	Local - Structrue Footprints	Local - Parcels	Local - Storm/Water/Sewer Infrastructure	Local - Topography	Local - Repetitive Loss Data	Aerial Photography
Mitigation Actions																	
F-15 Elevate or Retrofit Structures and Utilities																	
A. Elevating structures so that the lowest floor, including the basement, is raised above the base flood elevation.	x			x						x		x					
B. Raising utilities or other mechanical devices above expected flood levels.				x						x		x					
C. Elevating and anchoring manufactured homes or, preferably, keeping manufactured homes out of the floodplain.				x						x		x					
D. Relocating utilities and water heaters above base flood elevation and using tankless water heaters in limited spaces.				x						x		x					

F-16 Floodproof Residential and Non-Residential Structures

A. Wet floodproofing in a basement, which may be preferable to attempting to keep water out completely because it allows for controlled flooding to balance exterior and interior wall forces and discourages structural collapse.

B. Encouraging wet floodproofing of areas above base flood elevation.

C. Using water resistant paints or other materials to allow for easy cleanup after floodwater exposure in accessory structures or in a garage area below an elevated residential structure.

D. Dry floodproofing non-residential structures by strengthening walls, sealing openings, or using waterproof compounds or plastic sheeting on walls to keep water out.

F-16.A Wet floodproofing in a basement, which may be preferable to attempting to keep water out completely because it allows for controlled flooding to balance exterior and interior wall forces and discourages structural collapse.

1. Select those MSDIS structures that intersect or are located within the 1% Annual Chance Floodplain and/or 1% Annual Chance Depth Grid. Note, the 1% Annual Chance Grid may be converted to a polygon using the ESRI "Raster to Polygon" tool, for ease of structure selection.
2. Filter MSDIS Structure data to select homes with basements.

F-16.B Encouraging wet floodproofing of areas above base flood elevation.

1. Select those MSDIS structures that intersect or are located within the 1% Annual Chance Floodplain and/or 1% Annual Chance Depth Grid. Note, the 1% Annual Chance Grid may be converted to a polygon using the ESRI "Raster to Polygon" tool, for ease of structure selection.
2. Filter MSDIS Structure data to select homes with finished floors below BFE.
3. Provide outreach materials on wet floodproofing to filtered structures.

F-16.C Using water resistant paints or other materials to allow for easy cleanup after floodwater exposure in accessory structures or in a garage area below an elevated residential structure.

1. Select those MSDIS structures that intersect or are located within the 1% Annual Chance Floodplain and/or 1% Annual Chance Depth Grid. Note, the 1% Annual Chance Grid may be converted to a polygon using the ESRI "Raster to Polygon" tool, for ease of structure selection.
2. Filter MSDIS Structure data to select homes with finished floors below BFE.
3. Provide outreach materials on water resistant paints to filtered structures.

F-16.D Dry floodproofing non-residential structures by strengthening walls, sealing openings, or using waterproof compounds or plastic sheeting on walls to keep water out.

1. Select those MSDIS structures that intersect or are located within the 1% Annual Chance Floodplain and/or 1% Annual Chance Depth Grid. Note, the 1% Annual Chance Grid may be converted to a polygon using the ESRI "Raster to Polygon" tool, for ease of structure selection.
2. Filter MSDIS Structure data to select non-residential structures with finished floors below BFE.

	FIRM Regulatory Products			Risk MAP Non-Regulatory Products						Missouri State Datasets		Local Datasets					
	1% Annual Chance Floodplain	0.5% Annual Chance Floodplain	FIRM Datasets - Profile Baselines (streams)	Depth Grids (10%, 4%, 2%, 1%, and 0.2%)	Percent Chance over 30-Year Period Grid	Percent Annual Chance Grids	Changes Since Last Firm (CSLF)	Areas of Mitigation Interest (AOMI)	Flood Risk Assessment	MSDIS - Structure Points and Data	MoDOT - Roadways	Local - Structrue Footprints	Local - Parcels	Local - Storm/Water/Sewer Infrastructure	Local - Topography	Local - Repetitive Loss Data	Aerial Photography
Mitigation Actions																	
F-16 Floodproof Residential and Non-Residential Structures																	
A. Wet floodproofing in a basement, which may be preferable to attempting to keep water out completely because it allows for controlled flooding to balance exterior and interior wall forces and discourages structural collapse.	x			x						x		x					
B. Encouraging wet floodproofing of areas above base flood elevation.	x			x						x		x					
C. Using water resistant paints or other materials to allow for easy cleanup after floodwater exposure in accessory structures or in a garage area below an elevated residential structure.	x			x						x		x					
D. Dry floodproofing non-residential structures by strengthening walls, sealing openings, or using waterproof compounds or plastic sheeting on walls to keep water out.	x			x						x		x					

IV. Examples of Tools-In-Action: Structure/Infrastructure Projects

F-13 Improve Stormwater Drainage System Capacity.

A. Installing, re-routing, or increasing the capacity of a storm drainage system.
B. Increasing drainage or absorption capacities with detention and retention basins, relief drains, spillways, drain widening/dredging or rerouting, logjam and debris removal, extra culverts, bridge modification, dike setbacks, flood gates and pumps, or channel redirection.
C. Increasing capacity of stormwater detention and retention basins.
D. Increasing dimensions of drainage culverts in flood-prone areas.
E. Using stream restoration to ensure adequate drainage and diversion of stormwater.
F. Requiring developers to construct on-site retention basins for excessive stormwater and as a firefighting water source.
G. Providing grassy swales along roadsides.

F-13.A Installing, re-routing, or increasing the capacity of a storm drainage system.

Are there locations in your community where the storm sewer system cannot adequately carry your community's design storm event? Is there localized flooding at high frequency events?

1. Review the AOMI for identified problem areas.
2. Identify stormwater infrastructure that is causing flooding at high frequency events by reviewing the 10% or 4% Annual Chance floodplains along with your local stormwater infrastructure and note mapped locations of backwater and/or mapped locations of flooded structures adjacent to the stormwater infrastructure.



F-13.B Increasing drainage or absorption capacities.

Hydrologic studies can be used to determine the appropriate amount of detention or retention necessary to prevent an increase in runoff as development occurs. Utilize the FIRM database and local stormwater infrastructure to note existing drainage features.

F-13.C Increasing capacity of stormwater detention and retention basins

1. Review local stormwater infrastructure to identify the location of all detention/retention ponds.
2. Are the retention/detention ponds located within a drainage area that experiences flooding? Review the percent annual chance grids along with intersecting MSDIS structures.
3. Compare current detention/retention ponds against existing topography to determine if additional storage capacity is available.
4. Hydrologic studies can be used to determine the appropriate amount of detention or retention necessary to prevent an increase in runoff as development occurs.

F-13.D Increasing dimensions of drainage culverts in flood-prone areas

See F-13A.

F-13.E Using stream restoration to ensure adequate drainage and diversion of stormwater

See F-13A. Utilize profile baseline (streams) and aerial photography to identify areas of stream restoration.

	FIRM Regulatory Products			Risk MAP Non-Regulatory Products						Missouri State Datasets		Local Datasets					
	1% Annual Chance Floodplain	0.5% Annual Chance Floodplain	FIRM Datasets - Profile Baselines (streams)	Depth Grids (10%, 4%, 2%, 1%, and 0.2%)	Percent Chance over 30-Year Period Grid	Percent Annual Chance Grids	Changes Since Last Firm (CSLF)	Areas of Mitigation Interest (AOMI)	Flood Risk Assessment	MSDIS - Structure Points and Data	MoDOT - Roadways	Local - Structrue Footprints	Local - Parcels	Local - Storm/Water/Sewer Infrastructure	Local - Topography	Local - Repetitive Loss Data	Aerial Photography
Mitigation Actions																	
F-13 Improve Stormwater Drainage System Capacity																	
A. Installing, re-routing, or increasing the capacity of a storm drainage system.						x		x		x				x			
B. Increasing drainage or absorption capacities with detention and retention basins, relief drains, spillways, drain widening/dredging or rerouting, logjam and debris removal, extra culverts, bridge modification, dike setbacks, flood gates and pumps, or channel redirection.			x											x			
C. Increasing capacity of stormwater detention and retention basins.						x				x				x	x		
D. Increasing dimensions of drainage culverts in flood-prone areas.						x		x		x				x			
E. Using stream restoration to ensure adequate drainage and diversion of stormwater.			x			x		x		x				x			x
F. Requiring developers to construct on-site retention basins for excessive stormwater and as a firefighting water source.						x				x				x	x		
G. Providing grassy swales along roadsides.						x		x		x	x			x			x

F-13.F Requiring developers to construct on-site retention basins for excessive stormwater and as a firefighting water source.

Requiring development to retain stormwater will alleviate downstream flooding caused by increased impervious areas. Hydrologic studies can be used to determine the appropriate amount of detention or retention necessary to prevent an increase in runoff as development occurs.

F-13.G Providing grassy swales along roadsides.

See F-13A. Utilize MoDOT Roadways and aerial photography to identify roadways not accompanied with grassy swales.

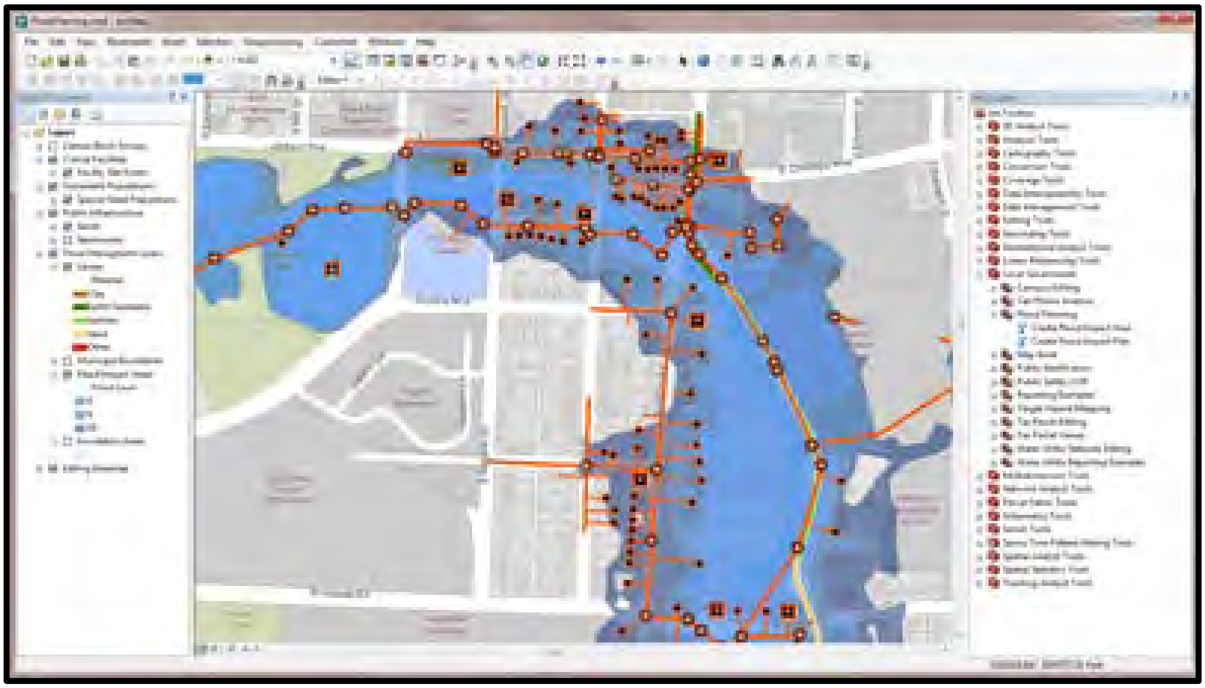
F-14. Conduct Regular Maintenance for Drainage Systems and Flood Control Structures

A. Performing regular drainage system maintenance.
B. Implementing an inspection, maintenance, and enforcement program to help ensure continued structural integrity of dams and levees.
C. Routinely cleaning debris from support bracing underneath low-lying bridges.
D. Routinely cleaning and repairing stormwater drains.
E. Regularly clearing sediment build-up on riverbanks near aerial lines.
F. Inspecting bridges and identifying if any repairs or retrofits are needed to prevent scour.
G. Incorporating ice jam prevention techniques as appropriate.

F-14.A Performing regular drainage system maintenance.

Utilize local stormwater infrastructure mapping to define regular maintenance schedules. Utilize high frequency flood events to identify locations where debris may accumulate due to frequent flooding.

1. Identify potential debris locations by selecting stormwater infrastructure and/or MoDOT roadways that intersect with 10% or 4% annual chance floodplains.



F-14.B Implementing an inspection, maintenance, and enforcement program to help ensure continued structural integrity of dams and levees.

Utilize the FIRM and AOMI datasets to identify locations of all dams/levees within your community. Utilizing partnerships with the USACE and local Levee owners, maintenance records for these systems can be assessed to ensure actions are being implemented.

F-14.C Routinely cleaning debris from support bracing underneath low-lying bridges.

See F-14A.

F-14.D Routinely cleaning and repairing stormwater drains.

See F-14A.

F-14.E Regularly clearing sediment build-up on riverbanks near aerial lines.

Utilize profile baselines and aerial photography to identify areas of riverbanks. Consider investment in bathymetry.

F-14.F Inspecting bridges and identifying if any repairs or retrofits are needed to prevent scour.

Utilize the FIRM database and local stormwater infrastructure to identify locations of existing bridges and associated infrastructure. For those structures not maintained by MoDOT, develop inspection and maintenance program.

F-14.G Incorporating ice jam prevention techniques as appropriate.

Review USACE Ice Jam Database, as maintained by the Ice Engineering Group to identify historic ice jams events and applicability to your community. Utilize profile baselines and aerial photography to identify locations for potential ice jam techniques. https://rsgisias.crrel.usace.army.mil/icejam/

	FIRM Regulatory Products			Risk MAP Non-Regulatory Products						Missouri State Datasets		Local Datasets					
	1% Annual Chance Floodplain	0.5% Annual Chance Floodplain	FIRM Datasets - Profile Baselines (streams)	Depth Grids (10%, 4%, 2%, 1%, and 0.2%)	Percent Chance over 30-Year Period Grid	Percent Annual Chance Grids	Changes Since Last Firm (CSLF)	Areas of Mitigation Interest (AOMI)	Flood Risk Assessment	MSDIS - Structure Points and Data	MoDOT - Roadways	Local - Structrue Footprints	Local - Parcels	Local - Storm/Water/Sewer Infrastructure	Local - Topography	Local - Repetitive Loss Data	Aerial Photography
Mitigation Actions																	
F-14 Conduct Regular Maintenance for Drainage Systems and Flood Control Structures																	
A. Performing regular drainage system maintenance, such as sediment and debris clearance, as well as detection and prevention of discharges into stormwater and sewer systems from home footing drains, downspouts, or sewer pumps.						x					x			x			
B. Implementing an inspection, maintenance, and enforcement program to help ensure continued structural integrity of dams and levees.			x					x									
C. Routinely cleaning debris from support bracing underneath low-lying bridges.						x					x			x			
D. Routinely cleaning and repairing stormwater drains.						x					x			x			
E. Regularly clearing sediment build-up on riverbanks near aerial lines.			x														x
F. Inspecting bridges and identifying if any repairs or retrofits are needed to prevent scour.						x					x			x			
G. Incorporating ice jam prevention techniques as appropriate.			x														x

F-17 Protect Infrastructure

A. Elevating roads and bridges above the base flood elevation to maintain dry access. In situations where flood waters tend to wash roads out, construction, reconstruction, or repair can include not only attention to drainage, but also stabilization or armoring of vulnerable shoulders or embankments.
B. Raising low-lying bridges.
C. Floodproofing wastewater treatment facilities located in flood hazard areas.
D. Floodproofing water treatment facilities located in flood hazard areas.
E. Depending on its infrastructure capabilities, using check valves, sump pumps, and backflow prevention devices in homes and buildings.
F. Using bioengineered bank stabilization techniques.

F-17.A Elevating roads and bridges above the base flood elevation.

Is "turn around, don't drown" a common theme in your community due to frequent roadway overtopping?
1. Identify low-flow roadway crossings by selecting those MoDOT roadways that intersect with high frequency flood events. Review for mapped overtopping.
2. Determine depth of flooding over roadways using high frequency flood depth dataset.

F-17.B Raising low-lying bridges.

See F-17 A.

F-17.C Floodproofing wastewater treatment facilities located in flood hazard areas.

1. Select those MSDIS structures that intersect or are located within the 1% Annual Chance Floodplain and/or 1% Annual Chance Depth Grid. Note, the 1% Annual Chance Grid may be converted to a polygon using the ESRI "Raster to Polygon" tool, for ease of structure selection.
2. Filter MSDIS Structure data to select critical facilities with finished floors below BFE.

F-17.D Floodproofing water treatment facilities located in flood hazard areas.

See F-17 C.

F-17.E Depending on its infrastructure capabilities, using check valves, sump pumps, and backflow prevention devices in homes and buildings.

See F-15 A.

F-17.F Using bioengineered bank stabilization techniques.

See F-13A. Utilize profile baseline (streams) and aerial photography to identify areas of stream restoration.

	FIRM Regulatory Products			Risk MAP Non-Regulatory Products						Missouri State Datasets		Local Datasets					
	1% Annual Chance Floodplain	0.5% Annual Chance Floodplain	FIRM Datasets - Profile Baselines (streams)	Depth Grids (10%, 4%, 2%, 1%, and 0.2%)	Percent Chance over 30-Year Period Grid	Percent Annual Chance Grids	Changes Since Last Firm (CSLF)	Areas of Mitigation Interest (AOMI)	Flood Risk Assessment	MSDIS - Structure Points and Data	MoDOT - Roadways	Local - Structrue Footprints	Local - Parcels	Local - Storm/Water/Sewer Infrastructure	Local - Topography	Local - Repetitive Loss Data	Aerial Photography
Mitigation Actions																	
F-17 Protect Infrastructure																	
A. Elevating roads and bridges above the base flood elevation to maintain dry access. In situations where flood waters tend to wash roads out, construction, reconstruction, or repair can include not only attention to drainage, but also stabilization or armoring of vulnerable shoulders or embankments.				x							x						
B. Raising low-lying bridges.	x			x							x						
C. Floodproofing wastewater treatment facilities located in flood hazard areas.		x		x						x		x					
D. Floodproofing water treatment facilities located in flood hazard areas.		x		x						x		x					
E. Depending on its infrastructure capabilities, using check valves, sump pumps, and backflow prevention devices in homes and buildings.	x			x						x		x					
F. Using bioengineered bank stabilization techniques.	x			x								x	x				x

F-19 Construct Flood Control Measures

A. Using minor structural projects that are smaller and more localized (e.g., floodwalls or small berms) in areas that cannot be mitigated through non-structural activities or where structural activities are not feasible due to low densities.

B. Using revetments (hardened materials placed atop existing riverbanks or slopes) to protect against floods.

C. Using bioengineered bank stabilization techniques.

F-19.A Using minor structural projects that are smaller and more localized.

Based on problem areas identified in the AOMI or through F-12A (structures); F-13A (stormwater infrastructure); and F17A (roadway infrastructure); use minor structural projects to address.

F-19.B Using revetments to protect against floods.

Utilize the profile baselines (streams) in the FIRM database and/or local stormwater infrastructure to identify riverbanks. Aerial photography and local topography may also be utilized to identify steep slopes for riprap and/or revetments.

F-19.C Using bioengineered bank stabilization techniques.

See F-13A. Utilize profile baselines (streams) and aerial photography to identify areas of stream restoration.

	FIRM Regulatory Products			Risk MAP Non-Regulatory Products						Missouri State Datasets		Local Datasets					
	1% Annual Chance Floodplain	0.5% Annual Chance Floodplain	FIRM Datasets - Profile Baselines (streams)	Depth Grids (10%, 4%, 2%, 1%, and 0.2%)	Percent Chance over 30-Year Period Grid	Percent Annual Chance Grids	Changes Since Last Firm (CSLF)	Areas of Mitigation Interest (AOMI)	Flood Risk Assessment	MSDIS - Structure Points and Data	MoDOT - Roadways	Local - Structrue Footprints	Local - Parcels	Local - Storm/Water/Sewer Infrastructure	Local - Topography	Local - Repetitive Loss Data	Aerial Photography
Mitigation Actions																	
F-19 Construct Flood Control Measures																	
A. Using minor structural projects that are smaller and more localized (e.g., floodwalls or small berms) in areas that cannot be mitigated through non-structural activities or where structural activities are not feasible due to low densities.				x		x		x		x	x	x		x		x	
B. Using revetments (hardened materials placed atop existing riverbanks or slopes) to protect against floods.			x											x	x		x
C. Using bioengineered bank stabilization techniques.	x			x								x	x				x

V. Overview and Examples of Tools-In-Action – Part II

- With an understanding of FEMA's flood risk regulatory and non-regulatory (Risk MAP) tools and their availability, the next step is to utilize each tool to identify mitigation actions. Following along with the mitigation categories/types as presented in FEMA's Mitigation Ideas publication, examples of tools-in-action are presented for the following
  - Prevention or Local Planning and Regulations (F1 through F11);
  - Public Education and Awareness (F22 and F23); and
  - Natural Systems Protection (F20 and F21).

- The graphic below was included in FEMA's Mitigation How-To Series within [How To Guide #3 Identifying Mitigation Actions and Implementation Strategies].

Mitigation actions can be grouped into six broad categories:

1. **Prevention.** Government administrative or regulatory actions or processes that influence the way land and buildings are developed and built. These actions also include public activities to reduce hazard losses. Examples include planning and zoning, building codes, capital improvement programs, open space preservation, and storm water management regulations.
2. **Property Protection.** Actions that involve the modification of existing buildings or structures to protect them from a hazard, or removal from the hazard area. Examples include acquisition, elevation, relocation, structural retrofits, storm shutters, and shatter-resistant glass.
3. **Public Education and Awareness.** Actions to inform and educate citizens, elected officials, and property owners about the hazards and potential ways to mitigate them. Such actions include outreach projects, real estate disclosure, hazard information centers, and school-age and adult education programs.
4. **Natural Resource Protection.** Actions that, in addition to minimizing hazard losses, also preserve or restore the functions of natural systems. These actions include sediment and erosion control, stream corridor restoration, watershed management, forest and vegetation management, and wetland restoration and preservation.
5. **Emergency Services.** Actions that protect people and property during and immediately after a disaster or hazard event. Services include warning systems, emergency response services, and protection of critical facilities.
6. **Structural Projects.** Actions that involve the construction of structures to reduce the impact of a hazard. Such structures include dams, levees, floodwalls, seawalls, retaining walls, and safe rooms.

- Each example will present, in tabular format, the GIS dataset needs, including federal, state, and local products, and associated instructional steps in the process to identify mitigation actions.
- A complete summary table of mitigation actions and associated datasets is provided as an appendix to the User Guide.

VI. Examples of Tools-In-Action: Prevention

F-1 Incorporate Flood Mitigation in Local Planning

A. Determining and enforcing acceptable land uses to alleviate the risk of damage by limiting exposure in flood hazard areas.

B. Developing a floodplain management plan and updating it regularly.

C. Mitigating hazards during infrastructure planning.

D. Adopting a post-disaster recovery ordinance based on a plan to regulate repair activity, generally depending on property location.

E. Passing and enforcing an ordinance that regulates dumping in streams and ditches.

F. Establishing a ”green infrastructure” program to link, manage, and expand existing parks, preserves, greenways, etc.

G. Obtaining easements for planned and regulated public use of privately-owned land for temporary water retention and drainage.

F-1.A Determining and enforcing acceptable land uses to alleviate the risk of damage by limiting exposure in flood hazard areas.

1. Overlay the flood risk assessment data with your local parcel data. Identify what types of land use are located within the high risk areas.
3. Determine any necessary adjustments to current land uses and/or parcel types to address the identified high risk areas.

F-1.B Developing a floodplain management plan and updating it regularly.

1. Identify local flood hazard utilizing mapped floodplain areas and percent annual chance grids.
2. Utilize Flood Risk Assessment to present flood risk in the community.
3. Utilize AOMI and Flood Risk Assessment to develop local flood mitigation actions.

F-1.C Mitigating hazards during infrastructure planning.

See F-17 actions A through F.

F-1.D Adopting a post-disaster recovery ordinance based on a plan to regulate repair activity, generally depending on property location.

Utilize the 1% Annual Chance Floodplain, Depth Grids, Flood Risk Assessment and MSDIS structure points to familiarize the community and your local floodplain administrator with the flood hazard risk identifying areas of high risk and potential post-disaster needs.

F-1.E Passing and enforcing an ordinance that regulates dumping in streams and ditches.

Utilize the profile baselines (streams) in the FIRM database and/or local stormwater infrastructure to identify streams and ditches.

F-1.F Establishing a ”green infrastructure” program to link, manage, and expand existing parks, preserves, greenways, etc.

1. Utilizing both your local parcel data and local building footprints and/or MSDIS structures, identify all open space parcels and existing parks, preserves, greenways, etc.
2. Overlay the open space parcels with the 1% Annual Chance Floodplain and/or Depth Grid to identify those open space parcels that are currently flood-prone, as well as, adjacent parcels for potential future open space.
3. Establish program to link identified parcels.

F-1.G Obtaining easements for planned and regulated public use of privately-owned land for temporary water retention and drainage.

See F-21 A; Coordinate easements with open space planning.

	FIRM Regulatory Products			Risk MAP Non-Regulatory Products						Missouri State Datasets		Local Datasets					
	1% Annual Chance Floodplain	0.5% Annual Chance Floodplain	FIRM Datasets - Profile Baselines (streams)	Depth Grids (10%, 4%, 2%, 1%, and 0.2%)	Percent Chance over 30-Year Period Grid	Percent Annual Chance Grids	Changes Since Last Firm (CSLF)	Areas of Mitigation Interest (AOMI)	Flood Risk Assessment	MSDIS - Structure Points and Data	MoDOT - Roadways	Local - Structrue Footprints	Local - Parcels	Local - Storm/Water/Sewer Infrastructure	Local - Topography	Local - Repetitive Loss Data	Aerial Photography
Mitigation Actions																	
F-1 Incorporate Flood Mitigation in Local Planning																	
A. Determining and enforcing acceptable land uses to alleviate the risk of damage by limiting exposure in flood hazard areas.									x				x				
B. Developing a floodplain management plan and updating it regularly.	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
C. Mitigating hazards during infrastructure planning. For example, decisions to extend roads or utilities to an area may increase exposure to flood hazards.				x				x	x		x			x			
D. Adopting a post-disaster recovery ordinance based on a plan to regulate repair activity, generally depending on property location.	x			x						x		x	x				
E. Passing and enforcing an ordinance that regulates dumping in streams and ditches.			x											x			
F. Establishing a "green infrastructure" program to link, manage, and expand existing parks, preserves, greenways, etc.	x											x	x				x
G. Obtaining easements for planned and regulated public use of privately-owned land for temporary water retention and drainage.	x											x	x				x

F-2 Form Partnerships to Support Floodplain Management

A. Developing a stormwater committee that meets regularly to discuss issues and recommend projects.

B. Forming a regional watershed council to help bring together resources for comprehensive analysis, planning, decision-making, and cooperation.

C. Establishing watershed-based planning initiatives to address the flood hazard with neighboring jurisdictions.

D. Forming a citizen plan implementation steering committee to monitor progress on local mitigation actions. Include a mix of representatives from neighborhoods, local businesses, and local government.

F-2.A Developing a stormwater committee that meets regularly to discuss issues and recommend projects.

Members of the stormwater committee should be familiar with locations in the community where the storm sewer system cannot adequately carry the community's design storm event.

1. Review the AOMI for identified problem areas.
2. Identify stormwater infrastructure that is causing flooding at high frequency events by reviewing the 10% or 4% Annual Chance floodplains along with your local stormwater infrastructure and note mapped locations of backwater and/or mapped locations of flooded structures adjacent to the stormwater infrastructure.

F-2.B Forming a regional watershed council to help bring together resources for comprehensive analysis, planning, decision-making, and cooperation.

Members of the regional watershed council should be familiar with the regional flood hazard risk.

1. Review all flood hazard data for the watershed both regulatory and non-regulatory.

F-2.C Establishing watershed-based planning initiatives to address the flood hazard with neighboring jurisdictions.

Utilize watershed-based Risk MAP tools to identify neighboring jurisdictions which are addressing the same flood hazards.

F-2.D Forming a citizen plan implementation steering committee to monitor progress on local mitigation actions. Include a mix of representatives from neighborhoods, local businesses, and local government.

Members of the steering committee should be familiar with local mitigation actions.

1. Review the AOMI and Flood Risk Assessment for identified problem areas.

	FIRM Regulatory Products			Risk MAP Non-Regulatory Products						Missouri State Datasets		Local Datasets					
	1% Annual Chance Floodplain	0.5% Annual Chance Floodplain	FIRM Datasets - Profile Baselines (streams)	Depth Grids (10%, 4%, 2%, 1%, and 0.2%)	Percent Chance over 30-Year Period Grid	Percent Annual Chance Grids	Changes Since Last Firm (CSLF)	Areas of Mitigation Interest (AOMI)	Flood Risk Assessment	MSDIS - Structure Points and Data	MoDOT - Roadways	Local - Structrue Footprints	Local - Parcels	Local - Storm/Water/Sewer Infrastructure	Local - Topography	Local - Repetitive Loss Data	Aerial Photography
Mitigation Actions																	
F-2 Form Partnerships to Support Floodplain Management																	
A. Developing a stormwater committee that meets regularly to discuss issues and recommend projects.								x	x					x			
B. Forming a regional watershed council to help bring together resources for comprehensive analysis, planning, decision-making, and cooperation.	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
C. Establishing watershed-based planning initiatives to address the flood hazard with neighboring jurisdictions.	x	x	x	x		x		x	x								
D. Forming a citizen plan implementation steering committee to monitor progress on local mitigation actions. Include a mix of representatives from neighborhoods, local businesses, and local government.								x	x								

F-3 Limit or Restrict Development in Floodplain Areas

A. Prohibiting or limiting floodplain development through regulatory and/or incentive-based measures.

B. Limiting the density of developments in the floodplain.

C. Requiring that floodplains be kept as open space.

D. Limiting the percentage of allowable impervious surface within developed parcels.

E. Developing a stream buffer ordinance to protect water resources and limit flood impacts.

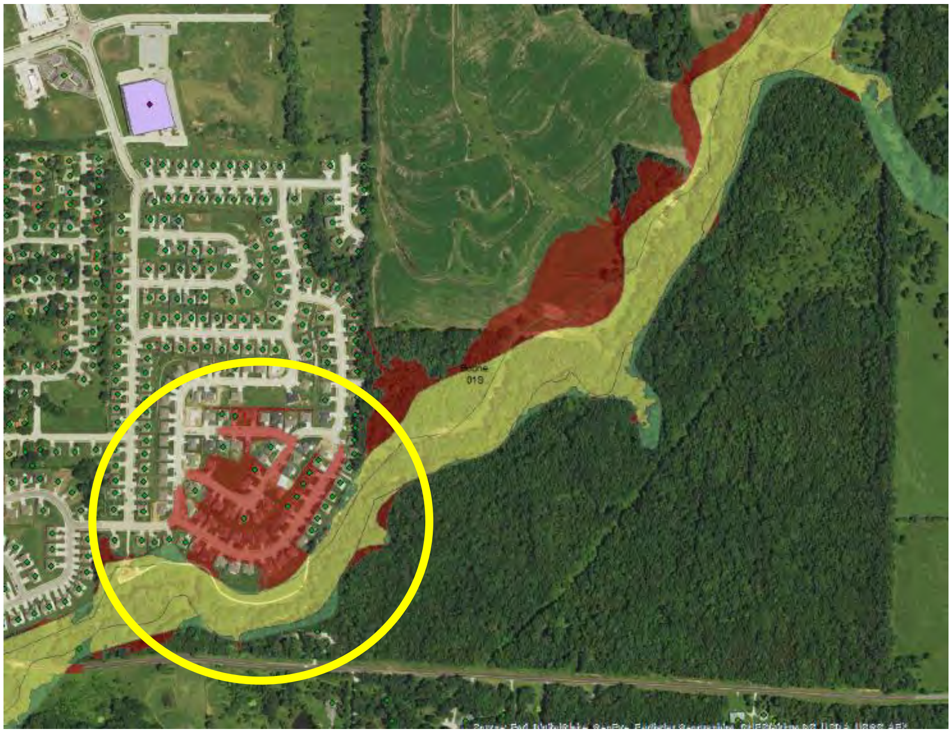
F. Prohibiting any fill in floodplain areas.

F-3.A Prohibiting or limiting floodplain development through regulatory and/or incentive-based measures.

1. Overlay the flood risk assessment data with your local parcel data and MSDIS Structures. Noting high risk areas as locations to limit develop and avoid increasing flood risk.
2. See F-21A, for Open Space Preservation Plan; and F-6 Actions A through H reducing stormwater runoff; both assist with limiting and addressing development.

F-3.B Limiting the density of developments in the floodplain.

Low-density, as credited through the CRS program, means that that size of the lots is at least 5 acres.
1. Utilizing both your local parcel data and local building footprints and/or MSDIS structures, identify all open space parcels.
2. Overlay the open space parcels with the 1% Annual Chance Floodplain and/or Depth Grid to identify those open space parcels that are currently flood-prone.
3. Limit areas of the identified floodplain to low-density development.



F-3.C Requiring that floodplains be kept as open space.

1. Utilizing both your local parcel data and local building footprints and/or MSDIS structures, identify all open space parcels.
2. Overlay the open space parcels with the 1% Annual Chance Floodplain and/or Depth Grid to identify those open space parcels that are currently flood-prone.
3. Designate the floodplain areas of these parcels remain as open space.

F-3.D Limiting the percentage of allowable impervious surface within developed parcels.

1. Community-wide, digitize impervious area within each parcel utilizing recent aerial photography.
2. For various parcel types, calculate the ratio of impervious area to total parcel area.
3. Based on the calculated ratios, determine allowable percentage of impervious area per parcel type.

F-3.E Developing a stream buffer ordinance to protect water resources and limit flood impacts.

See F-20 B. Utilize the profile baselines (streams) in the FIRM database to identify locations for linear buffers.

F-3.F Prohibiting any fill in floodplain areas.

Utilize the 1% Annual Chance Floodplain and/or Depth Grid to identify floodplain areas to prohibit fill.

	FIRM Regulatory Products			Risk MAP Non-Regulatory Products						Missouri State Datasets		Local Datasets					
	1% Annual Chance Floodplain	0.5% Annual Chance Floodplain	FIRM Datasets - Profile Baselines (streams)	Depth Grids (10%, 4%, 2%, 1%, and 0.2%)	Percent Chance over 30-Year Period Grid	Percent Annual Chance Grids	Changes Since Last Firm (CSLF)	Areas of Mitigation Interest (AOMI)	Flood Risk Assessment	MSDIS - Structure Points and Data	MoDOT - Roadways	Local - Structrue Footprints	Local - Parcels	Local - Storm/Water/Sewer Infrastructure	Local - Topography	Local - Repetitive Loss Data	Aerial Photography
Mitigation Actions																	
F-3 Limit or Restrict Development in Floodplain Areas																	
A. Prohibiting or limiting floodplain development through regulatory and/or incentive-based measures.	x							x	x			x	x				x
B. Limiting the density of developments in the floodplain.	x			x								x					
C. Requiring that floodplains be kept as open space.	x			x								x					
D. Limiting the percentage of allowable impervious surface within developed parcels.	x										x	x	x				x
E. Developing a stream buffer ordinance to protect water resources and limit flood impacts.			x														
F. Prohibiting any fill in floodplain areas.	x			x													

F-4 Adopt and Enforce Building Codes and Development Standards

A. Adopting the International Building Code (IBC) and International Residential Code (IRC).

B. Adopting ASCE 24-05 Flood Resistant Design and Construction

C. Adding or increasing "freeboard" requirements

D. Prohibiting all first floor enclosures below base flood elevation for all structures in flood hazard areas.

E. Considering orientation of new development during design

F. Setting the design flood elevation at or above the historical high water mark if it is above the mapped base flood elevation.

G. Using subdivision design standards to require elevation data collection during platting and to have buildable space on lots above the base flood elevation.

H. Requiring standard tie-downs of propane tanks.

F-4.A Adopting the International Building Code (IBC) and International Residential Code (IRC).

Coordinating floodplain management with local building codes has several advantages. As noted in the CRS Manual:

- There is better coordination with permitting the construction of new buildings and repairs and improvements to existing buildings;
- More staff and more knowledgeable staff can better enforce floodplain building construction standards, such as foundation protection and placement of mechanical
- Equipment;
- Experienced inspectors can check compliance in the field; and
- There is more frequent observation of construction progress and quality of construction.

F-4.B Adopting ASCE 24-05 Flood Resistant Design and Construction.

Is there a mapped floodplain within your community?

1. Download flood hazard data from the Map Service Center.
2. Review flood hazard data against existing community building and parcel data.
3. Adopt policy, as applicable.

F-4.C Adding or increasing "freeboard" requirements.

In most cases, flood premiums can be cut in half by elevating a home 2 feet above the BFE.

1. Select those MSDIS structures that intersect or are located within the 1% Annual Chance Floodplain and/or 1% Annual Chance Depth Grid. Note, the 1% Annual Chance Grid may be converted to a polygon using the ESRI "Raster to Polygon" tool, for ease of structure selection.
2. Sort structures by depth of flooding.
3. 3, Based on depths of flooding, determine the number of structures that would be removed from the floodplain with the additional 2 feet of freeboard. Utilize this information to leverage your mitigation action to extend the freeboard. In additional, a comprehensive study of freeboard (American Institutes for Research, 2006) has demonstrated that adding freeboard at the time of house construction is cost-effective.

F-4.D Prohibiting all first floor enclosures below base flood elevation for all structures in flood hazard areas.

1. Select those MSDIS structures that intersect or are located within the 1% Annual Chance Floodplain and/or 1% Annual Chance Depth Grid. Note, the 1% Annual Chance Grid may be converted to a polygon using the ESRI "Raster to Polygon" tool, for ease of structure selection.
2. Determine depth of flooding at the identified structures.
3. Prohibit enclosures within the first floor enclosures below base flood elevations.

F-4.E Considering orientation of new development during design.

1. Utilizing both your local parcel data and local building footprints and/or MSDIS structures, identify all open space parcels. Open space parcels will be potential future subdivision development areas.
2. Overlay the open space parcels with the 1% annual chance depth grid to flood prone properties, base flood elevations, and orientation of flood hazard.

F-4.F Setting the design flood elevation at or above the historical high water mark if it is above the mapped base flood elevation.

Coordinate with F-7A.

F-4.G Using subdivision design standards to require elevation data collection during platting and to have buildable space on lots above the base flood elevation.

Utilizing both your local parcel data and local building footprints and/or MSDIS structures, identify all open space parcels. Open space parcels will be potential future subdivision development areas.

F-4.H Requiring standard tie-downs of propane tanks.

1. Select MSDIS structures or local parcels that intersect or are located within the 1% Annual Chance Floodplain and/or 1% Annual Chance Depth Grid. Note, the 1% Annual Chance Grid may be converted to a polygon using the ESRI "Raster to Polygon" tool, for ease of structure selection.

2. Provide education materials to property owners within the floodplain regarding requirements for propane tie-downs.

	FIRM Regulatory Products			Risk MAP Non-Regulatory Products						Missouri State Datasets		Local Datasets					
	1% Annual Chance Floodplain	0.5% Annual Chance Floodplain	FIRM Datasets - Profile Baselines (streams)	Depth Grids (10%, 4%, 2%, 1%, and 0.2%)	Percent Chance over 30-Year Period Grid	Percent Annual Chance Grids	Changes Since Last Firm (CSLF)	Areas of Mitigation Interest (AOMI)	Flood Risk Assessment	MSDIS - Structure Points and Data	MoDOT - Roadways	Local - Structrue Footprints	Local - Parcels	Local - Storm/Water/Sewer Infrastructure	Local - Topography	Local - Repetitive Loss Data	Aerial Photography
Mitigation Actions																	
F-4 Adopt and Enforce Building Codes and Development Standards																	
A. Adopting the International Building Code (IBC) and International Residential Code (IRC).																	
B. Adopting ASCE 24-05 Flood Resistant Design and Construction. ASCE 24 is a referenced standard in the IBC that specifies minimum requirements and expected performance for the design and construction of buildings and structures in the flood hazard areas to make them more resistant to flood loads and flood damage.				x						x		x					
C. Adding or increasing "freeboard" requirements (feet above base flood elevation) in the flood damage ordinance.				x						x		x					
D. Prohibiting all first floor enclosures below base flood elevation for all structures in flood hazard areas.				x						x		x					
E. Considering orientation of new development during design (e.g., subdivisions, buildings, infrastructure, etc.).	x			x									x				x
F. Setting the design flood elevation at or above the historical high water mark if it is above the mapped base flood elevation.	x			x				x									
G. Using subdivision design standards to require elevation data collection during platting and to have buildable space on lots above the base flood elevation.	x			x						x		x	x				
H. Requiring standard tie-downs of propane tanks.	x			x						x		x	x				

F-5 Improve Stormwater Management Planning

A. Completing a stormwater drainage study for known problem areas.

B. Preparing and adopting a stormwater drainage plan and ordinance.

C. Preparing and adopting a community-wide stormwater management master plan.

D. Regulating development in upland areas in order to reduce stormwater run-off through a stormwater ordinance.

E. Linking flood hazard mitigation objectives with EPA Stormwater Phase II initiatives.

F. Developing engineering guidelines for drainage from new development.

G. Requiring a drainage study with new development.

H. Encouraging the use of Low Impact Development techniques

F-5.A Completing a stormwater drainage study for known problem areas.

Are there locations in your community where the storm sewer system cannot adequately carry your community's design storm event? Is there localized flooding at high frequency events?

1. Review the AOMI for identified problem areas.
2. Identify stormwater infrastructure that is causing flooding at high frequency events by reviewing the 10% or 4% Annual Chance floodplains along with your local stormwater infrastructure and note mapped locations of backwater and/or mapped locations of flooded structures adjacent to the stormwater infrastructure.
3. Complete a stormwater drainage study for the identified problem areas.

F-5.B Preparing and adopting a stormwater drainage plan and ordinance.

See F-5 A; Based on the stormwater drainage study, identify mitigation actions to address problem areas through a stormwater drainage plan, and adopt completed plan.

F-5.C Preparing and adopting a community-wide stormwater management master plan.

See F-5 A; Based on completed stormwater drainage studies, identify mitigation actions to address problem areas throughout the community through a stormwater drainage plan, and adopt completed plan.

F-5.D Regulating development in upland areas in order to reduce stormwater run-off through a stormwater ordinance.

Utilize watershed boundaries in coordination with the profile baselines to identify upland areas for development regulation.

F-5.E Linking flood hazard mitigation objectives with EPA Stormwater Phase II initiatives.

Coordinate stormwater regulations F-5A through H with community-wide floodplain management program.

F-5.F Developing engineering guidelines for drainage from new development.

1. Utilizing both your local parcel data and local building footprints and/or MSDIS structures, identify all open space parcels. Open space parcels will be potential new development areas.
2. Develop guidelines for drainage from these identified areas.

F-5.G Requiring a drainage study with new development.

See F-5.F.

F-5.H Encouraging the use of Low Impact Development techniques.

Low Impact Development (LID) techniques can significantly reduce or eliminate the increase in stormwater runoff created by traditional development, encourage aquifer recharge, and promote better water quality. Utilize low-impact development features throughout the community to minimize the effective of impervious areas.

	FIRM Regulatory Products			Risk MAP Non-Regulatory Products						Missouri State Datasets		Local Datasets					
	1% Annual Chance Floodplain	0.5% Annual Chance Floodplain	FIRM Datasets - Profile Baselines (streams)	Depth Grids (10%, 4%, 2%, 1%, and 0.2%)	Percent Chance over 30-Year Period Grid	Percent Annual Chance Grids	Changes Since Last Firm (CSLF)	Areas of Mitigation Interest (AOMI)	Flood Risk Assessment	MSDIS - Structure Points and Data	MoDOT - Roadways	Local - Structrue Footprints	Local - Parcels	Local - Storm/Water/Sewer Infrastructure	Local - Topography	Local - Repetitive Loss Data	Aerial Photography
Mitigation Actions																	
F-5 Improve Stormwater Management Planning																	
A. Completing a stormwater drainage study for known problem areas.			x	x		x		x		x	x	x					
B. Preparing and adopting a stormwater drainage plan and ordinance.			x	x		x		x		x	x	x					
C. Preparing and adopting a community-wide stormwater management master plan.			x	x		x		x		x	x	x					
D. Regulating development in upland areas in order to reduce stormwater run-off through a stormwater ordinance.			x	x		x		x		x	x	x	x				
E. Linking flood hazard mitigation objectives with EPA Stormwater Phase II initiatives.			x	x		x		x			x						
F. Developing engineering guidelines for drainage from new development.			x	x		x		x			x		x				
G. Requiring a drainage study with new development.			x	x		x		x			x		x				
H. Encouraging the use of Low Impact Development techniques			x	x		x				x	x	x	x				

F-6 Adopt Policies to Reduce Stormwater Runoff

A. Designing a “natural runoff” or “zero discharge” policy for stormwater in subdivision design.

B. Requiring more trees be preserved and planted in landscape designs to reduce the amount of stormwater runoff.

C. Requiring developers to plan for on-site sediment retention.

D. Requiring developers to construct on-site retention basins for excessive stormwater and as a firefighting water source.

E. Encouraging the use of porous pavement, vegetative buffers, and islands in large parking areas.

F. Conforming pavement to land contours so as not to provide easier avenues for stormwater.

G. Encouraging the use of permeable driveways and surfaces to reduce runoff and increase groundwater recharge.

H. Adopting erosion and sedimentation control regulations for construction and farming

F-6.A Designing a “natural runoff” or “zero discharge” policy for stormwater in subdivision design.

1. Identify stormwater infrastructure that is causing flooding at high frequency events by reviewing the 10% or 4% Annual Chance floodplains along with your local stormwater infrastructure and note mapped locations of backwater and/or mapped locations of flooded structures adjacent to the stormwater infrastructure.
2. Require implementation of on-site treatment.

F-6.B Requiring more trees be preserved and planted in landscape designs to reduce the amount of stormwater runoff.

Utilize low-impact development features throughout the community to minimize the effective imperviousness to create functional and appealing site drainage that treats stormwater as a resource rather than a waste product.

F-6.C Requiring developers to plan for on-site sediment retention.

Sediment control measures should be taken on land throughout the community that is disturbed during development. Drainage systems cannot perform to their design standards if they are choked with eroded soil that has been captured in stormwater.

F-6.D Requiring developers to construct on-site retention basins for excessive stormwater and as a firefighting water source.

Hydrologic studies can be used to determine the appropriate amount of detention or retention necessary to prevent an increase in runoff as development occurs.

F-6.E Encouraging the use of porous pavement, vegetative buffers, and islands in large parking areas.

See F-6B.

F-6.F Conforming pavement to land contours so as not to provide easier avenues for stormwater.

Utilize local topographic data in coordination with defined floodplains and/or depth grids to define stormwater flow paths.

F-6.G Encouraging the use of permeable driveways and surfaces to reduce runoff and increase groundwater recharge.

See F-6B.

F-6.H Adopting erosion and sedimentation control regulations for construction and farming.

See F-6C.

	FIRM Regulatory Products			Risk MAP Non-Regulatory Products						Missouri State Datasets		Local Datasets					
	1% Annual Chance Floodplain	0.5% Annual Chance Floodplain	FIRM Datasets - Profile Baselines (streams)	Depth Grids (10%, 4%, 2%, 1%, and 0.2%)	Percent Chance over 30-Year Period Grid	Percent Annual Chance Grids	Changes Since Last Firm (CSLF)	Areas of Mitigation Interest (AOMI)	Flood Risk Assessment	MSDIS - Structure Points and Data	MoDOT - Roadways	Local - Structrue Footprints	Local - Parcels	Local - Storm/Water/Sewer Infrastructure	Local - Topography	Local - Repetitive Loss Data	Aerial Photography
Mitigation Actions																	
F-6 Adopt Polices to Reduce Stormwater Runoff																	
A. Designing a "natural runoff" or "zero discharge" policy for stormwater in subdivision design.						x		x						x			
B. Requiring more trees be preserved and planted in landscape designs to reduce the amount of stormwater runoff.								x									
C. Requiring developers to plan for on-site sediment retention.										x		x	x		x		x
D. Requiring developers to construct on-site retention basins for excessive stormwater and as a firefighting water source.			x					x									
E. Encouraging the use of porous pavement, vegetative buffers, and islands in large parking areas.								x									
F. Conforming pavement to land contours so as not to provide easier avenues for stormwater.	x			x		x								x	x		
G. Encouraging the use of permeable driveways and surfaces to reduce runoff and increase groundwater recharge.								x									
H. Adopting erosion and sedimentation control regulations for construction and farming.								x									

F-7 Improve Flood Risk Assessment

A. Incorporating the procedures for tracking high water marks following a flood into emergency response plans.

B. Conducting cumulative impact analyses for multiple development projects within the same watershed.

C. Conducting a verification study of FEMA's repetitive loss inventory and developing an associated tracking database.

D. Regularly calculating and documenting the amount of flood-prone property preserved as open space.

E. Requiring a thorough watershed analysis for all proposed dam or reservoir projects.

F. Developing a dam failure study and emergency action plan.

G. Using GIS to map areas that are at risk of flooding.

H. Obtaining depth grid data and using it to illustrate flood risk to citizens.

I. Incorporating digital floodplain and topographic data into GIS systems, in conjunction with Hazus, to assess risk.

J. Developing and maintaining a database to track community exposure to flood risk.

K. Revising and updating regulatory floodplain maps.

F-7.A Incorporating the procedures for tracking high water marks following a flood into emergency response plans.

One of the most important uses for high water marks (HWM) is allowing for comparison and revision of flood risk maps. Compare any HWMs collected with the 1% Annual Chance Depth Grid to determine if the event exceeded the mapped inundation areas, indicating additional threats to your community.

F-7.B Conducting cumulative impact analyses for multiple development projects within the same watershed.

Coordinate with F-4 Actions A through H

F-7.C Conducting a verification study of FEMA's repetitive loss inventory and developing an associated tracking database.

1. Does your community have any repetitive loss (RL) properties? See State NFIP coordinator for updated information.
2. Identify properties with the same exposure to repeated flood damage by selecting MSDIS structures with the similar depths of flooding for high frequency events as the RL properties.
3. Select those MSDIS structures that intersect or are located within the 1% Annual Chance Floodplain and/or 1% Annual Chance Depth Grid. Note, the 1% Annual Chance Grid may be converted to a polygon using the ESRI "Raster to Polygon" tool, for ease of structure selection.
4. Sort structures by depth of flooding and select those structures adjacent to the RL properties that have equal or greater flooding to define your RL area.
5. Maintain tracking database of RL areas and associated properties.

F-7.D Regularly calculating and documenting the amount of flood-prone property preserved as open space.

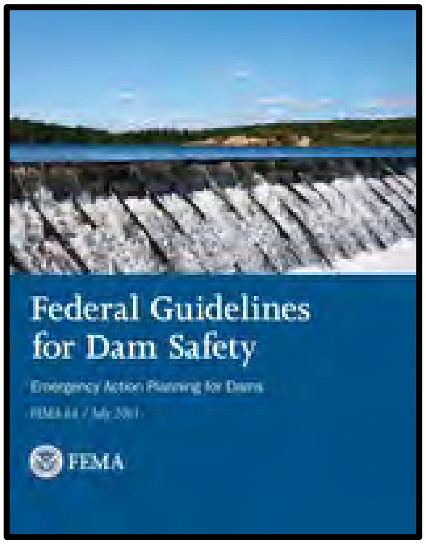
1. Utilizing both your local parcel data and local building footprints and/or MSDIS structures, identify all open space parcels.
2. Overlay the open space parcels with the 1% annual chance depth grid to identify those open space parcels that are currently flood-prone.

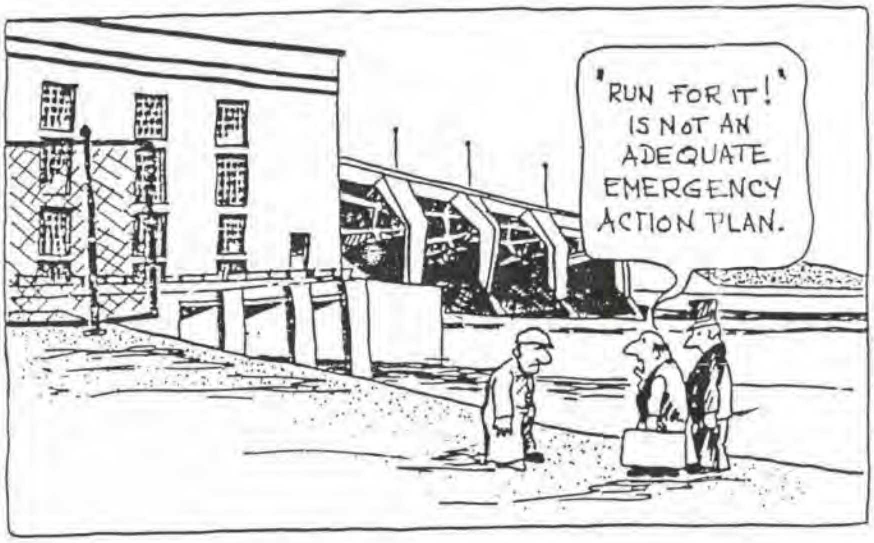
F-7.E Requiring a thorough watershed analysis for all proposed dam or reservoir projects.

Utilize the AOMI datasets to identify locations of proposed dam locations within your community.

F-7.F Developing a dam failure study and emergency action plan.

Incorporate structure information into Dam Failure Study and Emergency Action Plan to identify structures located within the dam failure inundation path, as well as, MoDOT roadway information to develop evacuation routes.





F-7.G Using GIS to map areas that are at risk of flooding.

These elements are wholly stored within your FIRM Database and Flood Risk Database (FRD).

F-7.H Obtaining depth grid data and using it to illustrate flood risk to citizens.

These elements are wholly stored within your Flood Risk Database (FRD).

F-7.I Incorporating digital floodplain and topographic data into GIS systems, in conjunction with Hazus, to assess risk.

These elements are wholly stored within your Flood Risk Database (FRD).

F-7.J Developing and maintaining a database to track community exposure to flood risk.

Maintain the Flood Risk Assessment which provides an assessment of potential financial consequences and other impacts associated with structures located in a SFHA.

F-7.K Revising and updating regulatory floodplain maps.

Coordinate with SEMA for information on the Risk MAP schedule

	FIRM Regulatory Products			Risk MAP Non-Regulatory Products						Missouri State Datasets		Local Datasets					
	1% Annual Chance Floodplain	0.5% Annual Chance Floodplain	FIRM Datasets - Profile Baselines (streams)	Depth Grids (10%, 4%, 2%, 1%, and 0.2%)	Percent Chance over 30-Year Period Grid	Percent Annual Chance Grids	Changes Since Last Firm (CSLF)	Areas of Mitigation Interest (AOMI)	Flood Risk Assessment	MSDIS - Structure Points and Data	MoDOT - Roadways	Local - Structrue Footprints	Local - Parcels	Local - Storm/Water/Sewer Infrastructure	Local - Topography	Local - Repetitive Loss Data	Aerial Photography
Mitigation Actions																	
F-7 Improve Flood Risk Assessment																	
A. Incorporating the procedures for tracking high water marks following a flood into emergency response plans.				x				x									
B. Conducting cumulative impact analyses for multiple development projects within the same watershed.						x					x	x	x				x
C. Conducting a verification study of FEMA's repetitive loss inventory and developing an associated tracking database.				x		x				x		x				x	
D. Regularly calculating and documenting the amount of flood-prone property preserved as open space.				x						x		x	x				
E. Requiring a thorough watershed analysis for all proposed dam or reservoir projects.			x					x									
F. Developing a dam failure study and emergency action plan.										x	x	x					
G. Using GIS to map areas that are at risk of flooding.	x	x	x	x	x	x	x	x	x								
H. Obtaining depth grid data and using it to illustrate flood risk to citizens.				x	x	x	x	x	x								
I. Incorporating digital floodplain and topographic data into GIS systems, in conjunction with Hazus, to assess risk.				x	x	x	x	x	x								
J. Developing and maintaining a database to track community exposure to flood risk.										x							
K. Revising and updating regulatory floodplain maps.	x	x	x	x	x	x	x	x	x								x

F-8 Join or Improve Compliance with NFIP

A. Participating in NFIP.

B. Adopting ordinances that meet minimum Federal and state requirements to comply with NFIP.

C. Conducting NFIP community workshops to provide information and incentives for property owners to acquire flood insurance.

D. Designating a local floodplain manager and/or CRS coordinator who achieves CFM certification.

E. Completing and maintaining FEMA elevation certificates for pre-FIRM and/or post-FIRM buildings.

F. Requiring and maintaining FEMA elevation certificates for all new and improved buildings located in floodplains.

F-8.A Participating in NFIP.

Is there a mapped floodplain within your community?
1. Download flood hazard data from the Map Service Center.
2. Review flood hazard data against existing community building and parcel data.

F-8.B Adopting ordinances that meet minimum Federal and state requirements to comply with NFIP.

See F-8 A.

F-8.C Conducting NFIP community workshops to provide information and incentives for property owners to acquire flood insurance.

See F-22 A.

F-8.D Designating a local floodplain manager and/or CRS coordinator who achieves CFM certification.

Local floodplain manager should be familiar with all regulatory and non-regulatory flood hazard products.

F-8.E Completing and maintaining FEMA elevation certificates for pre-FIRM and/or post-FIRM buildings.

1. Filter all MSDIS structures within your community for elevation information.
2. Collect EC data for remaining structures and update as available.

F-8.F Requiring and maintaining FEMA elevation certificates for all new and improved buildings located in floodplains.

See F-8 E.

	FIRM Regulatory Products			Risk MAP Non-Regulatory Products						Missouri State Datasets		Local Datasets					
	1% Annual Chance Floodplain	0.5% Annual Chance Floodplain	FIRM Datasets - Profile Baselines (streams)	Depth Grids (10%, 4%, 2%, 1%, and 0.2%)	Percent Chance over 30-Year Period Grid	Percent Annual Chance Grids	Changes Since Last Firm (CSLF)	Areas of Mitigation Interest (AOMI)	Flood Risk Assessment	MSDIS - Structure Points and Data	MoDOT - Roadways	Local - Structrue Footprints	Local - Parcels	Local - Storm/Water/Sewer Infrastructure	Local - Topography	Local - Repetitive Loss Data	Aerial Photography
Mitigation Actions																	
F-8 Join or Improve Compliance with NFIP																	
A. Participating in NFIP.	x											x	x				
B. Adopting ordinances that meet minimum Federal and state requirements to comply with NFIP.	x											x	x				
C. Conducting NFIP community workshops to provide information and incentives for property owners to acquire flood insurance.				x	x	x	x			x							
D. Designating a local floodplain manager and/or CRS coordinator who achieves CFM certification.	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
E. Completing and maintaining FEMA elevation certificates for pre-FIRM and/or post-FIRM buildings.										x		x					
F. Requiring and maintaining FEMA elevation certificates for all new and improved buildings located in floodplains.										x		x	x				

F-9 Manage the Floodplain Beyond Minimum Requirements

A. Incorporating the ASFPM's "No Adverse Impact" policy into local floodplain management programs.

B. Revising the floodplain ordinance to incorporate cumulative substantial damage requirements.

C. Adopting a "no-rise" in base flood elevation clause for the flood damage prevention ordinance.

D. Extending the freeboard requirement past the mapped floodplain to include an equivalent land elevation.

E. Including requirements in the local floodplain ordinance for homeowners to sign non-conversion agreements for areas below base flood elevation.

F. Establishing and publicizing a user-friendly, publicly-accessible repository for inquirers to obtain Flood Insurance Rate Maps.

G. Developing an educational flyer targeting NFIP policyholders on increased cost of compliance during post-flood damage assessments. ▪ Annually notifying the owners of repetitive loss properties of Flood Mitigation Assistance funding.

H. Annually notifying the owners of repetitive loss properties of Flood Mitigation Assistance funding.

I. Offering incentives for building above the required freeboard minimum (code plus).

F-9.A Incorporating the ASFPM's "No Adverse Impact" policy into local floodplain management programs.

No Adverse Impact is defined as "…an approach that ensures the action of any property owner, public or private, does not adversely impact the property and rights of others."
"Adverse impact" is measured by increased flood stages, increased flood velocity, increased flows, or the increased potential for erosion and sedimentation.
See F-9C for no-rise in base flood elevations and See F-6H for erosion and sedimentation.

F-9.B Revising the floodplain ordinance to incorporate cumulative substantial damage requirements.

Risk MAP products may be utilized to demonstrate benefits of ordinances. Structures that flood repetitively will be making improvements to their structures on a frequent basis. By adding the cumulative substantial damage clause to your local flood ordinance, structures that flood repetitively will now be brought up to current standards and avoid frequent flooding. How many structures flood frequently in your community?

1. Does your community have any repetitive loss properties? See State NFIP coordinator for updated information.
2. Identify structures that flood at high frequency events.
3. Convert the 10% and 4% Annual Chance Grids to polygons using the ESRI "Raster to Polygon" tool.
4. Select the MSDIS structures that intersect or are located within the 10% or 4% Annual Chance Floodplains.
5. From the identified structures, review depths of flooding at these high frequency events to identify priority acquisitions.

F-9.C Adopting a "no-rise" in base flood elevation clause for the flood damage prevention ordinance.

Procedures for No-Rise Certification are provided on SEMA's website; sema.dps.mo.gov/programs/floodplain/documents/no-rise-instructions.doc; Hydraulic analysis will need to be performed to support the no-rise certification for proposed development. Utilize FIRM database information and hydraulic models to review submitted No-Rise Certifications.

F-9.D Extending the freeboard requirement past the mapped floodplain to include an equivalent land elevation.

See F-4 C.

F-9.E Including requirements in the local floodplain ordinance for homeowners to sign non-conversion agreements for areas below base flood elevation.

1. Select those MSDIS structures that intersect or are located within the 1% Annual Chance Floodplain and/or 1% Annual Chance Depth Grid. Note, the 1% Annual Chance Grid may be converted to a polygon using the ESRI "Raster to Polygon" tool, for ease of structure selection.
2. Sort structures by depth of flooding.

F-9.F Establishing and publicizing a user-friendly, publicly-accessible repository for inquirers to obtain Flood Insurance Rate Maps.

Local communities may utilize and/or publicize the availability of flood risk information and GIS elements on the MSDIS website and the Map Service Center.

F-9.G Developing an educational flyer targeting NFIP policyholders on increased cost of compliance during post-flood damage assessments. ▪ Annually notifying the owners of repetitive loss properties of Flood Mitigation Assistance funding.

Having a complete inventory of properties within a community's regulatory floodplain allows for rapid data collection and more immediate use of damage assessments to develop recovery priorities. Prepare for post-flood damage assessments and delivery of educational materials by keeping property data up to date including address, ownership, year of construction, and elevation certificate information.

F-9.H Annually notifying the owners of repetitive loss properties of Flood Mitigation Assistance funding.

1. Does your community have any repetitive loss properties? See State NFIP coordinator for updated information.
2. Identify properties with the same exposure to repeated flood damage by selecting MSDIS structures with the similar depths of flooding for high frequency events.
3. Select those MSDIS structures that intersect or are located within the 10% or 4% Annual Chance Floodplain. Note, you may convert the 10% and 4% Annual Chance Grids to polygons using the ESRI "Raster to Polygon" tool.
4. Sort structures by depth of flooding.

F-9.I Offering incentives for building above the required freeboard minimum (code plus).

See F-4 C, with incentives such as reduced development fees, instead of changes to floodplain ordinance.

	FIRM Regulatory Products			Risk MAP Non-Regulatory Products						Missouri State Datasets		Local Datasets					
	1% Annual Chance Floodplain	0.5% Annual Chance Floodplain	FIRM Datasets - Profile Baselines (streams)	Depth Grids (10%, 4%, 2%, 1%, and 0.2%)	Percent Chance over 30-Year Period Grid	Percent Annual Chance Grids	Changes Since Last Firm (CSLF)	Areas of Mitigation Interest (AOMI)	Flood Risk Assessment	MSDIS - Structure Points and Data	MoDOT - Roadways	Local - Structrue Footprints	Local - Parcels	Local - Storm/Water/Sewer Infrastructure	Local - Topography	Local - Repetitive Loss Data	Aerial Photography
Mitigation Actions																	
F-9 Manage the Floodplain Beyond Minimum Requirements																	
A. Incorporating the ASFPM's "No Adverse Impact" policy into local floodplain management programs.									x				x				
B. Revising the floodplain ordinance to incorporate cumulative substantial damage requirements.				x		x				x		x				x	
C. Adopting a "no-rise" in base flood elevation clause for the flood damage prevention ordinance.	x		x							x		x	x				
D. Extending the freeboard requirement past the mapped floodplain to include an equivalent land elevation.				x						x					x		
E. Including requirements in the local floodplain ordinance for homeowners to sign non-conversion agreements for areas below base flood elevation.				x						x		x					
F. Establishing and publicizing a user-friendly, publicly-accessible repository for inquirers to obtain Flood Insurance Rate Maps.	x	x	x	x	x	x	x	x	x	x	x						
G. Developing an educational flyer targeting NFIP policyholders on increased cost of compliance during post-flood damage assessments.	x									x		x	x				
H. Annually notifying the owners of repetitive loss properties of Flood Mitigation Assistance funding.				x						x		x	x			x	
I. Offering incentives for building above the required freeboard minimum (code plus).	x			x						x		x					

F-10 Participate in the CRS Program

A. Advising the public about the local flood hazard, flood insurance, and flood protection measures.

B. Enacting and enforcing regulations that exceed NFIP minimum standards so that more flood protection is provided for new development.

C. Implementing damage reduction measures for existing buildings such as acquisition, relocation, retrofitting, and maintenance of drainageways and retention basins.

D. Taking action to minimize the effects of flooding on people, property, and building contents through measures including flood warning, emergency response, and evacuation planning.

F-10.A Advising the public about the local flood hazard, flood insurance, and flood protection measures.

See F-22 A utilizing Risk MAP products to publicize the local flood hazard and to demonstrate the need for flood insurance.
See F-23 actions A through E for flood protection measures.

F-10.B Enacting and enforcing regulations that exceed NFIP minimum standards so that more flood protection is provided for new development.

See F-9 actions A through I.

F-10.C Implementing damage reduction measures for existing buildings such as acquisition, relocation, retrofitting, and maintenance of drainageways and retention basins.

See F-12 A and F-13 actions A through G.

F-10.D Taking action to minimize the effects of flooding on people, property, and building contents through measures including flood warning, emergency response, and evacuation planning.

See F-17 A, by identifying roadways that become flooded, evacuation routes can be determined to avoid these areas.
In addition, by identifying structures that intersect or are located within the 1% annual floodplain, the number of evacuees may also be calculated and directed toward evacuation routes.

	FIRM Regulatory Products			Risk MAP Non-Regulatory Products						Missouri State Datasets		Local Datasets					
	1% Annual Chance Floodplain	0.5% Annual Chance Floodplain	FIRM Datasets - Profile Baselines (streams)	Depth Grids (10%, 4%, 2%, 1%, and 0.2%)	Percent Chance over 30-Year Period Grid	Percent Annual Chance Grids	Changes Since Last Firm (CSLF)	Areas of Mitigation Interest (AOMI)	Flood Risk Assessment	MSDIS - Structure Points and Data	MoDOT - Roadways	Local - Structrue Footprints	Local - Parcels	Local - Storm/Water/Sewer Infrastructure	Local - Topography	Local - Repetitive Loss Data	Aerial Photography
Mitigation Actions																	
F-10 Participate in the CRS																	
A. Advising the public about the local flood hazard, flood insurance, and flood protection measures.				x	x	x	x			x							
B. Enacting and enforcing regulations that exceed NFIP minimum standards so that more flood protection is provided for new development.																	
C. Implementing damage reduction measures for existing buildings such as acquisition, relocation, retrofitting, and maintenance of drainageways and retention basins.				x		x			x	x		x				x	
D. Taking action to minimize the effects of flooding on people, property, and building contents through measures including flood warning, emergency response, and evacuation planning.				x						x	x	x					

F-11 Establish Local Funding Mechanisms for Flood Mitigation

A. Using taxes to support a regulatory system.

B. Using impact fees to help fund public projects to mitigate impacts of land development (e.g., increased runoff).

C. Levying taxes to finance maintenance of drainage systems and capital improvements.

F-11.A Using taxes to support a regulatory system.

GIS elements, such as parcels, may be used in coordination with your local tax assessor to calculate adjustments to local taxes.

F-11.B Using impact fees to help fund public projects to mitigate impacts of land development (e.g., increased runoff).

For an impact fee such as a stormwater user fee, impervious area within each parcel may be digitized, using aerial photography, to quantify the impact of stormwater runoff on a community and to determine user fee rates.

F-11.C Levying taxes to finance maintenance of drainage systems and capital improvements.

The AOMI and Mitigation Action Tracker can be utilized to demonstrate the magnitude of drainage and capital improvements that would benefit from the use of tax dollars to address.

	FIRM Regulatory Products			Risk MAP Non-Regulatory Products						Missouri State Datasets		Local Datasets					
	1% Annual Chance Floodplain	0.5% Annual Chance Floodplain	FIRM Datasets - Profile Baselines (streams)	Depth Grids (10%, 4%, 2%, 1%, and 0.2%)	Percent Chance over 30-Year Period Grid	Percent Annual Chance Grids	Changes Since Last Firm (CSLF)	Areas of Mitigation Interest (AOMI)	Flood Risk Assessment	MSDIS - Structure Points and Data	MoDOT - Roadways	Local - Structrue Footprints	Local - Parcels	Local - Storm/Water/Sewer Infrastructure	Local - Topography	Local - Repetitive Loss Data	Aerial Photography
Mitigation Actions																	
F-11 Establish Local Funding Mechanisms for Flood Mitigation																	
A. Using taxes to support a regulatory system.												x	x				
B. Using impact fees to help fund public projects to mitigate impacts of land development (e.g., increased runoff).													x				x
C. Levying taxes to finance maintenance of drainage systems and capital improvements.								x						x			

VII. Examples of Tools-In-Action: Public Education and Awareness

F-22 Increase Awareness of Flood Risk and Safety

A. Encouraging homeowners to purchase flood insurance.

B. Annually distributing flood protection safety pamphlets or brochures to the owners of flood-prone property.

C. Educating citizens about safety during flood conditions, including the dangers of driving on flooded roads.

D. Using outreach programs to advise homeowners of risks to life, health, and safety.

E. Offering GIS hazard mapping online for residents and design professionals.

F. Establishing a Program for Public Information (PPI) with a PPI committee.

F-22.A Encouraging homeowners to purchase flood insurance.

1. Utilize depth grids and MSDIS structures to show depth of flooding at individual structures to encourage purchase of flood insurance.
2. Utilize the 30-Year Period Grid and MSDIS structures to show potential for flood events during a 30-year mortgage to encourage purchase of flood insurance.
3. Utilize Percent Annual Chance events and MSDIS structures to show frequency of potential flooding to encourage purchase of flood insurance.
4. Utilize CSLF and MSDIS structures to show updated need for flood insurance.

F-22.B Annually distributing flood protection safety pamphlets or brochures to the owners of flood-prone property.

1. Identify flood-prone structures by selecting MSDIS structures that intersect or are located within 1% annual chance floodplain.
2. Provide outreach materials to selected structures.

F-22.C Educating citizens about safety during flood conditions, including the dangers of driving on flooded roads.

See F-22 A.

F-22.D Using outreach programs to advise homeowners of risks to life, health, and safety.

See F-22 B.

F-22.E Offering GIS hazard mapping online for residents and design professionals.

See F-22 A.

F-22.F Establishing a Program for Public Information (PPI) with a PPI committee.

See F-22 A.

	FIRM Regulatory Products			Risk MAP Non-Regulatory Products						Missouri State Datasets		Local Datasets					
	1% Annual Chance Floodplain	0.5% Annual Chance Floodplain	FIRM Datasets - Profile Baselines (streams)	Depth Grids (10%, 4%, 2%, 1%, and 0.2%)	Percent Chance over 30-Year Period Grid	Percent Annual Chance Grids	Changes Since Last Firm (CSLF)	Areas of Mitigation Interest (AOMI)	Flood Risk Assessment	MSDIS - Structure Points and Data	MoDOT - Roadways	Local - Structrue Footprints	Local - Parcels	Local - Storm/Water/Sewer Infrastructure	Local - Topography	Local - Repetitive Loss Data	Aerial Photography
Mitigation Actions																	
F-22 Increase Awareness of Flood Risk and Safety																	
A. Encouraging homeowners to purchase flood insurance.				x	x	x	x			x							
B. Annually distributing flood protection safety pamphlets or brochures to the owners of flood-prone property.	x						x			x							
C. Educating citizens about safety during flood conditions, including the dangers of driving on flooded roads.						x					x						x
D. Using outreach programs to advise homeowners of risks to life, health, and safety.						x	x				x	x	x				x
E. Offering GIS hazard mapping online for residents and design professionals.	x	x		x	x	x	x	x		x	x	x	x				x
F. Establishing a Program for Public Information (PPI) with a PPI committee (as suggested by Activity 332 of the CRS Coordinator's Manual).	x	x		x	x	x	x	x		x	x	x	x				x

F-23 Educate Property Owners about Flood Mitigation Techniques

A. Using outreach activities to facilitate technical assistance programs that address measures that citizens can take or facilitate funding for mitigation measures.

B. Encouraging homeowners to install backflow valves to prevent reverse-flow flood damages.

C. Encouraging residents in flood-prone areas to elevate homes.

D. Educating the public about securing debris, propane tanks, yard items, or stored objects that may otherwise be swept away, damaged, or pose a hazard if picked up and washed away by floodwaters.

E. Asking residents to help keep storm drains clear of debris during storms (not to rely solely on Public Works).

F-23.A Using outreach activities to facilitate technical assistance programs that address measures that citizens can take or facilitate funding for mitigation measures.

1. Overlay the 1% Annual Chance Floodplain and/or Depth Grid on MSDIS structures and/or local structures to identify property owners located in the floodplain.
2. Provide education outreach to identified property owners.

F-23.B Encouraging homeowners to install backflow valves to prevent reverse-flow flood damages.

See F-23 A.

F-23.C Encouraging residents in flood-prone areas to elevate homes.

See F-23 A.

F-23.D Educating the public about securing debris, propane tanks, yard items, or stored objects that may otherwise be swept away, damaged, or pose a hazard if picked up and washed away by floodwaters.

See F-23 A.

F-23.E Asking residents to help keep storm drains clear of debris during storms (not to rely solely on Public Works).

1. Identify stormwater infrastructure that is causing flooding at high frequency events by reviewing the 10% or 4% Annual Chance floodplains along with your local stormwater infrastructure and note mapped locations of backwater and/or mapped locations of flooded structures adjacent to the stormwater infrastructure.
2. Utilize this flood mapping to encourage property owners to assist in keeping storm drains clear of debris.

	FIRM Regulatory Products			Risk MAP Non-Regulatory Products						Missouri State Datasets		Local Datasets					
	1% Annual Chance Floodplain	0.5% Annual Chance Floodplain	FIRM Datasets - Profile Baselines (streams)	Depth Grids (10%, 4%, 2%, 1%, and 0.2%)	Percent Chance over 30-Year Period Grid	Percent Annual Chance Grids	Changes Since Last Firm (CSLF)	Areas of Mitigation Interest (AOMI)	Flood Risk Assessment	MSDIS - Structure Points and Data	MoDOT - Roadways	Local - Structrue Footprints	Local - Parcels	Local - Storm/Water/Sewer Infrastructure	Local - Topography	Local - Repetitive Loss Data	Aerial Photography
Mitigation Actions																	
F-23 Educate Property Owners about Flood Mitigation Techniques																	
A. Using outreach activities to facilitate technical assistance programs that address measures that citizens can take or facilitate funding for mitigation measures.				x		x	x			x		x					x
B. Encouraging homeowners to install backflow valves to prevent reverse-flow flood damages.				x						x		x					x
C. Encouraging residents in flood-prone areas to elevate homes.				x	x					x		x					x
D. Educating the public about securing debris, propane tanks, yard items, or stored objects that may otherwise be swept away, damaged, or pose a hazard if picked up and washed away by floodwaters.				x						x		x					x
E. Asking residents to help keep storm drains clear of debris during storms (not to rely solely on Public Works).						x		x		x				x			

VIII. Examples of Tools-In-Action: Natural Systems Protection

F-20 Protect and Restore Natural Flood Mitigation Features

A. Protecting and enhancing landforms that serve as natural mitigation features (i.e., riverbanks, wetlands, dunes, etc.).

B. Using vegetative management, such as vegetative buffers, around streams and water sources.

C. Protecting and preserving wetlands to help prevent flooding in other areas.

D. Establishing and managing riparian buffers along rivers and streams.

E. Retaining natural vegetative beds in stormwater channels.

F. Retaining thick vegetative cover on public lands flanking rivers.

F-20.A Protecting and enhancing landforms that serve as natural mitigation features.

Utilize the profile baselines (streams) in the FIRM database and/or local stormwater infrastructure to identify natural mitigation features.

F-20.B Using vegetative management, such as vegetative buffers, around streams and water sources.

A buffer is typically a setback of a specific distance, such as 25 or 100 feet, from a channel, floodway, wetland, or other water feature. Utilize the profile baselines (streams) in the FIRM database and/or local stormwater infrastructure to identify locations for linear buffers.

F-20.C Protecting and preserving wetlands to help prevent flooding in other areas.

Utilize the profile baselines (streams) in the FIRM database and/or local stormwater infrastructure to identify locations of wetlands.

F-20.D Establishing and managing riparian buffers along rivers and streams.

See F-20 B. Utilize the profile baselines (streams) in the FIRM database to identify locations for linear buffers.

F-20.E Retaining natural vegetative beds in stormwater channels.

Utilize the profile baselines (streams) in the FIRM database and/or local stormwater infrastructure to identify locations of stormwater channels.

F-20.E Retaining thick vegetative cover on public lands flanking rivers.

1. Utilize the profile baselines (streams) in the FIRM database and/or local stormwater infrastructure to identify locations of rivers.
2. Filter MSDIS structures and/or local structure and parcel information to identify public lands.
3. Note identified public lands adjacent to identified rivers.

	FIRM Regulatory Products			Risk MAP Non-Regulatory Products						Missouri State Datasets		Local Datasets					
	1% Annual Chance Floodplain	0.5% Annual Chance Floodplain	FIRM Datasets - Profile Baselines (streams)	Depth Grids (10%, 4%, 2%, 1%, and 0.2%)	Percent Chance over 30-Year Period Grid	Percent Annual Chance Grids	Changes Since Last Firm (CSLF)	Areas of Mitigation Interest (AOMI)	Flood Risk Assessment	MSDIS - Structure Points and Data	MoDOT - Roadways	Local - Structrue Footprints	Local - Parcels	Local - Storm/Water/Sewer Infrastructure	Local - Topography	Local - Repetitive Loss Data	Aerial Photography
Mitigation Actions																	
F-20 Protect and Restore Natural Flood Mitigation Features																	
A. Protecting and enhancing landforms that serve as natural mitigation features (i.e., riverbanks, wetlands, dunes, etc.).			x											x			
B. Using vegetative management, such as vegetative buffers, around streams and water sources.			x											x			
C. Protecting and preserving wetlands to help prevent flooding in other areas.			x											x			
D. Establishing and managing riparian buffers along rivers and streams.			x														
E. Retaining natural vegetative beds in stormwater channels.			x											x			
F. Retaining thick vegetative cover on public lands flanking rivers.			x							x		x	x	x			x

F-21 Preserve Floodplains as Open Space

A. Developing an open space acquisition, reuse, and preservation plan targeting hazard areas.

B. Developing a land banking program for the preservation of the natural and beneficial functions of flood hazard areas.

C. Using transfer of development rights to allow a developer to increase densities on another parcel that is not at risk in return for keeping floodplain areas vacant.

D. Compensating an owner for partial rights, such as easement or development rights, to prevent a property from being developed.

F-21.A Developing an open space acquisition, reuse, and preservation plan targeting hazard areas.

1. Utilizing both your local parcel data and local building footprints and/or MSDIS structures, identify all open space parcels.
2. Overlay the open space parcels with the 1% annual chance depth grid to identify those open space parcels that are currently flood-prone, as well as, adjacent parcels for potential future open space.
3. Develop acquisition, reuse, and preservation plan for identified parcels.

F-21.B Developing a land banking program for the preservation of the natural and beneficial functions of flood hazard areas.

See F-21 A; Develop land banking program for identified parcels.

F-21.C Using transfer of development rights to allow a developer to increase densities on another parcel that is not at risk in return for keeping floodplain areas vacant.

See F-21 A; Utilize incentives for development outside of the flood hazard area and outside of the identified parcels.

F-21.D Compensating an owner for partial rights, such as easement or development rights, to prevent a property from being developed.

See F-21 A; Compensate property owners for partial rights to identified parcels and/or portions of identified parcels.

	FIRM Regulatory Products			Risk MAP Non-Regulatory Products						Missouri State Datasets		Local Datasets					
	1% Annual Chance Floodplain	0.5% Annual Chance Floodplain	FIRM Datasets - Profile Baselines (streams)	Depth Grids (10%, 4%, 2%, 1%, and 0.2%)	Percent Chance over 30-Year Period Grid	Percent Annual Chance Grids	Changes Since Last Firm (CSLF)	Areas of Mitigation Interest (AOMI)	Flood Risk Assessment	MSDIS - Structure Points and Data	MoDOT - Roadways	Local - Structrue Footprints	Local - Parcels	Local - Storm/Water/Sewer Infrastructure	Local - Topography	Local - Repetitive Loss Data	Aerial Photography
Mitigation Actions																	
F-21 Preserve Floodplains as Open Space																	
A. Developing an open space acquisition, reuse, and preservation plan targeting hazard areas.	x											x	x				x
B. Developing a land banking program for the preservation of the natural and beneficial functions of flood hazard areas.	x											x	x				x
C. Using transfer of development rights to allow a developer to increase densities on another parcel that is not at risk in return for keeping floodplain areas vacant.	x											x	x				x
D. Compensating an owner for partial rights, such as easement or development rights, to prevent a property from being developed.	x											x	x				x

Step. 3 Using the Mitigation Action Tracker

- Community officials, such as floodplain administrators, public works directors, utility directors, planning directors and other jurisdictional staff are encouraged to access the Mitigation Action Tracker and record areas of mitigation concern and current and mitigation projects.
- Register/Create New Account at https://mat.msc.fema.gov/AccessManagerSignin.aspx?ReturnUrl=%2f
- To add a New Action:
  - Select your County and/or Watershed from the drop-down menus to the left of the map viewer.
  - Check box your community and select the green "+ Add Mitigation Action" button
  - An interactive Mitigation Form will open (see image below).
  - Record the mitigation action or project using a series of selections and drop downs.
- To search for Existing Action:
  - Above the map viewer, select the Data tab
  - Search for your community using the "Search" box on the right.

- Action Measure 1 is defined as the percentage of population where Risk MAP helped identify new strategies or improved current planned mitigation actions in direct collaboration with communities.
- Action Measure 2 is defined as the percentage of population that has advanced identified mitigation actions. This includes communities that began implementing mitigation actions, either from their Mitigation Plan or from new strategies identified during Risk MAP.

Mitigation Action Form

Part B : Reference Sheet

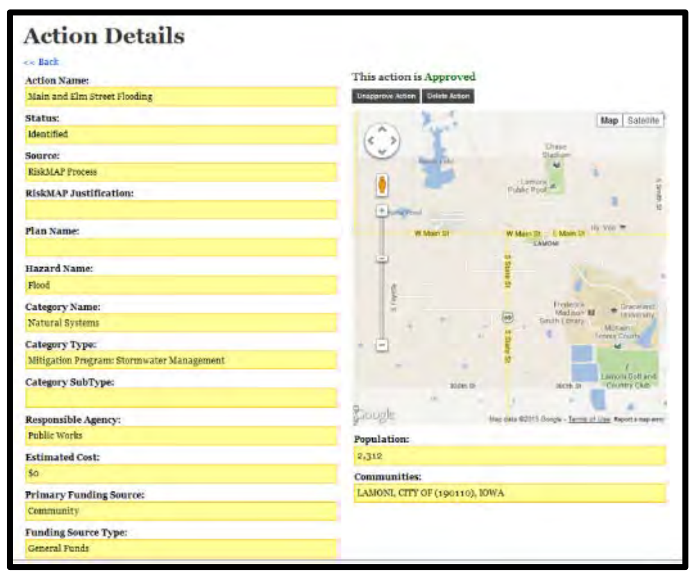
Category Types and SubTypes

Use for answering Question 11.

Local Plans and Regulations
- Building Codes
  - Enforcement
  - International Building Code
  - International Residential Code
  - Higher Standards
  - Post Disaster Code Enforcement
  - Other
- Capital Improvement Plan
- Coastal Zone Management
- Comprehensive Plan
- Easements
- Floodplain Management
- Master Plan
- Open Space Preservation
- Setbacks
- Stormwater Management
- Subdivision Ordinance
- Zoning
- Other

Community Identified Program
- Funding Mechanisms for Local Risk Reduction
- Incentives for Local Risk Reduction
- Mitigation Program
  - Fire Protection
  - Stream Maintenance
  - Tree Management
  - Other

Structure and Infrastructure Projects
- Acquisition
- UHI Albedo Enhancement
- Elevation
  - Structure
  - Utilities
  - Other
- Flood Control/Management
  - Culvert
  - Bridge Expansion
  - Detention Basin
  - Dams
  - Drainage Improvements
  - Green Roofs
  - Jetties
  - Levees
  - Permeable Paving
  - Rain Gardens
  - Revetments
  - Seawalls
  - Other
- Forest or Vegetation Management
- Natural Systems
  - Beach Nourishment
  - Dune Rehabilitation/Protection
  - Ground Water Recharge
  - Sediment Trapping Vegetation
  - Wetlands Restoration
  - Other
- Retrofit
  - Structural
  - Non-Structural
  - Other
- Safe Room Construction
- Soil Stabilization or Erosion Control
  - Sloping/Grading
  - Vegetation
  - Terracing
  - Rip Rap
  - Geotextile Fabric
- Underground Utilities
- Other



Action Details

<< Back

Action Name: Main and Elm Street Flooding

Status: Identified

Source: RiskMAP Process

RiskMAP Justification:

Plan Name:

Hazard Name: Flood

Category Name: Natural Systems

Category Type: Mitigation Program: Stormwater Management

Category SubType:

Responsible Agency: Public Works

Estimated Cost: $0

Primary Funding Source: Community

Funding Source Type: General Funds

This action is Approved

Unapprove Action | Delete Action

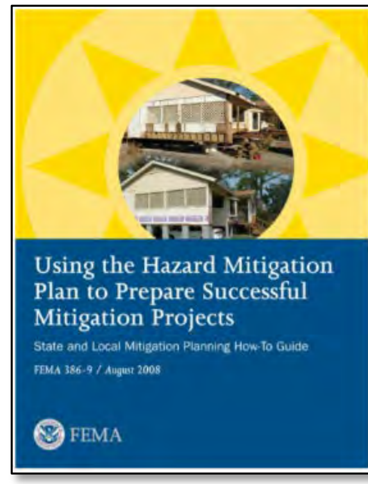
Map | Satellite

Population: 2,312

Communities: LAMONI, CITY OF (190110), IOWA

Step. 4 Moving from Mitigation Actions to Mitigation Projects

IX. Overview of Actions to Projects



- Be sure to utilize FEMA's Guide for preparing successful mitigation projects to assist in developing mitigation projects that may be implemented fully using FEMA Hazard Mitigation Assistance as appropriate.
- This Guide explains the process of developing the scope of a project, identifies the key components of a successful mitigation project funding application, and describes how to identify funding available through FEMA and other agencies.

A. Seven-Step Process

FEMA's guidance outlines a seven-step process for developing proposed mitigation actions into well-defined mitigation projects:

1. Review the Local Hazard Mitigation Plan (LHMP)
   - Review the mitigations actions included in the Mitigation Strategy section and the information contained in the Risk Assessment section of the LHMP to identify opportunities to develop mitigation projects.
2. Specify problem (SMART)
   - Specify the problem and identify alternative projects that will solve the problem.
3. Conduct feasibility review
   - Conduct a feasibility review to: (1) identify obstacles to implementing the project; and (2) to determine the best alternative for the community. The feasibility review should include a preliminary evaluation of mitigation funding opportunities to determine whether funding beyond existing community resources might be available.
4. Develop detailed scope of work
   - Fully develop the project scope of work by establishing the exact specifications and costs of the project.
5. Obtain sufficient funding
   - Obtain sufficient funding to implement and maintain the proposed mitigation project. This step may entail completing and submitting an application for funding to FEMA or another agency.
6. Implement and manage project
   - Implement, manage, and maintain the mitigation project. Communities receiving FEMA Hazard Mitigation Assistance must also comply with all reporting and administrative requirements.
7. Update Mitigation Plan and Mitigation Tracker
   - The final step is to update the community's hazard mitigation plan AND the mitigation action tracker.

B. Step 4. Develop Detailed Scope of Work

- The project scope of work fully defines and documents all associated tasks, costs, and effects of the project. Preparing the scope of work including a timeline and budget for a project can be both time consuming and costly, but the scope of work is key to developing a successful application for grant funding.
- Detailed description of the proposed project
  - Planning and design details
  - Construction details
  - Operation and maintenance plan
- Timeline or work schedule
- Detailed engineer's cost estimate

C. Step 5. Obtain Sufficient Funding

1. Identify appropriate source of funding
2. Complete an eligibility review
    - Does the community meet grant requirements – such as NFIP participation?
    - Is the funding intended for this type of project?
    - Do I have time to complete the application?
    - Do I have sufficient documentation?
3. Complete and submit application
    - Grant application components
        - Define the Problem
        - Conduct Feasibility Review
        - Develop Scope of Work
    - Use hazard mitigation plan to support the application
4. FEMA Review
    - Engineering Review
    - Benefit-Cost Review
    - Environmental and Historic Preservation Review

Eligible Mitigation Project Types	FEMA Hazard Mitigation Assistance Program				
	HMGP	PDM	FMA	RFC	SRL
Voluntary Property Acquisition/Demolition and Conversion to Open Space	√	√	√	√	√
Relocation of structure	√	√	√	√	√
Elevation of Floodprone Structures	√	√	√	√	√
Localized Minor Flood Control Projects	√	√	√	√	√
Dry Floodproofing of Residential Property meeting the definition of Historic Structure in Title 44 of the Code of Federal Regulations (CFR) Section 59.1			√		√
Dry Floodproofing of Non-residential Structures	√		√	√	
Stormwater Management/Drainage	√	√	√		√
Infrastructure Protection Measures	√	√			
Vegetative Management/Soil Stabilization	√	√			
Retrofitting or Rehabilitating Existing Buildings and Facilities (Wind/Earthquake/Wildfire)	√	√			
Safe Room Construction	√	√			
Post-disaster Code Enforcement Activities	√				
All Hazard/Flood Mitigation Planning	√	√	√		

D. Common Mistakes to Avoid

- After a grant application is prepared, it must be reviewed to ensure that it is clearly written and complete. Many applications are denied because application preparers have made mistakes. Many of these mistakes can be avoided if the project scope has been diligently developed and if each section of the application is written clearly and completely, documenting all assumptions. Common mistakes include:
  - × Project will not actually mitigate the effects of a hazard
  - × Scope of work is inadequate and provides too little detail
  - × Not providing precise information about the hazard at the project location
  - × Nuisance issue vs. real threat
  - × Project not eligible
  - × Application is incomplete
  - × Not addressing environmental and/or historic considerations
  - × Data is inconsistent

E. Step 6. Implement and Manage Project

- As practicable, a project must be implemented as described in the scope of work. Applicants or sub-applicants must adhere to project schedules and budgets. As obstacles are encountered or as the scope of work changes because of unanticipated difficulties or changing conditions, responsible parties must contact technical monitors at the funding agencies for assistance and guidance.
  - Submit quarterly programmatic and financial reports to SEMA
  - Project closeout documentation
  - Evaluate the project

F. Step 7. Update Mitigation Plan and Mitigation Tracker

1. Mitigation Plan Update

- A community can use the experience of implementing mitigation projects to update the hazard mitigation plan in five ways:
  - Summarize progress on the actions proposed in the previous plan. Routine monitoring of mitigation projects will make it easy to explain if proposed actions were completed, deleted, or deferred.
  - Improve, update, and refine the mitigation strategy. The updated mitigation strategy will outline the mitigation actions that the community will implement over the next 5 years. Progress reports reveal obstacles to project implementation that can lead to development of more realistic timelines for proposed actions. A community might want to continue to propose actions that led to successful mitigation projects and consider redefining actions that did not lead to successful mitigation projects.
  - Track the degree to which projects mitigate the effects of identified hazards to build a record of mitigation successes. For example, if a project was designed to reduce losses from flooding, whenever a flood event occurs the losses avoided as result of the mitigation project can be estimated by comparing total losses of the event with losses from a similar event before mitigation. The hazard mitigation plan can record these accomplishments to show that the

community is reducing its risk of damage and that investments in mitigation projects are benefiting the community as a whole.
  - Publicize success! Publicizing local achievements in saving lives and reducing economic losses will build support for mitigation.
  - Use the experience of developing an application for mitigation project funding to determine what types of better data are needed in the update. A well-developed plan that contains detailed information about hazards and vulnerabilities will facilitate the process of completing an application for funding to implement a mitigation project.

2. Mitigation Action Tracker Update

- Once the mitigation project is completed, update the Mitigation Action Tracker, moving the action forward to an Action Measure 2, an advanced identified mitigation action. This includes communities that began implementing mitigation actions, either from their Mitigation Plan or from new strategies identified during Risk MAP.

Appendix:
Mitigation Action Reference Table

	FIRM Regulatory Products			Risk MAP Non-Regulatory Products						Missouri State Datasets		Local Datasets						
	1% Annual Chance Floodplain	0.5% Annual Chance Floodplain	FIRM Datasets - Profile Baselines (streams)	Depth Grids (10%, 4%, 2%, 1%, and 0.2%)	Percent Chance over 30-Year Period Grid	Percent Annual Chance Grids	Changes Since Last Firm (CSLF)	Areas of Mitigation Interest (AOMI)	Flood Risk Assessment	MSDIS - Structure Points and Data	MoDOT - Roadways	Local - Structure Footprints	Local - Parcels	Local - Storm/Water/Sewer Infrastructure	Local - Topography	Local - Repetitive Loss Data	Aerial Photography	Instruction and Comments
Mitigation Actions																		
F-1 Incorporate Flood Mitigation in Local Planning																		
A. Determining and enforcing acceptable land uses to alleviate the risk of damage by limiting exposure in flood hazard areas.									X				X					1. Overlay the flood risk assessment data with your local parcel data. Identify what types of land use are located within the high risk areas. 3. Determine any necessary adjustments to current land uses and/or parcel types to address the identified high risk areas.
B. Developing a floodplain management plan and updating it regularly.	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	1. Identify local flood hazard utilizing mapped floodplain areas and percent annual chance grids. 2. Utilize Flood Risk Assessment to present flood risk in the community. 3. Utilize AOMI and Flood Risk Assessment to develop local flood mitigation actions.
C. Mitigating hazards during infrastructure planning. For example, decisions to extend roads or utilities to an area may increase exposure to flood hazards.				X				X	X		X			X				See F-17 actions A through F.
D. Adopting a post-disaster recovery ordinance based on a plan to regulate repair activity, generally depending on property location.	X			X						X		X	X					Utilize the 1% Annual Chance Floodplain, Depth Grids, Flood Risk Assessment and MSDIS structure points to familiarize the community and your local floodplain administrator with the flood hazard risk identifying areas of high risk and potential post-disaster needs.
E. Passing and enforcing an ordinance that regulates dumping in streams and ditches.			X											X				Utilize the profile baselines (streams) in the FIRM database and/or local stormwater infrastructure to identify streams and ditches.
F. Establishing a "green infrastructure" program to link, manage, and expand existing parks, preserves, greenways, etc.	X											X	X				X	1. Utilizing both your local parcel data and local building footprints and/or MSDIS structures, identify all open space parcels and existing parks, preserves, greenways, etc. 2. Overlay the open space parcels with the 1% Annual Chance Floodplain and/or Depth Grid to identify those open space parcels that are currently flood-prone, as well as, adjacent parcels for potential future open space. 3. Establish program to link identified parcels.
G. Obtaining easements for planned and regulated public use of privately-owned land for temporary water retention and drainage.	X											X	X				X	See F-21 A; Coordinate easements with open space planning.

	FIRM Regulatory Products			Risk MAP Non-Regulatory Products						Missouri State Datasets		Local Datasets						
	1% Annual Chance Floodplain	0.5% Annual Chance Floodplain	FIRM Datasets - Profile Baselines (streams)	Depth Grids (10%, 4%, 2%, 1%, and 0.2%)	Percent Chance over 30-Year Period Grid	Percent Annual Chance Grids	Changes Since Last Firm (CSLF)	Areas of Mitigation Interest (AOMI)	Flood Risk Assessment	MSDIS - Structure Points and Data	MoDOT - Roadways	Local - Structure Footprints	Local - Parcels	Local - Storm/Water/Sewer Infrastructure	Local - Topography	Local - Repetitive Loss Data	Aerial Photography	Instruction and Comments
F-2 Form Partnerships to Support Floodplain Management																		
A. Developing a stormwater committee that meets regularly to discuss issues and recommend projects.								X	X					X				Members of the stormwater committee should be familiar with locations in the community where the storm sewer system cannot adequately carry the community's design storm event. 1. Review the AOMI for identified problem areas. 2. Identify stormwater infrastructure that is causing flooding at high frequency events by reviewing the 10% or 4% Annual Chance floodplains along with your local stormwater infrastructure and note mapped locations of backwater and/or mapped locations of flooded structures adjacent to the stormwater infrastructure.
B. Forming a regional watershed council to help bring together resources for comprehensive analysis, planning, decision-making, and cooperation.	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	Members of the regional watershed council should be familiar with the regional flood hazard risk. 1. Review all flood hazard data for the watershed both regulatory and non-regulatory.
C. Establishing watershed-based planning initiatives to address the flood hazard with neighboring jurisdictions.	X	X	X	X		X		X	X									Utilize watershed-based Risk MAP tools to identify neighboring jurisdictions which are addressing the same flood hazards.
D. Forming a citizen plan implementation steering committee to monitor progress on local mitigation actions. Include a mix of representatives from neighborhoods, local businesses, and local government.								X	X									Members of the steering committee should be familiar with local mitigation actions. 1. Review the AOMI and Flood Risk Assessment for identified problem areas.

	FIRM Regulatory Products			Risk MAP Non-Regulatory Products						Missouri State Datasets		Local Datasets						
	1% Annual Chance Floodplain	0.5% Annual Chance Floodplain	FIRM Datasets - Profile Baselines (streams)	Depth Grids (10%, 4%, 2%, 1%, and 0.2%)	Percent Chance over 30-Year Period Grid	Percent Annual Chance Grids	Changes Since Last Firm (CSLF)	Areas of Mitigation Interest (AOMI)	Flood Risk Assessment	MSDIS - Structure Points and Data	MoDOT - Roadways	Local - Structure Footprints	Local - Parcels	Local - Storm/Water/Sewer Infrastructure	Local - Topography	Local - Repetitive Loss Data	Aerial Photography	Instruction and Comments
F-3 Limit or Restrict Development in Floodplain Areas																		
A. Prohibiting or limiting floodplain development through regulatory and/or incentive-based measures.	X							X	X			X	X				X	1. Overlay the flood risk assessment data with your local parcel data and MSDIS Structures. Noting high risk areas as locations to limit develop and avoid increasing flood risk. 2. See F-21A, for Open Space Preservation Plan; and F-6 Actions A through H reducing stormwater runoff; both assist with limiting and addressing development.
B. Limiting the density of developments in the floodplain.	X			X								X						Low-density, as credited through the CRS program, means that that size of the lots is at least 5 acres. 1. Utilizing both your local parcel data and local building footprints and/or MSDIS structures, identify all open space parcels. 2. Overlay the open space parcels with the 1% Annual Chance Floodplain and/or Depth Grid to identify those open space parcels that are currently flood-prone. 3. Limit areas of the identified floodplain to low-density development.
C. Requiring that floodplains be kept as open space.	X			X								X						1. Utilizing both your local parcel data and local building footprints and/or MSDIS structures, identify all open space parcels. 2. Overlay the open space parcels with the 1% Annual Chance Floodplain and/or Depth Grid to identify those open space parcels that are currently flood-prone. 3. Designate the floodplain areas of these parcels remain as open space.
D. Limiting the percentage of allowable impervious surface within developed parcels.	X										X	X	X				X	1. Community-wide, digitize impervious area within each parcel utilizing recent aerial photography. 2. For various parcel types, calculate the ratio of impervious area to total parcel area. 3. Based on the calculated ratios, determine allowable percentage of impervious area per parcel type.
E. Developing a stream buffer ordinance to protect water resources and limit flood impacts.			X															See F-20 B. Utilize the profile baselines (streams) in the FIRM database to identify locations for linear buffers.
F. Prohibiting any fill in floodplain areas.	X			X														Utilize the 1% Annual Chance Floodplain and/or Depth Grid to identify floodplain areas to prohibit fill.
F-4 Adopt and Enforce Building Codes and Development Standards																		

	FIRM Regulatory Products			Risk MAP Non-Regulatory Products						Missouri State Datasets		Local Datasets						
	1% Annual Chance Floodplain	0.5% Annual Chance Floodplain	FIRM Datasets - Profile Baselines (streams)	Depth Grids (10%, 4%, 2%, 1%, and 0.2%)	Percent Chance over 30-Year Period Grid	Percent Annual Chance Grids	Changes Since Last Firm (CSLF)	Areas of Mitigation Interest (AOMI)	Flood Risk Assessment	MSDIS - Structure Points and Data	MoDOT - Roadways	Local - Structure Footprints	Local - Parcels	Local - Storm/Water/Sewer Infrastructure	Local - Topography	Local - Repetitive Loss Data	Aerial Photography	Instruction and Comments
A. Adopting the International Building Code (IBC) and International Residential Code (IRC).																		Coordinating floodplain management with local building codes has several advantages. As noted in the CRS Manual: • There is better coordination with permitting the construction of new buildings and repairs and improvements to existing buildings; • More staff and more knowledgeable staff can better enforce floodplain building construction standards, such as foundation protection and placement of mechanical equipment; • Experienced inspectors can check compliance in the field; • There is more frequent observation of construction progress and quality of construction.
B. Adopting ASCE 24-05 Flood Resistant Design and Construction. ASCE 24 is a referenced standard in the IBC that specifies minimum requirements and expected performance for the design and construction of buildings and structures in the flood hazard areas to make them more resistant to flood loads and flood damage.				X						X		X						Is there a mapped floodplain within your community? 1. Download flood hazard data from the Map Service Center. 2. Review flood hazard data against existing community building and parcel data. 3. Adopt policy, as applicable.
C. Adding or increasing “freeboard” requirements (feet above base flood elevation) in the flood damage ordinance.				X						X		X						In most cases, flood premiums can be cut in half by elevating a home 2 feet above the BFE. 1. Select those MSDIS structures that intersect or are located within the 1% Annual Chance Floodplain and/or 1% Annual Chance Depth Grid. Note, the 1% Annual Chance Grid may be converted to a polygon using the ESRI "Raster to Polygon" tool, for ease of structure selection. 2. Sort structures by depth of flooding. 3, Based on depths of flooding, determine the number of structures that would be removed from the floodplain with the additional 2 feet of freeboard. Utilize this information to leverage your mitigation action to extend the freeboard. In additional, a comprehensive study of freeboard (American Institutes for Research, 2006) has demonstrated that adding freeboard at the time of house construction is cost-effective.

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D. Prohibiting all first floor enclosures below base flood elevation for all structures in flood hazard areas.				X						X		X						1. Select those MSDIS structures that intersect or are located within the 1% Annual Chance Floodplain and/or 1% Annual Chance Depth Grid. Note, the 1% Annual Chance Grid may be converted to a polygon using the ESRI "Raster to Polygon" tool, for ease of structure selection. 2. Determine depth of flooding at the identified structures. 3. Prohibit enclosures within the first floor enclosures below base flood elevations.
E. Considering orientation of new development during design (e.g., subdivisions, buildings, infrastructure, etc.).	X			X									X				X	1. Utilizing both your local parcel data and local building footprints and/or MSDIS structures, identify all open space parcels. Open space parces will be potential future sudivision development areas. 2. Overlay the open space parcels with the 1% annual chance depth grid to flood prone properties, base flood elevations, and orientation of flood hazard.
F. Setting the design flood elevation at or above the historical high water mark if it is above the mapped base flood elevation.	X			X				X										Coordinate with F-7A.
G. Using subdivision design standards to require elevation data collection during platting and to have buildable space on lots above the base flood elevation.	X			X						X		X	X					Utilizing both your local parcel data and local building footprints and/or MSDIS structures, identify all open space parcels. Open space parces will be potential future sudivision development areas.
H. Requiring standard tie-downs of propane tanks.	X			X						X		X	X					1. Select MSDIS structures or local parcels that intersect or are located within the 1% Annual Chance Floodplain and/or 1% Annual Chance Depth Grid. Note, the 1% Annual Chance Grid may be converted to a polygon using the ESRI "Raster to Polygon" tool, for ease of structure selection. 2. Provide education materials to property owners within the floodplain regarding requirments for propane tie-downs.

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F-5 Improve Stormwater Management Planning																		
A. Completing a stormwater drainage study for known problem areas.			X	X		X		X		X	X	X						Are there locations in your community where the storm sewer system cannot adequately carry your community's design storm event? Is there localized flooding at high frequency events? 1. Review the AOMI for identified problem areas. 2. Identify stormwater infrastructure that is causing flooding at high frequency events by reviewing the 10% or 4% Annual Chance floodplains along with your local stormwater infrastructure and note mapped locations of backwater and/or mapped locations of flooded structures adjacent to the stormwater infrastructure. 3. Complete a stormwater drainage study for the identified problem areas.
B. Preparing and adopting a stormwater drainage plan and ordinance.			X	X		X		X		X	X	X						See F-5 A; Based on the stormwater drainage study, identify mitigation actions to address problem areas through a stormwater drainage plan, and adopt completed plan.
C. Preparing and adopting a community-wide stormwater management master plan.			X	X		X		X		X	X	X						See F-5 A; Based on completed stormwater drainage studies, identify mitigation actions to address problem areas throughout the community through a stormwater drainage plan, and adopt completed plan.
D. Regulating development in upland areas in order to reduce stormwater run-off through a stormwater ordinance.			X	X		X		X		X	X	X	X					Utilize watershed boundaries in coordination with the profile baselines to identify upland areas for development regulation.
E. Linking flood hazard mitigation objectives with EPA Stormwater Phase II initiatives.			X	X		X		X			X							Coordinate stormwater regulations F-5A through H with community-wide floodplain management program.
F. Developing engineering guidelines for drainage from new development.			X	X		X		X			X		X					1. Utilizing both your local parcel data and local building footprints and/or MSDIS structures, identify all open space parcels. Open space parcels will be potential new development areas. 2. Develop guidelines for drainage from these identified areas.
G. Requiring a drainage study with new development.			X	X		X		X			X		X					See F-5.F.

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H. Encouraging the use of Low Impact Development techniques			X	X		X				X	X	X	X					Low Impact Development (LID) techniques can significantly reduce or eliminate the increase in stormwater runoff created by traditional development, encourage aquifer recharge, and promote better water quality. Utilize low-impact development features throughout the community to minimize the effective of impervious areas.
F-6 Adopt Polices to Reduce Stormwater Runoff																		
A. Designing a “natural runoff” or “zero discharge” policy for stormwater in subdivision design.						X		X						X				1. Identify stormwater infrastructure that is causing flooding at high frequency events by reviewing the 10% or 4% Annual Chance floodplains along with your local stormwater infrastructure and note mapped locations of backwater and/or mapped locations of flooded structures adjacent to the stormwater infrastructure. 2. Require implementation of on-site treatment.
B. Requiring more trees be preserved and planted in landscape designs to reduce the amount of stormwater runoff.								X										Utilize low-impact development features throughout the community to minimize the effective of imperviousness to create functional and appealing site drainage that treats stormwater as a resource rather than a waste product.
C. Requiring developers to plan for on-site sediment retention.										X		X	X		X		X	Sediment control measures should be taken on land throughout the community that is disturbed during development. Drainage systems cannot perform to their design standards if they are choked with eroded soil that has been captured in stormwater.
D. Requiring developers to construct on-site retention basins for excessive stormwater and as a firefighting water source.			X					X										Hydrologic studies can be used to determine the appropriate amount of detention or retention necessary to prevent an increase in runoff as development occurs.
E. Encouraging the use of porous pavement, vegetative buffers, and islands in large parking areas.								X										See F-6B.
F. Conforming pavement to land contours so as not to provide easier avenues for stormwater.	X			X		X								X	X			Utilize local topographic data incoordination with defined floodplains and/or depth grids to define stormwater flow paths.
G. Encouraging the use of permeable driveways and surfaces to reduce runoff and increase groundwater recharge.								X										See F-6B.
H. Adopting erosion and sedimentation control regulations for construction and farming.								X										See F-6C.

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F-7 Improve Flood Risk Assessment																		
A. Incorporating the procedures for tracking high water marks following a flood into emergency response plans.				X				X										One of the most important uses for high water marks (HWM) is allowing for comparison and revision of flood risk maps. Compare any HWMs collected with the 1% Annual Chance Depth Grid to determine if the event exceeded the mapped inundation areas, indicating additional threats to your community.
B. Conducting cumulative impact analyses for multiple development projects within the same watershed.						X					X	X	X				X	Coordinate with F-4 Actions A through H
C. Conducting a verification study of FEMA's repetitive loss inventory and developing an associated tracking database.				X		X				X		X				X		1. Does your community have any repetitive loss (RL) properties? See State NFIP coordinator for updated information. 2. Identify properties with the same exposure to repeated flood damage by selecting MSDIS structures with the similar depths of flooding for high frequency events as the RL properties. 3. Select those MSDIS structures that intersect or are located within the 1% Annual Chance Floodplain and/or 1% Annual Chance Depth Grid. Note, the 1% Annual Chance Grid may be converted to a polygon using the ESRI "Raster to Polygon" tool, for ease of structure selection. 4. Sort structures by depth of flooding and select those structures adjacent to the RL properties that have equal or greater flooding to define your RL area. 5. Maintain tracking database of RL areas and associated properties.
D. Regularly calculating and documenting the amount of flood-prone property preserved as open space.				X						X		X	X					1. Utilizing both your local parcel data and local building footprints and/or MSDIS structures, identify all open space parcels. 2. Overlay the open space parcels with the 1% annual chance depth grid to identify those open space parcels that are currently flood-prone.
E. Requiring a thorough watershed analysis for all proposed dam or reservoir projects.			X					X										Utilize the AOMI datasets to identify locations of proposed dam locations within your community.
F. Developing a dam failure study and emergency action plan.										X	X	X						Incorporate structure information into Dam Failure Study and Emergency Action Plan to identify structures located within the dam failure inundation path, as well as, MoDOT roadway information to develop evacuation routes.

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G. Using GIS to map areas that are at risk of flooding.	X	X	X	X	X	X	X	X	X									These elements are wholly stored within your FIRM Database and Flood Risk Database (FRD).
H. Obtaining depth grid data and using it to illustrate flood risk to citizens.				X	X	X	X	X	X									These elements are wholly stored within your Flood Risk Database (FRD).
I. Incorporating digital floodplain and topographic data into GIS systems, in conjunction with Hazus, to assess risk.				X	X	X	X	X	X									These elements are wholly stored within your Flood Risk Database (FRD).
J. Developing and maintaining a database to track community exposure to flood risk.										X								Maintain the Flood Risk Assessment which provides an assessment of potential financial consequences and other impacts associated with structures located in a SFHA.
K. Revising and updating regulatory floodplain maps.	X	X	X	X	X	X	X	X	X								X	Coordinate with SEMA for information on the Risk MAP schedule
F-8 Join or Improve Compliance with NFIP																		
A. Participating in NFIP.	X											X	X					Is there a mapped floodplain within your community? 1. Download flood hazard data from the Map Service Center. 2. Review flood hazard data against existing community building and parcel data.
B. Adopting ordinances that meet minimum Federal and state requirements to comply with NFIP.	X											X	X					See F-8 A.
C. Conducting NFIP community workshops to provide information and incentives for property owners to acquire flood insurance.				X	X	X	X			X								See F-22 A.
D. Designating a local floodplain manager and/or CRS coordinator who achieves CFM certification.	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	Local floodplain manager should be familiar with all regulatory and non-regulatory flood hazard products.
E. Completing and maintaining FEMA elevation certificates for pre-FIRM and/or post-FIRM buildings.										X		X						1. Filter all MSDIS structures within your community for elevation information. 2. Collect EC data for remaining structures and update as available.
F. Requiring and maintaining FEMA elevation certificates for all new and improved buildings located in floodplains.										X		X	X					See F-8 E.

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F-9 Manage the Floodplain Beyond Minimum Requirements																		
A. Incorporating the ASFPM's "No Adverse Impact" policy into local floodplain management programs.									X				X					No Adverse Impact is defined as "…an approach that ensures the action of any property owner, public or private, does not adversely impact the property and rights of others." "Adverse impact" is measured by increased flood stages, increased flood velocity, increased flows, or the increased potential for erosion and sedimentation. See F-9C for no-rise in base flood elevations and See F-6H for erosion and sedimentation.
B. Revising the floodplain ordinance to incorporate cumulative substantial damage requirements.				X		X				X		X				X		Risk MAP products may be utilized to demonstrate benefits of ordinances. Structures that flood repetitively will be making improvements to their structures on a frequent basis. By adding the cumulative substantial damage clause to your local flood ordinance, structures that flood repetitively will now be brought up to current standards and avoid frequent flooding. How many structures flood frequently in your community? 1. Does your community have any repetitive loss properties? See State NFIP coordinator for updated information. 2. Identify structures that flood at high frequency events. 3. Convert the 10% and 4% Annual Chance Grids to polygons using the ESRI "Raster to Polygon" tool. 4. Select the MSDIS structures that intersect or are located within the 10% or 4% Annual Chance Floodplains. 5. From the identified structures, review depths of flooding at these high frequency events to identify priority acquisitions.
C. Adopting a "no-rise" in base flood elevation clause for the flood damage prevention ordinance.	X		X							X		X	X					Procedures for No-Rise Certification are provided on SEMA's website; sema.dps.mo.gov/programs/floodplain/documents/no-rise-instructions.doc; Hydraulic analysis will need to be performed to support the no-rise certification for proposed development. Utlize FIRM database information and hydraulic models to review submitted No-Rise Certifications.
D. Extending the freeboard requirement past the mapped floodplain to include an equivalent land elevation.				X						X					X			See F-4 C.

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E. Including requirements in the local floodplain ordinance for homeowners to sign non-conversion agreements for areas below base flood elevation.				X						X		X						1. Select those MSDIS structures that intersect or are located within the 1% Annual Chance Floodplain and/or 1% Annual Chance Depth Grid. Note, the 1% Annual Chance Grid may be converted to a polygon using the ESRI "Raster to Polygon" tool, for ease of structure selection. 2. Sort structures by depth of flooding.
F. Establishing and publicizing a user-friendly, publicly-accessible repository for inquirers to obtain Flood Insurance Rate Maps.	X	X	X	X	X	X	X	X	X	X	X							Local communities may utilize and/or publicize the availability of flood risk information and GIS elements on the MSDIS website and the Map Service Center.
G. Developing an educational flyer targeting NFIP policyholders on increased cost of compliance during post-flood damage assessments.	X									X		X	X					Having a complete inventory of properties within a community's regulatory floodplain allows for rapid data collection and more immediate use of damage assessments to develop recovery priorities. Prepare for post-flood damage assessments and delivery of educational materials by keeping property data up to date including address, ownership, year of construction, and elevation certificate information.
H. Annually notifying the owners of repetitive loss properties of Flood Mitigation Assistance funding.				X						X		X	X			X		1. Does your community have any repetitive loss properties? See State NFIP coordinator for updated information. 2. Identify properties with the same exposure to repeated flood damage by selecting MSDIS structures with the similar depths of flooding for high frequency events. 3. Select those MSDIS structures that intersect or are located within the 10% or 4% Annual Chance Floodplain. Note, you may convert the 10% and 4% Annual Chance Grids to polygons using the ESRI "Raster to Polygon" tool. 4. Sort structures by depth of flooding.
I. Offering incentives for building above the required freeboard minimum (code plus).	X			X						X		X						See F-4 C, with incentives such as reduced development fees, instead of changes to floodplain ordinance.

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F-10 Participate in the CRS																		
A. Advising the public about the local flood hazard, flood insurance, and flood protection measures.				X	X	X	X			X								See F-22 A utilizing Risk MAP products to publicize the local flood hazard and to demonstrate the need for flood insurance. See F-23 actions A through E for flood protection measures.
B. Enacting and enforcing regulations that exceed NFIP minimum standards so that more flood protection is provided for new development.																		See F-9 actions A through I.
C. Implementing damage reduction measures for existing buildings such as acquisition, relocation, retrofitting, and maintenance of drainageways and retention basins.				X		X			X	X		X				X		See F-12 A and F-13 actions A through G.
D. Taking action to minimize the effects of flooding on people, property, and building contents through measures including flood warning, emergency response, and evacuation planning.				X						X	X	X						See F-17 A, by identifying roadways that become flooded, evacuation routes can be determined to avoid these areas. In addition, by identifying structures that intersect or are located within the 1% annual floodplain, the number of evacuees may also be calculated and directed toward evacuation routes.
F-11 Establish Local Funding Mechanisms for Flood Mitigation																		
A. Using taxes to support a regulatory system.												X	X					GIS elements, such as parcels, may be used in coordination with your local tax assessor to calculate adjustments to local taxes.
B. Using impact fees to help fund public projects to mitigate impacts of land development (e.g., increased runoff).													X				X	For an impact fee such as a stormwater user fee, impervious area within each parcel may be digitized, using aerial photography, to quantify the impact of stormwater runoff on a community and to determine user fee rates.
C. Levying taxes to finance maintenance of drainage systems and capital improvements.								X						X				The AOMI and Mitigation Action Tracker can be utilized to demonstrate the magnitude of drainage and capital improvements that would benefit from the use of tax dollars to address.

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	1% Annual Chance Floodplain	0.5% Annual Chance Floodplain	FIRM Datasets - Profile Baselines (streams)	Depth Grids (10%, 4%, 2%, 1%, and 0.2%)	Percent Chance over 30-Year Period Grid	Percent Annual Chance Grids	Changes Since Last Firm (CSLF)	Areas of Mitigation Interest (AOMI)	Flood Risk Assessment	MSDIS - Structure Points and Data	MoDOT - Roadways	Local - Structure Footprints	Local - Parcels	Local - Storm/Water/Sewer Infrastructure	Local - Topography	Local - Repetitive Loss Data	Aerial Photography	Instruction and Comments
F-12 Remove Existing Structures from Flood Hazard Areas																		
A. Communities may remove structures from flood-prone areas to minimize future flood losses by acquiring and demolishing or relocating structures from voluntary property owners and reserving lands subject to repetitive flooding.				X		X				X		X				X		Acquisitions may be prioritized for a community by previous flood history, potential future flooding, and other community priorities such as linked open space and greenways. 1. Does your community have any repetitive loss properties? See State NFIP coordinator for updated information. 2. Identify structures that flood at <u>high frequency events.</u> 3. Convert the 10% and 4% Annual Chance Grids to polygons using the ESRI "Raster to Polygon" tool. 4. Select the MSDIS structures that intersect or are located within the 10% or 4% Annual Chance Floodplains. 5. From the identified structures, review depths of flooding at these high frequency events to identify priority acquisitions.
F-13 Improve Stormwater Drainage System Capacity																		
A. Installing, re-routing, or increasing the capacity of a storm drainage system.						X		X		X				X				Are there locations in your community where the storm sewer system cannot adequately carry your community's design storm event? Is there localized flooding at high frequency events? 1. Review the AOMI for identified problem areas. 2. Identify stormwater infrastructure that is causing flooding at high frequency events by reviewing the 10% or 4% Annual Chance floodplains along with your local stormwater infrastructure and note mapped locations of backwater and/or mapped locations of flooded structures adjacent to the stormwater infrastructure.
B. Increasing drainage or absorption capacities with detention and retention basins, relief drains, spillways, drain widening/dredging or rerouting, logjam and debris removal, extra culverts, bridge modification, dike setbacks, flood gates and pumps, or channel redirection.			X											X				Hydrologic studies can be used to determine the appropriate amount of detention or retention necessary to prevent an increase in runoff as development occurs. Utlize the FIRM database and local stormwater infrastructure to note existing drainage features.

	FIRM Regulatory Products			Risk MAP Non-Regulatory Products						Missouri State Datasets		Local Datasets						
	1% Annual Chance Floodplain	0.5% Annual Chance Floodplain	FIRM Datasets - Profile Baselines (streams)	Depth Grids (10%, 4%, 2%, 1%, and 0.2%)	Percent Chance over 30-Year Period Grid	Percent Annual Chance Grids	Changes Since Last Firm (CSLF)	Areas of Mitigation Interest (AOMI)	Flood Risk Assessment	MSDIS - Structure Points and Data	MoDOT - Roadways	Local - Structure Footprints	Local - Parcels	Local - Storm/Water/Sewer Infrastructure	Local - Topography	Local - Repetitive Loss Data	Aerial Photography	Instruction and Comments
C. Increasing capacity of stormwater detention and retention basins.						X				X				X	X			1. Review local stormwater infrastructure to identify the location of all detention/retention ponds. 2. Are the retention/detention ponds located within a drainage area that experiences flooding? Review the percent annual chance grids along with intersecting MSDIS structures. 3. Compare current detention/retention ponds against existing topography to determine if additional storage capacity is available. 4. Hydrologic studies can be used to determine the appropriate amount of detention or retention necessary to prevent an increase in runoff as development occurs.
D. Increasing dimensions of drainage culverts in flood-prone areas.						X		X		X				X				See F-13A.
E. Using stream restoration to ensure adequate drainage and diversion of stormwater.			X			X		X		X				X			X	See F-13A. Utilize profile baseline (streams) and aerial photography to identify areas of stream restoration.
F. Requiring developers to construct on-site retention basins for excessive stormwater and as a firefighting water source.						X				X				X	X			Requiring development to retain stormwater will alleviate downstream flooding caused by increased impervious areas. Hydrologic studies can be used to determine the appropriate amount of detention or retention necessary to prevent an increase in runoff as development occurs.
G. Providing grassy swales along roadsides.						X		X		X	X			X			X	See F-13A. Utilize MoDOT Roadways and aerial photography to identify roadways not accompanied with grassy swales.

	FIRM Regulatory Products			Risk MAP Non-Regulatory Products						Missouri State Datasets		Local Datasets						
	1% Annual Chance Floodplain	0.5% Annual Chance Floodplain	FIRM Datasets - Profile Baselines (streams)	Depth Grids (10%, 4%, 2%, 1%, and 0.2%)	Percent Chance over 30-Year Period Grid	Percent Annual Chance Grids	Changes Since Last Firm (CSLF)	Areas of Mitigation Interest (AOMI)	Flood Risk Assessment	MSDIS - Structure Points and Data	MoDOT - Roadways	Local - Structure Footprints	Local - Parcels	Local - Storm/Water/Sewer Infrastructure	Local - Topography	Local - Repetitive Loss Data	Aerial Photography	Instruction and Comments
F-14 Conduct Regular Maintenance for Drainage Systems and Flood Control Structures																		
A. Performing regular drainage system maintenance, such as sediment and debris clearance, as well as detection and prevention of discharges into stormwater and sewer systems from home footing drains, downspouts, or sewer pumps.						X					X			X				Utilize local stormwater infrastructure mapping to define regular maintenance schedules. Utilize high frequency flood events to identify locations where debris may accumulate due to frequent flooding. 1. Identify potential debris locations by selecting stormwater infrastructure and/or MoDOT roadways that intersect with 10% or 4% annual chance floodplains.
B. Implementing an inspection, maintenance, and enforcement program to help ensure continued structural integrity of dams and levees.			X					X										Utilize the FIRM and AOMI datasets to identify locations of all dams/levees within your community. Utilizing partnerships with the USACE and local Levee owners, maintenance records for these systems can be assessed to ensure actions are being implemented.
C. Routinely cleaning debris from support bracing underneath low-lying bridges.						X					X			X				See F-14A.
D. Routinely cleaning and repairing stormwater drains.						X					X			X				See F-14A.
E. Regularly clearing sediment build-up on riverbanks near aerial lines.			X														X	Utilize profile baselines and aerial photography to identify areas of riverbanks. Consider investment in bathymetry.
F. Inspecting bridges and identifying if any repairs or retrofits are needed to prevent scour.						X					X			X				Utilize the FIRM database and local stormwater infrastructure to identify locations of existing bridges and associated infrastructure. For those structures not maintained by MoDOT, develop inspection and maintenance program.
G. Incorporating ice jam prevention techniques as appropriate.			X														X	Review USACE Ice Jam Database, as maintained by the Ice Engineering Group to identify historic ice jams events and applicability to your community. Utilize profile baselines and aerial photography to identify locations for potential ice jam techniques. https://rsgisias.crrel.usace.army.mil/icejam/

	FIRM Regulatory Products			Risk MAP Non-Regulatory Products						Missouri State Datasets		Local Datasets						
	1% Annual Chance Floodplain	0.5% Annual Chance Floodplain	FIRM Datasets - Profile Baselines (streams)	Depth Grids (10%, 4%, 2%, 1%, and 0.2%)	Percent Chance over 30-Year Period Grid	Percent Annual Chance Grids	Changes Since Last Firm (CSLF)	Areas of Mitigation Interest (AOMI)	Flood Risk Assessment	MSDIS - Structure Points and Data	MoDOT - Roadways	Local - Structure Footprints	Local - Parcels	Local - Storm/Water/Sewer Infrastructure	Local - Topography	Local - Repetitive Loss Data	Aerial Photography	Instruction and Comments
F-15 Elevate or Retrofit Structures and Utilities																		
A. Elevating structures so that the lowest floor, including the basement, is raised above the base flood elevation.	X			X						X		X						1. Select those MSDIS structures that intersect or are located within the 1% Annual Chance Floodplain and/or 1% Annual Chance Depth Grid. Note, the 1% Annual Chance Grid may be converted to a polygon using the ESRI "Raster to Polygon" tool, for ease of structure selection. 2. Sort structures by depth of flooding.
B. Raising utilities or other mechanical devices above expected flood levels.				X						X		X						See F-15 A. Review Elevation Certificates, as available, for elevations of utilities or other mechanical devices at specific structures.
C. Elevating and anchoring manufactured homes or, preferably, keeping manufactured homes out of the floodplain.				X						X		X						See F-15 A. Filter MSDIS Structure data to select mobile homes.
D. Relocating utilities and water heaters above base flood elevation and using tankless water heaters in limited spaces.				X						X		X						See F-15 A. Review Elevation Certificates, as available, for elevations of utilities or water heaters at specific structures.
F-16 Floodproof Residential and Non-Residential Structures																		
A. Wet floodproofing in a basement, which may be preferable to attempting to keep water out completely because it allows for controlled flooding to balance exterior and interior wall forces and discourages structural collapse.	X			X						X		X						1. Select those MSDIS structures that intersect or are located within the 1% Annual Chance Floodplain and/or 1% Annual Chance Depth Grid. Note, the 1% Annual Chance Grid may be converted to a polygon using the ESRI "Raster to Polygon" tool, for ease of structure selection. 2. Filter MSDIS Structure data to select homes with basements.
B. Encouraging wet floodproofing of areas above base flood elevation.	X			X						X		X						1. Select those MSDIS structures that intersect or are located within the 1% Annual Chance Floodplain and/or 1% Annual Chance Depth Grid. Note, the 1% Annual Chance Grid may be converted to a polygon using the ESRI "Raster to Polygon" tool, for ease of structure selection. 2. Filter MSDIS Structure data to select homes with finished floors below BFE. 3. Provide outreach materials on wet floodproofing to filtered structures.

	FIRM Regulatory Products			Risk MAP Non-Regulatory Products						Missouri State Datasets		Local Datasets						
	1% Annual Chance Floodplain	0.5% Annual Chance Floodplain	FIRM Datasets - Profile Baselines (streams)	Depth Grids (10%, 4%, 2%, 1%, and 0.2%)	Percent Chance over 30-Year Period Grid	Percent Annual Chance Grids	Changes Since Last Firm (CSLF)	Areas of Mitigation Interest (AOMI)	Flood Risk Assessment	MSDIS - Structure Points and Data	MoDOT - Roadways	Local - Structure Footprints	Local - Parcels	Local - Storm/Water/Sewer Infrastructure	Local - Topography	Local - Repetitive Loss Data	Aerial Photography	Instruction and Comments
C. Using water resistant paints or other materials to allow for easy cleanup after floodwater exposure in accessory structures or in a garage area below an elevated residential structure.	X			X						X		X						1. Select those MSDIS structures that intersect or are located within the 1% Annual Chance Floodplain and/or 1% Annual Chance Depth Grid. Note, the 1% Annual Chance Grid may be converted to a polygon using the ESRI "Raster to Polygon" tool, for ease of structure selection. 2. Filter MSDIS Structure data to select homes with finished floors below BFE. 3. Provide outreach materials on water resistant paints to filtered structures.
D. Dry floodproofing non-residential structures by strengthening walls, sealing openings, or using waterproof compounds or plastic sheeting on walls to keep water out.	X			X						X		X						1. Select those MSDIS structures that intersect or are located within the 1% Annual Chance Floodplain and/or 1% Annual Chance Depth Grid. Note, the 1% Annual Chance Grid may be converted to a polygon using the ESRI "Raster to Polygon" tool, for ease of structure selection. 2. Filter MSDIS Structure data to select non-residential structures with finished floors below BFE.
F-17 Protect Infrastructure																		
A. Elevating roads and bridges above the base flood elevation to maintain dry access. In situations where flood waters tend to wash roads out, construction, reconstruction, or repair can include not only attention to drainage, but also stabilization or armoring of vulnerable shoulders or embankments.				X							X							Is "turn around, don't drown" a common theme in your community due to frequent roadway overtopping? 1. Identify low-flow roadway crossings by selecting those MoDOT roadways that intersect with high frequency flood events. Review for mapped overtopping. 2. Determine depth of flooding over roadways using high frequency flood depth dataset.
B. Raising low-lying bridges.	X			X							X							See F-17 A.
C. Floodproofing wastewater treatment facilities located in flood hazard areas.		X		X						X		X						1. Select those MSDIS structures that intersect or are located within the 1% Annual Chance Floodplain and/or 1% Annual Chance Depth Grid. Note, the 1% Annual Chance Grid may be converted to a polygon using the ESRI "Raster to Polygon" tool, for ease of structure selection. 2. Filter MSDIS Structure data to select critical facilities with finished floors below BFE.

	FIRM Regulatory Products			Risk MAP Non-Regulatory Products						Missouri State Datasets		Local Datasets						
	1% Annual Chance Floodplain	0.5% Annual Chance Floodplain	FIRM Datasets - Profile Baselines (streams)	Depth Grids (10%, 4%, 2%, 1%, and 0.2%)	Percent Chance over 30-Year Period Grid	Percent Annual Chance Grids	Changes Since Last Firm (CSLF)	Areas of Mitigation Interest (AOMI)	Flood Risk Assessment	MSDIS - Structure Points and Data	MoDOT - Roadways	Local - Structure Footprints	Local - Parcels	Local - Storm/Water/Sewer Infrastructure	Local - Topography	Local - Repetitive Loss Data	Aerial Photography	Instruction and Comments
D. Floodproofing water treatment facilities located in flood hazard areas.		X		X						X		X						See F-17 C.
E. Depending on its infrastructure capabilities, using check valves, sump pumps, and backflow prevention devices in homes and buildings.	X			X						X		X						See F-15 A.
F. Using bioengineered bank stabilization techniques.	X			X								X	X				X	See F-13A. Utilize profile baseline (streams) and aerial photography to identify areas of stream restoration.
F-18 Protect Critical Facilities																		
A. Requiring that all critical facilities including emergency operations centers (EOC), police stations, and fire department facilities be located outside of flood-prone areas.		X		X						X		X						1. Select those MSDIS structures that intersect or are located within the 0.2% Annual Chance Floodplain and/or 0.2% Annual Chance Depth Grid. Note, the 0.2% Annual Chance Grid may be converted to a polygon using the ESRI "Raster to Polygon" tool, for ease of structure selection. 2. Filter MSDIS Structure data to select critical facilities. 3. Note any critical facilities located within the mapped floodplain. 4. Utilize 0.2% floodplain boundary for future construction of critical facilities.
B. Requiring all critical facilities to meet requirements of Executive Order 11988 and be built 1 foot above the 500-year flood elevation.		X		X						X		X						1. Select those MSDIS structures that intersect or are located within the 0.2% Annual Chance Floodplain and/or 0.2% Annual Chance Depth Grid. Note, the 0.2% Annual Chance Grid may be converted to a polygon using the ESRI "Raster to Polygon" tool, for ease of structure selection. 2. Filter MSDIS Structure data to select critical facilities. 3. Review finished floor of critical facilities and 0.2% flood elevation.
C. Installing/upgrading stormwater pumping stations.		X		X						X		X						1. Select those MSDIS structures that intersect or are located within the 0.2% Annual Chance Floodplain and/or 0.2% Annual Chance Depth Grid. Note, the 0.2% Annual Chance Grid may be converted to a polygon using the ESRI "Raster to Polygon" tool, for ease of structure selection. 2. Filter MSDIS Structure data to select critical facilities/stormwater pump stations. 3. Coordinate with local stormwater infrastructure, as needed.

	FIRM Regulatory Products			Risk MAP Non-Regulatory Products						Missouri State Datasets		Local Datasets						
	1% Annual Chance Floodplain	0.5% Annual Chance Floodplain	FIRM Datasets - Profile Baselines (streams)	Depth Grids (10%, 4%, 2%, 1%, and 0.2%)	Percent Chance over 30-Year Period Grid	Percent Annual Chance Grids	Changes Since Last Firm (CSLF)	Areas of Mitigation Interest (AOMI)	Flood Risk Assessment	MSDIS - Structure Points and Data	MoDOT - Roadways	Local - Structure Footprints	Local - Parcels	Local - Storm/Water/Sewer Infrastructure	Local - Topography	Local - Repetitive Loss Data	Aerial Photography	Instruction and Comments
D. Raising electrical components of sewage lift stations above base flood elevation.		X		X						X		X						See F-18 A. Review Elevation Certificates, as available, for elevations of sewer lift stations at specific structures.
E. Raising manhole openings using concrete pillars.		X		X							X							1. Identify sewer manholes located within the 1% Annual Chance floodplain by overlaying the local sewer infrastructure with the 1% annual chance depth grid. Note, the 1% Annual Chance Grid may be converted to a polygon using the ESRI "Raster to Polygon" tool, for ease of structure selection.
F. Installing watertight covers or inflow guards on sewer manholes.		X		X							X			X				1. Identify sewer manholes located within the 1% Annual Chance floodplain by overlaying the local sewer infrastructure with the 1% annual chance depth grid. 2. Install water tight covers or inflow guards on all manholes identified in the floodplain.
G. Installing flood telemetry systems in sewage lift stations.		X		X						X		X		X				1. Select those MSDIS structures that intersect or are located within the 0.2% Annual Chance depth grid. 2. Filter MSDIS Structure data to select critical facilities/sanitary sewer lift stations. 3. Coordinate with local sewer infrastructure, as needed.
H. Installing back-up generators for pumping and lift stations in sanitary sewer systems along with other measures (e.g., alarms, meters, remote controls, and switchgear upgrades).		X		X						X		X		X				1. Select those MSDIS structures that intersect or are located within the 0.2% Annual Chance depth grid. 2. Filter MSDIS Structure data to select critical facilities/sanitary sewer pumping and lift stations. 3. Coordinate with local sewer infrastructure, as needed.
I. Building earthen dikes around flood-threatened critical facilities.		X		X						X		X	X				X	See F-18 A.
J. Using bioengineered bank stabilization techniques.		X		X								X	X				X	See F-13A. Utilize profile baselines (streams) and aerial photography to identify areas of stream restoration.
F-19 Construct Flood Control Measures																		
A. Using minor structural projects that are smaller and more localized (e.g., floodwalls or small berms) in areas that cannot be mitigated through non-structural activities or where structural activities are not feasible due to low densities.				X		X		X		X	X	X		X		X		Based on problem areas identified in the AOMI or through F-12A (structures); F-13A (stormwater infrastructure); and F17A (roadway infrastructure); use minor structural projects to address.

	FIRM Regulatory Products			Risk MAP Non-Regulatory Products						Missouri State Datasets		Local Datasets						
	1% Annual Chance Floodplain	0.5% Annual Chance Floodplain	FIRM Datasets - Profile Baselines (streams)	Depth Grids (10%, 4%, 2%, 1%, and 0.2%)	Percent Chance over 30-Year Period Grid	Percent Annual Chance Grids	Changes Since Last Firm (CSLF)	Areas of Mitigation Interest (AOMI)	Flood Risk Assessment	MSDIS - Structure Points and Data	MoDOT - Roadways	Local - Structure Footprints	Local - Parcels	Local - Storm/Water/Sewer Infrastructure	Local - Topography	Local - Repetitive Loss Data	Aerial Photography	Instruction and Comments
B. Using revetments (hardened materials placed atop existing riverbanks or slopes) to protect against floods.			X											X	X		X	Utilize the profile baselines (streams) in the FIRM database and/or local stormwater infrastructure to identify riverbanks. Aerial photography and local topography may also be utilized to identify steep slopes for riprap and/or revetments.
C. Using bioengineered bank stabilization techniques.	X			X								X	X				X	See F-13A. Utilize profile baselines (streams) and aerial photography to identify areas of stream restoration.
F-20 Protect and Restore Natural Flood Mitigation Features																		
A. Protecting and enhancing landforms that serve as natural mitigation features (i.e., riverbanks, wetlands, dunes, etc.).			X											X				Utilize the profile baselines (streams) in the FIRM database and/or local stormwater infrastructure to identify natural mitigation features.
B. Using vegetative management, such as vegetative buffers, around streams and water sources.			X											X				A buffer is typically a setback of a specific distance, such as 25 or 100 feet, from a channel, floodway, wetland, or other water feature. Utilize the profile baselines (streams) in the FIRM database and/or local stormwater infrastructure to identify locations for linear buffers.
C. Protecting and preserving wetlands to help prevent flooding in other areas.			X											X				Utilize the profile baselines (streams) in the FIRM database and/or local stormwater infrastructure to identify locations of wetlands.
D. Establishing and managing riparian buffers along rivers and streams.			X															See F-20 B. Utilize the profile baselines (streams) in the FIRM database to identify locations for linear buffers.
E. Retaining natural vegetative beds in stormwater channels.			X											X				Utilize the profile baselines (streams) in the FIRM database and/or local stormwater infrastructure to identify locations of stormwater channels.
F. Retaining thick vegetative cover on public lands flanking rivers.			X							X		X	X	X			X	1. Utilize the profile baselines (streams) in the FIRM database and/or local stormwater infrastructure to identify locations of rivers. 2. Filter MSDIS structures and/or local structure and parcel information to identify public lands. 3. Note identified public lands adjacent to identified rivers.
F-21 Preserve Floodplains as Open Space																		

	FIRM Regulatory Products			Risk MAP Non-Regulatory Products						Missouri State Datasets		Local Datasets						
	1% Annual Chance Floodplain	0.5% Annual Chance Floodplain	FIRM Datasets - Profile Baselines (streams)	Depth Grids (10%, 4%, 2%, 1%, and 0.2%)	Percent Chance over 30-Year Period Grid	Percent Annual Chance Grids	Changes Since Last Firm (CSLF)	Areas of Mitigation Interest (AOMI)	Flood Risk Assessment	MSDIS - Structure Points and Data	MoDOT - Roadways	Local - Structure Footprints	Local - Parcels	Local - Storm/Water/Sewer Infrastructure	Local - Topography	Local - Repetitive Loss Data	Aerial Photography	Instruction and Comments
A. Developing an open space acquisition, reuse, and preservation plan targeting hazard areas.	X											X	X				X	1. Utilizing both your local parcel data and local building footprints and/or MSDIS structures, identify all open space parcels. 2. Overlay the open space parcels with the 1% annual chance depth grid to identify those open space parcels that are currently flood-prone, as well as, adjacent parcels for potential future open space. 3. Develop acquisition, reuse, and preservation plan for identified parcels.
B. Developing a land banking program for the preservation of the natural and beneficial functions of flood hazard areas.	X											X	X				X	See F-21 A; Develop land banking program for identified parcels.
C. Using transfer of development rights to allow a developer to increase densities on another parcel that is not at risk in return for keeping floodplain areas vacant.	X											X	X				X	See F-21 A; Utilize incentives for development outside of the flood hazard area and outside of the identified parcels.
D. Compensating an owner for partial rights, such as easement or development rights, to prevent a property from being developed.	X											X	X				X	See F-21 A; Compensate property owners for partial rights to identified parcels and/or portions of identified parcels.
F-22 Increase Awareness of Flood Risk and Safety																		
A. Encouraging homeowners to purchase flood insurance.				X	X	X	X			X								1. Utilize depth grids and MSDIS structures to show depth of flooding at individual structures to encourage purchase of flood insurance. 2. Utilize the 30-Year Period Grid and MSDIS structures to show potential for flood events during a 30-year mortgage to encourage purchase of flood insurance. 3. Utilize Percent Annual Chance events and MSDIS structures to show frequency of potential flooding to encourage purchase of flood insurance. 4. Utilize CSLF and MSDIS structures to show updated need for flood insurance.

	FIRM Regulatory Products			Risk MAP Non-Regulatory Products						Missouri State Datasets		Local Datasets						
	1% Annual Chance Floodplain	0.5% Annual Chance Floodplain	FIRM Datasets - Profile Baselines (streams)	Depth Grids (10%, 4%, 2%, 1%, and 0.2%)	Percent Chance over 30-Year Period Grid	Percent Annual Chance Grids	Changes Since Last Firm (CSLF)	Areas of Mitigation Interest (AOMI)	Flood Risk Assessment	MSDIS - Structure Points and Data	MoDOT - Roadways	Local - Structure Footprints	Local - Parcels	Local - Storm/Water/Sewer Infrastructure	Local - Topography	Local - Repetitive Loss Data	Aerial Photography	Instruction and Comments
B. Annually distributing flood protection safety pamphlets or brochures to the owners of flood-prone property.	X						X			X								1. Identify flood-prone structures by selecting MSDIS structures that intersect or are located within 1% annual chance floodplain. 2. Provide outreach materials to selected structures.
C. Educating citizens about safety during flood conditions, including the dangers of driving on flooded roads.						X					X						X	See F-22 A.
D. Using outreach programs to advise homeowners of risks to life, health, and safety.						X	X				X	X	X				X	See F-22 B.
E. Offering GIS hazard mapping online for residents and design professionals.	X	X		X	X	X	X	X		X	X	X	X				X	See F-22 A.
F. Establishing a Program for Public Information (PPI) with a PPI committee (as suggested by Activity 332 of the CRS Coordinator's Manual).	X	X		X	X	X	X	X		X	X	X	X				X	See F-22 A.

	FIRM Regulatory Products			Risk MAP Non-Regulatory Products						Missouri State Datasets		Local Datasets						
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F-23 Educate Property Owners about Flood Mitigation Techniques																		
A. Using outreach activities to facilitate technical assistance programs that address measures that citizens can take or facilitate funding for mitigation measures.				X		X	X			X		X					X	1. Overlay the 1% Annual Chance Floodplain and/or Depth Grid on MSDIS structures and/or local structures to identify property owners located in the floodplain. 2. Provide education outreach to identified property owners.
B. Encouraging homeowners to install backflow valves to prevent reverse-flow flood damages.				X						X		X					X	See F-23 A.
C. Encouraging residents in flood-prone areas to elevate homes.				X	X					X		X					X	See F-23 A.
D. Educating the public about securing debris, propane tanks, yard items, or stored objects that may otherwise be swept away, damaged, or pose a hazard if picked up and washed away by floodwaters.				X						X		X					X	See F-23 A.
E. Asking residents to help keep storm drains clear of debris during storms (not to rely solely on Public Works).						X		X		X				X				1. Identify stormwater infrastructure that is causing flooding at high frequency events by reviewing the 10% or 4% Annual Chance floodplains along with your local stormwater infrastructure and note mapped locations of backwater and/or mapped locations of flooded structures adjacent to the stormwater infrastructure. 2. Utilize this flood mapping to encourage property owners to assist in keeping storm drains clear of debris.

Appendix C1

Missouri Earthquake Risk Assessment Enhancements

Bridges and Hazardous Materials Facilities

Missouri Earthquake Risk Assessment Enhancements

Bridges and Hazardous Materials Facilities

Prepared for:

Central United States Earthquake Consortium

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This report was prepared for the Central United States Earthquake Consortium (CUSEC) in coordination with the Missouri State Emergency Management Agency (SEMA) by Amec Foster Wheeler Environment & Infrastructure, Inc., (Amec Foster Wheeler). The quality of information, conclusions and estimates contained herein are consistent with the level of effort involved in Amec Foster Wheeler's services and based on: i) information available at the time of preparation, ii) data supplied by outside sources and iii) the assumptions, conditions and qualifications set forth in this report. This report is intended to be used by CUSEC and SEMA subject to the terms and conditions of the contract with Amec Foster Wheeler. Any other use of, or reliance on, this report by any third party is at that party's sole risk.

TABLE OF CONTENTS

List of Figures

List of Tables

List of Appendices

Missouri Earthquake Risk Assessment Enhancements
Bridges and Hazardous Materials Facilities Analysis

1.0 Background

Earthquake hazards are significant risk in eastern and southeastern Missouri due to the proximity of the New Madrid Seismic Zone. The risk from earthquakes associated with the New Madrid and other seismic zones is characterized and analyzed in the Missouri State Hazard Mitigation Plan (HMP). Losses from earthquakes are commonly modeled with FEMA's Hazus-MH program. The earthquake vulnerability assessment of Missouri's HMP, previously updated in 2013, included a Hazus-MH 2.1 earthquake loss scenario based on an event with a 2% probability of exceedance in 50 years to model a worst case earthquake using a level of ground shaking recognized in earthquake-resistant design. A limitation of the analysis used at that time was the use of Level I inventory data for bridges and hazardous materials facilities. The plan included a recommendation to expand the risk assessment in the next update to incorporate additional hazard data (groundwater depths to refine the liquefaction data inputs); and updated hazardous materials facility and bridge inventory to further refine the vulnerability assessment to identify areas that may warrant further analysis or targeted mitigation. This report, completed in June and July 2017, is part of an effort to enhance earthquake risk assessment as an enhancement to a parallel effort associated with the 2017-2018 update of the Missouri State Hazard Mitigation Plan (HMP). Amec Foster Wheeler performed a Hazus V 3.2. Level II Hazus earthquake analysis for these facilities under a contract with the Central Unites States Earthquake Consortium. A similar analysis, focused on high potential loss facilities (schools, fire and medical facilities) was completed through a contract with the Missouri State Emergency Management Agency and is summarized in a separate report. Both of these efforts will be summarized to inform the 2018 Missouri HMP Update and provide information for basing additional hazard mitigation efforts for the State Risk Management Team.

1.1 Hazus-MH Data Enhancements

This study included Level II enhancements to both the hazard and inventory inputs to the Hazus model. These data sets were used as additional, Level II data inputs to enhance the accuracy of earthquake hazard modeling. These are discussed further below.

1.1.1 Hazard Data

1.1.1.1 Soils and Soil Liquefaction Hazards

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. A general statewide soils layer, with assigned site classification characteristics based on National Earthquake Hazards Reduction Program (NEHRP) shaking potential, was obtained from the Missouri Department of Natural Resources.

1.1.1.2 Groundwater Depth

Hazus allows the user to set a single value for groundwater depth when defining hazard layers for a scenario. This is an important aspect of soil liquefaction potential, as liquefiable soils are saturated soils with a shallow groundwater tables, typically within 30 ft. of the ground surface. A statewide wells databased was obtained from the Missouri Department of Natural Resources (MODNR). A GIS query was performed to obtain the wells within liquefaction hazard areas. A second query was done to obtain the average value of the depth to groundwater within the well in liquefaction areas. The average was 10 ft., which was used to define the groundwater depth for the scenario.

1.1.1.3 Ground Shaking

Hazus V 3.2 was the version used to analyze vulnerability to earthquakes. Included with Hazus is USGS probabilistic ground shaking mapping, which provided the source of shaking based on an event with a 2% probability of exceedance in 50 years. This shaking level was used to model a worst case earthquake using a level of ground shaking recognized in earthquake-resistant design. Version 3.2 of Hazus incorporates the USGS national seismic hazard maps that were updated in 2014.

1.1.2 Inventory Data

Default Hazus inventories for bridges and hazardous materials facilities were replaced with data supplied by the State of Missouri. These are described further below. The bridges data set was formatted for use in Hazus using the Hazus Comprehensive Data Management System (CDMS) tool. This tool syncs data and attributes field necessary for Hazus analysis and imports the enhanced data set into the Hazus study region. The hazardous materials facilities were not formatted using CDMS as the analysis for these facilities was completed outside of Hazus.

1.1.2.1 Bridges

Data was collected from the Missouri Department of Transportation (MoDOT) which included the construction and/or rehabilitation date of bridges to determine if seismic retrofitting was addressed within the design. Bridges constructed prior to the 1981 AASHTO approval of Seismic Design Guidelines for Highway Bridges are inadequately prepared for a seismic event. Bridges constructed after 1981 were identified within the database as having seismic design incorporated. An attribute in the database also identified those bridges that had been seismically retrofitted. The seismic design and other bridge elements necessary for Hazus analysis were formatted for incorporation into Hazus with the CDMS tool.

1.1.2.2 Hazardous Materials Facilities

Data provided by the Missouri Emergency Response Commission (MERC) provided the baseline for hazardous materials facilities. A spreadsheet of hazardous materials storage facilities, based on Tier II reporting forms filed and maintained by the MERC at SEMA, provided the basis to develop a complete and updated GIS database of facilities which store hazardous materials. The locations of facilities were geolocated based on an address field provided with the data. The Emergency Planning and Community Right-to-Know Act (EPCRA) of 1986 requires industries to report on the storage, use and releases of hazardous substances to federal, state, and local governments. Facilities in Missouri must submit an emergency and hazardous chemical inventory form to the Missouri Emergency Response Commission, their Local Emergency Planning Committee (LEPC), and local fire departments annually. The inventory forms require basic facility identification information, employee contact information for both emergencies and non-emergencies, and information about chemicals stored or used at the facility.

This data was supplemented with hazardous materials facilities GIS-based information from the Homeland Security Infrastructure Program (HSIP Freedom 2016) to ensure a comprehensive analysis of facilities including those that may not be associated with the Tier II reporting list. The HSIP data includes hazardous materials facilities based on the Environmental Protection Agency Facility Registry Service (FRS) Emergency Response (ER) databases. Within this report, these facilities are referred to as “EPA-tracked facilities”. This data includes the following datasets within Missouri:

- Comprehensive Environmental Response, Compensation, and Liability Information System (CERCLIS) facilities
  - 283 facilities
- Toxic Release Inventory (TRI) facilities
  - 1,391 Facilities
- Toxic Substances Control Act (TSCA) facilities
  - 264 facilities
- Facility Response Plan (FRP) facilities
  - 49 facilities
- Resource Conservation and Recovery Act, Treatment, Storage, and Disposal (RCRATSD) facilities
  - 48 facilities
- Risk Management Plan (RMP) facilities
  - 512 facilities

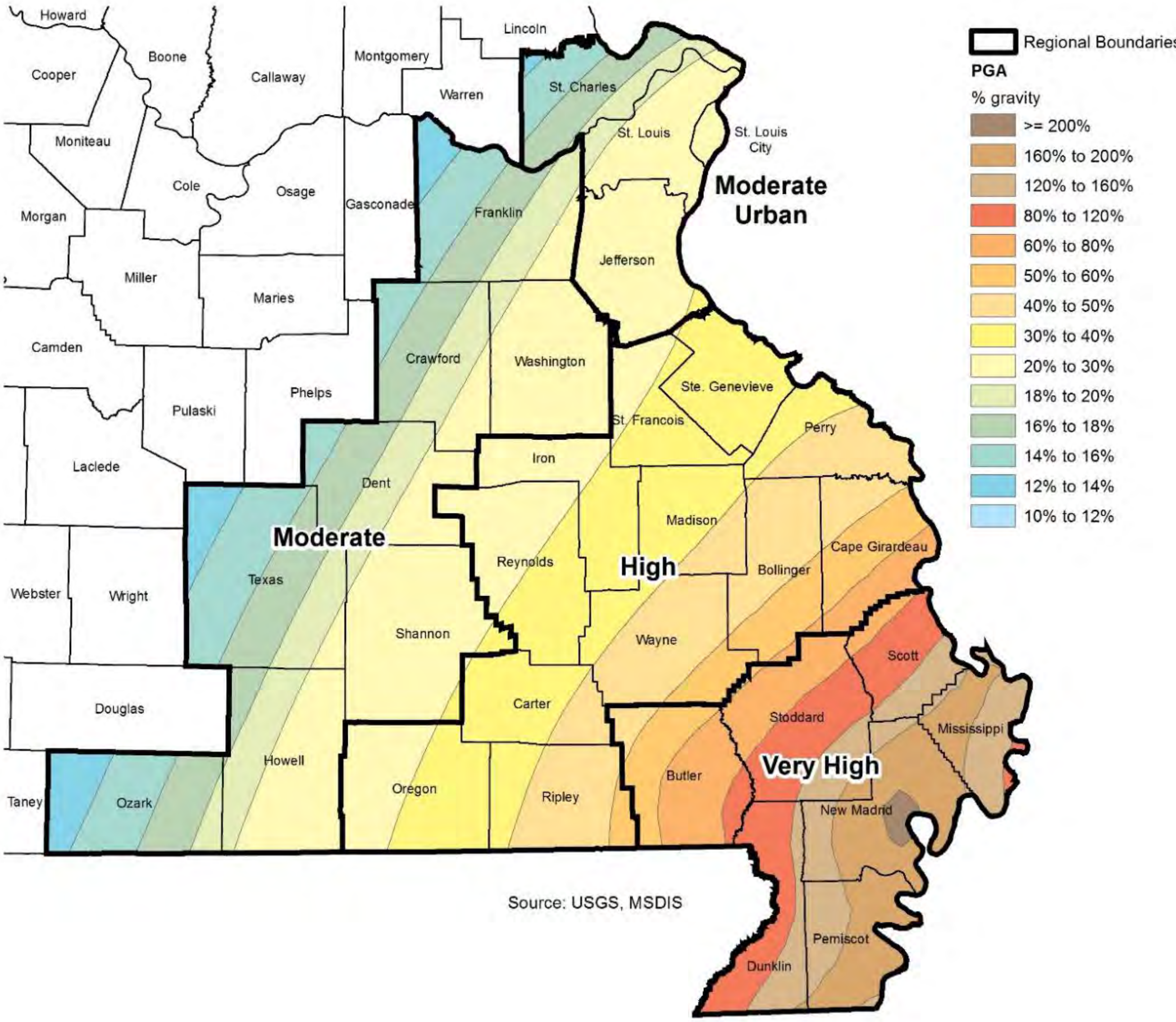
1.2 Methodology

The scenario for this assessment, based on an event with a 2% probability of exceedance in 50 years, was done to model a worst case scenario that is consistent with that utilized for earthquake risk modeling for the Missouri State HMP. This scenario is equivalent to the 2,500 year earthquake scenario in Hazus-MH. The methodology is based on probabilistic seismic hazard shaking grids developed by the U.S. Geological Survey (USGS) for the National Seismic Hazard Maps that are included with Hazus MH. The USGS maps provide estimates of peak ground acceleration and spectral acceleration at periods of 0.3 second and 1.0 second, respectively, which have a 2% probability of exceedance in the next 50 years. The International Building Code uses this level of ground shaking for building design in seismic areas. This scenario used a 7.7 driving magnitude in Hazus-MH, which is the magnitude used for typical New Madrid fault planning scenarios in Missouri. While the 2% probability of exceedance in the next 50 years ground motion maps incorporate the shaking potential from all faults with earthquake potential in and around Missouri, the most severe shaking is predominately generated by the New Madrid Fault. This pattern of shaking can be seen in Figure 1, with corresponding potential for damage.

1.2.1 Analysis Regions

Counties with damaging Peak Ground Acceleration (PGA) ground shaking levels were analyzed based on the 2% in 50 years probabilistic ground shaking maps. This was based on a PGA levels ranging from at least 18% g, where moderate damage could be anticipated, to over 200% g where very heavy damages could occur. This level of shaking affects 31counties in southeast and eastern Missouri. Another consideration was ground shaking needed to produce liquefaction in liquefaction-susceptible soils, which generally requires PGA levels of 15% g and above. Analysis sub-regions were created to further subdivide and group the counties into regions generally categorized by damage potential ranging from moderate, high, to very high. The other reason for subdividing the regions was to reduce processing time, as Hazus would take several days to process a region of 15 or more counties. The moderate sub-region was further sub-divided into an urban-moderate region to represent the St Louis metropolitan area counties. Initial Hazus runs indicated that bridge damage potential dropped considerably outside of the counties located in the very southeast corner of the state, thus Hazus analysis of regions in other parts of the state were not considered further so that effort could be focused in the highest risk areas.

Figure 1. Study Area and Sub-regions Analyzed in Hazus



2.0 Analysis and Results

2.1 Bridge Analysis

Hazus regions based on the parameters previously described were set up and processed to model earthquake damages to bridges. For bridges, fragility curves are defined within the Hazus model in terms of Spectral Acceleration - Sa - (0.3 sec), Sa (1.0 sec) and Potential Ground Deformation (PGD, which reflects liquefaction potential). The model also takes into account the bridge structural characteristics. Within Hazus, bridges are classified based on the following structural characteristics:

- Seismic Design
- Number of spans: single vs. multiple span bridges
- Structure type: concrete, steel, others
- Pier type: multiple column bents, single column bents and pier walls
- Abutment type and bearing type: monolithic vs. non-monolithic; high rocker bearings,
- low steel bearings and neoprene rubber bearings
- Span continuity: continuous, discontinuous (in-span hinges), and simply supported.

Based on the ground shaking, PGD, and structural characteristics Hazus calculates the likelihood or probability of each bridge to be damaged. A total of five damage categories, termed damage states (ds), are defined for bridges within Hazus. These are none (ds1), slight/minor (ds2), moderate (ds3), extensive (ds4) and complete (ds5). These are described in more detail in the table below.

Table 1. Bridge Damage States Defined by Hazus

Damage Category	Description
None (ds1)	No damage
Slight/Minor Damage (ds2)	For bridges, ds2 is defined by minor cracking and spalling to the abutment, cracks in shear keys at abutments, minor spalling and cracks at hinges, minor spalling at the column (damage requires no more than cosmetic repair) or minor cracking to the deck
Moderate Damage (ds3)	For bridges, ds3 is defined by any column experiencing moderate (shear cracks) cracking and spalling (column structurally still sound), moderate movement of the abutment (<2"), extensive cracking and spalling of shear keys, any connection having cracked shear keys or bent bolts, keeper bar failure without unseating, rocker bearing failure or moderate settlement of the approach.
Extensive Damage (ds4)	For bridges, ds4 is defined by any column degrading without collapse – shear failure - (column structurally unsafe), significant residual movement at connections, or major settlement approach, vertical offset of the abutment, differential settlement at connections, shear key failure at abutments.
Complete Damage (ds5)	For bridges, ds5 is defined by any column collapsing and connection losing all bearing support, which may lead to imminent deck collapse, tilting of substructure due to foundation failure.

Source: Hazus Technical Manual

Hazus also provide an estimate of post-earthquake bridge functionality. This is presented by the level of functionality estimated at days 1, 3, 7, 14, 30 and 90 following the earthquake. Thus, a low percent functionality indicates a high risk bridge. Bridges with a high percent functional value (i.e. 90% or higher) are expected to be operational.

The Hazus model results indicate that a large number of bridges in the extreme southeast 'bootheel' region (Very High Damage Hazus sub-region) of the state would be completely damaged and out of service for extensive periods of time following a major earthquake.

The map in the following figure illustrates the results of the analysis. Bridges with a seismic design incorporation or retrofits are highlighted on the map. These bridges have a lower probability for damage. In some areas, the functionality of the road networks with these seismically-designed bridges would be compromised by damages of bridges without seismic design. While the road network itself was not analyzed, it can be assumed that the road network itself would have extensive damage due to the liquefiable soils in the bootheel region which would likely result in lateral ground spreading and differential settlement.

The following table summarizes the average damage probability for bridges by county. Counties where over 50% of the bridges are likely to be completely damaged are highlighted in the table. This includes Dunklin, New Madrid, Mississippi, and Pemiscot counties.

Figure 2. Map of Bridge Damage Probability

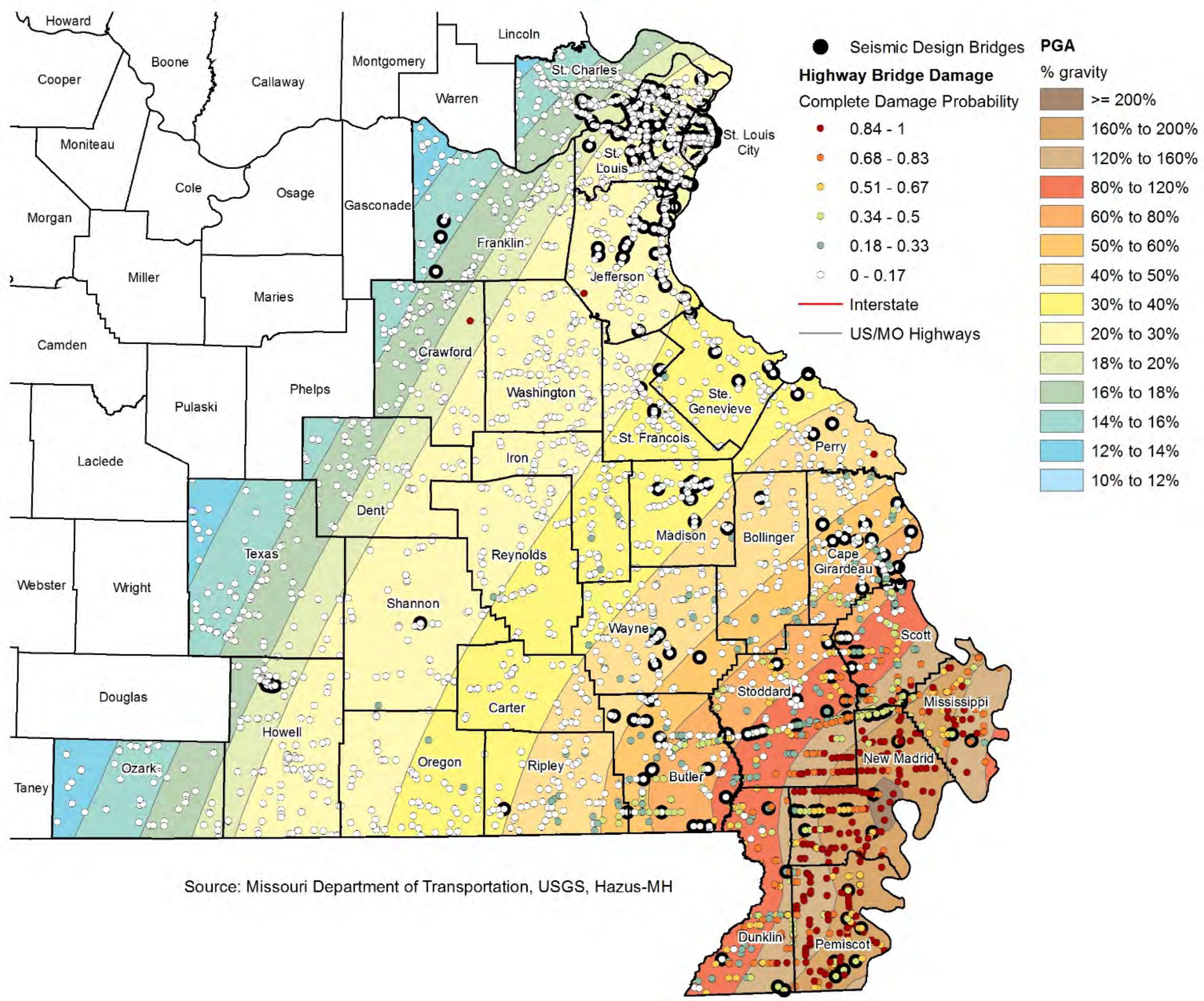


Table 2. Bridge Damage Probability by County

Counties	Average for Damage State					
	Bridge Counts	None	Slight	Moderate	Extensive	Complete
Bollinger	65	0.56	0.17	0.09	0.1	0.08
Butler	136	0.39	0.16	0.13	0.14	0.18
Cape Girardeau	147	0.5	0.17	0.11	0.12	0.11
Carter	43	0.71	0.13	0.07	0.05	0.04
Crawford	86	0.88	0.06	0.03	0.01	0.02
Dent	60	0.83	0.09	0.04	0.03	0.01
Dunklin	110	0.11	0.09	0.1	0.18	0.52
Franklin	134	0.86	0.07	0.04	0.02	0.01
Howell	123	0.87	0.07	0.03	0.02	0.01
Iron	80	0.76	0.12	0.05	0.04	0.03
Jefferson	189	0.78	0.09	0.06	0.04	0.03
Madison	67	0.68	0.15	0.07	0.06	0.04
Mississippi	61	0.04	0.06	0.06	0.15	0.7
New Madrid	148	0.03	0.04	0.04	0.11	0.77
Oregon	58	0.72	0.14	0.06	0.05	0.03
Ozark	46	0.82	0.09	0.04	0.03	0.02
Pemiscot	135	0.02	0.04	0.05	0.12	0.76
Perry	51	0.62	0.14	0.1	0.07	0.07
Reynolds	64	0.75	0.12	0.06	0.04	0.03
Ripley	70	0.61	0.14	0.08	0.09	0.08
Scott	99	0.19	0.13	0.13	0.17	0.38
Shannon	43	0.72	0.12	0.07	0.05	0.03
St. Charles	199	0.88	0.06	0.04	0.01	0.01
St. Francois	87	0.75	0.12	0.07	0.04	0.03
St. Louis	165	0.86	0.07	0.04	0.02	0.02
St. Louis City	468	0.85	0.07	0.04	0.02	0.01
Ste. Genevieve	64	0.71	0.12	0.08	0.06	0.04
Stoddard	188	0.19	0.14	0.1	0.17	0.41
Texas	85	0.86	0.07	0.04	0.02	0.01
Washington	95	0.85	0.07	0.04	0.02	0.01
Wayne	121	0.64	0.16	0.08	0.07	0.05

Summary results by Hazus sub-region (refer to Figure 1.1) are shown in Table 3 and Table 4. The analysis also indicates that the probability of complete damage drops considerably in the Hazus sub-regions designated as high, moderate, moderate-urban, or high damage potential. No bridges in the St Louis metropolitan area had complete or extensive damage based on the Hazus modeling.

Table 3. Expected Bridge Damage Summary by Hazus sub-region

EQ Sub-Regions	Bridge Counts	With at Least Mod. Damage	With Complete Damage	With Functionality > 50 %	
				After Day 1	After Day 7
Very High	877	698	460	176	276
High	917	103	1	823	883
Urban Moderate	1,021	13	2	1,008	1,019
Moderate	672	5	1	667	671
Total	**3,487**	**819**	**464**	**2,674**	**2,849**

Table 4. Bridge Damage Probability by Hazus sub-region

EQ Sub-Regions based on expected damage	Average for Damage State					
	Bridge Counts	None	Slight	Moderate	Extensive	Complete
Very High	877	0.14	0.09	0.09	0.15	0.53
High	917	0.67	0.14	0.08	0.07	0.05
Urban Moderate	1,021	0.84	0.07	0.05	0.02	0.02
Moderate	672	0.84	0.08	0.04	0.03	0.02

Additional details on bridges with a greater than 0.90 complete damage probability can be referenced in Appendix A. Details include the Bridge ID, county, route designation, and feature crossed by the bridge. Appendix B includes similar details for the highest risk bridges and functionality estimated at days 1, 3, 7, 14, 30 and 90 following the earthquake.

The following tables summarize the highest risk bridges by county and route as an indication of which routes would be most compromised due to the number of bridges with a high likelihood of complete damage (>0.90). The analysis shows New Madrid County having the greatest number of completely damaged buildings. The major routes that could have completely damaged bridges include Interstate 55 S (3 bridges) and 55 N (1 bridge). US routes 62, 61, and 60 could be compromised as well.

Table 5. Count of Bridges with Damage Probability >0.90 Complete by County and Route

County	Route	# of Bridges Complete Damage >0.90
Mississippi	MO 75 S	2
	RT C E	1
	RT D E	1
	US 60 E	1
	US 62 E	1
	Total	**6**
New Madrid	604 E	1
	IS 55 N	1
	IS 55 S	1
	MO 153 S	3
	MO 162 E	8
	MO 80 E	4
	RT A E	1
	RT AA S	1

County	Route	# of Bridges Complete Damage >0.90
	RT B S	1
	RT D E	13
	RT E S	2
	RT EE E	2
	RT F S	2
	RT H E	3
	RT HH E	2
	RT M E	2
	RT P E	4
	RT TT S	1
	RT U E	3
	RT W E	3
	RT ZZ E	3
	US 61 S	3
	US 62 E	4
	Total	**68**
Pemiscot	IS 55 S	2
	MO 164 E	1
	RT C S	3
	RT CC S	1
	RT F E	1
	RT H S	1
	RT J E	1
	RT K E	2
	RT M E	1
	RT O E	1
	RT P S	5
	RT T E	1
	US 61 N	1
	US 61 S	1
	Total	**22**
Stoddard	RT A E	5
	Total	**5**
	Grand Total	**101**

Table 6. Count of Bridge Damage Probability >0.90 Complete by Route

Route	# of Bridges Complete Damage >0.90
RT D E	14
MO 162 E	8
RT A E	6
RT P S	5
US 62 E	5
MO 80 E	4
RT P E	4
US 61 S	4
IS 55 S	3
MO 153 S	3
RT C S	3
RT H E	3
RT M E	3
RT U E	3
RT W E	3
RT ZZ E	3
MO 75 S	2
RT E S	2
RT F S	2
RT EE E	2
RT HH E	2
RT K E	2
604 E	1
IS 55 N	1
MO 164 E	1
RT AA S	1
RT B S	1
RT C E	1
RT CC S	1
RT F E	1
RT H S	1
RT J E	1
RT O E	1
RT T E	1
RT TT S	1
US 60 E	1
US 61 N	1
Total	**101**

2.1.1 Bridges Over Major Waterways Analysis

Bridges over major waterways that are likely to be impassable and/or not viable for emergency evacuation routes based on Hazus estimates of damage, probability and functionality were analyzed. Major waterways in the study area include the Mississippi and Missouri Rivers; no bridges were found to be potentially compromised on the Missouri River in the northern portion of the study area. There are only four bridges crossing the Mississippi River south of Cape Girardeau in the area of greatest seismic risk. The anticipated damage probability of these bridges is summarized in the table below. Based on this analysis the bridges with the greatest potential for damage include Interstate 57 S, US 60 W, and Interstate 57 S. The bridge on State Highway 34 E in Cape Girardeau County has less potential for damage which is likely a result of the incorporated seismic design. Details on all bridges crossing major river waterways in the study area can be referenced in Appendix A (damage potential) and Appendix B (functionality).

Table 7. Bridge Damage Potential on Mississippi River Crossings in Southeast Missouri

County	Average for Damage State					
	Route	None	Slight	Moderate	Extensive	Complete
Cape Girardeau	MO 34 E *	0.3950	0.2638	0.1126	0.1575	0.0709
Mississippi	Interstate 57 S	0.0175	0.0237	0.0785	0.1046	0.7754
Mississippi	US 60 W	0.0043	0.0149	0.0300	0.1306	0.8200
Pemiscot	Interstate 155 S	0.0099	0.0151	0.0558	0.0825	0.8364

*Incorporated seismic design

2.2 Hazardous Materials Facilities Analysis

Hazardous materials storage facilities within high risk areas (high ground shaking and liquefaction) were analyzed to identify facilities of potential concern. Hazus does not specifically model the potential for releases and other earthquake impacts from hazardous materials facilities. This is due to the many variables that exist in the type of building construction and types of materials present at the facilities. Due to this limitation, the damage potential for Tier II hazardous materials facilities were modeled outside of Hazus using a GIS overlay of the facilities with the 2,500 yr earthquake ground shaking levels. The following levels of damage are typically associated with PGA levels shown in the table below. Counts of Tier II facilities are summarized based on the potential damage levels. The analysis shows that 187 Tier II facilities and 56 EPA-tracked facilities would likely experience very heavy damage. The facilities most at risk are within Mississippi, New Madrid, Pemiscot, Dunklin, Scott, and Stoddard counties in the bootheel or Very High Damage Hazus sub-region. Additionally, these facilities are also potentially at risk to liquefaction. A count of all facilities that intersect liquefaction areas are shown below in the table; those in the moderate to very heavy potential damage ranges could potentially sustain damage from liquefaction in susceptible soils. Appendix C has more detail on the facilities that intersect very heavy damage potential shaking zones including the county, facility name, facility name, and PGA range. Note: some facilities are repeated if they are classified as Tier II facilities and/or fall into more than one EPA facility type.

Table 8. Tier II Facilities Damage Summary Table

Acceleration (%g) (PGA)	2% Map Contour Range (%g) (PGA)	Potential Damage	Facility count by PGA range	Facility count by PGA range on Liquefiable Soils
<0.17	0-2	None	0	NA
0.17 – 1.4	0-2	None	0	NA
0.17 – 1.4	0-2	None	0	NA
1.4 – 3.9	2-4	None	278	64
3.9 – 9.2	4-10	Very Light	4,429	621
9.2 – 18	10-18	Light	1,119	121
18 – 34	18-30	Moderate	1,578	483
34 – 65	30-60	Moderate to Heavy	300	50
65 – 124	60-120	Heavy	235	173
>124	120-160	Very Heavy	82	82
>124	160- 200	Very Heavy	86	86
>124	200	Very Heavy	19	19

Figure 3. Map of Hazardous Materials Tier II Facilities and Damage Potential

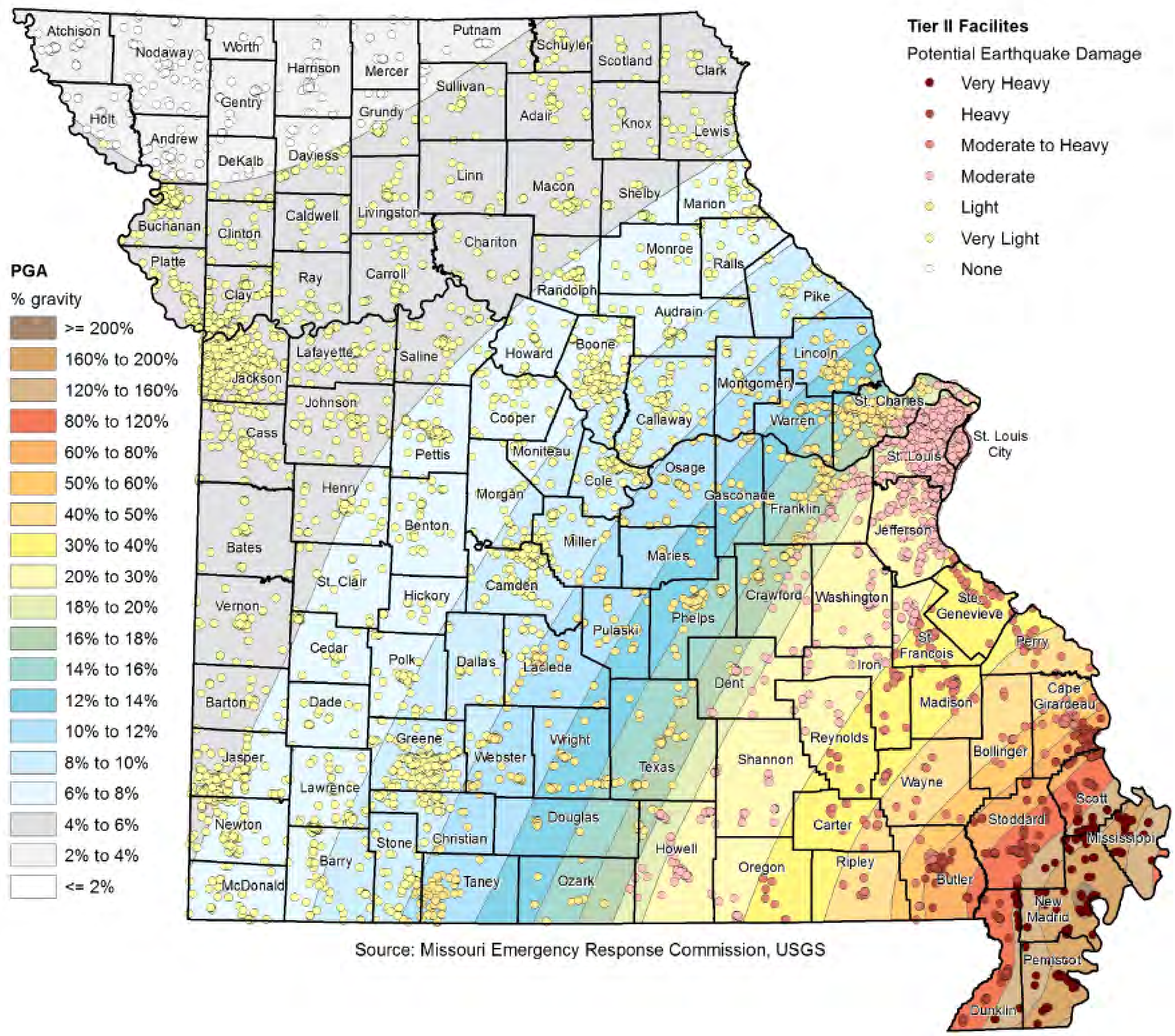
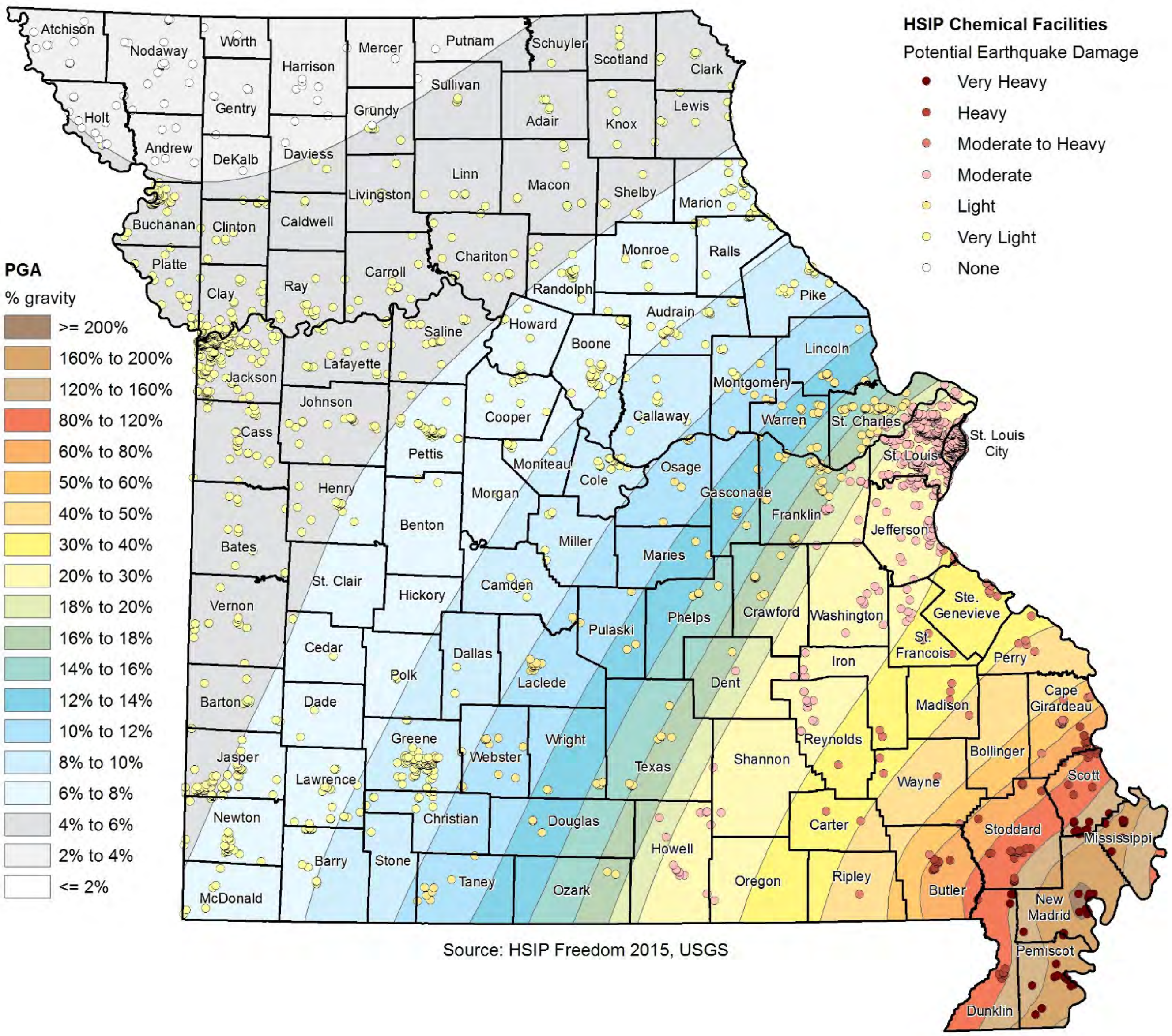


Table 9. EPA-Tracked Hazardous Materials Facilities Damage Summary Table

Acceleration (%g) (PGA)	2% Map Contour Range (%g) (PGA)	Potential Damage	Facility count by PGA range	Facility count by PGA range on Liquefiable Soils
<0.17	0-2	None	0	NA
0.17 – 1.4	0-2	None	0	NA
0.17 – 1.4	0-2	None	0	NA
1.4 – 3.9	4-Feb	None	78	38
3.9 – 9.2	10-Apr	Very Light	1,312	386
9.2 – 18	18-Oct	Light	242	31
18 – 34	18-30	Moderate	728	320
34 – 65	30-60	Moderate to Heavy	60	23
65 – 124	60-120	Heavy	69	59
>124	120-160	Very Heavy	21	21
>124	160- 200	Very Heavy	23	23
>124	200	Very Heavy	12	12

Figure 4. Map of EPA-Tracked Hazardous Materials Facilities and Damage Potential



3.0 Recommendations for Next Steps and Further Analysis

The results presented in this report can be used to identify bridges that could be targeted for additional hazard mitigation including seismic retrofitting. The results can also be used to support hazardous materials planning, emergency preparedness, response and evacuation planning.

1. Specific bridge seismic hazard assessment

Bridges with a high probability of damage/low post-earthquake functionality that are on major routes should be further evaluated for seismic hazard and retrofit potential.

2. Incorporate road and overall system functionality into the analysis.

Interdependence of components (roads and bridges) on overall system functionality is not addressed by the Hazus methodology. Such considerations require a network system analysis that would need to be performed by a highway system expert.

3. Emergency ingress/egress planning to high-risk counties

The initial analysis indicates that many routes in the high-risk counties will have compromised emergency ingress/egress. Alternate methods to provide ingress of emergency services may need to be planned for such as suitable helipads and air support.

4. Refined analysis of Hazardous Materials Facility Risk

The databases of facilities shown to have the potential for severe damage could be further analyzed based on hazardous materials types and quantities. These facilities could be targeted for on-site assessments for earthquake induced release potential and investigated for mitigation needs such as bracing storage containers and shelving to limit potential releases.

5. Use Results to plan for post-earthquake Hazardous Materials preparedness

The databases of facilities shown to have the potential for severe damage could be used to support Local Emergency Planning Committee preparedness planning and exercises to better prepare state and local entities that may be tasked to respond to a hazardous materials release within a challenging post-earthquake response and recovery environment.

6. Improved Accuracy of Tier II Facility Locations

A spreadsheet of hazardous materials storage facilities, based on Tier II reporting forms filed and maintained by the Missouri Emergency Response Commission at SEMA, provided the basis to develop a complete and updated GIS database of Tier II facilities which store hazardous materials. For this report, the locations of facilities were then geolocated based on an address field provided with the data. Through this process, it was observed that some errors and inaccuracies exist within the MERC facility address entries. A system to collect and provide more accurate locations of Tier II facilities in the state would increase the accuracy of this analysis.

Table A1 - Bridges with a Greater than 0.90 Complete Damage Probability

Sorted by most potential for damage

County	Feature Crossed	Bridge-ID	Route	Seismic Design	Average for Damage State				
					None	Slight	Moderate	Extensive	Complete
New Madrid	DTCH #21	1922871	RT M E	No	0.0002	0.0009	0.0029	0.024	0.9718
New Madrid	DRAIN DTCH #3	1922960	RT D E	No	0.0002	0.0009	0.0031	0.0248	0.9707
New Madrid	DRAIN DTCH #4	1923015	RT D E	No	0.0002	0.0009	0.0031	0.0248	0.9707
New Madrid	LIT RVR DTCH #29	1929228	RT EE E	No	0.0002	0.0012	0.0036	0.0281	0.9666
New Madrid	DRAIN DTCH #52	1923016	RT ZZ E	No	0.0002	0.0012	0.0036	0.0281	0.9666
New Madrid	DRAIN DTCH #37	1922957	RT D E	No	0.0003	0.0013	0.004	0.0304	0.9637
New Madrid	DRAIN DTCH #1	1922958	RT D E	No	0.0003	0.0013	0.004	0.0304	0.9637
New Madrid	DRAIN DTCH #2	1922959	RT D E	No	0.0003	0.0013	0.004	0.0304	0.9637
New Madrid	LIT RVR DTCH	1922984	RT W E	No	0.0003	0.0014	0.0042	0.0314	0.9625
New Madrid	OTTER SLU DTCH	1929209	RT W E	No	0.0003	0.0014	0.0042	0.0314	0.9625
New Madrid	MAIN DRAIN DTCH #5	1923019	RT P E	No	0.0003	0.0015	0.0044	0.0326	0.961
New Madrid	DTCH #10	1922993	RT HH E	No	0.0003	0.0015	0.0045	0.0331	0.9603
New Madrid	ASH SLU DTCH	1922992	RT HH E	No	0.0003	0.0015	0.0045	0.0331	0.9603
New Madrid	PORTAGE BYU	1923006	RT TT S	No	0.0003	0.0016	0.0048	0.0348	0.9582
Pemiscot	MAIN DTCH NO 8	1923286	RT T E	No	0.0004	0.0017	0.0051	0.0363	0.9564
New Madrid	OLD CHNL LITTLE RV	1923017	RT ZZ E	No	0.0004	0.0017	0.0051	0.0366	0.956
New Madrid	DRAIN DTCH #42	1922953	RT D E	No	0.0004	0.0021	0.006	0.041	0.9502
New Madrid	DRAIN DTCH #41	1922954	RT D E	No	0.0004	0.0021	0.006	0.041	0.9502
New Madrid	DRAIN DTCH #40	1922955	RT D E	No	0.0004	0.0021	0.006	0.041	0.9502
New Madrid	LEVEE DTCH	1923013	RT E S	No	0.0004	0.0021	0.006	0.0413	0.9499
New Madrid	LIT RVR DTCH 251	1923014	RT E S	No	0.0004	0.0021	0.006	0.0413	0.9499
New Madrid	LATERAL 2 ST JOHNS	1922963	MO 80 E	No	0.0005	0.0023	0.0063	0.0429	0.9477
New Madrid	LITTLE RVR	1922970	MO 162 E	No	0.0005	0.0024	0.0066	0.0443	0.9459
New Madrid	MAPLE SLU DTCH	1929229	RT P E	No	0.0005	0.0024	0.0067	0.0449	0.9452
New Madrid	MAIN DRAIN DTCH #1	1926885	RT P E	No	0.0005	0.0024	0.0067	0.0449	0.9452
New Madrid	ST JOHNS DTCH	1922950	MO 80 E	No	0.0005	0.0025	0.0069	0.0459	0.9439

County	Feature Crossed	Bridge-ID	Route	Seismic Design	Average for Damage State				
					None	Slight	Moderate	Extensive	Complete
New Madrid	ASH SLU DTCH	1922972	RT H E	No	0.0006	0.0028	0.0076	0.049	0.9398
New Madrid	DRAIN DTCH	1922973	RT H E	No	0.0006	0.0028	0.0076	0.049	0.9398
New Madrid	IS 55	1922886	US 61 S	No	0.002	0.004	0.0196	0.0374	0.9366
New Madrid	BNSF RR	1922949	US 62 E	No	0.0004	0.0056	0.0076	0.0494	0.9366
New Madrid	DTCH #4	1923012	MO 153 S	No	0.0007	0.0031	0.0082	0.0521	0.9357
Stoddard	DRAIN DTCH #37	1924167	RT A E	No	0.0007	0.0031	0.0084	0.0528	0.9348
New Madrid	IS 55	1922892	RT EE E	No	0.0023	0.0045	0.0213	0.0399	0.9319
New Madrid	DRAIN DTCH #44	1922943	US 62 E	No	0.0007	0.0034	0.0089	0.0553	0.9314
New Madrid	DRAIN DTCH #43	1922944	US 62 E	No	0.0007	0.0034	0.0089	0.0553	0.9314
New Madrid	CADE SCHOOL DTCH	1922961	MO 80 E	No	0.0008	0.0035	0.0092	0.0565	0.9297
New Madrid	MAIN DRAIN DTCH #1	1922962	MO 80 E	No	0.0008	0.0035	0.0092	0.0565	0.9297
New Madrid	IS 55	1923000	RT U E	No	0.0024	0.0047	0.0222	0.0412	0.9292
New Madrid	DRAIN DTCH #62	1922968	MO 162 E	No	0.0008	0.0036	0.0094	0.0573	0.9288
New Madrid	DRAIN DTCH #60	1922969	MO 162 E	No	0.0008	0.0036	0.0094	0.0573	0.9288
New Madrid	LITTLE RVR	1922909	US 62 E	No	0.0025	0.0048	0.0225	0.0416	0.9283
New Madrid	IS 55	1922901	RT M E	No	0.0026	0.0049	0.023	0.0423	0.927
New Madrid	CANEY SLU	1922951	RT D E	No	0.0008	0.0037	0.0097	0.0586	0.9269
New Madrid	DRAIN DTCH #43	1922952	RT D E	No	0.0008	0.0037	0.0097	0.0586	0.9269
New Madrid	ASH SLU DTCH	1922868	RT W E	No	0.0006	0.0069	0.0091	0.0563	0.9269
New Madrid	DRAIN DTCH #1	1922974	RT H E	No	0.0008	0.0038	0.0099	0.0598	0.9253
New Madrid	DRAIN DTCH #60	1929227	RT B S	No	0.0009	0.0042	0.0106	0.063	0.921
Mississippi	DRAIN DTCH #32	1922839	RT C E	No	0.0009	0.0042	0.0107	0.0633	0.9206
Pemiscot	LATERAL DTCH NO 22	1923247	RT P S	No	0.001	0.0043	0.0108	0.0638	0.9199
Pemiscot	LATERAL DTCH NO 24	1923250	RT P S	No	0.001	0.0043	0.0108	0.0638	0.9199
Pemiscot	MAIN DTCH NO 8	1923287	RT K E	No	0.001	0.0043	0.0109	0.0643	0.9193
Pemiscot	LATERAL DTCH NO 9	1923288	RT K E	No	0.001	0.0043	0.0109	0.0643	0.9193
Pemiscot	LATERAL DTCH NO 23	1923248	RT P S	No	0.001	0.0043	0.0109	0.0643	0.9193
Pemiscot	LATERAL DTCH NO 25	1923249	RT P S	No	0.001	0.0043	0.0109	0.0643	0.9193
Pemiscot	MAIN DTCH NO 8	1923259	RT P S	No	0.001	0.0043	0.0109	0.0643	0.9193
New Madrid	IS 55	1922880	RT P E	No	0.003	0.0056	0.0257	0.0462	0.9192
New Madrid	IS 55	1922883	US 61 S	No	0.003	0.0056	0.0257	0.0462	0.9192

County	Feature Crossed	Bridge-ID	Route	Seismic Design	Average for Damage State				
					None	Slight	Moderate	Extensive	Complete
New Madrid	BNSF RR	1922890	IS 55 S	No	0.003	0.0056	0.0257	0.0462	0.9192
New Madrid	BNSF RR	1922891	IS 55 N	No	0.003	0.0056	0.0257	0.0462	0.9192
Stoddard	DRAIN DTCH #42	1924163	RT A E	No	0.001	0.0047	0.0116	0.0671	0.9153
Stoddard	DRAIN DTCH #41	1924164	RT A E	No	0.001	0.0047	0.0116	0.0671	0.9153
Stoddard	DRAIN DTCH #40	1924165	RT A E	No	0.001	0.0047	0.0116	0.0671	0.9153
Stoddard	DRAIN DTCH #1	1924166	RT A E	No	0.001	0.0047	0.0116	0.0671	0.9153
Pemiscot	MAIN DTCH NO 6	1923253	US 61 N	No	0.001	0.0047	0.0116	0.0672	0.9152
Pemiscot	DRAIN DTCH NO 3	1923254	MO 164 E	No	0.001	0.0047	0.0116	0.0672	0.9152
Pemiscot	DRAIN DTCH NO 3	1923265	IS 55 S	No	0.001	0.0047	0.0116	0.0672	0.9152
Pemiscot	DRAIN DTCH NO 66	1923297	RT CC S	No	0.0011	0.0047	0.0117	0.0674	0.9149
Mississippi	MAPLE SWITCH SLU	1922829	US 62 E	No	0.0011	0.0047	0.0117	0.0677	0.9146
New Madrid	DRAIN DTCH #18	1922947	US 61 S	No	0.0008	0.0089	0.0111	0.0658	0.9132
New Madrid	DTCH #8	1924525	MO 153 S	No	0.0011	0.0048	0.012	0.0688	0.913
New Madrid	DRAIN DTCH #6	1923018	MO 153 S	No	0.0011	0.0048	0.012	0.0688	0.913
Pemiscot	PEMISCOT BYU	1923270	RT O E	No	0.0011	0.0049	0.0121	0.0691	0.9125
Pemiscot	PEMISCOT BYU	1923252	US 61 S	No	0.0011	0.005	0.0124	0.0704	0.9108
Pemiscot	MAIN DTCH	1923266	IS 55 S	No	0.0011	0.005	0.0124	0.0704	0.9108
New Madrid	DRY RUN DTCH	1926873	RT U E	No	0.0008	0.0092	0.0115	0.0675	0.9106
New Madrid	DRY RUN DITCH	1925791	RT U E	No	0.0008	0.0092	0.0115	0.0675	0.9106
Pemiscot	COUNTY DTCH	1923296	RT M E	No	0.0012	0.0051	0.0126	0.0711	0.9098
Pemiscot	DRAIN DTCH NO 8	1923298	RT F E	No	0.0012	0.0051	0.0126	0.0711	0.9098
New Madrid	N CUT DTCH	1922991	RT AA S	No	0.0012	0.0052	0.0127	0.0717	0.909
Pemiscot	OLD FRANKLIN DRAIN	1923268	RT H S	No	0.0012	0.0052	0.0127	0.0718	0.9088
Pemiscot	MAIN DTCH NO 6	1923295	RT J E	No	0.0012	0.0052	0.0128	0.0718	0.9088
New Madrid	IS 55	1929213	604 E	No	0.0037	0.0068	0.0298	0.0518	0.9076
New Madrid	LITTLE RVR	1929210	RT A E	No	0.0012	0.0053	0.013	0.0727	0.9075
New Madrid	DRAIN DTCH #18	1926872	RT F S	No	0.0009	0.01	0.0123	0.0708	0.9058
New Madrid	DRAIN DTCH #18	1925798	RT F S	No	0.0009	0.01	0.0123	0.0708	0.9058
Mississippi	DRAIN DTCH #14	1922831	MO 75 S	No	0.0013	0.0055	0.0133	0.0741	0.9056
Mississippi	DITCH #14	1922845	RT D E	No	0.0013	0.0055	0.0133	0.0741	0.9056
New Madrid	DRAIN DTCH #6	1922916	MO 162 E	No	0.0013	0.0055	0.0133	0.0741	0.9055

County	Feature Crossed	Bridge-ID	Route	Seismic Design	Average for Damage State				
					None	Slight	Moderate	Extensive	Complete
New Madrid	DRAIN DTCH #290	1922964	MO 162 E	No	0.0013	0.0055	0.0133	0.0741	0.9055
New Madrid	DRAIN DTCH #1	1922965	MO 162 E	No	0.0013	0.0055	0.0133	0.0741	0.9055
New Madrid	DRAIN DTCH #251	1922966	MO 162 E	No	0.0013	0.0055	0.0133	0.0741	0.9055
New Madrid	DRAIN DTCH #256	1922967	MO 162 E	No	0.0013	0.0055	0.0133	0.0741	0.9055
New Madrid	DRAIN DTCH #6	1922978	RT D E	No	0.0013	0.0056	0.0136	0.0753	0.9039
New Madrid	DRAIN DTCH #7	1922979	RT D E	No	0.0013	0.0056	0.0136	0.0753	0.9039
New Madrid	DRAIN DTCH #8	1922980	RT D E	No	0.0013	0.0056	0.0136	0.0753	0.9039
Mississippi	WHITE POND	1922833	MO 75 S	No	0.0013	0.0057	0.0138	0.0761	0.9028
Pemiscot	DRAIN DTCH NO 2	1923280	RT C S	No	0.0014	0.0058	0.0139	0.0766	0.9021
Pemiscot	DRAIN DTCH NO 1	1923281	RT C S	No	0.0014	0.0058	0.0139	0.0766	0.9021
Pemiscot	DRAIN DTCH NO 4	1923282	RT C S	No	0.0014	0.0058	0.0139	0.0766	0.9021
Mississippi	DRAIN DTCH #23	1922830	US 60 E	No	0.0014	0.0058	0.014	0.0768	0.9018
New Madrid	DRAINAGE DITCH #55	1926886	RT ZZ E	No	0.001	0.0107	0.013	0.074	0.901

Table A2 - Bridges with a Greater than 0.90 Complete Damage Probability

Sorted by most potential for damage

County	River	Bridge-ID	Route	Seismic Design	Average for Damage State				
					None	Slight	Moderate	Extensive	Complete
Pemiscot	Mississippi River	1929267	IS 155 S	No	0.0099	0.0151	0.0558	0.0825	0.8364
Mississippi	Mississippi River	1922842	US 60 W	No	0.0043	0.0149	0.03	0.1306	0.82
Mississippi	Mississippi River	1922808	IS 57 S	No	0.0175	0.0237	0.0785	0.1046	0.7754
Perry	Mississippi River	1923358	MO 51 S	No	0.4214	0.1474	0.1996	0.1069	0.1244
St. Charles	Missouri River	1914811	MO 370 E	No	0.3927	0.2207	0.1467	0.1652	0.0744
St. Louis	Missouri River	1915592	MO 370 W	No	0.3927	0.2207	0.1467	0.1652	0.0744
Cape Girardeau	Mississippi River	1922263	MO 34 E	Yes	0.395	0.2638	0.1126	0.1575	0.0709
St. Louis City	Mississippi River	1922293	MO 799 S	No	0.6281	0.1295	0.1383	0.0572	0.0467
St. Louis City	Mississippi River	1928462	SALISBURY ST	No	0.6281	0.1295	0.1383	0.0572	0.0467
St. Louis City	Mississippi River	1922203	IS 270 E	No	0.6563	0.1242	0.1283	0.0511	0.0397
St. Charles	Missouri River	1919337	US 67 S	No	0.6881	0.1176	0.1168	0.0445	0.0328

County	River	Bridge-ID	Route	Seismic Design	Average for Damage State				
					None	Slight	Moderate	Extensive	Complete
St. Charles	Missouri River	1914774	IS 70 E	No	0.6883	0.1175	0.1167	0.0445	0.0327
St. Louis	Missouri River	1915528	IS 64 W	No	0.6942	0.1162	0.1145	0.0433	0.0315
St. Charles	Mississippi River	1914801	US 67 S	No	0.697	0.1155	0.1135	0.0427	0.0309
St. Louis	Mississippi River	1915319	IS 255 N	Yes	0.8249	0.1213	0.0277	0.0221	0.0038
St. Louis	Mississippi River	1915702	IS 255 S	Yes	0.8249	0.1213	0.0277	0.0221	0.0038
St. Louis City	Mississippi River	1916382	IS 55 S	Yes	0.8335	0.1162	0.0261	0.0204	0.0035
St. Louis City	Mississippi River	1916593	IS 70 E	Yes	0.8419	0.1113	0.0245	0.0189	0.0031
St. Louis	Missouri River	1916236	IS 70 W	Yes	0.8783	0.0888	0.0179	0.0128	0.0019
St. Charles	Missouri River	1924538	MO 364 E	Yes	0.8783	0.0888	0.0179	0.0128	0.0019
St. Louis	Missouri River	1924504	MO 364 W	Yes	0.8783	0.0888	0.0179	0.0128	0.0019
St. Charles	Missouri River	1915022	IS 64 E	Yes	0.8816	0.0867	0.0173	0.0123	0.0018

Table B1. Transportation Highway Bridge Functionality
Sorted on Day 1 Lowest to Highest

County	River	Bridge ID	Route	Functionality (%)					
				At Day 1	At Day 3	At Day 7	At Day 14	At Day 30	At Day 90
New Madrid	DTCH #21	1922871	RT M E	2	2.2	2.5	2.9	4.1	11.8
New Madrid	DRAIN DTCH #3	1922960	RT D E	2	2.2	2.6	3	4.1	11.8
New Madrid	DRAIN DTCH #4	1923015	RT D E	2	2.2	2.6	3	4.1	11.8
New Madrid	LIT RVR DTCH	1922984	RT W E	2.1	2.4	2.7	3.2	4.3	12.3
New Madrid	OTTER SLU DTCH	1929209	RT W E	2.1	2.4	2.7	3.2	4.3	12.3
New Madrid	DRAIN DTCH #37	1922957	RT D E	2.1	2.4	2.7	3.1	4.3	12.2
New Madrid	DRAIN DTCH #1	1922958	RT D E	2.1	2.4	2.7	3.1	4.3	12.2
New Madrid	DRAIN DTCH #2	1922959	RT D E	2.1	2.4	2.7	3.1	4.3	12.2
New Madrid	LIT RVR DTCH #29	1929228	RT EE E	2.1	2.3	2.7	3.1	4.2	12.1
New Madrid	DRAIN DTCH #52	1923016	RT ZZ E	2.1	2.3	2.7	3.1	4.2	12.1
Pemiscot	MAIN DTCH NO 8	1923286	RT T E	2.2	2.5	2.9	3.3	4.5	12.7
New Madrid	OLD CHNL LITTLE RV	1923017	RT ZZ E	2.2	2.5	2.9	3.3	4.5	12.7
New Madrid	PORTAGE BYU	1923006	RT TT S	2.2	2.4	2.8	3.3	4.4	12.6
New Madrid	DTCH #10	1922993	RT HH E	2.2	2.4	2.8	3.2	4.4	12.5
New Madrid	ASH SLU DTCH	1922992	RT HH E	2.2	2.4	2.8	3.2	4.4	12.5
New Madrid	MAIN DRAIN DTCH #5	1923019	RT P E	2.2	2.4	2.8	3.2	4.4	12.4
New Madrid	ST JOHNS DTCH	1922950	MO 80 E	2.3	2.7	3.2	3.6	4.9	13.5
New Madrid	MAPLE SLU DTCH	1929229	RT P E	2.3	2.7	3.1	3.6	4.8	13.4
New Madrid	MAIN DRAIN DTCH #1	1926885	RT P E	2.3	2.7	3.1	3.6	4.8	13.4
New Madrid	LITTLE RVR	1922970	MO 162 E	2.3	2.7	3.1	3.6	4.8	13.3
New Madrid	LATERAL 2 ST JOHNS	1922963	MO 80 E	2.3	2.6	3.1	3.5	4.7	13.2
New Madrid	DRAIN DTCH #42	1922953	RT D E	2.3	2.6	3	3.5	4.7	13.1
New Madrid	DRAIN DTCH #41	1922954	RT D E	2.3	2.6	3	3.5	4.7	13.1
New Madrid	DRAIN DTCH #40	1922955	RT D E	2.3	2.6	3	3.5	4.7	13.1

County		Functionality (%)							
	River	Bridge ID	Route	At Day 1	At Day 3	At Day 7	At Day 14	At Day 30	At Day 90
New Madrid	LEVEE DTCH	1923013	RT E S	2.3	2.6	3	3.5	4.7	13.1
New Madrid	LIT RVR DTCH 251	1923014	RT E S	2.3	2.6	3	3.5	4.7	13.1
New Madrid	DTCH #4	1923012	MO 153 S	2.4	2.9	3.4	3.9	5.1	14
New Madrid	ASH SLU DTCH		RT H E	2.4	2.8	3.3	3.7	5	13.7
New Madrid	DRAIN DTCH	1922973	RT H E	2.4	2.8	3.3	3.7	5	13.7
New Madrid	CADE SCHOOL DTCH	1922961	MO 80 E	2.5	3	3.5	4	5.3	14.4
New Madrid	MAIN DRAIN DTCH #1	1922962	MO 80 E	2.5	3	3.5	4	5.3	14.4
New Madrid	DRAIN DTCH #62	1922968	MO 162 E	2.5	3	3.6	4.1	5.4	14.4
New Madrid	DRAIN DTCH #60	1922969	MO 162 E	2.5	3	3.6	4.1	5.4	14.4
New Madrid	DRAIN DTCH #44	1922943	US 62 E	2.5	2.9	3.5	4	5.3	14.3
New Madrid	DRAIN DTCH #43	1922944	US 62 E	2.5	2.9	3.5	4	5.3	14.3
Stoddard	DRAIN DTCH #37	1924167	RT A E	2.5	2.9	3.4	3.9	5.2	14
Mississippi	DRAIN DTCH #32	1922839	RT C E	2.6	3.2	3.8	4.3	5.6	14.9
New Madrid	DRAIN DTCH #60	1929227	RT B S	2.6	3.1	3.8	4.3	5.6	14.9
New Madrid	DRAIN DTCH #1	1922974	RT H E	2.6	3.1	3.6	4.1	5.5	14.6
New Madrid	CANEY SLU	1922951	RT D E	2.6	3	3.6	4.1	5.4	14.5
New Madrid	DRAIN DTCH #43	1922952	RT D E	2.6	3	3.6	4.1	5.4	14.5
New Madrid	BNSF RR	1922949	US 62 E	2.6	3	3.5	4	5.3	14
New Madrid	DTCH #8	1924525	MO 153 S	2.7	3.3	4	4.5	5.9	15.4
New Madrid	DRAIN DTCH #6	1923018	MO 153 S	2.7	3.3	4	4.5	5.9	15.4
Mississippi	MAPLE SWITCH SLU	1922829	US 62 E	2.7	3.3	4	4.5	5.8	15.3
Pemiscot	MAIN DTCH NO 6	1923253	US 61 N	2.7	3.3	3.9	4.4	5.8	15.3
Pemiscot	DRAIN DTCH NO 3	1923254	MO 164 E	2.7	3.3	3.9	4.4	5.8	15.3
Pemiscot	DRAIN DTCH NO 3	1923265	IS 55 S	2.7	3.3	3.9	4.4	5.8	15.3
Stoddard	DRAIN DTCH #42	1924163	RT A E	2.7	3.3	3.9	4.4	5.8	15.3
Stoddard	DRAIN DTCH #41	1924164	RT A E	2.7	3.3	3.9	4.4	5.8	15.3
Stoddard	DRAIN DTCH #40	1924165	RT A E	2.7	3.3	3.9	4.4	5.8	15.3

County	River	Functionality (%)							
		Bridge ID	Route	At Day 1	At Day 3	At Day 7	At Day 14	At Day 30	At Day 90
Stoddard	DRAIN DTCH #1	1924166	RT A E	2.7	3.3	3.9	4.4	5.8	15.3
Pemiscot	DRAIN DTCH NO 66	1923297	RT CC S	2.7	3.3	4	4.5	5.8	15.3
Pemiscot	MAIN DTCH NO 8	1923287	RT K E	2.7	3.2	3.8	4.3	5.7	15
Pemiscot	LATERAL DTCH NO 9	1923288	RT K E	2.7	3.2	3.8	4.3	5.7	15
Pemiscot	LATERAL DTCH NO 22	1923247	RT P S	2.7	3.2	3.8	4.3	5.7	15
Pemiscot	LATERAL DTCH NO 23	1923248	RT P S	2.7	3.2	3.8	4.3	5.7	15
Pemiscot	LATERAL DTCH NO 25	1923249	RT P S	2.7	3.2	3.8	4.3	5.7	15
Pemiscot	LATERAL DTCH NO 24	1923250	RT P S	2.7	3.2	3.8	4.3	5.7	15
Pemiscot	MAIN DTCH NO 8	1923259	RT P S	2.7	3.2	3.8	4.3	5.7	15
New Madrid	ASH SLU DTCH	1922868	RT W E	2.7	3.3	3.8	4.3	5.6	14.6
New Madrid	LITTLE RVR	1929210	RT A E	2.8	3.4	4.2	4.7	6.1	15.8
Pemiscot	OLD FRANKLIN DRAIN	1923268	RT H S	2.8	3.4	4.1	4.6	6	15.7
New Madrid	N CUT DTCH	1922991	RT AA S	2.8	3.4	4.1	4.6	6	15.7
Pemiscot	MAIN DTCH NO 6	1923295	RT J E	2.8	3.4	4.1	4.7	6	15.7
Pemiscot	PEMISCOT BYU	1923252	US 61 S	2.8	3.4	4.1	4.6	6	15.6
Pemiscot	MAIN DTCH	1923266	IS 55 S	2.8	3.4	4.1	4.6	6	15.6
Pemiscot	COUNTY DTCH	1923296	RT M E	2.8	3.4	4.1	4.6	6	15.6
Pemiscot	DRAIN DTCH NO 8	1923298	RT F E	2.8	3.4	4.1	4.6	6	15.6
Pemiscot	PEMISCOT BYU	1923270	RT O E	2.8	3.3	4	4.5	5.9	15.5
Mississippi	DRAIN DTCH #23	1922830	US 60 E	2.9	3.6	4.3	4.9	6.3	16.1
Mississippi	WHITE POND	1922833	MO 75 S	2.9	3.5	4.3	4.8	6.2	16.1
Pemiscot	DRAIN DTCH NO 2	1923280	RT C S	2.9	3.6	4.3	4.9	6.3	16.1
Pemiscot	DRAIN DTCH NO 1	1923281	RT C S	2.9	3.6	4.3	4.9	6.3	16.1
Pemiscot	DRAIN DTCH NO 4	1923282	RT C S	2.9	3.6	4.3	4.9	6.3	16.1
New Madrid	DRAIN DTCH #6	1922978	RT D E	2.9	3.5	4.3	4.8	6.2	16
New Madrid	DRAIN DTCH #7	1922979	RT D E	2.9	3.5	4.3	4.8	6.2	16
New Madrid	DRAIN DTCH #8	1922980	RT D E	2.9	3.5	4.3	4.8	6.2	16

County		Functionality (%)							
	River	Bridge ID	Route	At Day 1	At Day 3	At Day 7	At Day 14	At Day 30	At Day 90
New Madrid	DRAIN DTCH #6	1922916	MO 162 E	2.9	3.5	4.2	4.8	6.1	15.9
Mississippi	DRAIN DTCH #14	1922831	MO 75 S	2.9	3.5	4.2	4.8	6.1	15.9
New Madrid	DRAIN DTCH #290	1922964	MO 162 E	2.9	3.5	4.2	4.8	6.1	15.9
New Madrid	DRAIN DTCH #1	1922965	MO 162 E	2.9	3.5	4.2	4.8	6.1	15.9
New Madrid	DRAIN DTCH #251	1922966	MO 162 E	2.9	3.5	4.2	4.8	6.1	15.9
New Madrid	DRAIN DTCH #256	1922967	MO 162 E	2.9	3.5	4.2	4.8	6.1	15.9
Mississippi	DTCH #14	1922845	RT D E	2.9	3.5	4.2	4.8	6.1	15.9
New Madrid	IS 55	1922886	US 61 S	2.9	3.7	4.6	5.1	6.3	14.4
New Madrid	DRY RUN DTCH	1926873	RT U E	3	3.7	4.4	4.9	6.2	15.7
New Madrid	DRY RUN DITCH	1925791	RT U E	3	3.7	4.4	4.9	6.2	15.7
New Madrid	DRAIN DTCH #18	1922947	US 61 S	3	3.6	4.3	4.8	6.1	15.5
New Madrid	IS 55	1922892	RT EE E	3	3.9	4.9	5.4	6.6	14.8
New Madrid	DRAIN DTCH #18	1926872	RT F S	3.1	3.8	4.5	5	6.4	16
New Madrid	DRAIN DTCH #18	1925798	RT F S	3.1	3.8	4.5	5	6.4	16
New Madrid	IS 55	1922901	RT M E	3.1	4	5.1	5.6	6.8	15.1
New Madrid	IS 55	1923000	RT U E	3.1	3.9	5	5.5	6.7	15
New Madrid	LITTLE RVR	1922909	US 62 E	3.1	4	5	5.5	6.7	15
New Madrid	DRAINAGE DITCH #55	1926886	RT ZZ E	3.2	4	4.7	5.2	6.6	16.3
New Madrid	IS 55	1922880	RT P E	3.3	4.3	5.5	6	7.2	15.7
New Madrid	IS 55	1922883	US 61 S	3.3	4.3	5.5	6	7.2	15.7
New Madrid	BNSF RR	1922890	IS 55 S	3.3	4.3	5.5	6	7.2	15.7
New Madrid	BNSF RR	1922891	IS 55 N	3.3	4.3	5.5	6	7.2	15.7
New Madrid	IS 55	1929213	604 E	3.6	4.7	6.1	6.6	7.9	16.5

Table B2. Transportation Highway Bridge Functionality - Major River Bridges

County	River	Bridge ID	Route	Functionality (%)					
				At Day 1	At Day 3	At Day 7	At Day 14	At Day 30	At Day 90
Mississippi	Mississippi River	1922842	US 60 W	4.4	5.8	7.2	7.9	9.6	21.6
Pemiscot	Mississippi River	1929267	IS 155 S	5.6	7.6	10	10.7	12.1	21.8
Mississippi	Mississippi River	1922808	IS 57 S	7.6	10.5	13.8	14.6	16.1	26.5
Perry	Mississippi River	1923358	MO 51 S	59.5	69	76.7	77.9	78.7	84.9
St. Charles	Missouri River	1914811	MO 370 E	60.7	70.6	76.3	77.4	78.6	87.3
St. Louis	Missouri River	1915592	MO 370 W	60.7	70.6	76.3	77.4	78.6	87.3
Cape Girardeau	Mississippi River	1922263	MO 34 E	63.2	73.1	77.5	78.4	79.6	87.9
St. Louis City	Mississippi River	1922293	MO 799 S	76.8	84	89.3	90.1	90.5	93.7
St. Louis City	Mississippi River	1928462	SALISBURY ST	76.8	84	89.3	90.1	90.5	93.7
St. Louis City	Mississippi River	1922203	IS 270 E	78.8	85.7	90.6	91.3	91.7	94.5
St. Charles	Missouri River	1919337	US 67 S	81.2	87.5	91.9	92.6	92.9	95.4
St. Charles	Missouri River	1914774	IS 70 E	81.2	87.5	91.9	92.6	92.9	95.4
St. Louis	Missouri River	1915528	IS 64 W	81.6	87.8	92.2	92.8	93.2	95.5
St. Charles	Mississippi River	1914801	US 67 S	81.8	88	92.3	92.9	93.3	95.6
St. Louis	Mississippi River	1915319	IS 255 N	92.4	96.3	97.3	97.5	97.7	98.8
St. Louis	Mississippi River	1915702	IS 255 S	92.4	96.3	97.3	97.5	97.7	98.8
St. Louis City	Mississippi River	1916382	IS 55 S	92.8	96.5	97.5	97.7	97.8	98.9
St. Louis City	Mississippi River	1916593	IS 70 E	93.2	96.8	97.7	97.9	98	99
St. Louis	Missouri River	1916236	IS 70 W	95	97.7	98.4	98.5	98.6	99.3
St. Charles	Missouri River	1924538	MO 364 E	95	97.7	98.4	98.5	98.6	99.3
St. Louis	Missouri River	1924504	MO 364 W	95	97.7	98.4	98.5	98.6	99.3
St. Charles	Missouri River	1915022	IS 64 E	95.1	97.8	98.5	98.6	98.7	99.3

Appendix C2

Missouri Earthquake Risk Assessment Enhancements

Essential Facilities

Missouri Earthquake Risk Assessment Enhancements

Essential Facilities Analysis

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Project No. 573330033

This report was prepared for the Missouri State Emergency Management Agency (SEMA) by Amec Foster Wheeler Environment & Infrastructure, Inc., (Amec Foster Wheeler). The quality of information, conclusions and estimates contained herein are consistent with the level of effort involved in Amec Foster Wheeler's services and based on: i) information available at the time of preparation, ii) data supplied by outside sources and iii) the assumptions, conditions and qualifications set forth in this report. This report is intended to be used by SEMA subject to the terms and conditions of the contract with Amec Foster Wheeler. Any other use of, or reliance on, this report by any third party is at that party's sole risk.

TABLE OF CONTENTS

List of Figures

List of Tables

List of Appendices

Missouri Earthquake Risk Assessment Enhancements
Essential Facilities Analysis

1.0 Background

Earthquake hazards are significant risk in eastern and southeastern Missouri due to the proximity of the New Madrid Seismic Zone. The risk from earthquakes associated with the New Madrid and other seismic zones is characterized and analyzed in the Missouri State Hazard Mitigation Plan (HMP). Losses from earthquakes are commonly modeled with FEMA's Hazus-MH program. The earthquake statewide vulnerability assessment of Missouri's HMP, previously updated in 2013, included a Hazus-MH 2.1 Level I earthquake loss scenario based on an event with a 2% probability of exceedance in 50 years to model a worst-case earthquake using a level of ground shaking recognized in earthquake-resistant design. For the 2017-2018 update of the Missouri State HMP, this Level I statewide vulnerability assessment was updated utilizing Hazus-MH 4.0, which includes updated census data as well as updated shaking grids developed by USGS in 2014.

The subject report, completed in September 2017, is part of a multi-pronged effort to enhance the earthquake risk assessment and is a parallel effort associated with the 2017-2018 update of the Missouri State HMP. In addition to the statewide vulnerability assessment, and in accordance with Requirement §201.5(b)(4)(ivi) - Element E3 - The enhanced plan must demonstrate that the state is committed to a comprehensive state mitigation program, which might include "A comprehensive, multiyear plan to mitigate the risks posed to the existing buildings that have been identified as necessary for post disaster response and recovery operations." Task 12 of the project scope for the 2017-2018 update of the Missouri HMP update includes identification of specific facilities that are necessary for post-disaster response and recovery operations that are at risk to flood and/or earthquake hazards as well as a multi-year plan to identify potential mitigation measures and funding sources. The analysis and findings of the subject report represent an enhanced aspect for the earthquake hazard elements of this scope by providing additional Hazus-based analysis for specific additional facility inventories.

Schools, as potential shelters, fire departments and medical facilities were identified by the Missouri State Emergency Management Agency (SEMA) as essential facilities for response and recovery at the local level. Amec Foster Wheeler performed a Hazus V 4.0. Level II Hazus earthquake analysis for these facilities under a contract with SEMA. The enhanced analysis and findings for these facility types presented in the remainder of this report include a Hazus level II analysis to both the hazard and inventory inputs as well as recommendations for next steps and further analysis. A similar additional analysis, focused on bridges and hazardous materials facilities, was completed through a contract with the Central United States Earthquake Consortium (CUSEC) and is summarized in a separate report. Both of these additional enhancement efforts will be summarized and included in the 2018 Missouri HMP Update and to provide information for basing additional hazard mitigation efforts for the State Risk Management Team.

1.1 Hazus-MH Data Enhancements

This study included Level II enhancements to both the hazard and inventory inputs to the Hazus model. These data sets were used as additional, Level II data inputs to enhance the accuracy of earthquake hazard modeling. These are discussed in further detail below.

1.1.1 Hazard Data

1.1.1.1 Soils and Soil Liquefaction Hazards

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. A general statewide soils layer, with assigned site classification characteristics based on National Earthquake Hazards Reduction Program (NEHRP) shaking potential, was obtained from the Missouri Department of Natural Resources.

1.1.1.2 Groundwater Depth

Hazus allows the user to set a single value for groundwater depth when defining hazard layers for a scenario. This is an important aspect of soil liquefaction potential, as liquefiable soils are saturated soils with shallow groundwater tables, typically within 30 ft. of the ground surface. A statewide wells databased was obtained from the Missouri Department of Natural Resources (MODNR). A GIS query was performed to obtain the wells within liquefaction hazard areas. A second query was done to obtain the average value of the depth to groundwater for the wells within liquefaction areas. The average was 10 ft., which was used to define the groundwater depth for the scenario.

1.1.1.3 Ground Shaking

Hazus-MH 4.0 was the version used to analyze vulnerability to earthquakes. Included with Hazus is USGS probabilistic ground shaking mapping, which provided the source of shaking based on an event with a 2% probability of exceedance in 50 years. This shaking level was used to model a worst-case earthquake using a level of ground shaking recognized in earthquake-resistant design. Version 4.0 of Hazus incorporates the USGS national seismic hazard maps that were updated in 2014.

1.1.2 Inventory Data

FEMA's Hazus loss estimation methodology defines essential facilities as those that if damaged would have devastating impacts on disaster response and/or recovery. Essential and high potential loss facilities within FEMA's HAZUS-multi hazard risk assessment tool include medical care facilities, emergency response facilities (fire stations) and schools. These facilities were compared to the 2016 HSIP data to create a complete and updated list. It was determined that the HSIP data was more complete and comprehensive than the default data in HAZUS.

The subtypes and counts of facilities within the greater study region include:

- Fire Departments -521
- Education Facilities – 2,079
  - College/University - 79
  - Private - 567
  - Public – 1,423
  - Supplemental College - 10
- Medical – 386
  - Medical Hospital - 69
  - Nursing Homes - 276
  - Urgent Care - 41

The data sets were formatted for use in Hazus using the Hazus Comprehensive Data Management System (CDMS) tool. This tool syncs data and attributes fields necessary for Hazus analysis and imports the enhanced data set into the Hazus study region.

1.2 Methodology

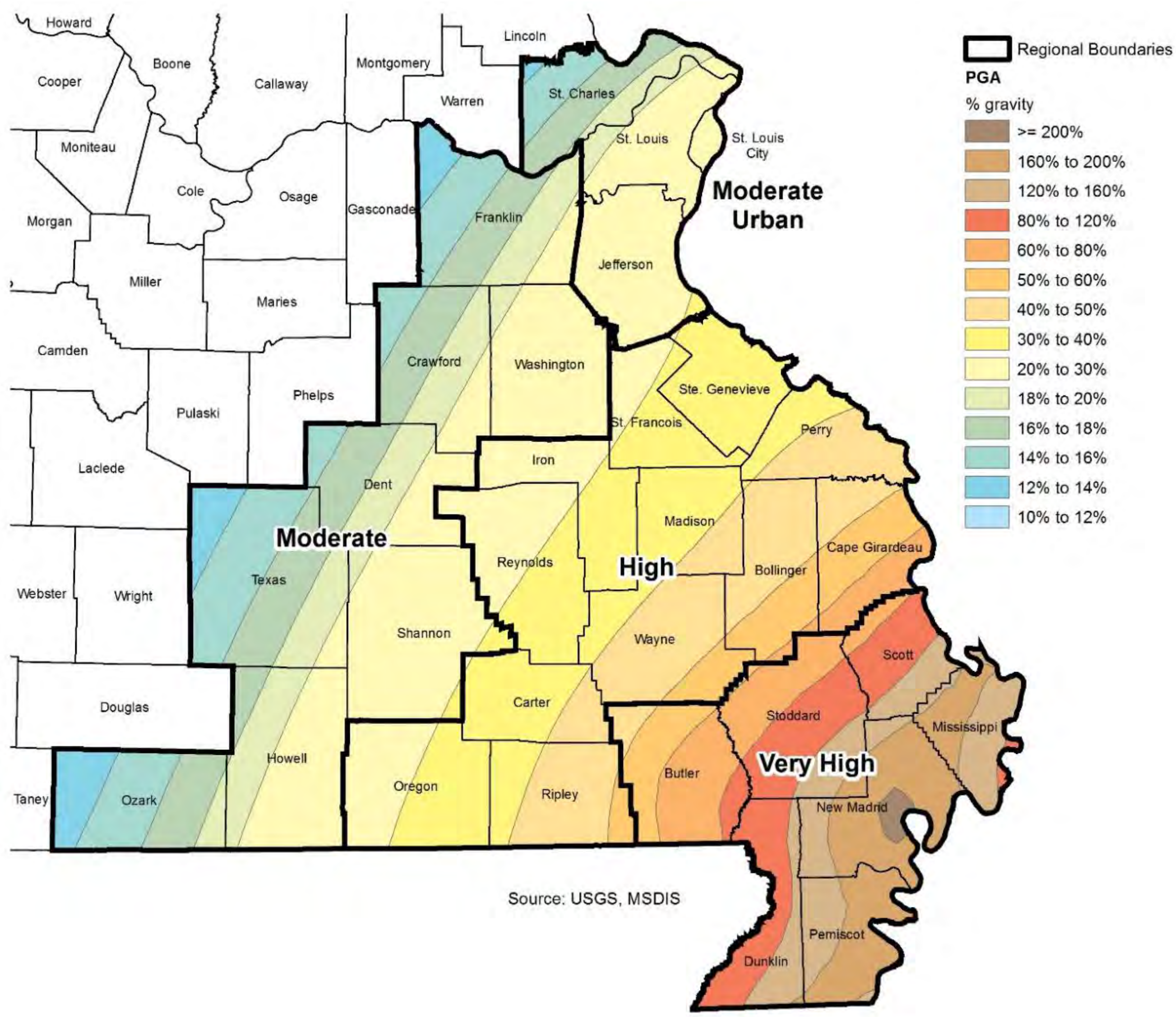
The scenario for this assessment, based on an event with a 2% probability of exceedance in 50 years, was done to model a worst-case scenario that is consistent with that utilized for earthquake risk modeling for the Missouri State HMP. This scenario is equivalent to the 2,500-year earthquake scenario in Hazus-MH. The methodology is based on probabilistic seismic hazard shaking grids developed by the U.S. Geological Survey (USGS) for the National Seismic Hazard Maps that are included with Hazus MH. The USGS maps provide estimates of peak ground acceleration and spectral acceleration at periods of 0.3 second and 1.0 second, respectively, which have a 2% probability of exceedance in the next 50 years. The International Building Code uses this level of ground shaking for building design in seismic areas. This scenario used a 7.7 driving magnitude in Hazus-MH, which is the magnitude used for typical New Madrid fault planning scenarios in

Missouri. While the 2% probability of exceedance in the next 50 years ground motion maps incorporate the shaking potential from all faults with earthquake potential in and around Missouri, the most severe shaking is predominately generated by the New Madrid Fault. This pattern of shaking can be seen in Figure 1, with corresponding potential for damage.

1.2.1 Analysis Regions

Counties with damaging Peak Ground Acceleration (PGA) ground shaking levels were analyzed based on the 2% in 50 years probabilistic ground shaking maps. This was based on PGA levels ranging from at least 18% g, where moderate damage could be anticipated, to over 200% g where very heavy damages could occur. This level of shaking affects 31counties in southeast and eastern Missouri. Another consideration was ground shaking needed to produce liquefaction in liquefaction-susceptible soils, which generally requires PGA levels of 15% g and above. Analysis sub-regions were created to further subdivide and group the counties into regions; generally categorized by damage potential ranging from moderate, high, to very high. Another reason for subdividing the regions was to reduce processing time, as Hazus takes several days to process a region of 15 or more counties. The moderate sub-region was further sub-divided into an urban-moderate region to represent the St Louis metropolitan area counties. Initial Hazus runs indicated that facility damage potential dropped considerably outside of the counties located in the very southeast corner of the state, thus Hazus analysis of regions in other parts of the state were not considered further so that effort could be focused in the highest risk areas.

Figure 1. Study Area and Sub-regions Analyzed in Hazus



2.0 Analysis and Results

Based on the ground shaking and structural characteristics, Hazus calculates the likelihood or probability of each essential facility to be damaged. Five damage categories, termed damage states (ds), are defined for essential facilities within Hazus. These damage state categories are: none, slight, moderate, extensive, and complete.

Hazus also provides estimates of post-earthquake facility functionality. This is presented by the level of functionality estimated at days 1, 3, 7, 14, 30 and 90 following the earthquake. Thus, a low percent functionality indicates a high-risk facility. Facilities with a high percent functional value (i.e. 90% or higher) are expected to be operational.

2.1 Fire Department, Medical Facility, and Education Facility Analysis Results

Summary results by Hazus sub-region (refer to Figure 1) are shown in Tables 1, 2 and 3. The facilities located in the 'Very High' Hazus sub-region counties are most vulnerable, particularly the fire stations. The upside of the analysis is that the probability of complete damage drops considerably in the Hazus sub-regions designated as high, moderate, moderate-urban, or high damage potential, though moderate damage potential does exist. No fire departments or education facilities in the Moderate sub-region had moderate or complete damage based on the Hazus modeling.

Table 1. Expected Fire Department Damage Summary by Hazus Sub-region

Hazus Sub-Regions	Fire Department Counts	With at Least Mod. Damage	With Complete Damage > 50%	With Functionality > 50 % After Day 1
Very High	85	85	82	0
High	127	105	0	0
Urban Moderate	197	4	1	56
Moderate	112	0	0	66
Total	**521**	**194**	**83**	**122**

Table 2. Expected Medical Facility Damage Summary by Hazus Sub-region

Hazus Sub-Regions	Medical Counts	With at Least Mod. Damage	With Complete Damage > 50%	With Functionality > 50 % After Day 1
Very High	53	53	37	0
High	69	68	1	0
Urban Moderate	218	35	0	38
Moderate	46	3	0	20
Total	**386**	**159**	**38**	**58**

Table 3. Expected Education Facility Damage Summary by Hazus Sub-region

Hazus Sub-Regions	Education Counts	With at Least Mod. Damage	With Complete Damage > 50%	With Functionality > 50 % After Day 1
Very High	149	149	37	0
High	160	136	0	0
Urban Moderate	1,621	54	3	251
Moderate	149	0	0	94
Total	**2,079**	**339**	**40**	**345**

Maps showing damage probabilities are shown below. Additional details on facilities with a greater than 50 percent complete damage probability can be referenced in Appendix A, B and C for fire, medical and school facilities respectively. Details include the facility name, county, damage probability and functionality estimated at days 1, 7, 14, and 90 following the earthquake. These details may be useful for further site-specific analysis and targeted mitigation.

Figure 2. Map of Fire Department Damage Probability

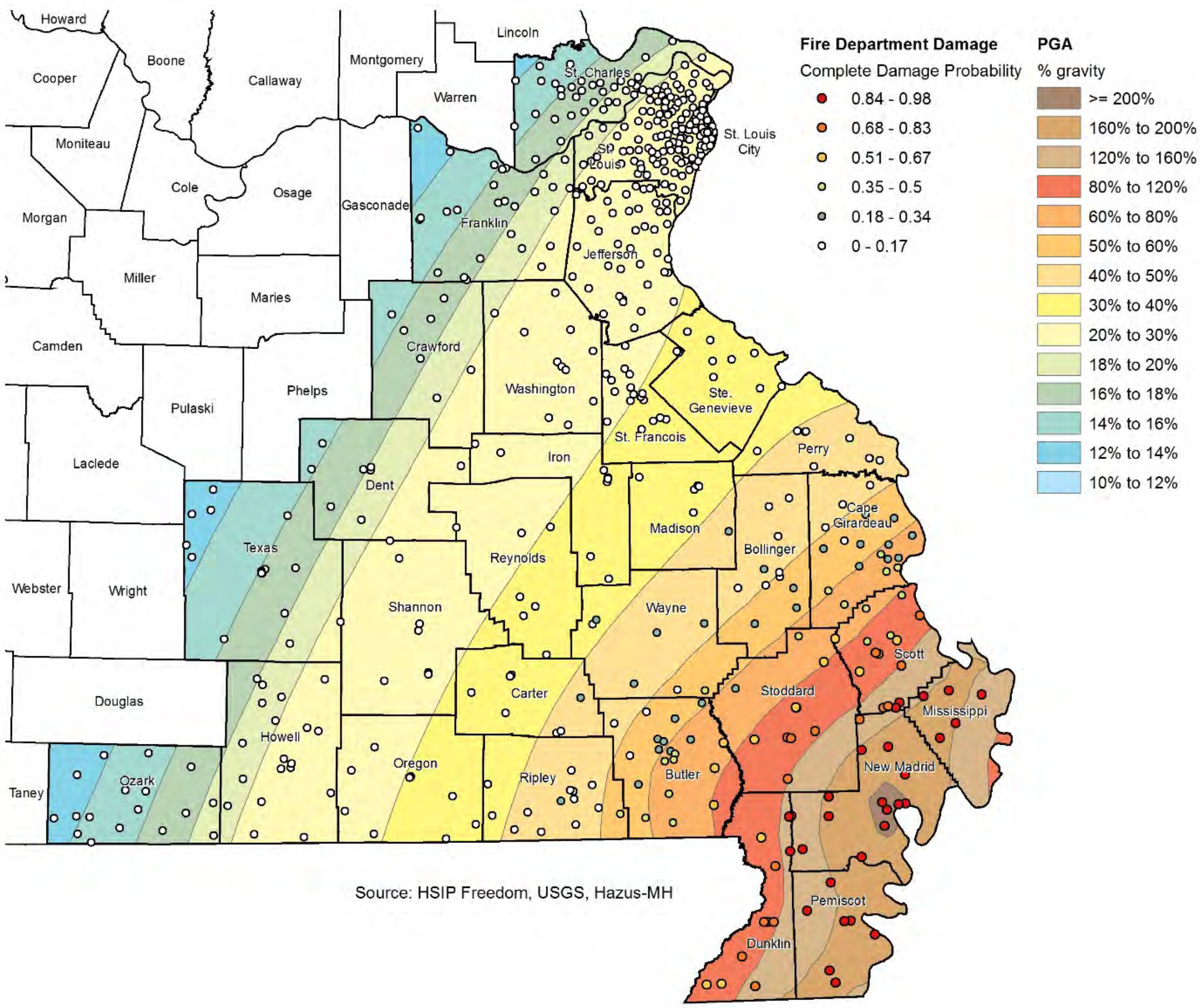


Figure 3. Map of Medical Care Facility Damage Probability

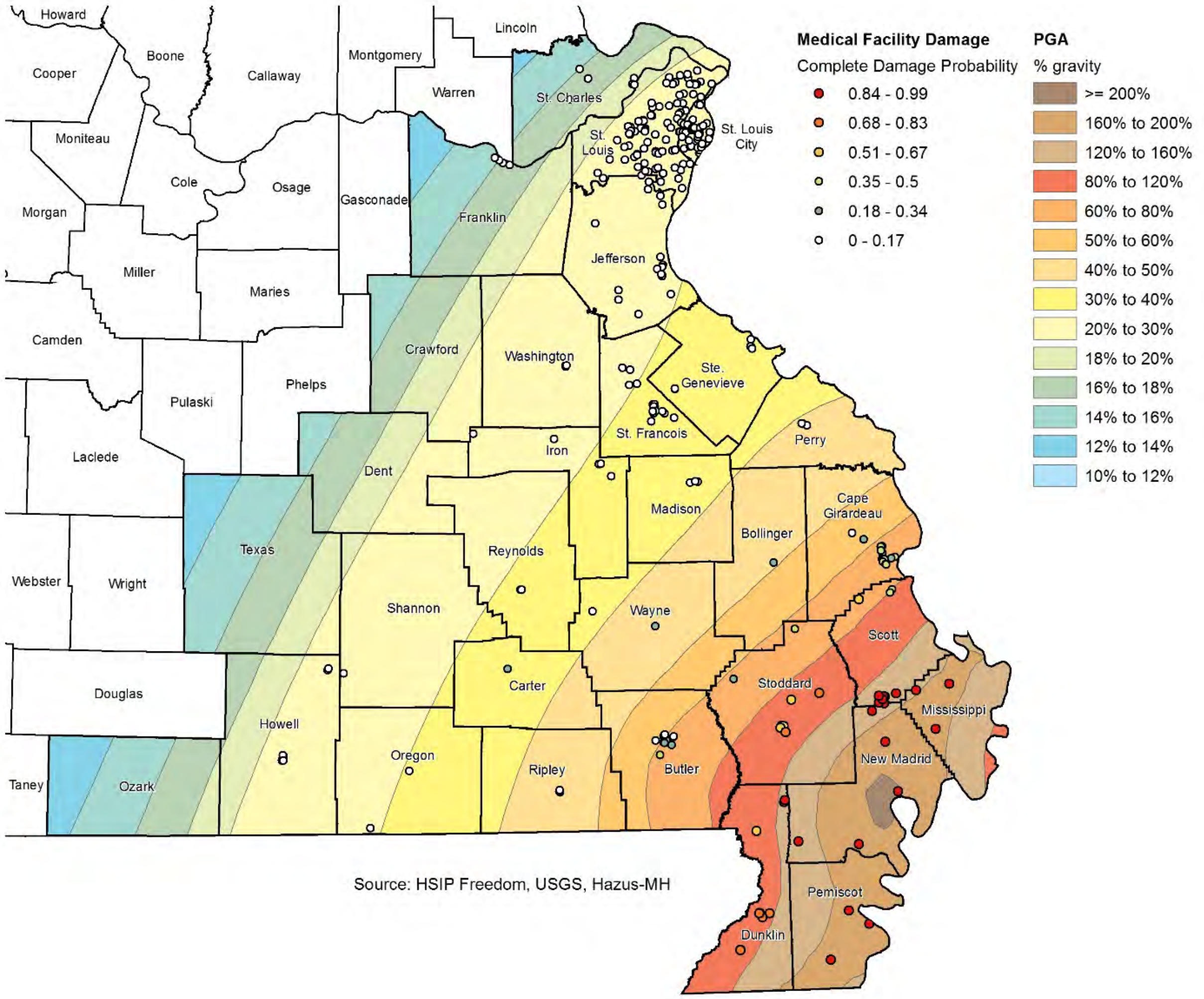
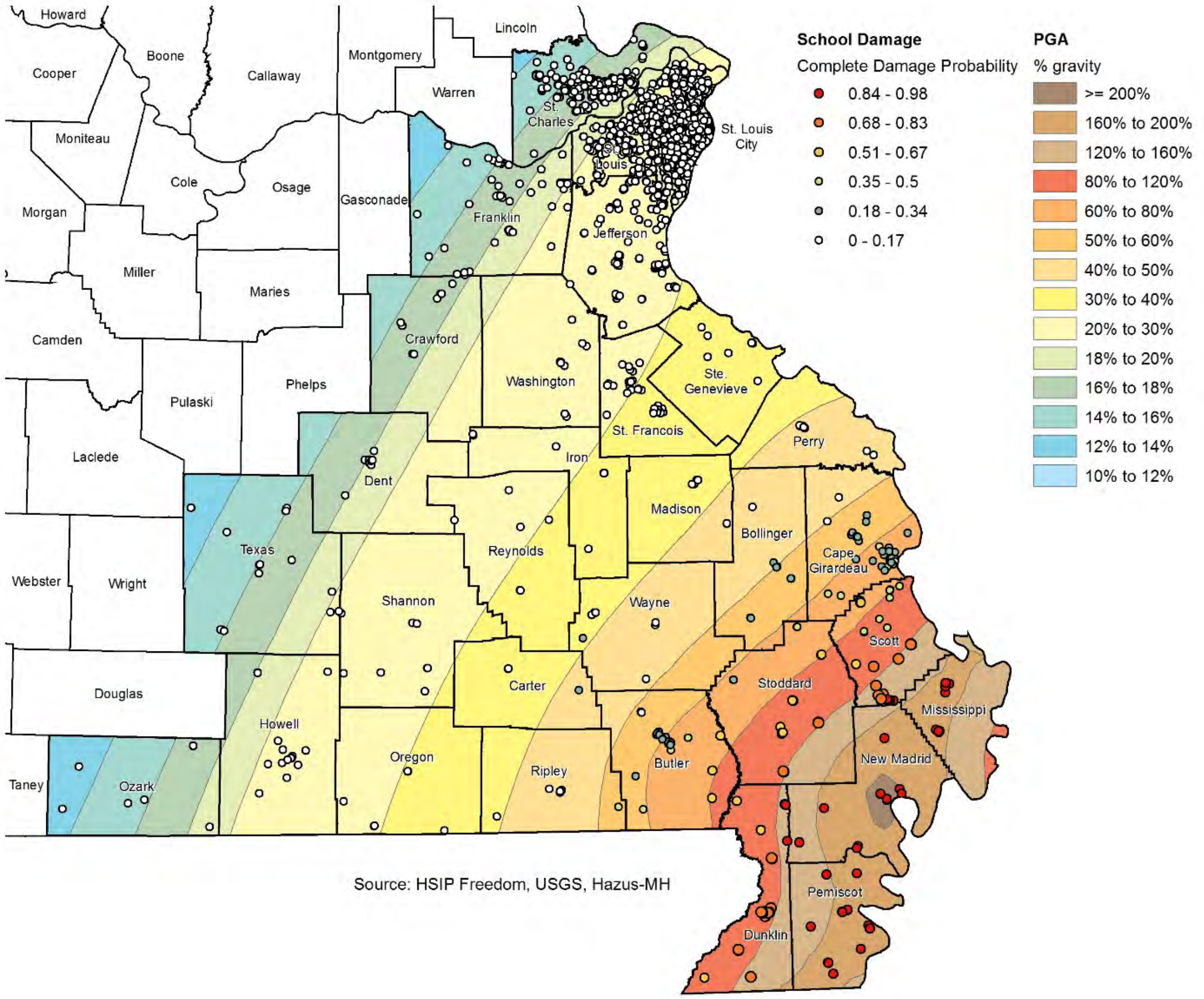


Figure 4. Map of Education Facility Damage Probability



2.1.1 Comparison of Shelter Requirements and Damage to Education Facilities and Red Cross-designated Shelters

Hazus provides estimates of displaced households and shelter needs based on modeled impacts to housing and Census population estimates. Since education facilities are often utilized to shelter displaced populations in the aftermath of a disaster, comparison was made of shelter requirements by county with the potential damage to education facilities. This analysis was further enhanced by reporting on designated shelters based on the Red Cross Shelter database included in the HSIP data.

The following table lists the displaced households and short term shelter requirements in the counties analyzed by Hazus. The analysis shows that Dunklin, Mississippi, New Madrid and Pemiscot counties have potential for a very high percentage of damaged education facilities. In the scenario, these counties also have a high displaced population that might have difficulty being sheltered due to anticipated damage. The table also notes which counties have designated Red Cross shelters likely to have significant damage. The counties with the highest number of potentially damaged Red Cross shelters include Dunkin, New Madrid, Scott and Stoddard. Note that the designation of Red Cross shelters regularly fluctuates and inaccuracies could be represented in the HSIP Red Cross shelter database. The upside of the analysis is that school and shelter damage potential is low outside of the counties in the Very High Hazus sub-region.

Table 4. Displaced Population and Damaged Education Facilities Comparison by County

EQ Sub-Region	County	# of Displaced Households	# of People Needing Short Term Shelter	# of Education Facilities Total in County	# of Education Facilities Complete Damage Probability 50% or more	% of Education Facilities in County with Complete Damage Probability 50% or more	# of Designated Shelters	# of Shelters Complete Damage Probability 50% or more
Very High	Butler	2,065	1,404	23	3	13%	0	0
	Dunklin	3,055	2,242	28	27	96%	2	2
	Mississippi	1,786	1,477	9	9	100%	0	0
	New Madrid	3,359	2,399	15	15	100%	5	5
	Pemiscot	2,819	2,173	19	19	100%	0	0
	Scott	3,678	2,481	34	24	71%	3	3
	Stoddard	2,465	1,584	21	15	71%	8	7
	Total	**19,227**	**13,760**	**149**	**112**	**75%**	**18**	**17**
High	Bollinger	407	276	10	0	0%	0	0
	Cape Girardeau	4,786	3,010	41	0	0%	3	0
	Carter	141	98	5	0	0%	0	0
	Iron	189	132	9	0	0%	3	0
	Madison	309	206	6	0	0%	0	0
	Oregon	155	112	8	0	0%	0	0
	Perry	513	301	10	0	0%	6	0
	Reynolds	103	68	8	0	0%	0	0
	Ripley	436	302	10	0	0%	0	0
	St. Francois	1,122	792	35	0	0%	3	0
	Ste. Genevieve	333	195	9	0	0%	1	0
	Wayne	420	281	9	0	0%	0	0
	Total	**8,914**	**5,773**	**160**	**0**	**0%**	**16**	**0**
Urban Moderate	Jefferson	2,183	1,264	159	0	0%	34	0
	St. Charles	1,360	726	230	0	0%	25	0
	St. Louis	4,857	3,422	902	0	0%	83	0
	St. Louis City	8,604	4,976	330	0	0%	5	0
	Total	**17,004**	**10,388**	**1,621**	**0**	**0%**	**147**	**0**
Moderate	Crawford	90	58	12	0	0%	0	0
	Dent	63	40	10	0	0%	0	0
	Franklin	403	238	59	0	0%	38	0
	Howell	249	164	18	0	0%	0	0
	Ozark	22	13	9	0	0%	0	0
	Shannon	79	55	9	0	0%	0	0
	Texas	73	53	19	0	0%	0	0
	Washington	175	132	13	0	0%	0	0
	Total	**1,154**	**753**	**149**	**0**	**0%**	**38**	**0**
	Grand Total	**46,299**	**30,674**	**2,079**	**112**	**75%**	**219**	**17**

3.0 Recommendations for Next Steps and Further Analysis

The results presented in this report can be used to identify, fire, medical, and education facilities that could be targeted for additional hazard mitigation including structural and non-structural seismic retrofitting. The results can also be used to support shelter planning, emergency preparedness, response and recovery planning. Specific recommendations are detailed below.

1. Conduct Rapid Visual Screening of Buildings for Potential Seismic Hazards using procedures specified in ATC 21 (FEMA 154)

Rapid Visual Screening of Building for Potential Seismic Hazards (RVS) is a pre-disaster procedure that can be implemented quickly and inexpensively to develop a list of potentially hazardous buildings without the cost of a detailed seismic analysis of individual buildings. The fire, medical, and education facilities identified in the appendix to this report could be targeted for RVS to identify buildings that may warrant further detailed seismic analysis.

2. Conduct Detailed Seismic Safety Inspections of High Risk Facilities

Fire, medical, and education facilities with a high probability of damage/low post-earthquake functionality should be further evaluated for seismic hazard and retrofit potential.

Specific Fire Department assessment

Fire department facilities with a high probability of damage/low post-earthquake functionality should be further evaluated for seismic hazard and retrofit potential. This should include assessment of engine bay doors that might be compromised.

Specific Medical care facilities assessment.

Medical care facilities with a high probability of damage/low post-earthquake functionality should be further evaluated for seismic hazard and retrofit potential. This should include non-structural seismic safety retrofits such as bracing or securing sensitive medical equipment and reduction of toppling hazards such as shelves and light fixtures that can cause injury and reduce facility functionality.

Specific Education Facilities assessment.

Education Facilities with a high probability of damage/low post-earthquake functionality should be further evaluated for seismic hazard and retrofit potential. This should include non-structural seismic safety retrofits such as bracing bookshelves and reduction of other toppling hazards that can cause injury and reduce facility functionality. Facilities designated as potential shelters should be given priority for detailed assessments.

3. Hold Training on ATC 20 Post Earthquake Safety Evaluation of Buildings

Following an earthquake disaster there is an immediate need for damage inspections throughout the affected areas. People need to be kept from using unsafe buildings, and safe shelter must be provided for those left homeless. It is essential that qualified building inspectors quickly identify structures that are safe for re-entry and those that must be avoided. Regular building inspection officials may become overloaded instantly and require additional help. Under such emergency conditions, qualified volunteer inspectors, including architects, engineers, and building inspectors are needed from unaffected regions and certain other qualified design and construction professionals can provide help with the post-earthquake safety evaluations. These volunteers will typically be activated through a pre-existing agreement with state and local emergency management officials. Training using the procedures outlined in ATC 20 should be implemented to bolster this capacity. Attendees of this course would receive inspector qualification training, experience to become a team member for inspecting earthquake damaged buildings, and a field manual to guide their future work.

4. Use Results to plan for post-earthquake shelter planning and preparedness

Post-earthquake shelter planning should look at alternate facilities and consider options for relocating people out of the hardest hit areas.

Table A1 – Fire Departments with a Greater than 0.50 Complete Damage Probability Grouped by County

County	Name	Address	City	Average for Damage State			Functionality (%)			
				Moderate	Extensive	Complete	At Day 1	At Day 7	At Day 14	At Day 90
Butler	Fisk Volunteer Fire Department	508 Garfield Street	Fisk	0.1699	0.2603	0.5196	0.8	4.9	5	35
Butler	Butler County Fire Protection District *	628 Mckinley Avenue	Fisk	0.1699	0.2603	0.5196	0.8	4.9	5	35
Butler	Butler County Fire Protection District *	7008 State Highway 51	Fisk	0.1642	0.2576	0.5313	0.7	4.5	4.6	33.9
Butler	Qulin Fire Protection Department	39 5Th Street	Qulin	0.1513	0.2508	0.5578	0.6	3.9	4	31.6
Dunklin	Campbell Volunteer Fire Department	203 North Locust Street	Campbell	0.1405	0.244	0.5806	0.5	3.4	3.4	29.7
Dunklin	Cardwell Volunteer Fire Department	119 North Main Street	Cardwell	0.1229	0.231	0.6187	0.3	2.6	2.7	26.5
Dunklin	Arbyrd Volunteer Fire Department	200 Broadway Street	Arbyrd	0.1045	0.2146	0.6602	0.2	1.9	2	23.2
Dunklin	Senath Volunteer Fire Department	100 South Main Street	Senath	0.0901	0.1994	0.6945	0.1	1.5	1.5	20.5
Dunklin	Holcomb Volunteer Fire Department	212 West Main Street	Holcomb	0.0733	0.1788	0.7364	0.1	1	1.1	17.3
Dunklin	Kennett Volunteer Fire Department Stati*	309 Saint Francis Street	Kennett	0.0681	0.1716	0.7501	0.1	0.9	1	16.3
Dunklin	Kennett Volunteer Fire Department Stati*	1701 First Street	Kennett	0.0681	0.1716	0.7501	0.1	0.9	1	16.3
Dunklin	Kennett Volunteer Fire Department Stati*	1424 Saint Francis Street	Kennett	0.0681	0.1716	0.7501	0.1	0.9	1	16.3
Dunklin	Hornersville Fire Department	400 Main Street	Hornersville	0.0474	0.139	0.8077	0	0.5	0.5	12.2
Dunklin	Clarkton Volunteer Fire Department	207 South Main Street	Clarkton	0.0362	0.1175	0.8423	0	0.3	0.3	9.8
Dunklin	Malden Fire Department	607 East Laclede Street	Malden	0.0353	0.1157	0.8452	0	0.3	0.3	9.6
Dunklin	Malden Volunteer Fire Department Statio*	301 South Beckwith Street	Malden	0.0353	0.1157	0.8452	0	0.3	0.3	9.6
Mississippi	Wyatt Volunteer Fire Department	200 3Rd Street	Wyatt	0.0261	0.0952	0.8763	0	0.2	0.2	7.6
Mississippi	Bertrand Fire Department	401 East Cedar Street	Bertrand	0.0198	0.0792	0.8993	0	0.1	0.1	6
Mississippi	Anniston Fire Department	235 Walnut Street	Anniston	0.0181	0.0746	0.9056	0	0.1	0.1	5.6
Mississippi	Charleston Department of Public Safety	204 North Main Street	Charleston	0.0166	0.0701	0.9119	0	0.1	0.1	5.2

County	Name	Address	City	Average for Damage State			Functionality (%)			
				Moderate	Extensive	Complete	At Day 1	At Day 7	At Day 14	At Day 90
Mississippi	East Prairie Fire Department	304 North Washington Avenue	East Prairie	0.0123	0.057	0.9297	0	0	0	4.1
New Madrid	Morehouse Fire and Rescue	115 Beech Street	Morehouse	0.0407	0.1265	0.8282	0	0.4	0.4	10.8
New Madrid	Gideon Volunteer Fire Department	109 South Main Street	Gideon	0.0259	0.0946	0.8771	0	0.2	0.2	7.5
New Madrid	Canalou Volunteer Fire Department	235 Madison Street	Canalou	0.0169	0.071	0.9106	0	0.1	0.1	5.3
New Madrid	Parma Volunteer Fire Department	201 East Main Street	Parma	0.0121	0.0564	0.9305	0	0	0	4.1
New Madrid	Risco Rural Fire Department	102 Riley Avenue	Risco	0.011	0.0528	0.9352	0	0	0	3.8
New Madrid	Risco Fire Department	102 Riley Avenue	Risco	0.011	0.0528	0.9352	0	0	0	3.8
New Madrid	Matthews Volunteer Fire Department	100 West Main Street	Matthews	0.0092	0.0464	0.9436	0	0	0	3.2
New Madrid	Portageville Fire Department	400 East 3Rd Street	Portageville	0.0054	0.0316	0.9625	0	0	0	2.1
New Madrid	Portageville Rural Fire Department Asso*	400 East 3Rd Street	Portageville	0.0054	0.0316	0.9625	0	0	0	2.1
New Madrid	Kewanee And Laforge Rural Volunteer Fir*	State Highway V and State Highway P	New Madrid	0.0049	0.0296	0.965	0	0	0	2
New Madrid	New Madrid Fire Department	560 Mott Street	New Madrid	0.0033	0.0221	0.9742	0	0	0	1.4
New Madrid	Missouri Department of Conservation For*	372 United States Highway 61	New Madrid	0.0033	0.0221	0.9742	0	0	0	1.4
New Madrid	Marston City Fire Department	209 East Elm Street	Marston	0.0031	0.0209	0.9756	0	0	0	1.3
New Madrid	Howardville Fire Department	105 Howard Street	Howardville	0.0028	0.0192	0.9777	0	0	0	1.2
New Madrid	Lilbourn Volunteer Fire Department	108 North 3Rd Street	Lilbourn	0.0024	0.0175	0.9797	0	0	0	1.1
Pemiscot	Bragg City Volunteer Fire Department	100 South Elm Street	Bragg City	0.0258	0.0946	0.8771	0	0.2	0.2	7.5
Pemiscot	Steele Fire Department	117 South Walnut Street	Steele	0.0165	0.0699	0.9122	0	0.1	0.1	5.2
Pemiscot	Cooter Volunteer Fire Department	1800 State Highway E	Cooter	0.0157	0.0677	0.9152	0	0.1	0.1	5
Pemiscot	Wardell Volunteer Fire Department	106 East Broad Street	Wardell	0.015	0.0654	0.9184	0	0	0.1	4.8
Pemiscot	Hayti Fire Department	101 Delta Lane	Hayti	0.0138	0.0619	0.9232	0	0	0	4.5

County	Name	Address	City	Average for Damage State			Functionality (%)			
				Moderate	Extensive	Complete	At Day 1	At Day 7	At Day 14	At Day 90
Pemiscot	Hayti Heights Fire Department	292 Rapoport Street	Hayti Heights	0.0138	0.0619	0.9232	0	0	0	4.5
Pemiscot	Caruthersville Fire Department	104 East 7Th Street	Caruthersville	0.0086	0.0442	0.9466	0	0	0	3.1
Scott	Perkins Volunteer Fire Department	580 State Highway P	Perkins	0.1695	0.2601	0.5204	0.8	4.8	4.9	34.9
Scott	New Hamburg/Benton/Commerce Fire Protec*	2596 County Highway 401	Benton	0.106	0.216	0.6568	0.2	2	2	23.4
Scott	Vanduser Fire and Rescue	1000 Vanduser Street	Vanduser	0.1048	0.2149	0.6595	0.2	2	2	23.2
Scott	Morley Volunteer Fire Department	106 Ball Park Circle	Morley	0.0992	0.2093	0.6727	0.2	1.8	1.8	22.2
Scott	Scott County Rural Fire Protection Dist*	910 West Harding Street	Benton	0.0992	0.2093	0.6727	0.2	1.8	1.8	22.2
Scott	New Hamburg/Benton/Commerce Fire Protec*	575 Saint Marys Street	Commerce	0.0972	0.2072	0.6774	0.2	1.7	1.8	21.8
Scott	Scott County Rural Fire Protection Dist*	220 North Hawkins Street	Sikeston	0.0661	0.1688	0.7554	0	0.9	0.9	16
Scott	Sikeston Department of Public Safety Fi*	301 North West Street	Sikeston	0.0417	0.1285	0.8249	0	0.4	0.4	11
Scott	Sikeston Department of Public Safety Fi*	506 North Main Street	Sikeston	0.0417	0.1285	0.8249	0	0.4	0.4	11
Scott	Miner Fire Department	103 State Highway H	Miner	0.0319	0.1085	0.8563	0	0.2	0.3	8.9
Scott	Sikeston Department of Public Safety Fi*	2003 Ables Road	Sikeston	0.0319	0.1085	0.8563	0	0.2	0.3	8.9
Stoddard	Dudley Volunteer Fire Department	12147 Mildred Street	Dudley	0.137	0.2417	0.588	0.4	3.2	3.3	29
Stoddard	Bell City Volunteer Fire Department	25246 Walnut Street	Bell City	0.1279	0.235	0.6077	0.4	2.8	2.9	27.4
Stoddard	Bloomfield Fire Department Station 1	200 Salem Street	Bloomfield	0.1244	0.2323	0.6153	0.3	2.7	2.7	26.8
Stoddard	Bloomfield Fire Department Station 2	402 Phelan Street	Bloomfield	0.1244	0.2323	0.6153	0.3	2.7	2.7	26.8
Stoddard	Dexter Fire Department Station 2	301 Cooper Street	Dexter	0.0855	0.1941	0.7056	0.1	1.4	1.4	19.7
Stoddard	Dexter Fire Department Station 3	301 East Stoddard Street	Dexter	0.0855	0.1941	0.7056	0.1	1.4	1.4	19.7
Stoddard	Essex Volunteer Fire Department	209 North Cypress Street	Essex	0.0566	0.1544	0.7814	0	0.7	0.7	14.1
Stoddard	Bernie Fire Department	107 North Allen Street	Bernie	0.0457	0.1358	0.813	0	0.5	0.5	11.8

Table B1 – Medical Facilities with a Greater than 0.50 Complete Damage Probability Grouped by County

County	Name	Facility Type	City	Average for Damage State			Functionality (%)			
				Moderate	Extensive	Complete	At Day 1	At Day 7	At Day 14	At Day 90
Dunklin	General Baptist Nursing Home	Nursing Homes	Campbell	0.1159	0.2636	0.5995	0.4	2	2	26.8
Dunklin	Heritage Gardens of Senath	Nursing Homes	Senath	0.0699	0.1779	0.7432	0.1	0.8	0.8	16.7
Dunklin	Heritage Gardens of Senath South	Nursing Homes	Senath	0.0699	0.1779	0.7432	0.1	0.8	0.8	16.7
Dunklin	Heritage Nursing Center	Nursing Homes	Kennett	0.0682	0.1741	0.7492	0.1	0.8	0.8	16.3
Dunklin	Saint Francis Park - Assisted Living By*	Nursing Homes	Kennett	0.0682	0.1741	0.7492	0.1	0.8	0.8	16.3
Dunklin	Twin Rivers Regional Medical Center	Medical Hospital	Kennett	0.051	0.1354	0.8081	0	0.5	0.5	12.3
Dunklin	NHC Healthcare of Kennett Limited Liabi*	Nursing Homes	Kennett	0.0466	0.1248	0.8239	0	0.4	0.4	11.3
Dunklin	Malden Nursing and Rehab	Nursing Homes	Malden	0.0384	0.1045	0.8535	0	0.3	0.3	9.3
Dunklin	Golden Livingcenter - Malden	Nursing Homes	Malden	0.0265	0.0733	0.8982	0	0.1	0.1	6.5
Mississippi	Bertrand Retirement Home	Nursing Homes	Bertrand	0.0132	0.0361	0.9498	0	0	0	3.1
Mississippi	Charleston Manor-Skilled Nursing by Ame*	Nursing Homes	Charleston	0.0109	0.0297	0.9586	0	0	0	2.6
Mississippi	East Prairie Nursing Center	Nursing Homes	East Prairie	0.0079	0.021	0.9706	0	0	0	1.8
New Madrid	Heritage Gardens of Sikeston	Nursing Homes	Sikeston	0.0219	0.0608	0.9156	0	0.1	0.1	5.3
New Madrid	Gideon Care Center	Nursing Homes	Gideon	0.0175	0.0485	0.9327	0	0	0	4.2
New Madrid	Sikeston Urgent Care	Urgent Care	Sikeston	0.0175	0.0485	0.9328	0	0	0	4.2
New Madrid	Sells Rest Home	Nursing Homes	Matthews	0.0057	0.0148	0.979	0	0	0	1.3
New Madrid	Heritage Gardens of Portageville	Nursing Homes	Portageville	0.0033	0.0079	0.9885	0	0	0	0.7
New Madrid	Golden Livingcenter - New Madrid	Nursing Homes	New Madrid	0.002	0.0044	0.9934	0	0	0	0.4
Pemiscot	River Oaks Care Center	Nursing Homes	Steele	0.0096	0.0259	0.9639	0	0	0	2.2
Pemiscot	Pemiscot County Health Center	Medical Hospital	Hayti	0.0089	0.0238	0.9668	0	0	0	2.1
Pemiscot	Caruthersville Nursing Center	Nursing Homes	Caruthersville	0.0053	0.0136	0.9806	0	0	0	1.2
Scott	Chaffee Nursing Center	Nursing Homes	Chaffee	0.1473	0.3091	0.5111	0.7	3.1	3.2	33.4
Scott	Westridge Place - Assisted Living by Am*	Nursing Homes	Sikeston	0.0296	0.0817	0.8863	0	0.2	0.2	7.2
Scott	Hunter Acres Caring Center	Nursing Homes	Sikeston	0.0296	0.0817	0.8863	0	0.2	0.2	7.2

County	Name	Facility Type	City	Average for Damage State			Functionality (%)			
				Moderate	Extensive	Complete	At Day 1	At Day 7	At Day 14	At Day 90
Scott	Missouri Delta Medical Center	Medical Hospital	Sikeston	0.0296	0.0817	0.8863	0	0.2	0.2	7.2
Scott	Sikeston Convalescent Center	Nursing Homes	Sikeston	0.0296	0.0817	0.8863	0	0.2	0.2	7.2
Scott	Ferguson Medical Group Urgent Care	Urgent Care	Sikeston	0.0296	0.0817	0.8863	0	0.2	0.2	7.2
Scott	Green Meadows Retirement Home	Nursing Homes	Sikeston	0.0296	0.0817	0.8863	0	0.2	0.2	7.2
Scott	Clearview Nursing and Rehabilitation Ce*	Nursing Homes	Sikeston	0.0296	0.0817	0.8863	0	0.2	0.2	7.2
Scott	Miner Nursing Center	Nursing Homes	Sikeston	0.022	0.0611	0.9153	0	0.1	0.1	5.3
Scott	Colonial Manor Llc	Nursing Homes	Sikeston	0.0175	0.0485	0.9328	0	0	0	4.2
Stoddard	Crowley Ridge Care Center	Nursing Homes	Dexter	0.1305	0.2859	0.5577	0.5	2.5	2.5	29.9
Stoddard	Cypress Point - Skilled Nursing by Amer*	Nursing Homes	Dexter	0.1305	0.2859	0.5577	0.5	2.5	2.5	29.9
Stoddard	Missouri Southern Healthcare	Medical Hospital	Dexter	0.1098	0.2534	0.6178	0.4	1.8	1.9	25.5
Stoddard	Golden Livingcenter - Bloomfield	Nursing Homes	Bloomfield	0.1011	0.2385	0.6439	0.3	1.6	1.6	23.6
Stoddard	Essex Residential Care	Nursing Homes	Essex	0.0768	0.1923	0.7205	0.1	0.9	1	18.3
Stoddard	Golden Livingcenter - Dexter	Nursing Homes	Dexter	0.0655	0.1683	0.7582	0.1	0.7	0.7	15.7

Table C1 – Education Facilities with a Greater than 0.50 Complete Damage Probability Grouped by County

County	Name	Facility Type	Shelter	City	Average for Damage State			Functionality (%)			
					Moderate	Extensive	Complete	At Day 1	At Day 7	At Day 14	At Day 90
Butler	Fisk Elem.	Public	No	Fisk	0.1699	0.2603	0.5196	0.8	4.9	5	35
Butler	Twin Rivers High	Public	No	Broseley	0.1642	0.2576	0.5313	0.7	4.5	4.6	33.9
Butler	Qulin Elem.	Public	No	Qulin	0.1513	0.2508	0.5578	0.6	3.9	4	31.6
Dunklin	St Teresa School	Private	No	Campbell	0.114	0.2235	0.6386	0.3	2.3	2.3	24.9
Dunklin	Campbell Elem.	Public	No	Campbell	0.1113	0.221	0.6447	0.2	2.2	2.2	24.4
Dunklin	Campbell High	Public	No	Campbell	0.1113	0.221	0.6447	0.2	2.2	2.2	24.4
Dunklin	Senath Elem.	Public	No	Senath	0.0901	0.1994	0.6945	0.1	1.5	1.5	20.5
Dunklin	Senath-Hornersville Sr. High	Public	No	Senath	0.0901	0.1994	0.6945	0.1	1.5	1.5	20.5
Dunklin	Holcomb Elem.	Public	No	Holcomb	0.0733	0.1788	0.7364	0.1	1	1.1	17.3
Dunklin	Holcomb High	Public	No	Holcomb	0.0733	0.1788	0.7364	0.1	1	1.1	17.3
Dunklin	Diagnostic Ctr.	Public	No	Kennett	0.0681	0.1716	0.7501	0.1	0.9	1	16.3
Dunklin	South Elem.	Public	No	Kennett	0.0681	0.1716	0.7501	0.1	0.9	1	16.3
Dunklin	Kennett Middle	Public	No	Kennett	0.0681	0.1716	0.7501	0.1	0.9	1	16.3
Dunklin	H. Byron Masterson Elem.	Public	No	Kennett	0.0681	0.1716	0.7501	0.1	0.9	1	16.3
Dunklin	Southeast Missouri State University - K*	Supplemental College	No	Kennett	0.0681	0.1716	0.7501	0.1	0.9	1	16.3
Dunklin	Kennett Christian Academy	Private	No	Kennett	0.0681	0.1716	0.7501	0.1	0.9	1	16.3
Dunklin	Kennett High	Public	No	Kennett	0.0681	0.1716	0.7501	0.1	0.9	1	16.3
Dunklin	Kennett Career & Tech. Ctr.	Public	No	Kennett	0.0681	0.1716	0.7501	0.1	0.9	1	16.3
Dunklin	Early Childhood Ctr.	Public	No	Kennett	0.0681	0.1716	0.7501	0.1	0.9	1	16.3
Dunklin	Kennett Career and Technology Center	College/ University	No	Kennett	0.0681	0.1716	0.7501	0.1	0.9	1	16.3
Dunklin	Hornersville Middle	Public	No	Hornersville	0.0474	0.139	0.8077	0	0.5	0.5	12.2
Dunklin	Southeast Missouri State University - S*	Supplemental College	No	Sikeston	0.0417	0.1285	0.8249	0	0.4	0.4	11
Dunklin	Bootheel School	Public	No	Clarkton	0.0362	0.1175	0.8423	0	0.3	0.3	9.8
Dunklin	Clarkton Elem.	Public	No	Clarkton	0.0362	0.1175	0.8423	0	0.3	0.3	9.8
Dunklin	Clarkton High	Public	No	Clarkton	0.0362	0.1175	0.8423	0	0.3	0.3	9.8
Dunklin	Malden Lower Elem.	Public	No	Malden	0.0353	0.1157	0.8452	0	0.3	0.3	9.6
Dunklin	Malden High	Public	No	Malden	0.0353	0.1157	0.8452	0	0.3	0.3	9.6
Dunklin	Southeast Missouri State University - M*	Supplemental College	No	Malden	0.0353	0.1157	0.8452	0	0.3	0.3	9.6

County	Name	Facility Type	Shelter	City	Average for Damage State			Functionality (%)			
					Moderate	Extensive	Complete	At Day 1	At Day 7	At Day 14	At Day 90
Dunklin	Southland Elem.	Public	Yes	Cardwell	0.1229	0.231	0.6187	0.3	2.6	2.7	26.5
Dunklin	Southland High	Public	Yes	Cardwell	0.1229	0.231	0.6187	0.3	2.6	2.7	26.5
Mississippi	Southeast Correctional Center	Public	No	Charleston	0.0166	0.0701	0.9119	0	0.1	0.1	5.2
Mississippi	Charleston High	Public	No	Charleston	0.0166	0.0701	0.9119	0	0.1	0.1	5.2
Mississippi	Warren E. Hearnes Elem.	Public	No	Charleston	0.0166	0.0701	0.9119	0	0.1	0.1	5.2
Mississippi	Charleston Middle	Public	No	Charleston	0.0166	0.0701	0.9119	0	0.1	0.1	5.2
Mississippi	St Henry Catholic School	Private	No	Charleston	0.0166	0.0701	0.9119	0	0.1	0.1	5.2
Mississippi	East Prairie High	Public	No	East Prairie	0.0132	0.0599	0.9258	0	0	0	4.4
Mississippi	A. J. Martin Elem.	Public	No	East Prairie	0.0123	0.057	0.9297	0	0	0	4.1
Mississippi	R. A. Doyle Elem.	Public	No	East Prairie	0.0123	0.057	0.9297	0	0	0	4.1
Mississippi	East Prairie Jr. High	Public	No	East Prairie	0.0123	0.057	0.9297	0	0	0	4.1
New Madrid	Gideon Elem.	Public	No	Gideon	0.0259	0.0946	0.8771	0	0.2	0.2	7.5
New Madrid	Gideon High	Public	No	Gideon	0.0259	0.0946	0.8771	0	0.2	0.2	7.5
New Madrid	Risco Elem.	Public	No	Risco	0.011	0.0528	0.9352	0	0	0	3.8
New Madrid	Risco High	Public	No	Risco	0.011	0.0528	0.9352	0	0	0	3.8
New Madrid	Matthews Elem.	Public	No	Matthews	0.0092	0.0464	0.9436	0	0	0	3.2
New Madrid	Portageville High	Public	No	Portageville	0.0054	0.0316	0.9625	0	0	0	2.1
New Madrid	Portageville Elem.	Public	No	Portageville	0.0054	0.0316	0.9625	0	0	0	2.1
New Madrid	St Eustachius Elementary School	Private	No	Portageville	0.0054	0.0316	0.9625	0	0	0	2.1
New Madrid	Immaculate Conception School	Private	No	New Madrid	0.0033	0.0221	0.9742	0	0	0	1.4
New Madrid	New Madrid Bend Youth Ctr.	Public	No	New Madrid	0.0033	0.0221	0.9742	0	0	0	1.4
New Madrid	New Madrid Elem.	Public	Yes	New Madrid	0.0033	0.0221	0.9742	0	0	0	1.4

County	Name	Facility Type	Shelter	City	Average for Damage State			Functionality (%)			
					Moderate	Extensive	Complete	At Day 1	At Day 7	At Day 14	At Day 90
New Madrid	Central High	Public	Yes	New Madrid	0.0028	0.0192	0.9777	0	0	0	1.2
New Madrid	New Madrid R-I Tech Skills Ctr	Public	Yes	New Madrid	0.0028	0.0192	0.9777	0	0	0	1.2
New Madrid	Lilbourn Elem.	Public	Yes	Lilbourn	0.0024	0.0175	0.9797	0	0	0	1.1
New Madrid	Central Middle	Public	Yes	New Madrid	0.0024	0.0175	0.9797	0	0	0	1.1
Pemiscot	Delta C-7 Elem.	Public	No	Deering	0.0233	0.0884	0.8862	0	0.1	0.1	6.9
Pemiscot	Delta C-7 High	Public	No	Deering	0.0233	0.0884	0.8862	0	0.1	0.1	6.9
Pemiscot	South Pemiscot High	Public	No	Steele	0.0165	0.0699	0.9122	0	0.1	0.1	5.2
Pemiscot	Cooter High	Public	No	Cooter	0.0157	0.0677	0.9152	0	0.1	0.1	5
Pemiscot	Cooter Elem.	Public	No	Cooter	0.0157	0.0677	0.9152	0	0.1	0.1	5
Pemiscot	North Pemiscot Sr. High	Public	No	Wardell	0.015	0.0654	0.9184	0	0	0.1	4.8
Pemiscot	South Pemiscot Elem.	Public	No	Steele	0.0149	0.0653	0.9186	0	0	0.1	4.8
Pemiscot	Diagnostic Ctr.	Public	No	Hayti	0.0138	0.0619	0.9232	0	0	0	4.5
Pemiscot	Pemiscot Co Career & Tech Ctr	Public	No	Hayti	0.0138	0.0619	0.9232	0	0	0	4.5
Pemiscot	Wallace Elem.	Public	No	Hayti	0.0138	0.0619	0.9232	0	0	0	4.5
Pemiscot	Hayti High	Public	No	Hayti	0.0138	0.0619	0.9232	0	0	0	4.5
Pemiscot	Mathis Elem.	Public	No	Hayti	0.0138	0.0619	0.9232	0	0	0	4.5
Pemiscot	Oak View Learning Ctr.	Public	No	Hayti	0.0138	0.0619	0.9232	0	0	0	4.5
Pemiscot	Pemiscot County Special School District	College/ University	No	Hayti	0.0138	0.0619	0.9232	0	0	0	4.5
Pemiscot	Pemiscot Co. R-Iii Elem.	Public	No	Caruthersville	0.0123	0.057	0.9298	0	0	0	4.1
Pemiscot	Ross Elem.	Public	No	Portageville	0.0097	0.0483	0.9412	0	0	0	3.4
Pemiscot	Caruthersville Elem.	Public	No	Caruthersville	0.0086	0.0442	0.9466	0	0	0	3.1
Pemiscot	Caruthersville High	Public	No	Caruthersville	0.0086	0.0442	0.9466	0	0	0	3.1
Pemiscot	Caruthersville Middle	Public	No	Caruthersville	0.0086	0.0442	0.9466	0	0	0	3.1
Scott	St Ambrose School	Private	No	Chaffee	0.1716	0.261	0.5162	0.8	4.9	5.1	35.3
Scott	Anchor Academy	Private	No	Vanduser	0.1048	0.2149	0.6595	0.2	2	2	23.2
Scott	Scott Co. Central Elem.	Public	No	Sikeston	0.0799	0.1873	0.7196	0.1	1.2	1.3	18.6
Scott	Scott Co. Central High	Public	No	Sikeston	0.0799	0.1873	0.7196	0.1	1.2	1.3	18.6
Scott	Scott Co. Middle	Public	No	Benton	0.0712	0.1759	0.7419	0.1	1	1	16.9
Scott	Sikeston Hope Ctr.	Public	No	Sikeston	0.0661	0.1688	0.7554	0	0.9	0.9	16
Scott	Scott Co. Elem.	Public	No	Benton	0.0554	0.1525	0.7846	0	0.6	0.7	13.8
Scott	Thomas W. Kelly High	Public	No	Benton	0.0554	0.1525	0.7846	0	0.6	0.7	13.8
Scott	Sikeston Kindergarten Ctr.	Public	No	Sikeston	0.0417	0.1285	0.8249	0	0.4	0.4	11

County	Name	Facility Type	Shelter	City	Average for Damage State			Functionality (%)			
					Moderate	Extensive	Complete	At Day 1	At Day 7	At Day 14	At Day 90
Scott	St Francis Xavier School	Private	No	Sikeston	0.0417	0.1285	0.8249	0	0.4	0.4	11
Scott	The Christian Academy	Private	No	Sikeston	0.0417	0.1285	0.8249	0	0.4	0.4	11
Scott	7Th And 8Th Grade Ctr.	Public	No	Sikeston	0.0417	0.1285	0.8249	0	0.4	0.4	11
Scott	Lee Hunter Elem.	Public	No	Sikeston	0.0417	0.1285	0.8249	0	0.4	0.4	11
Scott	Southeast Elem.	Public	No	Sikeston	0.0319	0.1085	0.8563	0	0.2	0.3	8.9
Scott	Southeast Missouri Christian Academy	Private	No	Sikeston	0.0319	0.1085	0.8563	0	0.2	0.3	8.9
Scott	Sikeston Career & Tech. Ctr.	Public	No	Sikeston	0.0319	0.1085	0.8563	0	0.2	0.3	8.9
Scott	Morehouse Elem.	Public	No	Sikeston	0.0319	0.1085	0.8563	0	0.2	0.3	8.9
Scott	5Th And 6Th Grade Ctr.	Public	No	Sikeston	0.0319	0.1085	0.8563	0	0.2	0.3	8.9
Scott	Sikeston Career and Technology Center	College/ University	No	Sikeston	0.0319	0.1085	0.8563	0	0.2	0.3	8.9
Scott	Sikeston Sr. High	Public	No	Sikeston	0.0319	0.1085	0.8563	0	0.2	0.3	8.9
Scott	New Dawn School	Public	No	Sikeston	0.0208	0.0818	0.8956	0	0.1	0.1	6.3
Scott	Chaffee Elem.	Public	Yes	Chaffee	0.1716	0.261	0.5162	0.8	4.9	5.1	35.3
Scott	Chaffee Jr.-Sr. High	Public	Yes	Chaffee	0.1716	0.261	0.5162	0.8	4.9	5.1	35.3
Scott	Matthews Elem.	Public	Yes	Sikeston	0.0208	0.0818	0.8956	0	0.1	0.1	6.3
Stoddard	Crowley Ridge School	Public	No	Dexter	0.1548	0.2527	0.5507	0.6	4	4.1	32.2
Stoddard	Bell City High	Public	No	Bell City	0.1279	0.235	0.6077	0.4	2.8	2.9	27.4
Stoddard	Bloomfield Elem.	Public	No	Bloomfield	0.1244	0.2323	0.6153	0.3	2.7	2.7	26.8
Stoddard	Bloomfield High	Public	No	Bloomfield	0.1244	0.2323	0.6153	0.3	2.7	2.7	26.8
Stoddard	Juvenile Ctr.	Public	No	Bloomfield	0.1244	0.2323	0.6153	0.3	2.7	2.7	26.8
Stoddard	Bloomfield Middle	Public	No	Bloomfield	0.1244	0.2323	0.6153	0.3	2.7	2.7	26.8
Stoddard	Richland High	Public	No	Essex	0.0566	0.1544	0.7814	0	0.7	0.7	14.1
Stoddard	Richland Elem.	Public	No	Essex	0.0566	0.1544	0.7814	0	0.7	0.7	14.1
Stoddard	Central Elem.	Public	Yes	Dexter	0.1548	0.2527	0.5507	0.6	4	4.1	32.2
Stoddard	T. S. Hill Middle	Public	Yes	Dexter	0.1548	0.2527	0.5507	0.6	4	4.1	32.2
Stoddard	Dexter High	Public	Yes	Dexter	0.1548	0.2527	0.5507	0.6	4	4.1	32.2
Stoddard	Southwest Elem.	Public	Yes	Dexter	0.1338	0.2394	0.595	0.4	3	3.1	28.5
Stoddard	Bell City Elem.	Public	Yes	Bell City	0.1279	0.235	0.6077	0.4	2.8	2.9	27.4
Stoddard	Bernie High	Public	Yes	Bernie	0.0643	0.1662	0.7602	0	0.8	0.9	15.6
Stoddard	Bernie Elem.	Public	Yes	Bernie	0.0457	0.1358	0.813	0	0.5	0.5	11.8

Appendix C3

Missouri Flood Risk Assessment Enhancements

Essential Facilities

2015 MISSOURI INSURANCE REPORT

THE STATE OF Earthquake Coverage

Statistics Section
August 2015

DIFP
Department of Insurance, Financial Institutions & Professional Registration

Jeremiah W. (Jay) Nixon
Governor

John M. Huff
Director

Table of Contents

Tables And Figures

Introduction

Missouri is the third largest market for earthquake insurance among the states, exceeded only by California and Washington.[1] The primary earthquake risk in the state is associated with the New Madrid fault, and is greatest in the Southeast quadrant of the state extending from the bootheel northwards to St. Louis and beyond. However, it is precisely in this high-risk area that the market for earthquake insurance has significantly contracted over the past 10 to 15 years – many insurers have left the market entirely while others refuse to issue new policies in the New Madrid area. Among insurers still willing to sell coverage, stricter underwriting standards make some types of dwellings ineligible for coverage. Those who can obtain coverage find that they are required to "self-insure" to a much greater extent than in the past. Deductibles up to 20 percent of the dwelling value are not uncommon, and "stacked" deductibles are often applied separately to the dwelling and contents. While coverage has contracted, the price of coverage has increased significantly, in some counties by more than 500 percent over the last 15 years. In short, coverage has become significantly less available and less affordable in the areas that require it most.

This report presents data on market trends over the past 15 years. Missouri is one of the few states that collect residential insurance data by ZIP code, including data for earthquake coverage. These data afford a fairly precise measure of market penetration and price by geographic region. In addition, these data were supplemented by a survey of Missouri's largest writers regarding market practices related to earthquake coverage.

Summary of Findings

Earthquake coverage has become less available and less affordable over the last 15 years. Where the coverage is available, prices have significantly increased and consumers are required to self-insure to a greater extent than ever before.

- On average, earthquake premiums in the six counties that comprise the New Madrid area have increased by nearly 500 percent between 2000 and 2014, and in one county by almost 700 percent.

- While rates have increased throughout the state, the rates in the highest risk areas of the state have increased much more rapidly, widening the costs between high and low risk areas. In 2000, average annual premium in the New Madrid area was only 64 percent higher than the lowest risk counties of Missouri. By 2015, premiums were nearly 330 percent higher.

- In 2000, over 60 percent of residences in the New Madrid area had earthquake insurance. By 2014, the rate of coverage had plummeted to just 20 percent.

- In other high risk areas outside of the New Madrid zone, take-up rates also substantially decreased, from 67.6 percent to 52.1 percent over the same period.

[1] Including territories, Puerto Rico also has a somewhat higher premium volume for earthquake insurance. However, Puerto Rico is a special case, in that earthquake insurance is required for most residences.

- A total of 562,734 residences that are not covered for earthquake losses are located in a Missouri county rated 7 or higher on the Mercalli scale (a measurement of vulnerability to earthquakes, see below). The total property value of these unprotected residences, excluding the value of contents that may also be at risk, is estimated to exceed $86 billion.

- Based on the Missouri market share for homeowners insurance,
  - Carriers with 10 percent of the market write no earthquake coverage
  - 19 percent write somewhere in Missouri, but will not provide the coverage in the New Madrid area
  - 44 percent issue some coverage in the New Madrid area, but with significant additional underwriting restrictions, such as refusing to insure masonry homes.
  - Only 26.6 percent of the market issues coverage in New Madrid on the same basis as elsewhere in the state.

- Those able to obtain earthquake insurance must still "self-insure" to a significant degree. No insurer (among those surveyed) offers a deductible of less than 10 percent of the insured value of the residence. Over 40 percent of the market requires a deductible of 20 percent or higher. Often, deductibles are "stacked," such that they apply separately to the building and contents.

- Of those who have earthquake coverage and are located in areas with a risk of 7 or higher on the Mercalli scale, the amount of risk they still retain due to deductibles exceeds $14.8 billion. When this amount is added to homes that have no earthquake coverage, the value of self-insured residential property in moderate to high-risk zones exceeds $100 billion ($86.2 billion with no earthquake insurance + 14.8 billion retained due to deductible).

In the following report, these trends are displayed by Missouri region and by county. More detailed tables can be found in the appendices.

Missouri's Earthquake Risk

Over the winter of 1811-1812, the New Madrid area of Missouri experienced a series of powerful earthquakes. By most estimates, these quakes were among the strongest ever experienced on what is now the continental US, at least since its settlement by Europeans. According to the US Geological Survey (USGS), the area of strong ground motion exceeded the 1964 Alaska earthquake by a factor of two to three, and was approximately ten times as large as the 1909 San Francisco earthquake. Because of the lack of instrumentation at the time, estimates of the magnitude of these earthquakes are primarily based on written accounts of those who witnessed the quake or its aftermath. The majority of researchers believe the three primary quakes ranged in magnitude from 7.0 to 7.5, with several aftershocks ranging from 6.0 to 6.5 (see USGS, http://earthquake.usgs.gov/earthquakes/states/events/1811-1812.php).

Eyewitness accounts of the event(s) vividly describe the extraordinary violence unleashed by the New Madrid fault. One eyewitness close to the epicenter of the December 16, 2011 earthquake details "…a scene truly horrible" in which the Mississippi River reversed course for a time:

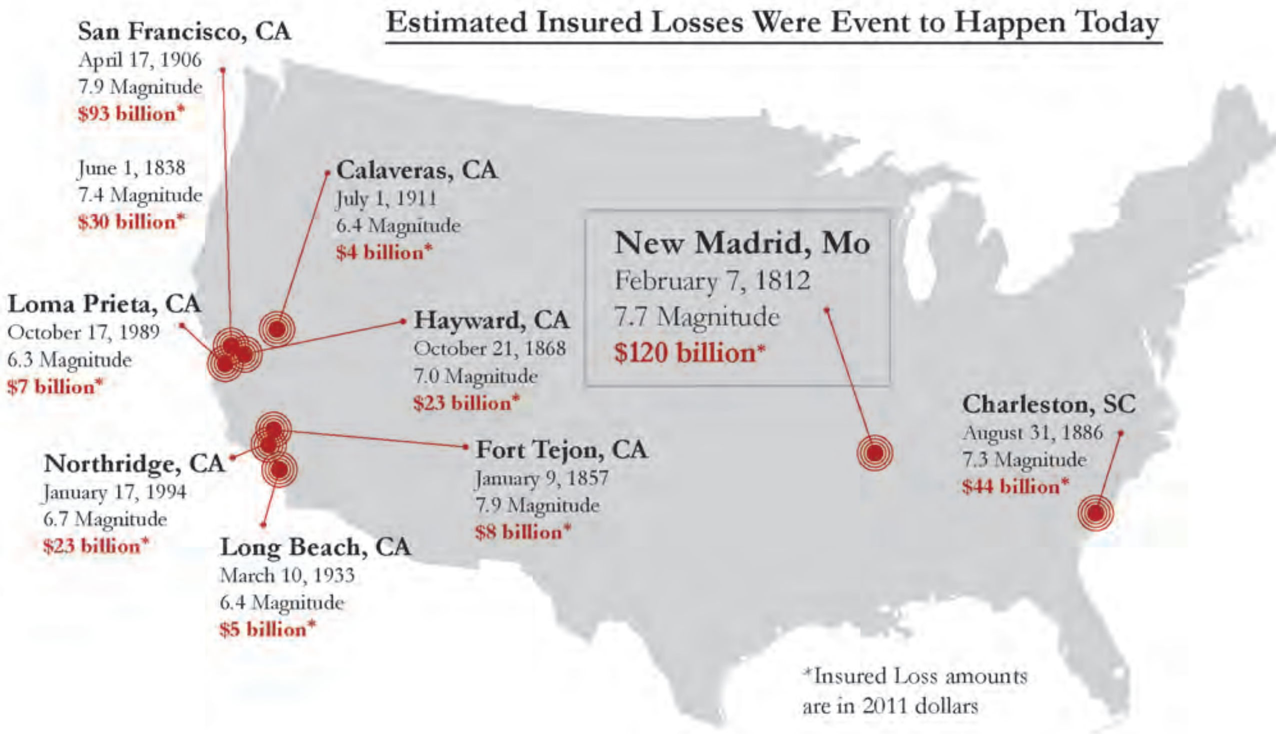
On the 16th of December, 1811, about two o'clock, A.M., we were visited by a violent shock of an earthquake, accompanied by a very awful noise resembling loud but distant thunder, but more hoarse and vibrating, which was followed in a few minutes by the complete saturation of the atmosphere, with sulphurious vapor, causing total darkness. The screams of the affrighted inhabitants running to and fro, not knowing where to go, or what to do - the cries of the fowls and beasts of every species - the cracking of trees falling, and the roaring of the Mississippi - the current of which was retrograde for a few minutes, owing as is supposed, to an irruption in its bed -- formed a scene truly horrible.[2]

Strong tremors and some property damage were reported as far away as Cleveland (where a local newspaper reported "serious alarm" at "shocks far more violent than any before experienced"), Alexandria, Pittsburgh, Washington D.C., New York and other eastern cities.

Were an earthquake of similar magnitude to occur today along the New Madrid fault, losses would be staggering. The risk modeling firm AIR Worldwide has estimated that a New Madrid recurrence would produce *insured* losses of $120 billion (2011 dollars). More recently, global reinsurer Swiss Re estimated total insured losses at $150 billion.[3] Such losses would only be rivaled by a repeat of the 1906 San Francisco earthquake, with estimated losses of $93 billion.

[2] Letter from Eliza Bryan, March 22, 1816. Reprinted by USGS, available at http://hsv.com/genlintr/newmadrd/accnt1.htm

[3] Swiss Re. 2015. **Four Earthquakes in 54 Days.** Swiss Re American Holding Corporation. 175 King Street, Armonk, NY 10504.



Source: AIR Worldwide. Estimated losses include property and contents loss, additional living expense, business interruption for residential, mobile home, commercial and automobile losses. Estimates include demand surge and fire following earthquake, and are based on earthquake insurance take-up rates in each area. See http://www.air-worldwide.com/Publications/AIR-Currents/2012/Top-10-Historical-Hurricanes-and-Earthquakes-in-the-U-S---What-Would-They-Cost-Today/

The USGS has estimated that the probability of a magnitude 7.5 or greater earthquake in the New Madrid zone over the next 50 years is between 7-10 percent. The probability of an earthquake exceeding magnitude 6 over the same time period is 25-40 percent.[4] A joint assessment by the Mid-America Earthquake Center of the University of Illinois and the Federal Emergency Management Agency predicted that a major New Madrid event could entail total economic losses of $300 billion, damage 715,000 buildings, and result in 86,000 casualties and 3,500 fatalities. It would constitute the highest total economic loss of any natural disaster in US history.[5]

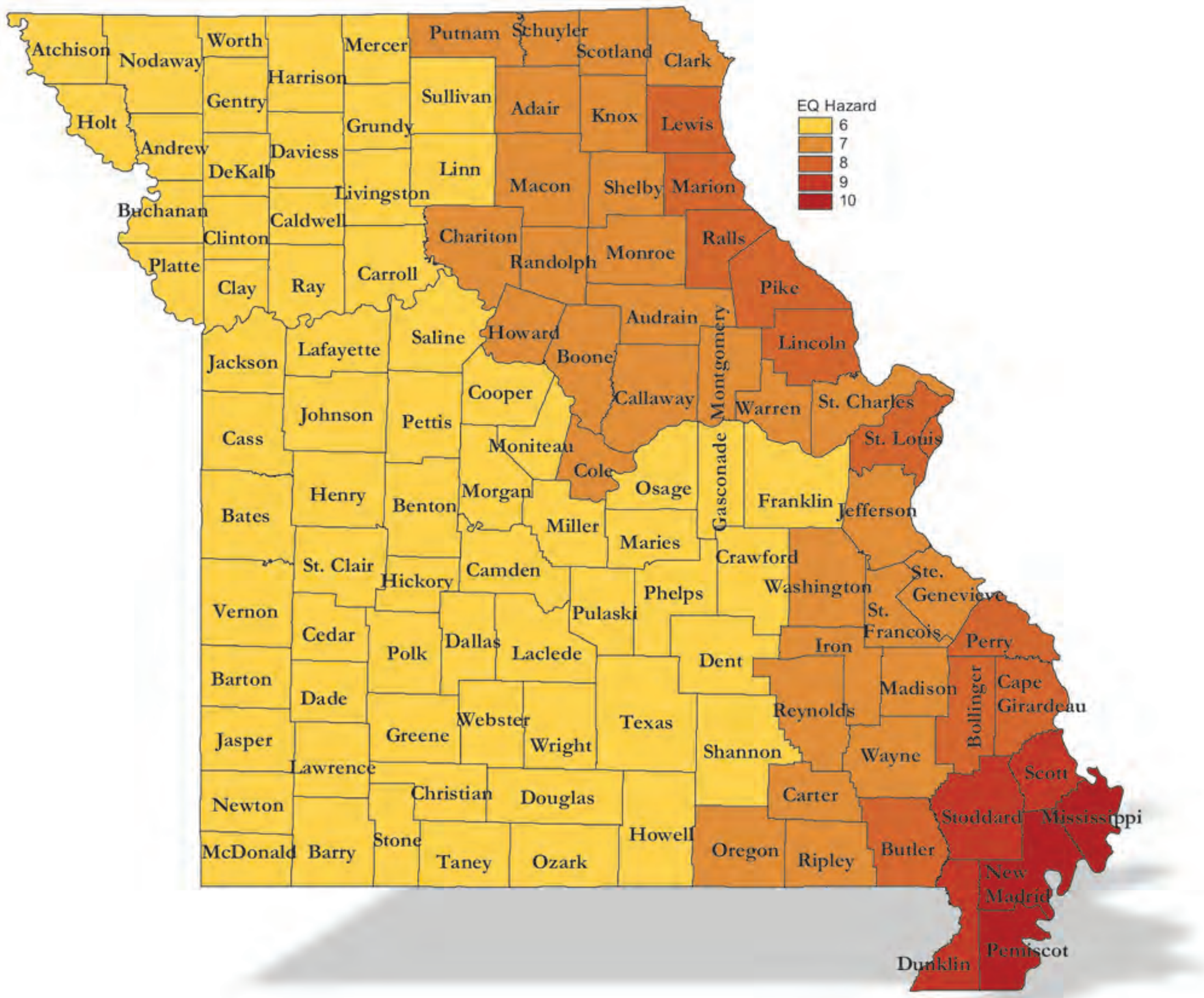
The Missouri counties most vulnerable to earthquake risk are the six southeastern-most counties in the bootheel: Dunklin, Mississippi, New Madrid, Pemiscot, Scott and Stoddard. Other high risk areas include counties adjacent to the New Madrid Region, extending north to St. Louis. The entire western portion of the state has a relatively lower risk for earthquake damage, a fact important for Missouri's earthquake insurance market.

The Mercalli Scale, a measure of shaking intensity ranging from 1 to 12, is depicted in the map on page 6. If a large New Madrid event were to occur today, large portions of the state would be subjected to shaking ranging from 7 to 10 on this scale. The remainder of the state would be subject to shaking intensity rated at a level of 6. The levels are defined by the intensity of ground movement, as follows:

[4] US Geological Survey Fact Sheet FS-131-02. October, 2002.

[5] Elnashai, Amr, Lisa Cleveland, Theresa Jefferson and John Harrald. 2009. Impact of New Madrid Seismic Zone Earthquakes on the Central USA, Vol I & II. MAE Center Report No. 09-03

Mercalli Scale (Projected Earthquake Intensity)
Projected Intensity from a 7.6 Magnitude Earthquake in New Madrid



Source: Adapted from the Missouri State Emergency Management Agency.

Mercalli Intensity Scale

According to the Missouri State Emergency Management Agency, the intensities are described as follows:

1 – People do not feel any Earth movement.

2 – A few people might notice movement.

3 – Many people indoors feel movement. Hanging objects swing.

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

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

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

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

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

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

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

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

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

According to the Missouri State Emergency Management Agency, intensity is a numerical index describing the effects of an earthquake on the surface of the Earth, on man, and on structures built by man. There will actually be a range in intensities within any small area such as a town or county, with the highest intensity generally occurring at only a few sites.

Source: Taken directly from the Missouri State Emergency Management Agency, available at http://sema.dps.mo.gov/docs/programs/Planning-Disaster-Recovery/HazardAnalysis/2013-State-Hazard-Analysis/Annex_F_Earthquakes.pdf.

Background: Managing Risk with Insurance Markets

Earthquake insurance markets possess features that depart significantly from what might be called "ideal" insurance markets, and such peculiarities are largely attributable to the nature of the underlying risk. In competitive markets, the price of a product reflects the cost of production plus administrative expenses and a normal rate of return (and, of course, elasticity of demand). Unlike traditional and particularly tangible products, the cost of insurance isn't known with certainty at the time the price is established and the product sold. To price in a meaningful way, insurers require a high degree of confidence that predictions regarding likely losses are accurate. The greater the uncertainty regarding the true risk and ultimate payout in claims, the less well a market will function in the traditional sense. Of course, this same uncertainty regarding the true nature of the risk is shared by consumers, which complicates decisions about incurring a known loss (the premium payment) to avoid a possible greater loss of unknown or uncertain probability.[6]

Traditionally, the most predictable and therefore insurable events are those characterized by high frequency and low severity losses. Statistical models rely on the "law of large numbers," such that the more one is able to observe an event over time, the greater the certainty that meaningful probabilities of loss can be ascertained.[7] In addition, risks are manageable because losses of this kind are *statistically independent events*. The probability that Driver B in Kansas City will be involved in an automobile accident on a given day isn't affected by the fact that Driver A in St. Louis experienced a crash. While automobile and homeowners insurance can be subject to catastrophic large-scale losses due to a single event, such losses are manageable and are generally a small proportion of overall losses when extended over a sufficient time period. Most automobile losses, for example, are due to day-to-day crashes whose costs are highly predictable over time, and where loss probabilities aren't subject to significant swings from year-to-year. In general, prior year losses are a very good predictor of current year losses.

Clearly, earthquake insurance markets depart from the idealized features discussed above in several important ways. First, the likelihood of a significant event cannot be determined with a high degree of confidence and precision, certainly not in a way that is analogous to predicting automobile losses. Secondly, rather than "high frequency / low severity" losses, earthquakes present exactly the opposite risk in which losses are very infrequent (in Missouri) but have the potential to be catastrophic. Nor are losses *independent events* – a loss on one policy will quite possibly entail losses of virtually every policy within the area of risk. Lastly, the earthquake risk in Missouri is largely localized geographically to the southeastern quadrant of the state, so there is little incentive for individuals residing outside of the high risk zone to purchase coverage (and in fact few homeowners in low risk areas have earthquake coverage). It is therefore difficult to spread risk geographically using traditional market mechanisms.

Many of these types of events have at various times in history become uninsurable by private markets. Some risks have been assumed by public bodies in whole or in part when private markets failed to produce adequate or affordable coverage. Examples include flood insurance, crop insurance and the terrorism risk backstop, where at various times such risks were considered too unpredictable and possible losses too

[6] See the excellent discussion of precisely this problem in Kunreuther, Howard, and Mark Pauly. 2004. Neglecting disaster: Why don't people insure against large losses? **Journal of Risk & Uncertainty.** 28(1): 5-21. The authors discuss "bounded rationality" stemming from information costs, and offer a formal model that explains why people fail to make optimal (in the economic sense) choices regarding the purchase of insurance for catastrophes when probabilities are very uncertain and generally very low.

[7] The "law of large numbers" explains why predictions about the ratio of heads to tales in a coin flip are much more accurate for 1,000 flips than 10 flips; or why larger sample sizes are more precise (have smaller margins of errors).

catastrophic for the private market to insure them via normal market operation. Similarly, after the 1994 Northridge Earthquake, the public California Earthquake Authority was established to stabilize the market, and it currently issues more than three-fourths of all residential earthquake policies in the state.[8]

Alternative Risk Management Mechanisms –Reinsurance

As noted above, primary insurance markets cannot easily accommodate risks when hazards are geographically localized. As discussed further below, few individuals residing outside the area of highest risk are likely to purchase coverage, and they are likely to be much more sensitive to price. An insurer willing to provide earthquake coverage will inevitably experience a degree of "adverse selection," and find that insureds are concentrated where the risk is greatest and minimal where the risk is least.

However, there are alternative market mechanisms available. One such mechanism is *reinsurance* - essentially insurance for insurance companies. Large reinsurers operate on a global scale, and primary insurers can transfer significant portions of the risk associated with a book of business to these entities in exchange for a premium. As might be expected, earthquake coverage is highly reinsured. In 2014, a little over 70 percent of direct earthquake premium was ceded to reinsurance.[9] Other mechanisms include catastrophe bonds, or securities issued by insurers to pass risk on to investors. Total outstanding catastrophe bonds amounted to more than $20 billion in 2015 and cover risks such as hurricanes and earthquakes.[10]

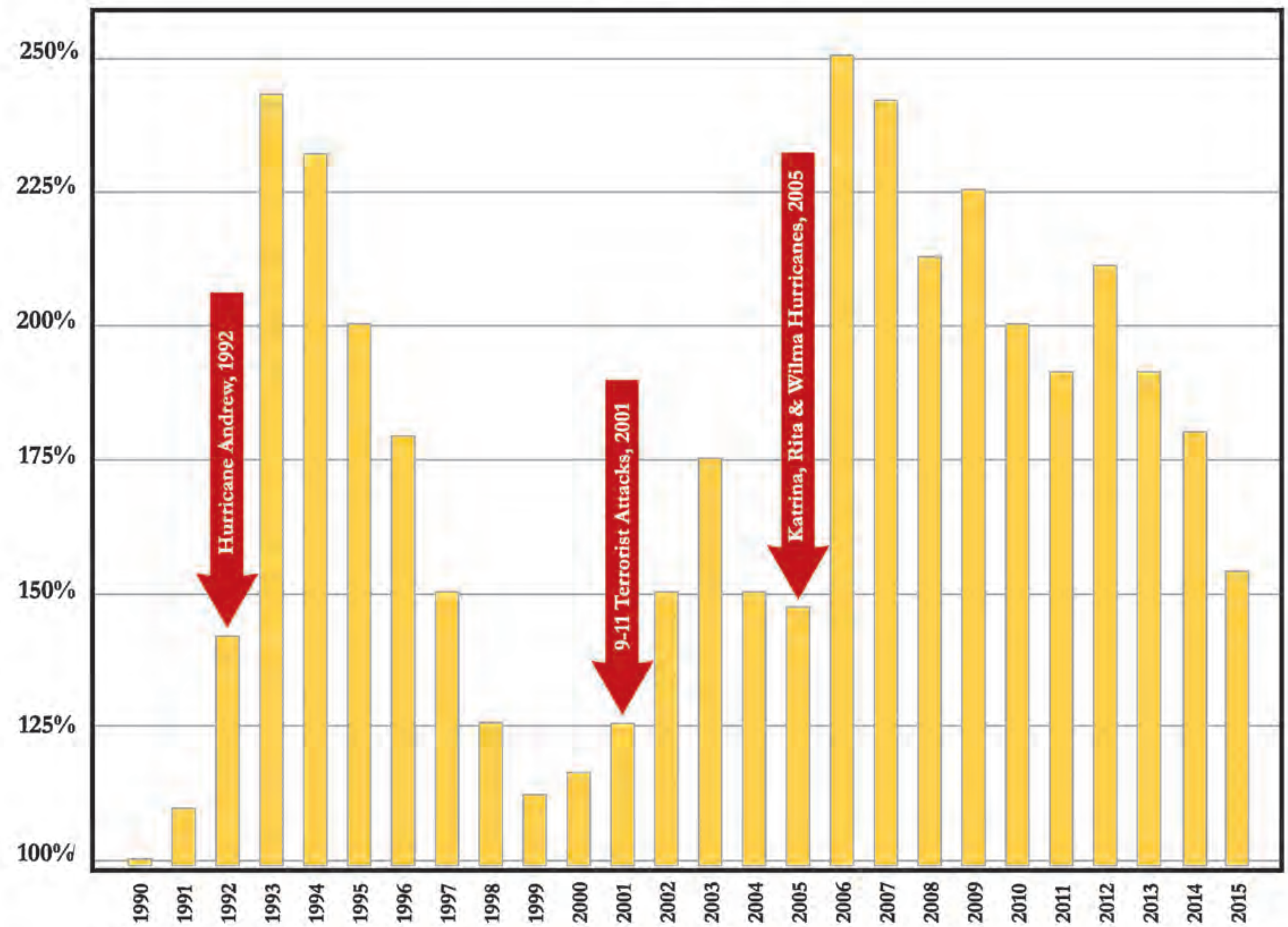
Reinsurance markets work well to manage catastrophic risks such as earthquakes. However, high dependence on reinsurance means that prices and availability of primary coverage is sensitive to the price of reinsurance. This sensitivity means that events unrelated to Missouri's earthquake risk can impact the price of insurance coverage in Missouri. As is apparent in the chart below, reinsurance became more expensive and less available after events such as the 9-11 terrorist attacks and the active 2005 hurricane season that included Katrina. However, the price of reinsurance has been on a downward trend since 2007, and does not appear to account for current market retractions in Missouri.

[8] California Earthquake Authority. 2013 Report to the Legislature. August, 2014. This report can be found on the CEA's website at www.earthquakeauthority.com

[9] Calculated from insurers' financial annual statements, Exhibit of Premium Written.

[10] ARTEMIS. Q1 2015 Catastrophe Bond and ILS Market Report.

Reinsurance Price Index in US
(1990 = 100%)



Source: Adapted from Guy Carpenter.

Missouri's Contracting Earthquake Insurance Market

As the previous discussion makes clear, it doesn't appear that anything in reinsurance markets accounts for the deterioration of the Missouri earthquake market, particularly in recent years. Rather, it appears that insurers have either determined that the New Madrid fault presents a risk greater than previously believed or, as is the case of at least one major insurer, have developed less tolerance for all catastrophe risks. Allstate announced in 2006 that it was pulling out of the earthquake market in all states, describing it as a general business decision to reduce exposure to all forms of catastrophe risks.[11] At the time, Allstate provided earthquake insurance to over 37,000 Missouri residences.

Other companies quickly followed Allstate's lead. Between 2000 and 2014, 64 insurers exited the Missouri earthquake market. Between them, these insurers had provided coverage to 113,923 residences in 2000. While 34 insurers entered the market over the same time period, those carriers only insured 53,923

[11] Jolayne Hoytz. Allstate Ends Quake Coverage. **The Seattle Times,** 6/2/2006.

policies in 2014. Over the same period, companies that remained in the market stopped writing in high risk areas or tightened underwriting criteria, scaled back the amount and type of coverage offered, and dramatically increased prices. The net result of these market practices has been a significant decline in the number of earthquake policies issued. Since 2000, the number of homeowners policies with earthquake coverage declined by 21 percent, from 670,968 in 2000 to 529,797 in 2014.

The remainder of this report examines these trends in detail. The figures in the following tables are derived from two primary data sources. Information pertaining to premium and policy counts[12] by geographic region is derived from residential insurance data collected by ZIP Code, pursuant to 20 CSR 600-3.100 (see http://www.sos.mo.gov/adrules/csr/current/20csr/20c600-3.pdf). Additional information was obtained by a survey of the largest homeowners writers in the state. In 2015, insurers with a combined homeowners insurance market share of 80 percent completed a questionnaire regarding market practices with respect to providing earthquake coverage.

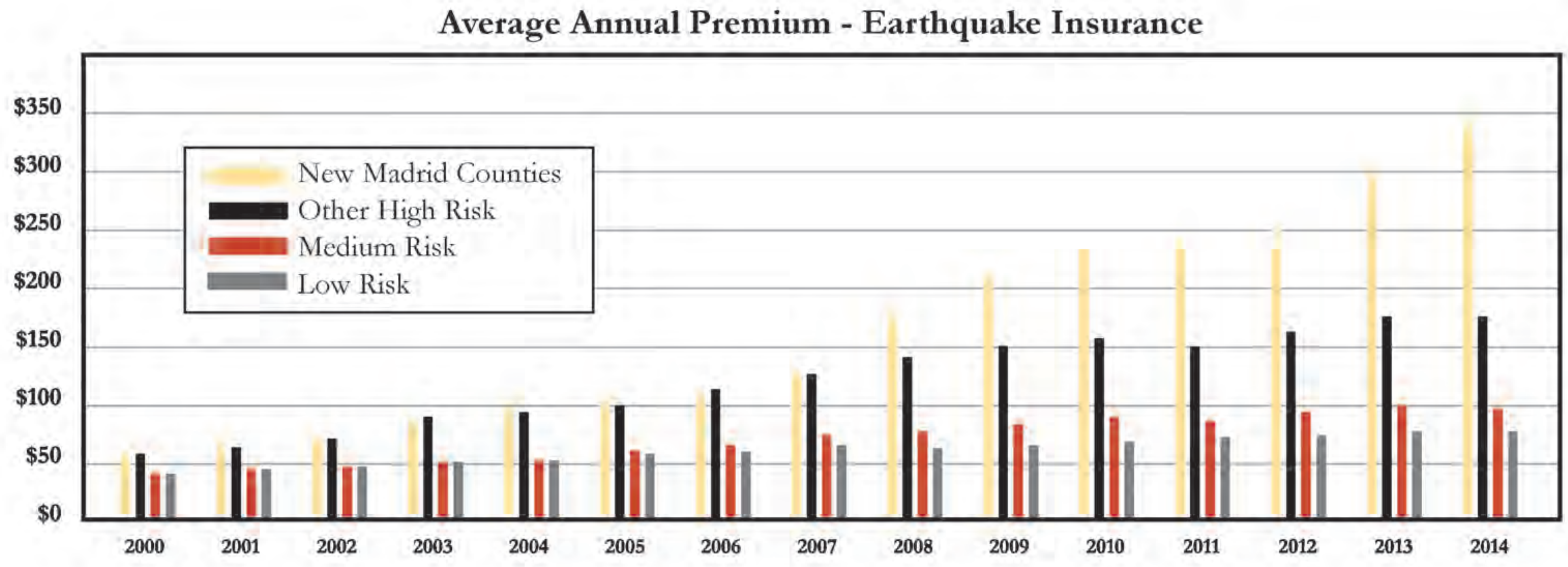
The Rising Cost of Coverage in a Declining Market

In 2000, residential earthquake coverage was readily available and inexpensive, even in the highest risk areas of the state. In that year, residents in the New Madrid region of Missouri[13] paid on average $57 per year for such coverage, an amount not significantly higher than the $35 annual premium paid by residents of the lowest risk area. Over the next 15 years, rates increased substantially, primarily within higher risk areas. By 2015, the average premium in the New Madrid area had increased by 485% to $335. While premiums also increased elsewhere in the state, the rate of increase was substantially less than experienced in New Madrid. In the lowest risk areas, premiums increased by 123% over the same time period.

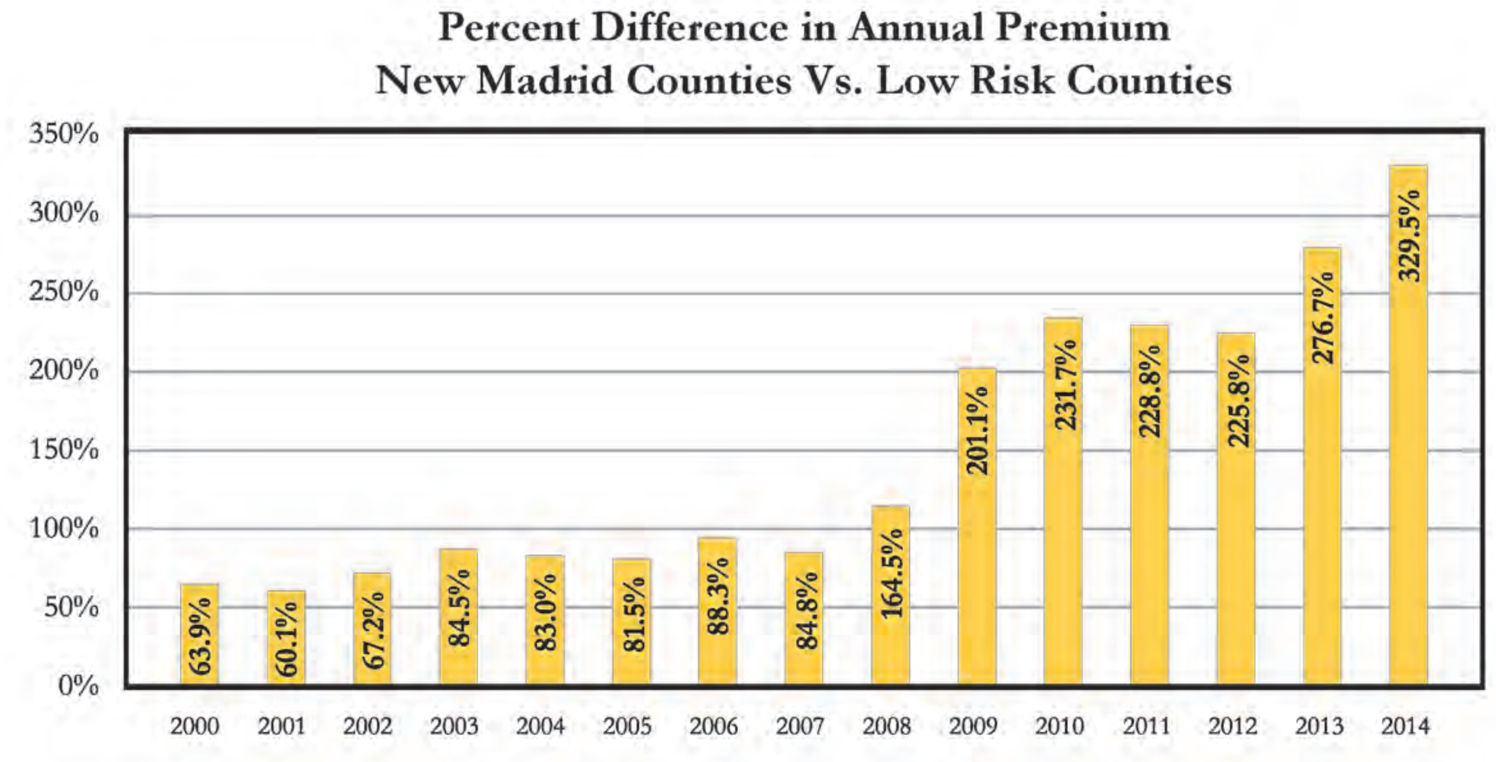
[12] Or, more strictly speaking, "exposures" rather than policy counts. The term "exposure" is equivalent to coverage for one residence for one year. Two six month policies issued in a year would count as a single exposure. To avoid overuse of specialized terminology, the terms "policies" or "covered residences" are used in this report.

[13] For purposes of this report, the region is composed of the six southeastern-most counties in Missouri: Dunklin, Mississippi, New Madrid, Pemiscot, Scott and Stoddard.

Average Annual Premium for Residential Earthquake Coverage																
Region	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**% Chg. 2000-2014**
New Madrid Counties	$57	$60	$67	$89	$98	$102	$114	$124	$174	$206	$236	$242	$249	$293	$335	484.9%
Other High Risk	$63	$66	$71	$84	$93	$99	$106	$122	$137	$149	$155	$153	$162	$175	$175	176.3%
Medium Risk	$39	$41	$44	$55	$60	$62	$68	$76	$80	$88	$90	$88	$94	$98	$94	141.2%
Low Risk	$35	$37	$40	$48	$53	$56	$61	$67	$66	$69	$71	$74	$76	$78	$78	123.3%
Difference - Zone 1 and Zone 4	**63.9%**	**60.1%**	**67.2%**	**84.5%**	**83.0%**	**81.5%**	**88.3%**	**84.8%**	**164.5%**	**201.1%**	**231.7%**	**228.8%**	**225.8%**	**276.7%**	**329.5%**	

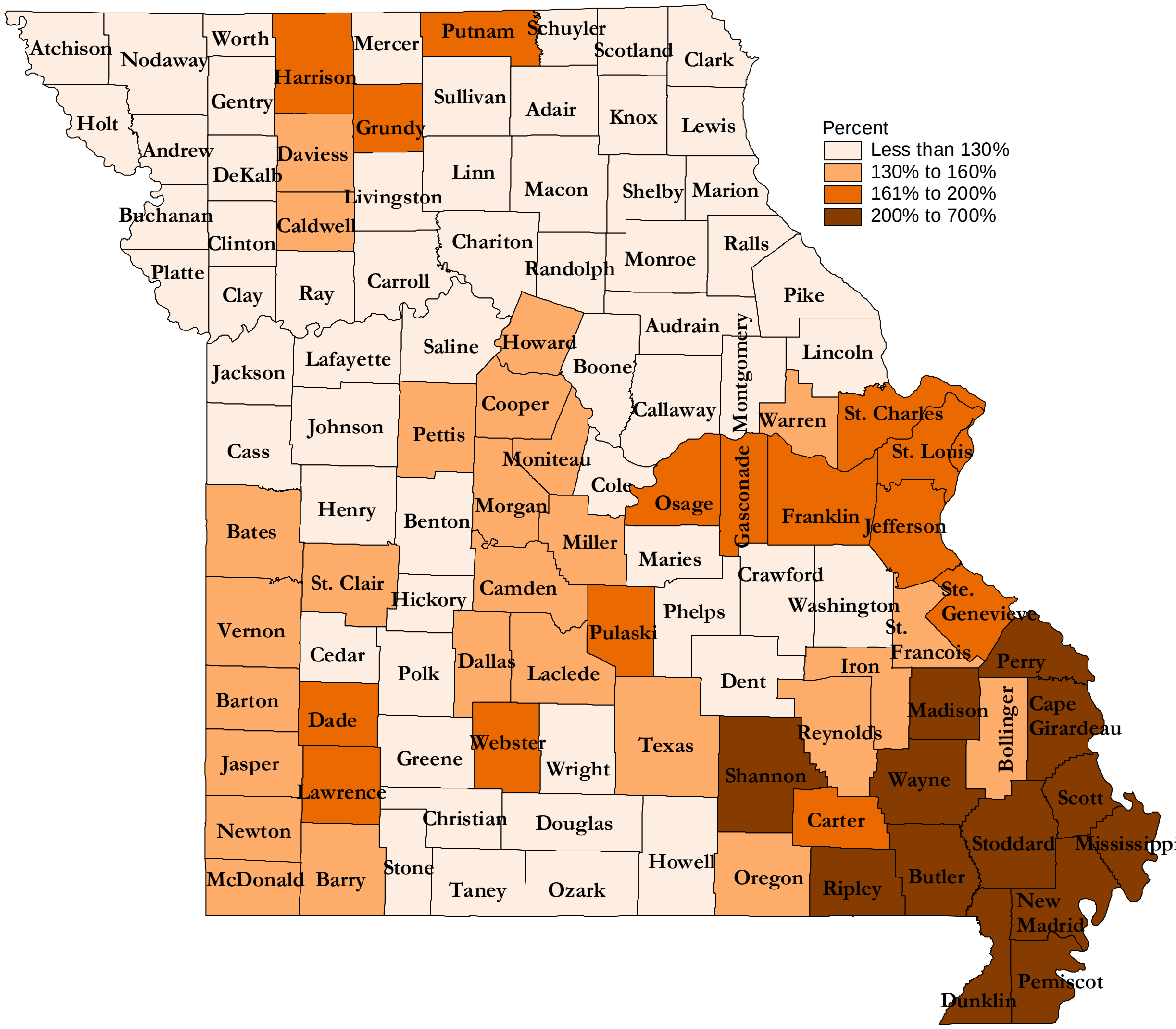


As a result of these trends, the gap in costs widened between high- and low-risk areas. In 2000, premiums in New Madrid were only 64% higher than the lowest-risk areas. The gap increased dramatically in 2008, and by 2015 had grown to 330%.



The map below depicts the change in annual premium by county. The reader will note that the rate of increase was significantly higher in counties most at risk. A table of these same data can be found in Appendix A.

% Change in Average Premium for Earthquake Coverage, 2000-2014



Declining Take-up Rates

In 2000, nearly 44 percent of all Missouri residences had earthquake coverage. In the New Madrid area, over 60 percent were covered, and in other high risk areas, including St. Louis, the take-up rate was almost 70 percent. In New Madrid, the take-up rate had declined to less than 50 percent in 2008, and by 2014 had plummeted to 20 percent. That is, four of every five homes in the six-county New Madrid area lacked earthquake coverage last year. The decline was less precipitous in the second highest risk area, and by 2014 just over half of residences still had coverage. In the lowest risk area, comprised of the western portion of the state, coverage rates declined by nearly 7 percentage points, to 14.9 percent (see illustrations on the following page). As depicted in the following table, only in 7 counties were more than half of residences covered.

% of Residences With Earthquake Coverage	# of Counties	Number of Owner-Occupied Homes & Mobile Homes*
Less than 10%	28	117,371
10% to 19.9%	50	689,290
20% to 29.9%	18	175,218
30% to 39.9%	9	115,501
40% to 49.9%	3	57,216
50% to 59.9%	3	391,866
60% to 69.9%	4	142,660
Total	**115**	**1,689,122**

**Based on insured dwellings. A small percentage of homes that have no insurance coverage are excluded.*
Source: Calculations based on Missouri homeowners and earthquake insurance data collected by ZIP Code

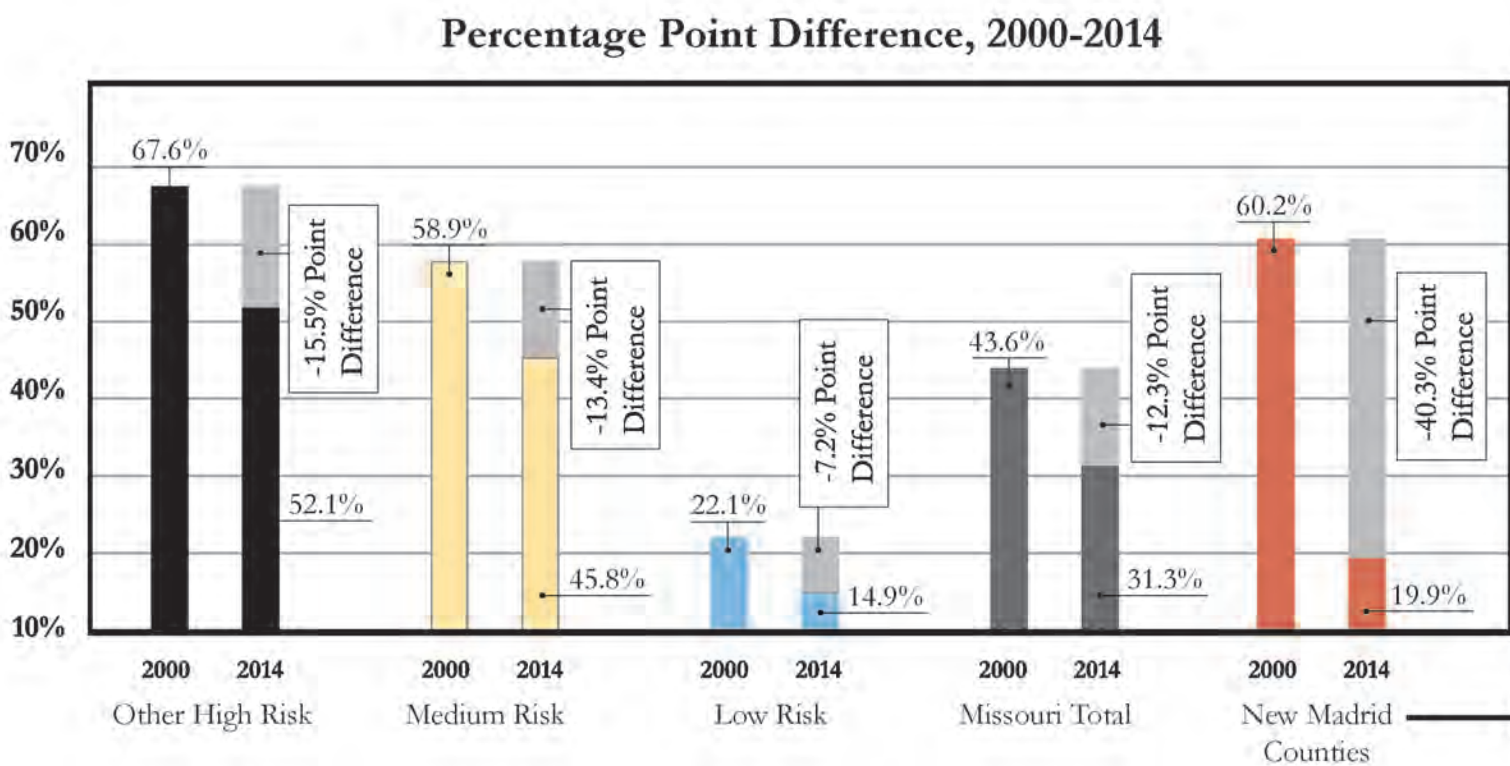
In moderate to high-risk areas, including all counties with a rating of seven or higher on the Mercalli Scale (see map, page 3), well over half a million private residences (excluding rental properties) lacked earthquake coverage in 2014. The estimated value of these uninsured residences totaled $86 billion, excluding the value of the contents. Even individuals that have earthquake coverage are at risk of significant loss. Assuming an average deductible equal to 15 percent of the value of the insured dwelling, property worth $14.9 billion is self-insured in moderate to high risk areas. Together, these amounts (homes which are completely uninsured for earthquake + risk retained under the typical deductible) total to more than $100 billion.

[14] The assumption is reasonable. Based on survey data discussed below, no insurer offers coverage with a deductible of less than 10 percent, and more than half require a deductible of between 15 and 25 percent.

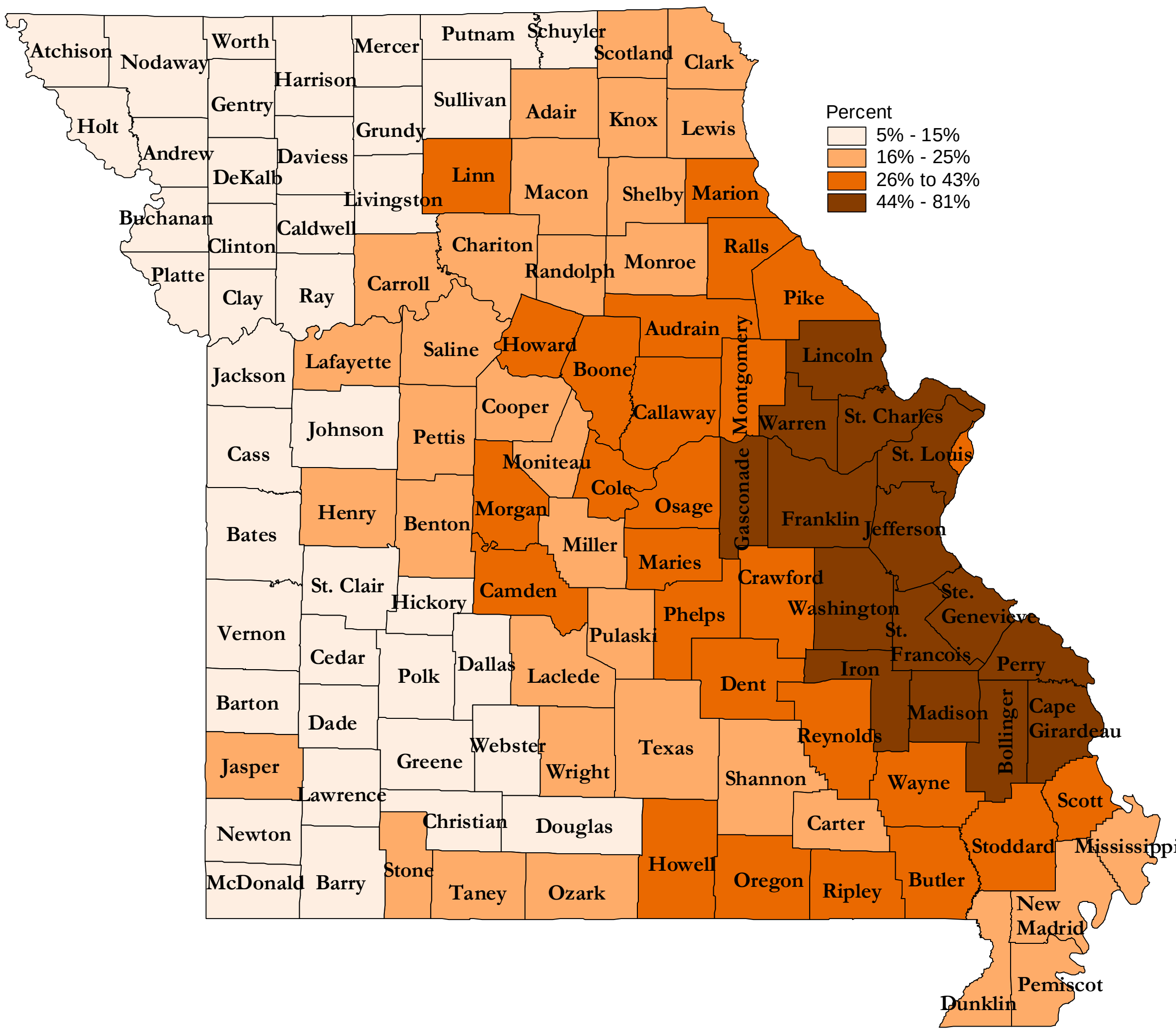
Value of Dwellings Not Insured for Earthquake Damage (uninsured homes + value retained under deductible)				
Earthquake Zone (Mercalli Scale)	Uninsured Dwellings	Uninsured Property Value	Value uninsured under a 15% deductible	Total Retained Risk
7	299,621	$45,218,080,000	$6,542,653,188	$51,760,733,188
8	223,808	$36,479,436,667	$8,090,103,813	$44,569,540,480
9	27,272	$3,222,370,000	$175,807,500	$3,398,177,500
10	12,034	$1,262,486,250	$46,279,625	$1,308,765,875
Total 7 - 9	**562,734**	**$86,182,372,917**	**$14,854,844,126**	**$101,037,217,043**

Source: Estimates produced by DIFP.

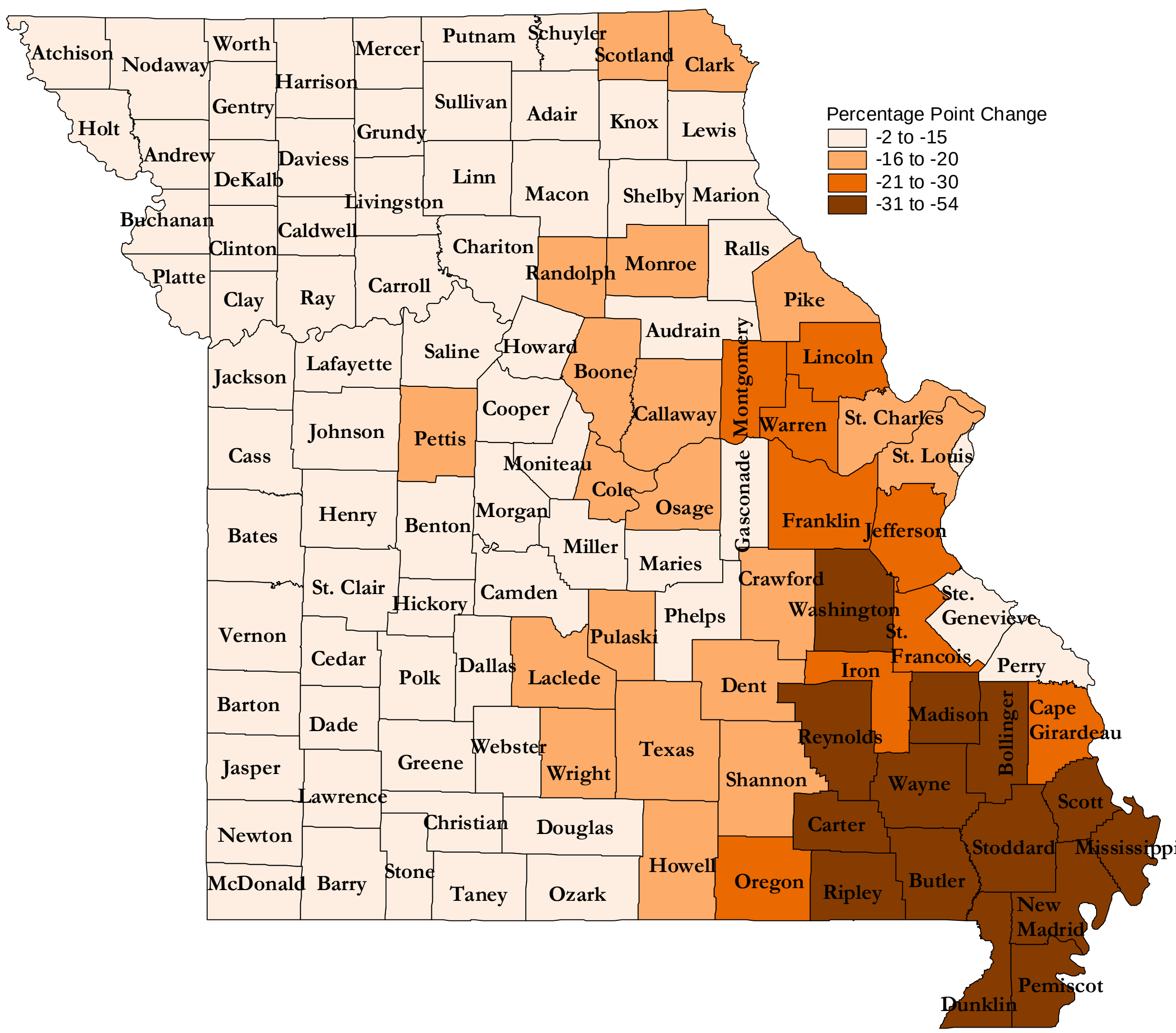
% of Residences With Earthquake Coverage																
Missouri Region	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**Percentage Point Difference, 2000-2014**
New Madrid	60.2%	59.3%	59.0%	57.7%	57.1%	57.1%	52.9%	53.9%	48.6%	44.9%	34.3%	33.3%	32.2%	25.9%	19.9%	-40.3%
Other High Risk	67.6%	67.8%	68.1%	67.2%	66.1%	64.7%	61.3%	55.8%	56.5%	58.1%	56.6%	57.2%	56.1%	54.6%	52.1%	-15.5%
Medium Risk	58.9%	58.0%	58.3%	57.6%	56.5%	55.6%	52.9%	50.0%	49.7%	50.4%	48.5%	48.8%	48.5%	47.6%	45.8%	-13.4%
Low Risk	22.1%	21.3%	20.6%	19.5%	18.5%	17.8%	16.9%	16.1%	15.9%	15.8%	15.5%	16.1%	16.2%	15.7%	14.9%	-7.2%
Missouri Total	**43.6%**	**43.0%**	**42.7%**	**41.7%**	**40.7%**	**39.8%**	**37.7%**	**35.2%**	**35.0%**	**35.4%**	**34.2%**	**34.6%**	**34.4%**	**33.2%**	**31.3%**	**-12.3%**



Percent of Residences with Earthquake Insurance, 2014



Residences with Earthquake Insurance, Percentage Point Change, 2000-2014



Declining Quality of Coverage

Based on survey responses from carriers representing over 80 percent of the homeowners market, most insurers still sell earthquake coverage in at least in some areas of the state. Weighting responses by market share, approximately 88 percent of the market still offers the coverage on both renewal and new business. However, coverage is far less available within the high-risk New Madrid area. Among respondents, nearly one-third of the market does not write earthquake coverage at all in New Madrid. An additional 44 percent of the market places significant additional underwriting restrictions on residences in the area. Among such restrictions are a refusal to insure specific types of dwellings and requiring substantially higher deductibles than elsewhere in the state. Only about a fourth of the market issues coverage in New Madrid on the same terms as elsewhere in the state.

Coverage issued in NM Zone?	Responses Weighted by Market Share
No, not writing eq. anywhere in MO	10.1%
No, write elsewhere in MO	19.1%
Yes, but with additional underwriting restrictions	44.2%
Yes, no additional underwriting restrictions	26.6%

Source: DIFP survey of top homeowners insurers

Even individuals with earthquake coverage are increasingly required to "self-insure" to a significant extent. Earthquake insurance typically requires deductibles specified as a percentage of the insured value of the dwelling. For example, a $200,000 home with a 10% deductible would require a homeowner to pay the first $20,000 of a claim before insurance would extend coverage. In addition, "stacked" deductibles are common, so that separate deductibles are applied to the dwelling and contents. With dual deductibles, then hypothetical insured described above would retain up to $40,000 of risk.

Based on the DIFP survey, in no area of the state does any insurer provide coverage with a deductible of less than 10 percent. In the six-county New Madrid area, nearly 58 percent of insurers (weighted by market share) require a 10 percent deductible, and nearly a third require deductibles of 20 percent. Among all insurers writing earthquake coverage outside of the New Madrid area, 11 percent require a deductible of 25 percent.

More information about the survey respondents, and the areas of Missouri in which they offer earthquake coverage, can be found in Appendix C.

Minimum Required Deductible in Each Insurers Highest Risk Zone	
Deductible Amount	**Weighted Responses**
Among carriers still writing in New Madrid	
5%	0.0%
10%	57.7%
15%	9.5%
20%	32.8%
25%	0.0%
Among insurers still writing anywhere in the state	
5%	0.0%
10%	45.5%
15%	13.7%
20%	29.7%
25%	11.1%

Source: DIFP survey of insurers.

Conclusion

Missouri's earthquake insurance market has significantly contracted over the past 10 to 15 years. Relatively few insurers issue earthquake coverage in the New Madrid region without significant underwriting restrictions. For example, many refuse to cover specific kinds of residences, such as masonry homes. At the same time, the price of residential earthquake insurance has increased significantly; in the highest risk area of the state average premiums paid have increased by over 500 percent since 2000. Even when homeowners can obtain coverage, they still must retain a large portion of the risk. No insurer surveyed offered a policy with a deductible of less than 10 percent of the value of the insured dwelling, while over 40 percent required a deductible of 20 percent or higher. As a result, many individuals have dropped earthquake coverage, and the market has contracted most dramatically in the New Madrid area. In 2000, over 60 percent of dwellings in the six-county New Madrid area had earthquake coverage. By 2014, only 20 percent had such coverage. The DIFP estimates that Missouri residential property valued at over $80 billion is exposed to significant earthquake risk but is not insured.

A comparison with Joplin is instructive. Struck by a devastating EF5 tornado on May 22, 2011, the insurance industry responded rapidly and within three months over $1 billion was made available to insureds. By June of the following year, more than $1.5 billion had been paid by insurers, who would eventually cover more than $2 billion in tornado-related losses.[15] Almost all structures were covered for this type of loss, resulting in a rapid infusion of funds that made recovery possible. Such a recovery mechanism is almost entirely lacking in the area of the state most vulnerable to a New Madrid earthquake.

[15] Based on a special data call of all P&C insurers active in Missouri.

Appendix A

County FIPS Code	County	2000	2005	2010	2013	2014	% Change, 2000-2014	% Change, 2013-2014
	Average Annual Premium for Earthquake Insurance (Counties in the New Madrid area are highlighted)							
001	Adair	$31	$52	$58	$60	$58	84.9%	-3.3%
003	Andrew	$30	$51	$52	$57	$56	86.6%	-1.8%
005	Atchison	$35	$52	$65	$69	$71	100.4%	2.9%
007	Audrain	$30	$50	$59	$70	$67	125.8%	-4.3%
009	Barry	$30	$50	$64	$69	$78	156.3%	13.0%
011	Barton	$27	$42	$47	$55	$63	134.0%	14.5%
013	Bates	$33	$62	$83	$80	$80	138.4%	0.0%
015	Benton	$26	$38	$46	$50	$56	117.3%	12.0%
017	Bollinger	$48	$82	$105	$118	$112	134.6%	-5.1%
019	Boone	$44	$77	$89	$93	$90	103.8%	-3.2%
021	Buchanan	$34	$52	$63	$68	$67	100.1%	-1.5%
023	Butler	$64	$100	$175	$229	$237	268.1%	3.5%
025	Caldwell	$29	$59	$65	$73	$68	136.6%	-6.8%
027	Callaway	$32	$55	$66	$70	$70	116.9%	0.0%
029	Camden	$36	$55	$76	$81	$86	140.5%	6.2%
031	Cape Girardeau	$68	$107	$178	$224	$229	237.0%	2.2%
033	Carroll	$30	$37	$48	$54	$58	94.9%	7.4%
035	Carter	$34	$61	$101	$113	$97	189.5%	-14.2%
037	Cass	$35	$57	$68	$77	$80	127.7%	3.9%
039	Cedar	$31	$48	$59	$61	$67	118.7%	9.8%
041	Chariton	$29	$56	$66	$56	$53	80.6%	-5.4%
043	Christian	$37	$60	$74	$78	$82	122.0%	5.1%
045	Clark	$29	$41	$50	$54	$56	93.7%	3.7%
047	Clay	$36	$55	$62	$69	$70	96.8%	1.4%
049	Clinton	$34	$55	$57	$62	$60	78.7%	-3.2%
051	Cole	$43	$62	$77	$83	$90	109.3%	8.4%
053	Cooper	$33	$49	$61	$68	$77	134.4%	13.2%
055	Crawford	$30	$54	$63	$69	$65	117.8%	-5.8%
057	Dade	$27	$43	$55	$62	$71	166.5%	14.5%
059	Dallas	$28	$44	$53	$59	$71	153.5%	20.3%
061	Daviess	$31	$61	$67	$72	$72	131.4%	0.0%
063	DeKalb	$37	$55	$57	$70	$65	74.8%	-7.1%
065	Dent	$31	$53	$66	$66	$65	112.9%	-1.5%
067	Douglas	$27	$39	$42	$50	$57	107.1%	14.0%
069	Dunklin	$57	$112	$234	$311	$394	595.9%	26.7%
071	Franklin	$37	$64	$96	$105	$108	190.0%	2.9%
073	Gasconade	$29	$47	$65	$76	$78	172.3%	2.6%
075	Gentry	$32	$59	$75	$81	$70	117.7%	-13.6%
077	Greene	$39	$60	$73	$79	$83	114.7%	5.1%

Average Annual Premium for Earthquake Insurance (Counties in the New Madrid area are highlighted)								
County FIPS Code	**County**	**2000**	**2005**	**2010**	**2013**	**2014**	**% Change, 2000-2014**	**% Change, 2013-2014**
079	Grundy	$27	$40	$56	$65	$71	160.7%	9.2%
081	Harrison	$24	$33	$44	$56	$63	161.3%	12.5%
083	Henry	$30	$51	$62	$65	$66	121.1%	1.5%
085	Hickory	$24	$34	$43	$49	$55	128.0%	12.2%
087	Holt	$35	$55	$73	$68	$75	116.3%	10.3%
089	Howard	$29	$54	$64	$70	$67	135.7%	-4.3%
091	Howell	$31	$62	$76	$80	$70	129.3%	-12.5%
093	Iron	$32	$50	$71	$77	$74	133.1%	-3.9%
095	Jackson	$41	$62	$73	$82	$85	107.6%	3.7%
097	Jasper	$31	$47	$60	$68	$73	131.8%	7.4%
099	Jefferson	$38	$59	$88	$94	$102	170.6%	8.5%
101	Johnson	$33	$59	$64	$74	$75	125.5%	1.4%
103	Knox	$27	$50	$54	$55	$53	100.1%	-3.6%
105	Laclede	$30	$46	$60	$65	$71	134.5%	9.2%
107	Lafayette	$29	$50	$57	$65	$67	129.5%	3.1%
109	Lawrence	$27	$44	$63	$69	$72	167.3%	4.3%
111	Lewis	$25	$48	$60	$63	$55	116.5%	-12.7%
113	Lincoln	$34	$59	$74	$79	$77	126.2%	-2.5%
115	Linn	$27	$37	$40	$44	$46	73.1%	4.5%
117	Livingston	$28	$41	$47	$49	$55	94.3%	12.2%
119	McDonald	$23	$39	$50	$56	$56	140.6%	0.0%
121	Macon	$27	$50	$52	$54	$53	94.4%	-1.9%
123	Madison	$34	$55	$82	$94	$102	203.7%	8.5%
125	Maries	$29	$52	$62	$66	$60	104.1%	-9.1%
127	Marion	$29	$50	$60	$64	$62	111.9%	-3.1%
129	Mercer	$28	$39	$50	$59	$55	99.0%	-6.8%
131	Miller	$26	$46	$57	$60	$64	148.0%	6.7%
133	Mississippi	$52	$97	$235	$269	$317	515.7%	17.8%
135	Moniteau	$27	$50	$59	$62	$66	142.3%	6.5%
137	Monroe	$26	$49	$57	$61	$55	111.9%	-9.8%
139	Montgomery	$31	$54	$68	$73	$70	126.3%	-4.1%
141	Morgan	$26	$42	$51	$55	$61	138.5%	10.9%
143	New Madrid	$54	$85	$281	$350	$364	570.6%	4.0%
145	Newton	$27	$42	$55	$61	$65	138.3%	6.6%
147	Nodaway	$33	$58	$62	$65	$62	85.8%	-4.6%
149	Oregon	$33	$56	$69	$78	$82	146.3%	5.1%
151	Osage	$32	$85	$107	$110	$93	188.2%	-15.5%
153	Ozark	$28	$42	$45	$51	$56	99.7%	9.8%
155	Pemiscot	$48	$97	$248	$297	$383	695.9%	29.0%
157	Perry	$42	$63	$95	$128	$132	211.8%	3.1%
159	Pettis	$27	$42	$51	$57	$65	136.7%	14.0%

Average Annual Premium for Earthquake Insurance (Counties in the New Madrid area are highlighted)								
County FIPS Code	County	2000	2005	2010	2013	2014	% Change, 2000-2014	% Change, 2013-2014
161	Phelps	$32	$54	$68	$74	$72	123.4%	-2.7%
163	Pike	$36	$61	$75	$84	$74	106.1%	-11.9%
165	Platte	$46	$70	$81	$92	$95	103.8%	3.3%
167	Polk	$31	$47	$60	$66	$71	125.1%	7.6%
169	Pulaski	$29	$58	$74	$88	$87	197.2%	-1.1%
171	Putnam	$30	$56	$67	$78	$79	164.5%	1.3%
173	Ralls	$27	$45	$57	$59	$56	107.8%	-5.1%
175	Randolph	$25	$41	$52	$57	$56	128.6%	-1.8%
177	Ray	$32	$52	$64	$67	$64	100.3%	-4.5%
179	Reynolds	$31	$63	$86	$78	$79	158.5%	1.3%
181	Ripley	$38	$59	$82	$104	$114	200.4%	9.6%
183	Saint Charles	$42	$66	$100	$109	$117	174.8%	7.3%
185	Saint Clair	$28	$45	$55	$61	$73	159.9%	19.7%
186	Ste. Genevieve	$42	$62	$87	$115	$119	184.8%	3.5%
187	Saint Francois	$35	$61	$79	$91	$90	158.1%	-1.1%
189	Saint Louis	$64	$101	$157	$177	$177	176.1%	0.0%
195	Saline	$28	$39	$52	$56	$60	114.7%	7.1%
197	Schuyler	$27	$45	$58	$64	$59	122.0%	-7.8%
199	Scotland	$27	$44	$56	$67	$62	126.9%	-7.5%
201	Scott	$65	$106	$274	$327	$357	448.3%	9.2%
203	Shannon	$28	$53	$73	$82	$92	228.7%	12.2%
205	Shelby	$27	$49	$56	$59	$52	90.2%	-11.9%
207	Stoddard	$54	$101	$169	$221	$247	353.6%	11.8%
209	Stone	$37	$54	$72	$77	$82	120.9%	6.5%
211	Sullivan	$22	$36	$41	$43	$50	124.3%	16.3%
213	Taney	$34	$49	$61	$66	$71	107.7%	7.6%
215	Texas	$30	$57	$68	$79	$74	145.7%	-6.3%
217	Vernon	$28	$44	$54	$61	$66	131.7%	8.2%
219	Warren	$36	$56	$80	$84	$88	145.5%	4.8%
221	Washington	$30	$44	$54	$63	$66	119.9%	4.8%
223	Wayne	$34	$53	$84	$101	$108	220.0%	6.9%
225	Webster	$33	$54	$77	$78	$86	162.8%	10.3%
227	Worth	$29	$32	$52	$49	$57	94.4%	16.3%
229	Wright	$32	$44	$52	$60	$63	100.5%	5.0%
510	Saint Louis City	$68	$103	$167	$185	$184	168.5%	-0.5%
999	**Missouri**	**$50**	**$79**	**$119**	**$131**	**$134**	**169.5%**	**2.0%**

Appendix B

County FIPS Code	County	2000	2005	2010	2013	2014	Percentage Point Difference, 2000-2014	Percentage Point Difference, 2013-2014
Percent of Residences With Earthquake Coverage (New Madrid counties are highlighted)								
001	Adair	29.1%	22.9%	20.1%	18.6%	17.8%	-11.3%	-0.8%
003	Andrew	18.5%	14.9%	12.5%	12.0%	11.2%	-7.2%	-0.8%
005	Atchison	10.2%	8.4%	8.0%	6.9%	6.9%	-3.3%	0.1%
007	Audrain	36.2%	31.9%	30.8%	29.3%	28.1%	-8.0%	-1.2%
009	Barry	15.4%	11.7%	8.9%	9.2%	8.8%	-6.7%	-0.4%
011	Barton	12.6%	9.8%	7.8%	7.9%	7.1%	-5.5%	-0.8%
013	Bates	13.0%	8.6%	5.9%	6.0%	5.6%	-7.4%	-0.4%
015	Benton	22.4%	16.9%	14.7%	15.0%	13.9%	-8.5%	-1.1%
017	Bollinger	62.4%	57.1%	38.9%	37.0%	33.5%	-28.9%	-3.5%
019	Boone	37.6%	29.8%	27.0%	26.5%	25.7%	-11.9%	-0.8%
021	Buchanan	16.5%	12.9%	11.2%	10.4%	9.9%	-6.7%	-0.6%
023	Butler	57.3%	51.8%	33.8%	27.1%	22.4%	-34.9%	-4.7%
025	Caldwell	11.4%	7.8%	6.6%	6.7%	6.7%	-4.7%	0.0%
027	Callaway	37.5%	31.9%	27.0%	26.6%	25.6%	-11.9%	-1.0%
029	Camden	42.1%	40.0%	37.5%	37.2%	35.3%	-6.7%	-1.8%
031	Cape Girardeau	81.2%	79.5%	71.9%	67.5%	60.8%	-20.4%	-6.7%
033	Carroll	23.0%	16.6%	10.6%	11.2%	10.9%	-12.1%	-0.3%
035	Carter	47.7%	42.4%	20.7%	18.4%	16.7%	-31.0%	-1.7%
037	Cass	19.4%	13.9%	11.6%	11.7%	11.3%	-8.2%	-0.5%
039	Cedar	14.3%	11.7%	9.1%	9.6%	8.6%	-5.7%	-1.0%
041	Chariton	24.0%	18.3%	15.9%	17.0%	15.8%	-8.2%	-1.3%
043	Christian	16.1%	11.6%	11.8%	12.8%	11.4%	-4.7%	-1.4%
045	Clark	22.3%	17.1%	12.6%	11.4%	10.7%	-11.6%	-0.7%
047	Clay	20.5%	15.2%	13.0%	13.0%	12.5%	-8.1%	-0.5%
049	Clinton	15.3%	10.7%	8.8%	8.9%	8.5%	-6.8%	-0.3%
051	Cole	43.5%	37.9%	32.5%	31.5%	29.7%	-13.7%	-1.7%
053	Cooper	26.9%	20.5%	15.7%	16.4%	15.9%	-11.0%	-0.5%
055	Crawford	45.4%	42.9%	36.2%	34.4%	33.0%	-12.4%	-1.4%
057	Dade	12.5%	9.1%	7.5%	7.9%	7.4%	-5.1%	-0.5%
059	Dallas	15.8%	9.7%	6.6%	6.6%	6.1%	-9.7%	-0.5%
061	Daviess	9.9%	6.2%	5.2%	5.8%	5.8%	-4.1%	-0.1%
063	DeKalb	8.9%	6.5%	4.3%	4.6%	4.6%	-4.3%	0.1%
065	Dent	32.3%	24.8%	20.4%	19.1%	18.4%	-13.8%	-0.6%
067	Douglas	12.6%	10.5%	10.4%	10.0%	8.9%	-3.7%	-1.1%
069	Dunklin	55.7%	47.3%	30.4%	22.3%	15.4%	-40.3%	-6.9%
071	Franklin	64.5%	61.4%	52.6%	51.7%	49.5%	-15.1%	-2.2%
073	Gasconade	48.9%	48.1%	42.9%	40.7%	38.8%	-10.1%	-1.9%
075	Gentry	12.9%	8.8%	7.2%	7.0%	6.8%	-6.1%	-0.2%
077	Greene	18.7%	14.1%	13.0%	13.5%	12.5%	-6.2%	-1.0%

Percent of Residences With Earthquake Coverage (New Madrid counties are highlighted)								
County FIPS Code	County	2000	2005	2010	2013	2014	Percentage Point Difference, 2000-2014	Percentage Point Difference, 2013-2014
079	Grundy	12.8%	9.9%	7.3%	7.2%	6.8%	-6.0%	-0.4%
081	Harrison	8.7%	6.1%	4.4%	4.3%	4.4%	-4.2%	0.1%
083	Henry	20.1%	16.6%	14.6%	14.9%	13.8%	-6.3%	-1.1%
085	Hickory	19.4%	14.7%	10.9%	11.0%	10.2%	-9.1%	-0.8%
087	Holt	9.4%	5.4%	4.8%	4.4%	4.6%	-4.8%	0.3%
089	Howard	32.5%	26.9%	23.6%	23.4%	23.2%	-9.3%	-0.1%
091	Howell	33.5%	27.9%	24.2%	24.2%	23.4%	-10.1%	-0.7%
093	Iron	56.8%	49.4%	36.9%	36.1%	35.7%	-21.2%	-0.5%
095	Jackson	17.1%	12.9%	11.3%	11.7%	11.4%	-5.7%	-0.2%
097	Jasper	18.2%	15.6%	13.8%	16.5%	14.9%	-3.3%	-1.6%
099	Jefferson	72.8%	70.0%	60.0%	59.0%	57.2%	-15.6%	-1.9%
101	Johnson	20.1%	14.5%	12.2%	13.2%	12.7%	-7.4%	-0.5%
103	Knox	16.4%	13.3%	11.8%	11.7%	10.8%	-5.5%	-0.8%
105	Laclede	28.4%	23.4%	20.6%	19.6%	18.0%	-10.4%	-1.6%
107	Lafayette	23.2%	16.1%	13.3%	13.9%	13.6%	-9.6%	-0.3%
109	Lawrence	15.0%	10.2%	7.8%	9.2%	8.5%	-6.4%	-0.6%
111	Lewis	22.9%	18.5%	16.1%	15.9%	14.1%	-8.8%	-1.8%
113	Lincoln	53.8%	49.8%	44.4%	44.1%	42.1%	-11.7%	-2.1%
115	Linn	30.6%	27.0%	23.7%	22.1%	20.8%	-9.7%	-1.3%
117	Livingston	15.7%	11.1%	11.6%	10.8%	10.5%	-5.2%	-0.3%
119	McDonald	13.5%	7.5%	5.8%	6.5%	5.5%	-7.9%	-0.9%
121	Macon	24.7%	17.9%	17.3%	16.6%	15.8%	-8.8%	-0.8%
123	Madison	65.7%	59.9%	39.5%	38.8%	37.2%	-28.5%	-1.6%
125	Maries	31.0%	29.7%	22.4%	23.9%	24.3%	-6.7%	0.4%
127	Marion	41.5%	36.2%	33.9%	32.1%	29.7%	-11.8%	-2.4%
129	Mercer	10.2%	7.2%	5.7%	5.6%	5.3%	-4.8%	-0.2%
131	Miller	24.3%	20.5%	17.4%	18.3%	16.9%	-7.4%	-1.4%
133	Mississippi	60.1%	54.1%	30.0%	22.1%	14.8%	-45.3%	-7.4%
135	Moniteau	24.2%	20.3%	19.1%	18.3%	17.6%	-6.6%	-0.8%
137	Monroe	31.6%	25.0%	21.3%	20.2%	18.5%	-13.1%	-1.7%
139	Montgomery	47.2%	42.4%	36.6%	34.2%	33.2%	-14.0%	-1.0%
141	Morgan	35.6%	33.7%	30.4%	29.2%	26.8%	-8.8%	-2.5%
143	New Madrid	51.2%	54.8%	27.7%	20.2%	16.6%	-34.5%	-3.5%
145	Newton	14.0%	9.6%	8.5%	10.3%	9.2%	-4.8%	-1.1%
147	Nodaway	7.1%	5.2%	4.7%	5.2%	4.7%	-2.5%	-0.5%
149	Oregon	42.7%	36.8%	24.1%	23.9%	24.1%	-18.6%	0.1%
151	Osage	33.3%	28.4%	23.8%	22.6%	21.8%	-11.5%	-0.8%
153	Ozark	18.5%	15.8%	14.1%	14.1%	13.6%	-4.9%	-0.5%
155	Pemiscot	49.4%	45.7%	21.1%	15.6%	14.1%	-35.3%	-1.5%
157	Perry	77.4%	79.2%	71.9%	69.2%	68.5%	-9.0%	-0.7%
159	Pettis	30.9%	25.3%	19.2%	17.7%	16.7%	-14.2%	-1.1%

Percent of Residences With Earthquake Coverage (New Madrid counties are highlighted)								
County FIPS Code	**County**	**2000**	**2005**	**2010**	**2013**	**2014**	**Percentage Point Difference, 2000-2014**	**Percentage Point Difference, 2013-2014**
161	Phelps	34.7%	28.9%	25.6%	25.8%	24.7%	-10.0%	-1.1%
163	Pike	41.3%	35.8%	30.3%	27.9%	27.0%	-14.2%	-0.8%
165	Platte	18.8%	14.3%	12.3%	12.7%	12.2%	-6.6%	-0.5%
167	Polk	17.8%	11.9%	10.5%	11.3%	10.0%	-7.8%	-1.3%
169	Pulaski	25.9%	18.9%	13.4%	14.2%	13.4%	-12.5%	-0.9%
171	Putnam	16.5%	9.9%	6.9%	7.2%	7.2%	-9.3%	0.0%
173	Ralls	31.2%	27.1%	25.7%	26.0%	25.7%	-5.5%	-0.3%
175	Randolph	30.9%	24.9%	20.5%	18.9%	17.8%	-13.1%	-1.1%
177	Ray	19.0%	14.1%	11.4%	11.7%	10.9%	-8.2%	-0.8%
179	Reynolds	42.4%	32.6%	21.4%	21.1%	18.8%	-23.6%	-2.2%
181	Ripley	44.3%	41.7%	24.4%	23.0%	19.5%	-24.9%	-3.5%
183	Saint Charles	79.2%	75.4%	67.0%	66.4%	64.1%	-15.1%	-2.2%
185	Saint Clair	14.9%	9.8%	6.0%	5.8%	6.1%	-8.8%	0.3%
186	Ste. Genevieve	76.1%	75.9%	68.7%	66.3%	64.6%	-11.5%	-1.7%
187	Saint Francois	65.4%	64.5%	56.7%	54.4%	51.2%	-14.2%	-3.2%
189	Saint Louis	74.4%	70.7%	62.9%	61.0%	58.9%	-15.5%	-2.1%
195	Saline	25.7%	21.6%	19.3%	19.2%	19.0%	-6.6%	-0.2%
197	Schuyler	13.9%	12.5%	9.5%	7.0%	6.2%	-7.6%	-0.8%
199	Scotland	20.9%	13.8%	12.1%	10.8%	10.1%	-10.8%	-0.7%
201	Scott	70.0%	67.9%	41.5%	33.5%	26.3%	-43.7%	-7.2%
203	Shannon	31.3%	22.3%	19.0%	17.8%	17.6%	-13.6%	-0.2%
205	Shelby	21.9%	16.0%	14.4%	14.9%	14.9%	-6.9%	0.1%
207	Stoddard	63.9%	61.4%	42.2%	30.6%	22.6%	-41.3%	-8.0%
209	Stone	18.1%	15.2%	14.6%	15.5%	15.1%	-3.0%	-0.5%
211	Sullivan	14.9%	9.3%	7.1%	6.5%	5.9%	-9.0%	-0.5%
213	Taney	20.2%	18.1%	17.0%	17.5%	17.1%	-3.1%	-0.4%
215	Texas	24.6%	18.9%	14.2%	13.9%	12.6%	-12.0%	-1.3%
217	Vernon	17.0%	12.2%	9.8%	9.5%	9.1%	-7.9%	-0.4%
219	Warren	60.7%	59.3%	49.5%	49.8%	49.5%	-11.2%	-0.3%
221	Washington	53.9%	48.2%	37.2%	38.4%	37.1%	-16.8%	-1.3%
223	Wayne	51.9%	43.1%	25.1%	21.9%	19.9%	-32.0%	-2.0%
225	Webster	17.8%	13.1%	11.5%	12.3%	11.2%	-6.6%	-1.1%
227	Worth	7.8%	5.3%	4.8%	6.2%	5.2%	-2.6%	-1.0%
229	Wright	23.9%	18.0%	13.9%	13.1%	12.2%	-11.7%	-0.9%
510	Saint Louis City	46.1%	45.9%	36.2%	34.8%	32.2%	-13.9%	-2.6%
999	**Missouri Total**	**43.6%**	**39.8%**	**34.2%**	**33.2%**	**31.3%**	**-12.3%**	**-1.8%**

Appendix C – Companies Offering Earthquake Insurance by Region

The companies below were offering new earthquake insurance policies in the regions checked (✓) as of April 2015. Each company has different restrictions on types of homes they cover and the coverage they offer. Contact the company or an agent who represents that company to find out if you can obtain coverage for your home.

Homeowners Insurers (sorted by descending market share)					
Company	**Southeast Missouri**	**St. Louis**	**Kansas City**	**Springfield**	**Columbia**
State Farm Fire and Casualty Co.	✓	✓	✓	✓	✓
American Family Mutual Insurance Co.	✓	✓	✓	✓	✓
Shelter Mutual Insurance Co.	✓	✓	✓	✓	✓
Safeco Insurance Co. of America		✓	✓	✓	✓
Farmers Insurance Exchange	✓	✓	✓	✓	✓
Auto Club Family Insurance Co.		✓	✓	✓	✓
Farm Bureau Town and Country Insurance Co. of Missouri					
Nationwide Affinity Insurance Co. of America	✓	✓	✓	✓	✓
The Travelers Home and Marine Insurance Co.		✓	✓	✓	✓
United Services Automobile Association (USAA)	✓	✓	✓	✓	✓
Liberty Insurance Corp.		✓	✓	✓	✓
Allstate Property & Casualty Insurance Co.					
Mid Century Insurance Co.					
Fire Insurance Exchange (Farmers)					
Liberty Mutual Fire Insurance Co.					
USAA Casualty Insurance Co.	✓	✓	✓	✓	✓
Country Mutual Insurance Co.	✓	✓	✓	✓	✓
Allstate Indemnity Co.					
Allstate Insurance Co.					
Auto Owners Insurance Co.		Did not respond to survey.			
The Standard Fire Insurance Co. (Travelers)		✓	✓	✓	✓
Palomar Specialty Insurance Company	✓	✓	✓	✓	✓

Insurance Consumer Hotline

Contact DIFP's Insurance Consumer Hotline
if you have questions about your insurance policy
or to file a complaint against an
insurance company or agent:

difp.mo.gov

800-726-7390

DIFP
Department of Insurance,
Financial Institutions &
Professional Registration

Harry S Truman Building
Room 530
301 W. High St.
PO Box 690
Jefferson City, MO 65102

AUGUST 2015

Appendix D

Funding Sources

Program/Activity	Type of Assistance	Agency and Contact
General Emergency Management Grants, Loans, and Technical Assistance		
Hazard Mitigation Grant Program	Postdisaster project grants to implement measures that will permanently reduce or eliminate future damages and losses from natural hazards through safer building practices and by improving existing structures and supporting infrastructure.	FEMA Region VII (816) 283-7061 https://www.fema.gov/region-vii-ia-ks-mo-ne SEMA (573) 526-9100 http://sema.dps.mo.gov/
Pre-Disaster Mitigation Program	Competitive project grants for cost-effective hazard mitigation activities that are part of a comprehensive mitigation program and that reduce injuries, loss of life, and damage and destruction of property.	FEMA Region VII (816) 283-7061 https://www.fema.gov/grants https://www.fema.gov/hazard-mitigation-assistance SEMA (573) 526-9100 http://sema.dps.mo.gov/
Disaster Mitigation Planning and Technical Assistance	Technical and planning assistance for capacity building and mitigation project activities focusing on creating disaster resistant jobs and workplaces.	Economic Development Administration (202) 482-2000 (202) 482-5081 www.eda.gov/ SEMA (573) 526-9100 https://sema.dps.mo.gov/
Emergency Management/Mitigation Training Emergency Management/Mitigation Training (continued)	Training in disaster mitigation, preparedness, and planning.	FEMA NFIP and Mitigation (816) 283-7002 http://training.fema.gov/ SEMA (573) 526-9100 https://sema.dps.mo.gov/about/prepardness.php

Program/Activity	Type of Assistance	Agency and Contact
Postdisaster Economic Recovery Grants and Assistance	Grant funding to assist with the long-term economic recovery of communities, industries, and firms adversely impacted by disasters.	Economic Development Administration (202) 482-2000 (202) 482-5081 https://www.eda.gov/funding-opportunities/ Missouri Department of Economic Development Community Development Block Grant Program (573) 751-3600 http://ded.mo.gov/
Physical Disaster Loans and Economic Injury Disaster Loans	Disaster loans to nonfarm, private sector owners of disaster damaged property for uninsured losses. Loans can be increased by up to 20 percent for mitigation purposes.	Small Business Administration (800) 659-2955 www.sba.gov/services/disasterassistance
Disaster Grants—Public Assistance	Grants for the repair, replacement, or restoration of disaster-damaged, publicly owned facilities and the facilities of certain private nonprofit organizations. Mitigation funding is available for work related to damaged components of eligible buildings/structures.	FEMA Region VII (816) 283-7061 https://www.fema.gov/grants SEMA (573) 526-9100 http://sema.dps.mo.gov/
Public Infrastructure Grants Public Infrastructure Grants (continued)	• Public Facilities: Grants for public improvement of facilities except work on general public office buildings, includes water facilities, flood and drainage facilities, fire protection facilities/equipment, and bridges. • Neighborhoods: Grants for housing and some public facilities. • Infrastructure: Grants for storm sewers, drainage, and land acquisitions. • Downtown Revitalization: Grants for improving public infrastructure and facilities in a central business district. • Emergencies: Grants for public improvement or facilities except work on general public office buildings, includes water facilities and solid waste disposal facilities.	Missouri Department of Economic Development Community Development Block Grant Program (573) 751-3600 http://ded.mo.gov/

Program/Activity	Type of Assistance	Agency and Contact
Community Development Block Grants State's Program	Grants to states to develop viable communities (e.g., housing, a suitable living environment, expanded economic opportunities) in non-entitled areas, for low- and moderate-income persons.	U.S. Department of Housing and Urban Development Community Planning and Development (202) 708-1112 https://www.hud.gov/program_offices/comm_planning HUD Kansas City Regional Office (western half of MO) (913) 551-5644 HUD St. Louis Field Office (eastern half of MO) (314) 4175400 https://www.hud.gov/states/missouri/working/missourioffices Missouri Department of Economic Development (573) 522-4173 http://ded.mo.gov/
Community Development Block Grants/Entitlement Grants Community Development Block Grants/Entitlement Grants (continued)	Grants to entitled cities and urban counties to develop viable communities (e.g., decent housing, suitable living environments, expanded economic opportunities), principally for low- and moderate-income persons.	U.S. Department of Housing and Urban Development Community Planning and Development (202) 708-1112 https://www.hud.gov/program_offices/comm_planning HUD Kansas City Regional Office (western half of MO) (913) 551-5644 HUD St. Louis Field Office (eastern half of MO) (314) 4175400 https://www.hud.gov/states/missouri/working/missourioffices Missouri Department of Economic Development CDBG Program (573) 751-3600 http://ded.mo.gov/
Disaster Recovery Assistance	Critical housing and community development resources to aid disaster recovery (including mitigation).	U.S. Department of Housing and Urban Development Community Planning and Development (202) 708-1112 https://www.hud.gov/program_offices/comm_planning

Program/Activity	Type of Assistance	Agency and Contact
		HUD Kansas City Regional Office (western half of MO) (913) 551-5644 HUD St. Louis Field Office (eastern half of MO) (314) 4175400 https://www.hud.gov/states/missouri/working/missourioffices Missouri Department of Economic Development Missouri Housing Development Commission (816) 759-6600 www.mhdc.com/
Public Housing Capital Fund Emergency/Natural Disaster Funding	Funding to public housing agencies that confront an emergency situation or a natural disaster.	U.S. Department of Housing and Urban Development Office of Capital Improvements (202) 402-2488 https://www.hud.gov/program_offices/public_indian_housing/programs/ph/capfund Missouri Department of Economic Development Missouri Housing Development Commission (816) 759-6600 www.mhdc.com/
Indian Housing Assistance (Housing Improvement Program)	Project grants and technical assistance to eliminate substantially sub-standard Indian owned and inhabited housing.	Bureau of Indian Affairs Office of Indian Services Division of Human Services (202) 208-5116 https://www.bia.gov/bia/ois/dhs/housing-improvement-program
Single Family Housing Repair Loans and Grants (Section 504 Rural Housing Loans and Grants)	Repair loans, grants, and technical assistance for very low-income homeowners living in rural areas to repair their homes and remove health and safety hazards.	U.S. Department of Agriculture (USDA) Rural Development Housing and Community Facilities Programs ((202) 720-1474 (direct loans) (202) 720-1452 (guaranteed loans) https://www.usda.gov/topics/rural/housing-assistance

Program/Activity	Type of Assistance	Agency and Contact
		USDA Rural Development State Office—Missouri (573) 876-0976 https://www.rd.usda.gov/mo
Guaranteed Single Family Housing Loans (Section 502 Rural Housing Loans)	Loans, loan guarantees, and technical assistance to help very low, low-income, and moderate-income households in rural areas buy, build, or improve permanent residences.	U.S. Department of Agriculture (USDA) Rural Development Housing and Community Facilities Programs (202) 720-1474 (direct loans) (202) 720-1452 (guaranteed loans) https://www.usda.gov/topics/rural/housing-assistance USDA Rural Development State Office—Missouri (573) 876-0976 https://www.rd.usda.gov/mo
Farm Ownership Loans	Direct loans, guaranteed/insured loans, and technical assistance to farmers to develop, construct, improve, or repair farm homes, farms, and service buildings and to make other necessary improvements.	U.S. Department of Agriculture Farm Service Agency https://www.fsa.usda.gov/programs-and-services/farm-loan-programs/ Missouri Department of Agriculture (573) 751-4211 http://mda.mo.gov/
HOME Investment Partnerships Program	Grants to states, local government, and consortia for permanent and transitional housing (including support for property acquisition, improvements, demolition, and relocation) for very low and low-income persons.	U.S. Department of Housing and Urban Development (HUD) Community Planning and Development Affordable Housing Programs HOME Investment Partnership Programs (202) 708-1112 https://www.hud.gov/program_offices/comm_planning/affordablehousing/ Missouri Department of Economic Development Missouri Housing Development Commission (816) 759-6600 www.mhdc.com
Rural Development Assistance—Housing	Grants, loans, and technical assistance for addressing rehabilitation and health and safety needs in primarily low-income rural areas. Declaration of major disaster	U.S. Department of Agriculture (USDA) Rural Development Housing and Community Facilities Programs

Program/Activity	Type of Assistance	Agency and Contact
	necessary.	(202) 720-1474 (direct loans) (202) 720-1452 (guaranteed loans) https://www.usda.gov/topics/rural/housing-assistance USDA Rural Development State Office—Missouri (573) 876-0976 https://www.rd.usda.gov/mo
Rural Development Assistance—Utilities Rural Development Assistance—Utilities (continued)	Direct and guaranteed rural economic loans and business enterprise grants to address utility issues and development needs.	U.S. Department of Agriculture (USDA) Rural Development Utilities Program (202) 720-9540 https://www.rd.usda.gov/about-rd/agencies/rural-utilities-service USDA Rural Development State Office—Missouri (573) 876-0976 https://www.rd.usda.gov/mo
Rural Development Assistance—Community Facility Direct Loans/Grants	Grants, direct and guaranteed loans, and technical assistance to construct, enlarge, or improve community facilities for healthcare, public safety, and public services in primarily low-income rural areas.	U.S. Department of Agriculture (USDA) Rural Development Housing and Community Facilities Programs (202) 720-1474 (direct loans) (202) 720-1452 (guaranteed loans) https://www.usda.gov/topics/rural/housing-assistance USDA Rural Development State Office—Missouri (573) 876-0976 https://www.rd.usda.gov/mo
Rural Community Fire Protection	Grants for rural fire projects or assistance, including dry fire hydrants, equipment, and training.	Missouri Department of Conservation (573) 751-4115 https://mdc.mo.gov/property/fire/fire-department-assistance-programs
Community Development Block Grant—Section 108 Loan Guarantees	Loan guarantees to public entities for economic development, housing rehabilitation, public facilities, and large-scale physical development projects (including mitigation measures).	U.S. Department of Housing and Urban Development Community Planning and Development/Section 108 (202) 708-1871 https://www.hud.gov/hudprograms/section108

Program/Activity	Type of Assistance	Agency and Contact
		HUD Kansas City Regional Office (western half of MO) (913) 551-5644 HUD St. Louis Field Office (eastern half of MO) (314) 4175400 https://www.hud.gov/states/missouri/working/missourioffices Missouri Department of Economic Development Missouri Housing Development Commission (816) 759-6600 www.mhdc.com/
Homeland Security Grant Program	Grants to enhance the ability of states, territories, and urban areas to prepare for, prevent, and respond to terrorist attacks and other major disasters. Includes State Homeland Security Program, Urban Areas Security Initiative, Law Enforcement Terrorism Prevention Program, Metropolitan Medical Response System, and Citizen Corps Program grant programs.	FEMA Grants Management 816-283-7084 https://www.fema.gov/region-vii-grants
Infrastructure Protection Program	Grants to strengthen the nation's ability to protect critical infrastructure facilities and systems. Includes Transit Security Grant Program, Port Security Grant Program, Intercity Bus Security Grant Program, Trucking Security Program, and Buffer Zone Protection Program grant programs.	FEMA Grants Management 816-283-7084 https://www.fema.gov/region-vii-grants
Assistance to Firefighters Grant Program	Grants to local fire departments to protect citizens and firefighters against the effects of fire and fire-related incidents.	FEMA U.S. Fire Administration (800) 238-3358 https://www.usfa.fema.gov/grants/ FEMA Region VII (816) 283-7951 https://www.fema.gov/region-vii-grant-programs-management-gpm-branch

Program/Activity	Type of Assistance	Agency and Contact
Fire Prevention and Safety Grant Program	Grants for projects that enhance the safety of the public and firefighters from fire and related hazards. The primary goal is to target high-risk populations and mitigate high incidences of death and injury.	FEMA U.S. Fire Administration (800) 238-3358 https://www.usfa.fema.gov/grants/ FEMA Region VII (816) 283-7951 https://www.fema.gov/region-vii-grant-programs-management-gpm-branch
Fire Management Assistance Grant Program	Grants for the mitigation, management, and control of fires on publicly or privately owned forests or grasslands, which threaten such destruction as would constitute a major disaster.	FEMA Region VII (816) 283-7951 https://www.fema.gov/region-vii-grant-programs-management-gpm-branch
Hazardous Materials Emergency Preparedness Program	Project grants and technical assistance to enhance hazardous materials emergency planning and training.	U.S. Department of Transportation Pipeline and Hazardous Materials Safety Administration (202) 366-4433 https://www.phmsa.dot.gov/about-phmsa/working-phmsa/grants
Floods/Flood Control Grants, Loans, and Technical Assistance		
Flood Mitigation Assistance Program	Planning, project, and technical assistance grants to reduce or eliminate the long-term risk of flood damage to buildings, manufactured homes, and other structures insurable under the National Flood Insurance Program.	FEMA (816) 283-7061 https://www.fema.gov/flood-mitigation-assistance-grant-program SEMA (573) 526-9375 http://sema.dps.mo.gov/
Repetitive Flood Claims Program	Project grants for activities that reduce or eliminate the long-term risk of flood damage to structures insured under the National Flood Insurance Program that have had one or more claims for flood damages.	FEMA (816) 283-7061 https://www.fema.gov/flood-mitigation-assistance-grant-program SEMA (573) 526-9375 http://sema.dps.mo.gov/

Program/Activity	Type of Assistance	Agency and Contact
Severe Repetitive Loss Program	Project grants to reduce or eliminate claims under the National Flood Insurance Program through activities that will result in the greatest savings to the National Flood Insurance Fund.	FEMA (816) 283-7061 https://www.fema.gov/flood-mitigation-assistance-grant-program SEMA (573) 526-9100 http://sema.dps.mo.gov/
National Flood Insurance Program	Flood insurance to residents of communities that adopt and enforce minimum floodplain management requirements.	FEMA Region VII NFIP and Mitigation (816) 283-7061 https://www.fema.gov/national-flood-insurance-program SEMA (573) 526-9129 https://sema.dps.mo.gov/programs/floodplain/
Flood Control Planning Assistance	Technical and planning assistance for the preparation of comprehensive plans for the development, utilization, and conservation of water and related land resources.	U.S. Army Corps of Engineers (USACE) www.usace.army.mil/ Omaha District (northwest MO) (402) 995-2229 www.nwo.usace.army.mil/ Rock Island District (northeast MO) (309) 794-4200 www.mvr.usace.army.mil/ Kansas City District (west central MO) (816) 389-2000 www.nwk.usace.army.mil/ St. Louis District (east central MO) (314) 331-8000 www.mvs.usace.army.mil/

Program/Activity	Type of Assistance	Agency and Contact
Flood Control Planning Assistance (continued)		Little Rock District (southern MO) (501) 324-5551 www.swl.usace.army.mil/ Memphis District (southeast MO) (901) 544-4109 www.mvm.usace.army.mil/ Tulsa District (southwest MO) (918) 669-7366 www.swt.usace.army.mil/
Nonstructural Alternatives to Structural Rehabilitation of Damaged Flood Control Works	Direct planning and construction grants for nonstructural alternatives to the structural rehabilitation of flood control works damaged in floods or coastal storms.	U.S. Army Corps of Engineers (USACE) www.usace.army.mil/ Omaha District (northwest MO) (402) 995-2229 www.nwo.usace.army.mil/ Rock Island District (northeast MO) (309) 794-4200 www.mvr.usace.army.mil/ Kansas City District (west central MO) (816) 389-2000 www.nwk.usace.army.mil/ St. Louis District (east central MO) (314) 331-8000 www.mvs.usace.army.mil/ Little Rock District (southern MO) (501) 324-5551 www.swl.usace.army.mil/ Memphis District (southeast MO) (901) 544-4109 www.mvm.usace.army.mil/ Tulsa District (southwest MO) (918) 669-7366 www.swt.usace.army.mil/

Program/Activity	Type of Assistance	Agency and Contact
Floodplain Management Services	Technical and planning assistance at the local, regional, or national level needed to support effective floodplain management.	U.S. Army Corps of Engineers (USACE) www.usace.army.mil/ Omaha District (northwest MO) (402) 995-2229 www.nwo.usace.army.mil/ Rock Island District (northeast MO) (309) 794-4200 www.mvr.usace.army.mil/ Kansas City District (west central MO) (816) 389-2000 www.nwk.usace.army.mil/ St. Louis District (east central MO) (314) 331-8000 www.mvs.usace.army.mil/ Little Rock District (southern MO) (501) 324-5551 www.swl.usace.army.mil/ Memphis District (southeast MO) (901) 544-4109 www.mvm.usace.army.mil/ Tulsa District (southwest MO) (918) 669-7366 www.swt.usace.army.mil/
Land Protection	Technical assistance for run-off retardation and soil erosion prevention to reduce hazards to life and property.	U.S. Department of Agriculture Natural Resources Conservation Service (202) 720-7246 https://www.nrcs.usda.gov/wps/portal/nrcs/site/national/home/

Program/Activity	Type of Assistance	Agency and Contact
Stormwater Grant Program	Grants for planning and construction of stormwater facilities. Only 1st class counties, cities in 1st class counties, and St. Louis City are eligible. Funds based on population base. County offices can approve/deny a city application (if population less than 25,000).	Missouri Department of Natural Resources Water Protection Program Water Pollution Control Branch (573) 751-1300 https://dnr.mo.gov/env/wpp/wp-index.html
Dam Safety Programs	Technical assistance, training, and grants to help improve state dam safety programs.	FEMA Dam Safety (816) 283-7061 https://www.fema.gov/dam-safety Missouri Department of Natural Resources Water Resources Center Dam and Reservoir Safety Program (573) 368-2100 https://dnr.mo.gov/geology/wrc/dam-safety/
Earthquake Grants, Loans, and Technical Assistance		
National Earthquake Hazards Reduction Program and Other Earthquake Hazards Reduction Programs	Technical and planning assistance for activities associated with earthquake hazards mitigation.	FEMA (816) 283-7002 https://www.fema.gov/earthquake-grants SEMA (573) 526-9100 https://sema.dps.mo.gov/programs/earthquake.php
Geological Survey Program	Acquire, maintain, and manage basic geological data and identify and evaluate geological hazards. The Geological Survey Program assists Missourians, industry, and government in the wise use of Missouri's minerals, land, and water resources.	Missouri Department of Natural Resources Geological Survey Program (573) 368-2100 https://dnr.mo.gov/geology/geosrv/
All-Hazard Mapping Grants, Loans, and Technical Assistance		
National Flood Insurance Program: Flood Mapping	Flood insurance rate maps and floodplain management maps for all NFIP communities.	FEMA National Flood Insurance Program (816) 283-7002 https://www.fema.gov/national-flood-insurance-program SEMA (573) 526-9375 http://sema.dps.mo.gov/

Program/Activity	Type of Assistance	Agency and Contact
National Digital Orthophoto Programs	Develops topographic quadrangles for use in mapping of flood and other hazards.	U.S. Geological Survey National Map https://nationalmap.gov/ortho.html SEMA (573) 526-9100 https://sema.dps.mo.gov/maps_and_disasters/
National Streamflow Information Program	Operation of a network of over 7,000 stream gaging stations that provide data on river flood characteristics.	U.S. Geological Survey Office of Surface Water (703) 648-5301 https://water.usgs.gov/osw/
Mapping Standards Support	Expertise in mapping and digital data standards to support the National Flood Insurance Program.	U.S. Geological Survey National Map https://nationalmap.gov/ortho.html SEMA (573) 526-9100 https://sema.dps.mo.gov/maps_and_disasters/
Earthquake Hazards Program Earthquake Hazards Program (continued)	Seismic hazard maps.	U.S. Geological Survey (650) 329-4668 https://earthquake.usgs.gov/hazards/hazmaps/ Missouri Department of Natural Resources Geological Survey Program (573) 368-2100 https://dnr.mo.gov/geology/geosrv/ SEMA (573) 526-9100 https://sema.dps.mo.gov/maps_and_disasters/
Cooperating Technical Partners	Technical assistance, training, and data to support flood hazard data development activities.	FEMA Region VII (816) 283-7073 https://www.fema.gov/cooperating-technical-partners-program-0

Program/Activity	Type of Assistance	Agency and Contact
Map Modernization Management Support	Provides funding to supplement, not supplant, ongoing flood hazard mapping management efforts by local, regional, and State agencies.	FEMA Region VII Map Modernization (816) 283-7009 https://www.fema.gov/media-library/assets/documents/10699
Community Assistance Program State Support Services Element (CAP-SSSE)	Provides funding to states to provide technical assistance to communities in the National Flood Insurance Program (NFIP) and to evaluate community performance in implementing NFIP floodplain management activities.	FEMA Region VII NFIP and Mitigation (800) 621-3362 https://www.fema.gov/community-assistance-program-state-support-services-element SEMA (573) 526-9100
Geospatial One-Stop (geodata.gov)	GIS portal that contains metadata records and links to live maps, features, and catalog services, downloadable data sets, images, clearinghouses, map files, and more.	Geospatial One-Stop http://www.opengeospatial.org/projects/initiatives/gos-pi
Missouri Spatial Data Information Service	Provides GIS and census data about the State of Missouri.	Missouri Spatial Data Information Service University of Missouri–Columbia (573) 882-6606 http://msdis.missouri.edu/
Center for Agriculture, Resource, and Environmental Systems	Provides maps and research findings to help better address resource, environmental, and socioeconomic issues.	Center for Agriculture, Resource, and Environmental Systems University of Missouri–Columbia http://www.cares.missouri.edu/
Ancillary Flood and Natural Resource Projects Grants, Loans, and Assistance		
Natural Resources Financial Assistance	Financial and technical assistance programs available to Missouri communities.	Missouri Department of Natural Resources (573) 751-3443 contact@dnr.mo.gov
	• User Charge Analysis—Computer software assisted analysis of water and wastewater user charge systems.	Water Pollution Control Branch Water Protection Program (573) 751-1300 www.dnr.mo.gov/env/wpp/wp-index.html

Program/Activity	Type of Assistance	Agency and Contact
	• Agriculture Loan Program—Loans to individual farmers for animal waste treatment facilities. • Cooperative Remonumentation Program—Contract with county commissions to remonument corners of the U.S. Public Land Survey System. • County Boundary Resurvey Program—Contract with county commissions to remonument county boundary lines where location of line is indefinite. • Geodetic Control Densification Project—Contract with county, city government, and municipal utilities to establish horizontal and vertical control monuments used for mapping and the development of land survey information system.	Missouri Department of Agriculture http://agriculture.mo.gov/abd/financial/ (573) 751-4762 State Surveyor http://agriculture.mo.gov/weights/landsurvey/ (573) 368-2300
	• Hazardous Substance Emergency Relief Loan Fund—Loans to political subdivisions or volunteer fire protection associations for reimbursement of actual costs incurred in responding to a hazardous substance emergency.	Missouri Department of Natural Resources Environmental Services Program (573) 526-3315 https://dnr.mo.gov/env/esp/
	• Local Government Reimbursement Program—Local communities can be reimbursed up to $25,000 for costs incurred in responding to a hazardous substance emergency.	U.S. Environmental Protection Agency Local Governments Reimbursement (800) 431-9209 https://www.epa.gov/emergency-response/local-governments-reimbursement-program
Natural Resources Financial Assistance (continued)	• Leaking Underground Storage Tank Cleanup Assistance—At eligible sites with preapproved plans and costs, the Underground Storage Tank Fund can assist the responsible party with the cleanup costs.	Missouri Department of Natural Resources Hazardous Waste Management Program Tanks Compliance and Technology Unit (573) 751-3176 https://dnr.mo.gov/env/hwp/tanks/enfcomp.htm
	• Private Activity Bond Financing—Issuance of tax-exempt and taxable revenue bonds for private and public companies for facilities and improvements with environmental and energy resource impacts.	Missouri Department of Natural Resources Environmental Improvement and Energy Resources Authority (573) 751-4919 eiera@dnr.mo.gov https://eiera.mo.gov/

Program/Activity	Type of Assistance	Agency and Contact
Environmental Quality Incentives Program	Technical and financial assistance to eligible farmers and ranchers to address soil, water, and related natural resource concerns on their lands.	U.S. Department of Agriculture Natural Resources Conservation Service (NRCS) 202) 720-4527 https://www.nrcs.usda.gov/wps/portal/nrcs/detailfull/national/programs/financial/eqip/?cid=stelprdb1044009%20 NRCS District Office—Columbia, MO (573) 876-0901 Missouri Department of Natural Resources Soil and Water Conservation Program (573) 751-4932 https://dnr.mo.gov/env/swcp/
Nonpoint Source Implementation Grants (Clean Water Act Section 319 Grants) Nonpoint Source Implementation Grants (Clean Water Act Section 319 Grants) (continued)	Grants to states to implement nonpoint source programs, including support for nonstructural watershed resource restoration activities.	U.S. Environmental Protection Agency Region VII Water, Wetlands, and Pesticides Division (913) 551-7003 https://dnr.mo.gov/env/swcp/nps/index.html https://www.cfda.gov/index?s=program&mode=list&tab=list Missouri Department of Natural Resources Non-Point Source Control Branch (573) 751-4932 https://dnr.mo.gov/env/swcp/nps/index.html
Capitalization Grants for Clean Water State Revolving Funds	Loans to fund water quality protection projects for wastewater treatment, nonpoint source pollution control, and watershed and estuary management.	U.S. Environmental Protection Agency Region VII Water, Wetlands, and Pesticides Division (913) 551-7003 https://dnr.mo.gov/env/swcp/nps/index.html www.epa.gov/owm/cwfinance/index.htm
National Wetland Program Development Grants	Grants to build capacity to protect, manage, and restore wetlands.	U.S. Environmental Protection Agency Region VII Water, Wetlands, and Pesticides Division (913) 551-7003 https://dnr.mo.gov/env/swcp/nps/index.html https://www.cfda.gov/index?s=program&mode=list&tab=list

Program/Activity	Type of Assistance	Agency and Contact
		Missouri Department of Natural Resources Geological Survey Program (573) 368-2100 https://dnr.mo.gov/geology/wrc/
Watershed Protection and Flood Prevention Program	Technical assistance for designing and installing watershed works of improvement and financial assistance for cost-sharing of measures for watershed protection, flood prevention, agricultural water management, sedimentation control, etc., in small watersheds under 250,000 acres.	U.S. Department of Agriculture Natural Resources Conservation Service (NRCS) Watersheds and Wetlands Division (202) 720-7246 https://www.nrcs.usda.gov/wps/portal/nrcs/main/national/programs/landscape/ NRCS District Office—Columbia, MO (573) 876-0901 Missouri Department of Natural Resources Soil and Water Conservation Program (573) 751-4932 https://dnr.mo.gov/env/swcp/

Program/Activity	Type of Assistance	Agency and Contact
Soil and Water Conservation Program	Technical assistance to the general public in planning and applying natural resource conservation practices, systems, and treatment; and furnishing technical natural resource conservation information to State and local governments.	U.S. Department of Agriculture Natural Resources Conservation Service (NRCS) Watersheds and Wetlands Division (202) 720-7246 https://www.nrcs.usda.gov/wps/portal/nrcs/main/national/programs/landscape/ NRCS District Office—Columbia, MO (573) 876-0901 Missouri Department of Natural Resources Soil and Water Conservation Program (573) 751-4932 https://dnr.mo.gov/env/swcp/
Watershed Surveys and Planning	Technical assistance planning activities to help solve water and related land resources problems.	U.S. Department of Agriculture Natural Resources Conservation Service (NRCS) Watersheds and Wetlands Division (202) 720-7246 https://www.nrcs.usda.gov/wps/portal/nrcs/main/national/programs/landscape/ NRCS District Office—Columbia, MO (573) 876-0901
Emergency Watershed Protection Program	Provides technical and financial assistance for relief from imminent hazards in small watersheds and to reduce vulnerability of life and property in small watershed areas damaged by natural hazard events.	U.S. Department of Agriculture Natural Resources Conservation Service (NRCS) Watersheds and Wetlands Division (202) 720-7246 https://www.nrcs.usda.gov/wps/portal/nrcs/main/national/programs/landscape/ NRCS District Office—Columbia, MO (573) 876-0901
Wetlands Reserve Program	Financial and technical assistance to protect and restore wetlands through easements and restoration agreements.	U.S. Department of Agriculture Natural Resources Conservation Service (NRCS) Watersheds and Wetlands Division (202) 720-7246 https://www.nrcs.usda.gov/wps/portal/nrcs/main/national/programs/landscape/

Program/Activity	Type of Assistance	Agency and Contact
Wetlands Reserve Program (continued)		NRCS District Office—Columbia, MO (573) 876-0901
Project Modifications for Improvement of the Environment	Provides for ecosystem restoration by modifying structures and/or operations or water resources projects constructed by the U.S. Army Corps of Engineers or restoring areas where a Corps project contributed to the degradation of an area.	U.S. Army Corps of Engineers (USACE) www.usace.army.mil/ Omaha District (northwest MO) (402) 995-2229 www.nwo.usace.army.mil/ Rock Island District (northeast MO) (309) 794-4200 www.mvr.usace.army.mil/ Kansas City District (west central MO) (816) 389-2000 www.nwk.usace.army.mil/ St. Louis District (east central MO) (314) 331-8000 www.mvs.usace.army.mil/ Little Rock District (southern MO) (501) 324-5551 www.swl.usace.army.mil/ Memphis District (southeast MO) (901) 544-4109 www.mvm.usace.army.mil/ Tulsa District (southwest MO) (918) 669-7366 www.swt.usace.army.mil/
Aquatic Ecosystem Restoration Aquatic Ecosystem Restoration (continued)	Direct support for carrying out aquatic ecosystem restoration projects that will improve the quality of the environment.	U.S. Army Corps of Engineers (USACE) www.usace.army.mil/ Omaha District (northwest MO) (402) 995-2229 www.nwo.usace.army.mil/

Program/Activity	Type of Assistance	Agency and Contact
		Rock Island District (northeast MO) (309) 794-4200 www.mvr.usace.army.mil/ Kansas City District (west central MO) (816) 389-2000 www.nwk.usace.army.mil/ St. Louis District (east central MO) (314) 331-8000 www.mvs.usace.army.mil/ Little Rock District (southern MO) (501) 324-5551 www.swl.usace.army.mil/ Memphis District (southeast MO) (901) 544-4109 www.mvm.usace.army.mil/ Tulsa District (southwest MO) (918) 669-7366 www.swt.usace.army.mil/
Planning Assistance to States (Water Resources Development Act) Planning Assistance to States (Water Resources Development Act) (continued)	Financial and technical assistance to prepare comprehensive plans for the development, use, and conservation of water and related land resources.	U.S. Army Corps of Engineers (USACE) www.usace.army.mil/ Omaha District (northwest MO) (402) 995-2229 www.nwo.usace.army.mil/ Rock Island District (northeast MO) (309) 794-4200 www.mvr.usace.army.mil/ Kansas City District (west central MO) (816) 389-2000 www.nwk.usace.army.mil/

Program/Activity	Type of Assistance	Agency and Contact
		St. Louis District (east central MO) (314) 331-8000 www.mvs.usace.army.mil/ Little Rock District (southern MO) (501) 324-5551 www.swl.usace.army.mil/ Memphis District (southeast MO) (901) 544-4109 www.mvm.usace.army.mil/ Tulsa District (southwest MO) (918) 669-7366 www.swt.usace.army.mil/
Beneficial Uses of Dredged Materials Beneficial Uses of Dredged Materials (continued)	Direct assistance for projects that protect, restore, and create aquatic and ecologically-related habitats, including wetlands, in connection with dredging an authorized federal navigation project.	U.S. Army Corps of Engineers (USACE) www.usace.army.mil/ Omaha District (northwest MO) (402) 995-2229 www.nwo.usace.army.mil/ Rock Island District (northeast MO) (309) 794-4200 www.mvr.usace.army.mil/ Kansas City District (west central MO) (816) 389-2000 www.nwk.usace.army.mil/ St. Louis District (east central MO) (314) 331-8000 www.mvs.usace.army.mil/ Little Rock District (southern MO) (501) 324-5551 www.swl.usace.army.mil/

Program/Activity	Type of Assistance	Agency and Contact
		Memphis District (southeast MO) (901) 544-4109 www.mvm.usace.army.mil/ Tulsa District (southwest MO) (918) 669-7366 www.swt.usace.army.mil/
North American Wetland Conservation Fund	Matching grants for projects that provide long-term protection, restoration, and/or enhancement of wetlands and associated uplands habitats in the United States.	U.S. Fish and Wildlife Service Division of Bird Habitat Conservation (703) 358-1784 https://www.fws.gov/birds/grants.php
Soil Survey	Maintains soil surveys of counties or other areas to assist with farming, conservation, mitigation or related purposes.	U.S. Department of Agriculture Natural Resources Conservation Service (NRCS) Soil Science and Resource Assessment 202-720-7246 http://soils.usda.gov/survey/ NRCS District Office—Columbia, MO (573) 876-0901
Land Acquisition	Acquires or purchases easements on high-quality lands and waters for inclusion into the National Wildlife Refuge System.	U.S. Fish and Wildlife Service Division of Realty (703) 358-1713 https://www.fws.gov/refuges/realty/index.html
Transfers of Inventory Farm Properties to Federal and State Agencies for Conservation Purposes	Transfers title of certain inventory farm properties owned by the Farm Service Agency to federal and state agencies for conservation purposes (including the restoration of wetlands and floodplain areas to reduce future flood potential).	U.S. Department of Agriculture Farm Service Agency https://www.fsa.usda.gov/programs-and-services/farm-loan-programs/
Disposal of Federal Surplus Real Property for Parks, Recreation, and Historic Monuments	Identifies, assesses, and transfers available federal real property for acquisition for state and local parks and recreation, such as open space.	National Park Service (NPS) (402) 661-1928 https://www.nps.gov/orgs/1246/index.htm NPS—Northeast/Midwest Regions (402)-661-1601 https://www.nps.gov/orgs/1671/index.htm
Recreation and Parks Grants	Grants available to cities, counties, and school districts for outdoor recreation facilities and land acquisition.	Missouri Department of Natural Resources Division of State Parks (573) 751-0848 https://mostateparks.com/page/55065/outdoor-recreation-grants

Program/Activity	Type of Assistance	Agency and Contact
Partners for Fish and Wildlife	Financial and technical assistance to private landowners interested in restoring or otherwise improving native habitats for fish and wildlife on their lands.	U.S. Fish and Wildlife Service Branch of Habitat Restoration (703) 358-2201 https://www.fws.gov/invasives/habitat-restoration.html
Tree Planting Program	Grants for planting trees for improving Missouri's erosion control, conservation, stream bank stabilization, etc.	Missouri Department of Conservation (573) 751-4115 https://mdc.mo.gov/property/community-conservation
Conservation Contracts	Debt reduction for delinquent and nondelinquent borrowers in exchange for conservation contracts placed on environmentally sensitive real property that secures Farm Service Agency loans.	U.S. Department of Agriculture Farm Service Agency https://www.fsa.usda.gov/programs-and-services/farm-loan-programs/
Historic Preservation Fund Grants	Federal matching grants, known as the Historic Preservation Fund to assist in carrying out historic preservation activities. Sponsored by the National Park Service.	Missouri Department of Natural Resources Division of State Parks (573) 751-7858 https://dnr.mo.gov/shpo/heritagegrants.htm
The Foundation Directory	Annual source of information about grants and loans from federal and private sources. Available for a fee.	The Foundation Directory (800) 478-4661 https://fconline.foundationcenter.org/
Federal Assistance Monitor	Published by CD Publications. Semi-monthly report on federal and private grants. Available for a fee.	CD Publications (855) 237-1396 https://www.cdpublications.com/fam/
Catalog of Federal Domestic Assistance	Database of all federal programs available to State and local governments; federally recognized Indian tribal governments; domestic public, quasi-public, and private profit and nonprofit organizations and institutions; specialized groups; and individuals.	Catalog of Federal Domestic Assistance https://www.cfda.gov/
Basic and Applied Research/Development		
Decision, Risk, and Management Sciences	Funding for research directed at increasing the understanding and effectiveness of decision making by individuals, groups, organizations, and society.	National Science Foundation Directorate for Social, Behavioral, and Economic Sciences (703) 292-7263 https://www.nsf.gov/funding/pgm_summ.jsp?pims_id=5423

Program/Activity	Type of Assistance	Agency and Contact
Science, Technology, and Society	Funding for research that examines questions that arise in the interactions of engineering, science, technology, and society.	National Science Foundation Directorate for Social, Behavioral, and Economic Sciences 703) 292-7283 https://www.nsf.gov/funding/pgm_summ.jsp?pims_id=5324
National Earthquake Hazards Reduction Program	Funding for research to mitigate earthquake losses by providing earth science data and assessments essential for land use planning, engineering design, and emergency preparedness decisions.	FEMA National Earthquake Hazards Reduction Program (816) 283-7061 https://www.fema.gov/national-earthquake-hazards-reduction-program
Structural Systems and Hazards Mitigation of Structures	Funding for research on new technologies for improving the behavior and response of structural systems subject to natural hazards.	National Science Foundation Directorate for Engineering Division of Civil, Mechanical, and Manufacturing Innovation (703) 292-5111 https://www.nsf.gov/funding/programs.jsp?org=ENG
Environmental Technology	Funding for research to develop and test new technologies in the field of environmental engineering emphasizing principles underlying pollution avoidance as well as pollution treatment and remediation.	National Science Foundation Directorate for Engineering Division of Chemical, Bioengineering, Environmental, and Transport Systems (703) 292-5111 https://www.nsf.gov/funding/programs.jsp?org=ENG
Infrastructure Management and Hazard Response	Funding for research on multidisciplinary issues concerning the impact of natural, technological, and manmade hazards upon critical infrastructure systems and society.	National Science Foundation Directorate for Engineering Division of Civil, Mechanical, and Manufacturing Innovation (703) 292-5111 https://www.nsf.gov/funding/programs.jsp?org=ENG
Environmental Sustainability	Funding for research with the goal of promoting sustainable engineered systems that support human well-being and that also are compatible with sustaining natural (environmental) systems, which provide ecological services vital for human survival.	National Science Foundation Directorate for Engineering Division of Chemical, Bioengineering, Environmental, and Transport Systems (703) 292-5111 https://www.nsf.gov/funding/programs.jsp?org=ENG
Behavioral and Social Research on Disasters and Health	Funding for research in the behavioral and social sciences on the consequences of natural and man-made disasters for the health of children, the elderly, and vulnerable	National Institutes of Health (866) 504-9552 https://grants.nih.gov/funding/index.htm

Program/Activity	Type of Assistance	Agency and Contact
	groups, with an ultimate goal of preventing or mitigating harmful consequences.	
Other Planning Resources: Demographics, Societal Data, and Transportation, Agricultural, Industrial, and Economic Statistics		
Demographics, Societal Statistics and Economic Statistics	Free planning information concerning jobs, business and economic statistics, population and housing statistics, and help with census products (i.e., statistics, maps, reports, etc.). Note: For statistics regarding clean water, wetlands, conservation, disasters, natural resources, rivers, and other subjects covered in this document, use the contact information provided in the subject matter areas.	U.S. Census Bureau (573) 884-9122 www.census.gov/ Bureau of Economic Analysis Public Information Office (301) 278-9004 www.bea.gov/ Bureau of Labor Statistics (BLS) Division of Information and Marketing Services (202) 691-5200 https://www.bls.gov/opub/opbinfo.htm Midwest BLS Kansas City Information Office (312) 353-1880 https://www.bls.gov/regions/midwest/contact.htm Missouri Census Data Center Missouri State Library (417) 895-6670 https://census.missouri.edu Technology Transfer and Economic Development University of Missouri–Rolla (573) 341-6579 https://ecodevo.mst.edu/ Missouri Office of Administration Budget and Planning (573) 751-2345 bpmail@oa.mo.gov https://oa.mo.gov/budget-planning

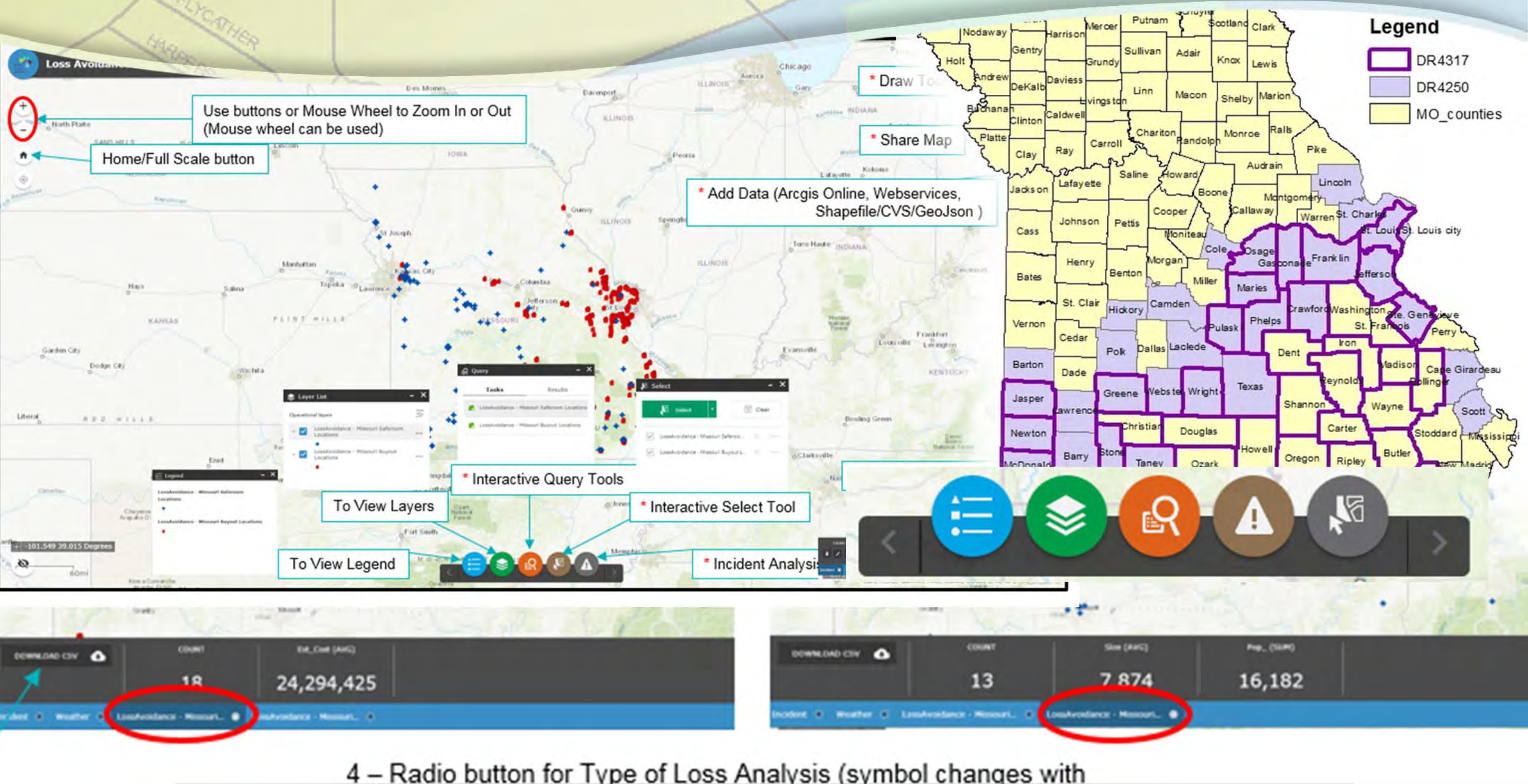
Program/Activity	Type of Assistance	Agency and Contact
Demographics, Societal Statistics and Economic Statistics (continued)		Office of Social and Economic Data Analysis University of Missouri–Columbia (573) 884-5116 https://oseda.missouri.edu/ Center for Economic Information University of Missouri–Kansas City (816) 235-2832 http://cei.umkc.edu/ Missouri Agricultural Statistics Service (314) 595-9594, (800) 551-1014 www.nassrfohlr@nass.usda.gov Missouri Department of Transportation (573) 751-2551, (888) 275-6636 www.modot.org/ Geographic Resources Center University of Missouri–Columbia (573) 882-2149 www.grc.missouri.edu/ Missouri Economic Research and Information Center (866) 225-8113 MERICData@ded.mo.gov https://www.missourieconomy.org/ Federal Committee on Statistical Methodology https://nces.ed.gov/FCSM/index.asp Missouri Department of Economic Development (573) 751-4962 https://ded.mo.gov/
Demographics, Societal Statistics and Economic Statistics (continued)		Missouri Spatial Data Information Service University of Missouri–Columbia (573) 882-3233 http://msdis.missouri.edu

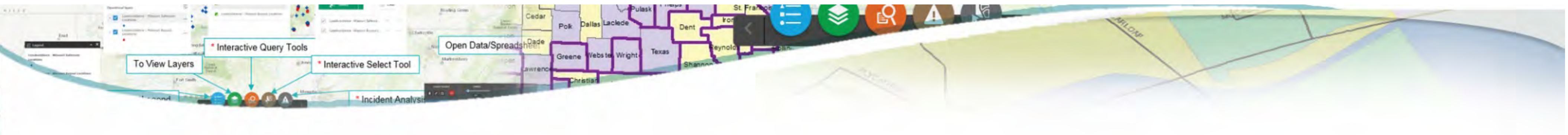
Appendix E

Loss Avoidance Analysis Tool

User Guide

Loss Avoidance Analysis Tool User Guide





Introduction

Following a hazard event, SEMA mitigation staff query local officials to document how mitigation actions instituted in the affected areas reduced the amount of damage or loss of life that could have resulted from an event. SEMA has updated this query process and formalized loss avoidance documentation through a newly-developed web-based tool which follows the loss avoidance methodology developed by FEMA.

FEMA developed the loss avoidance methodology to evaluate the effectiveness of mitigation projects based on the analysis of actual events. This methodology can be applied to the mitigation of any type of natural hazard. Losses avoided are determined by comparing the damage that would likely have been caused by the same storms without the project (Mitigation Project Absent, MP_A) with damage that actually occurred with the project in place (Mitigation Project Complete, MP_C). There are three phases of the general methodology for loss avoidance studies:

1) Initial Project Selection
2) Project Effectiveness Analysis
3) Loss Estimation Analysis

Table of Contents

Phase 1 focuses on the selection of the completed project area to be included in the loss avoidance study. Structures are screened based on the availability of data required for completion of the study. This includes actual project costs, construction completion dates, first floor elevations, structure location information, and structure information, including the type, basement information, number of floors, square footage, and building replacement value. Structures with adequate data advance to Phase 2.

Phase 2 includes a storm event analysis, to determine whether a post-construction storm event is severe enough to have caused damage if the project had not been completed (MP_A scenario), and a hazard analysis, to determine the impact of the hazard event (e.g., depth of flooding) at the mitigation project location.

Phase 3 includes two steps. First, an economic evaluation of the project scope is completed for both the MP_A and MP_C scenarios for each hazard event analyzed. The difference between the total losses for the two scenarios is calculated and losses avoided are determined. Second, the return on investment (ROI) is assessed by comparing the losses avoided to the total project investment.

For the 2018 State Plan Update, SEMA has developed a web-based, loss avoidance analysis tool (LAAT) to assist SEMA staff and local officials to collect and store the data necessary to complete a loss avoidance study following a hazard event.

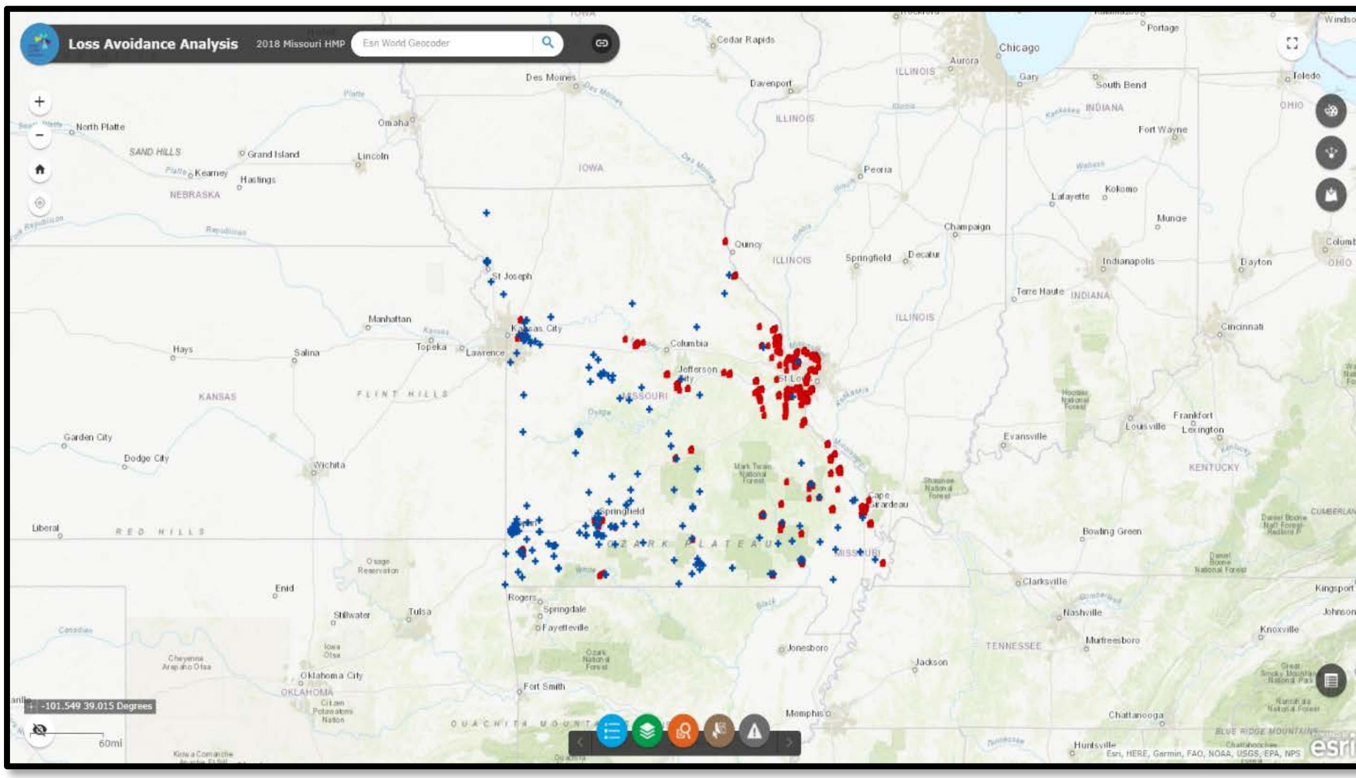
Loss Avoidance Analysis Tool (LAAT) Overview

The web-based, loss avoidance analysis tool (LAAT) is a database of the structural data necessary to complete Phase 1 of a loss avoidance study and is a data collection tool for the storm event data necessary to complete Phase 2 of a loss avoidance study. This is currently for tornado Saferooms and flood buyouts locations. The LAAT website can be accessed here: http://bit.ly/SEMA_LossAvoidance.

Step 1

Step 1: Initial Project Selection – For all completed mitigation projects for Buyout and Saferoom projects within the State, the LAAT database has been populated with project details as included in the approved grant application and project closeout documents. This includes actual project costs, construction completion dates, first floor elevations, and structure information where it was available. Not all locations have all the information. The FEMA Corps improved the latitude and longitude data for each acquisition site, at the time of the 2018 State Mitigation Plan Update. This data has been incorporated into the LAAT. **Figure 1** presents the LAAT website showing the tornado safe room locations in blue and residential buyout locations in red.

Figure 1. Loss Avoidance Analysis Tool (LAAT) Website



Each mitigation project has also been spatially located based upon the street address or latitude/longitude, as either obtained from the project grant application or field located with GPS. Efforts to map completed buyouts prior to 2002 have proven difficult because communities have combined parcels and lots into combined open spaces, streets and addresses no longer exist (as a result of the buyouts).

Those mitigation projects with limited structural or location data are included in the LAAT database, but should move forward to Phase 2 with an understanding of the known deficits before being utilized in a loss avoidance study.

The LAAT database may be updated at any time to include additional project information. For future mitigation projects, the structure data necessary to complete Phase 1 of a loss avoidance study will be entered by SEMA staff upon project completion and closeout.

Step 2

Step 2: Project Effectiveness Analysis – Because a loss avoidance study measures benefits of a completed project based upon an actual event, the local official will be tasked with completing the storm event data collection form following a hazard event within their community or SEMA staff can add this information easily to any reports resulting from disaster declarations. The user can spatially select those mitigation projects within the hazard event area and do a simple export to show the calculated loss avoidance. **Figure 2** displays the Operational Tools available on the website. **Figure 3** shows the Add Data Tool options. Users can either upload a project area shapefile or simple draw an area of interest to use for the analysis as shown in **Figure 7**, respectively. The user can also share the data from the analysis with others as shown in **Figure 5**.

Figure 2. LAAT Website – Operational Tools

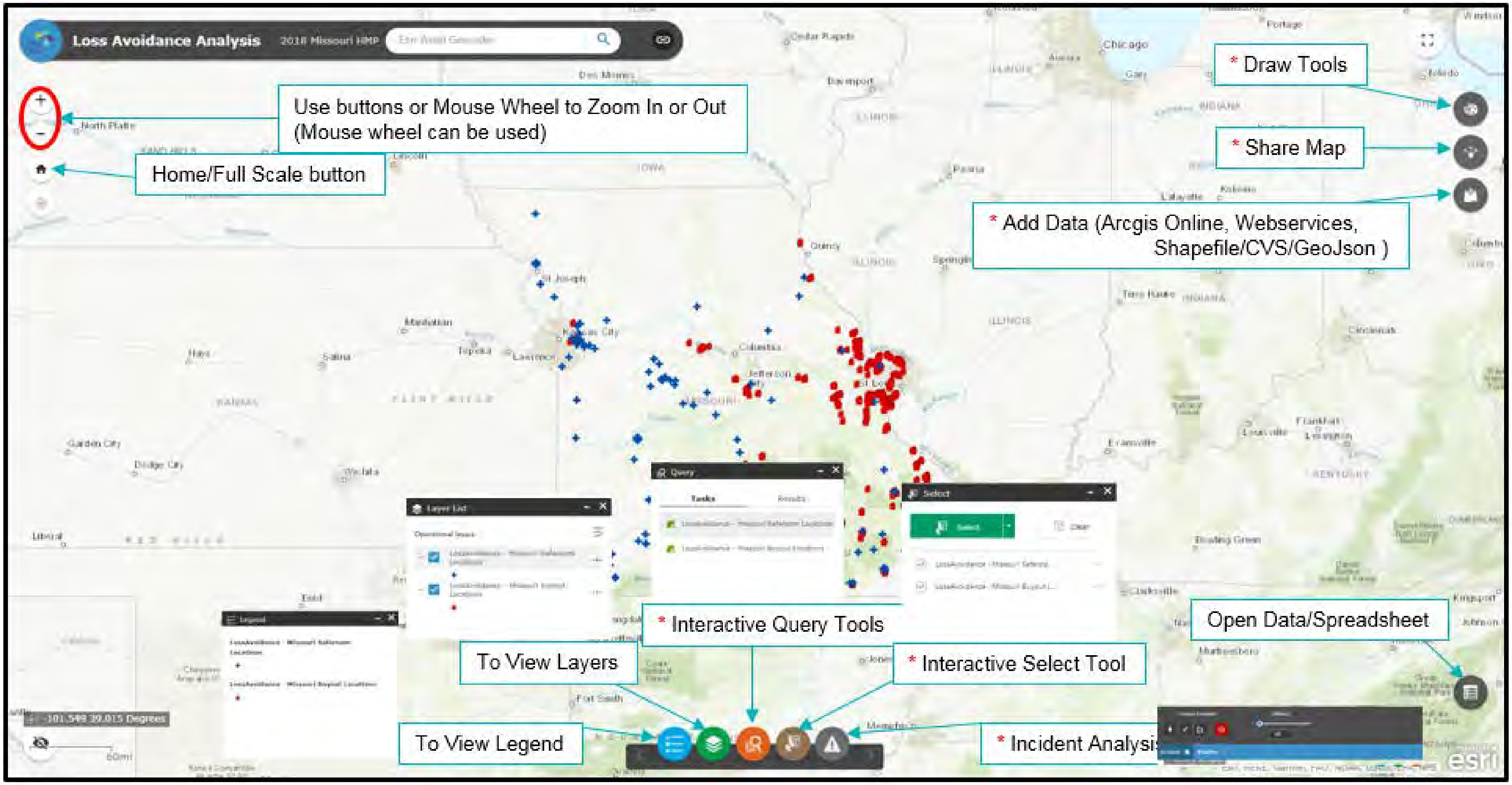
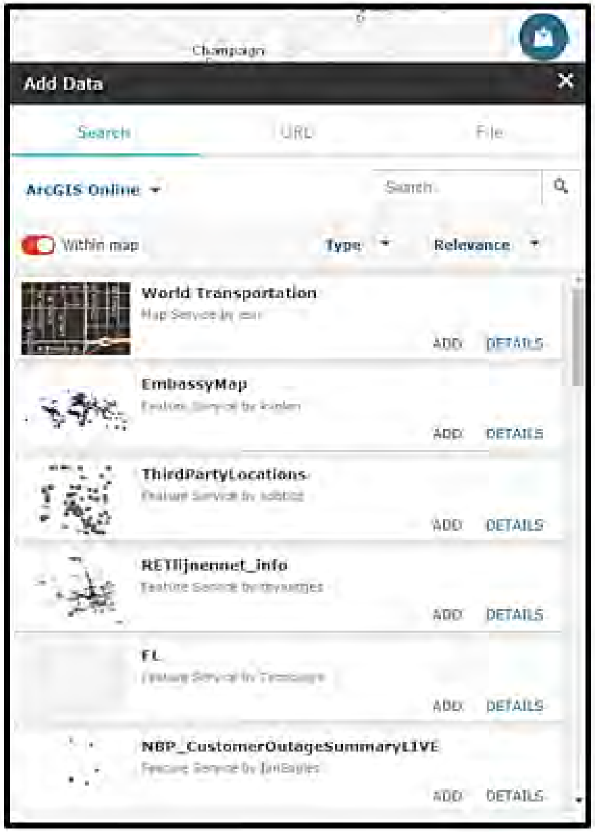
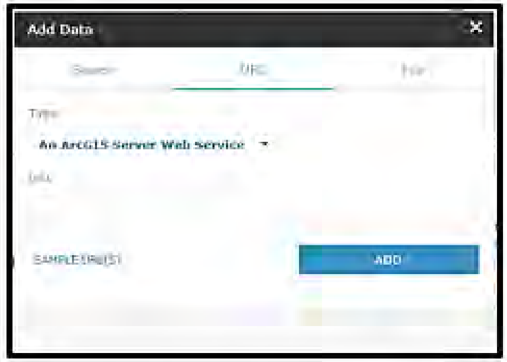


Figure 3. LAAT Website – "Add Data" Tool

1) From ArcGIS Online



2) From another Public Location/Agency



Add Data from following:

- ArcGIS Server Web Service
- WMS OGC Web Service
- KML
- GeoRSS File
- CSV File

3) Project and/or Personal Data

Add Data from Local Computer by Drag/Drop or Browse to Location.

Files Include:

- Shapefile
- CSV
- GPX
- GeoJson

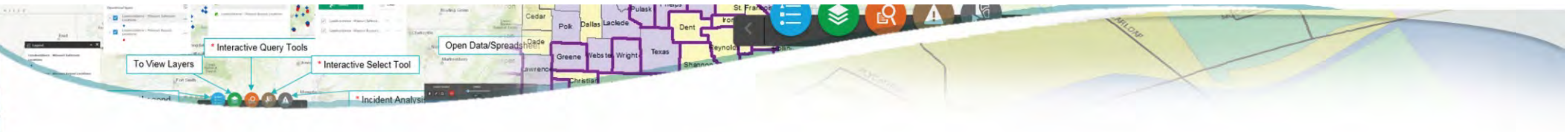


Figure 4. LAAT Website – "Draw" Tool

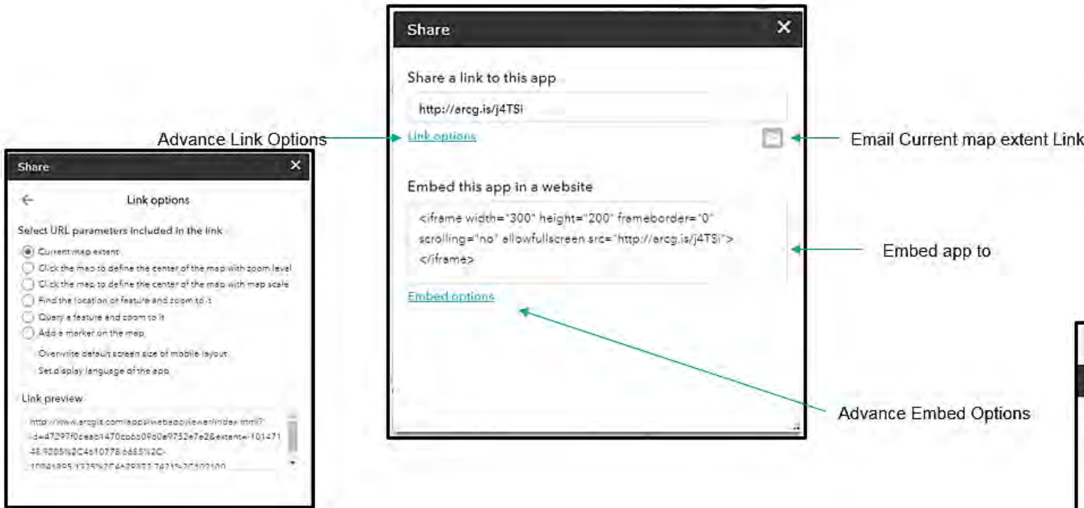
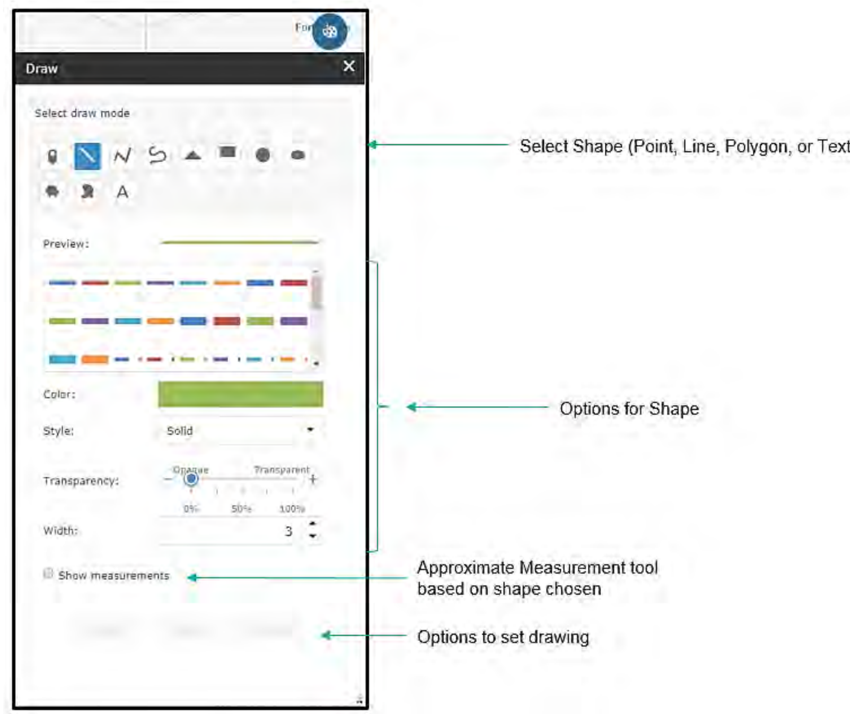


Figure 5. LAAT Website – "Share" Tool



Step 3

Step 3: Loss Estimation Analysis - This final phase consists of estimating losses avoided based on the effectiveness of the mitigation project during the MP_C storm events. The two major tasks in Phase 3 are (1) calculating losses avoided and (2) calculating the return on investment. This can now be done "on the fly" with the LAT by utilizing the Query Tool as shown in **Figure 6**.

This information and the results of completed loss avoidance studies will be incorporated into mitigation success stories to aid in the assessment of the current and future goals, objectives, and actions by simply exporting the data in the needed format using the Incident Analysis Tool shown in **Figure 7**.

Figure 6. LAAT Website – "Query" Tool

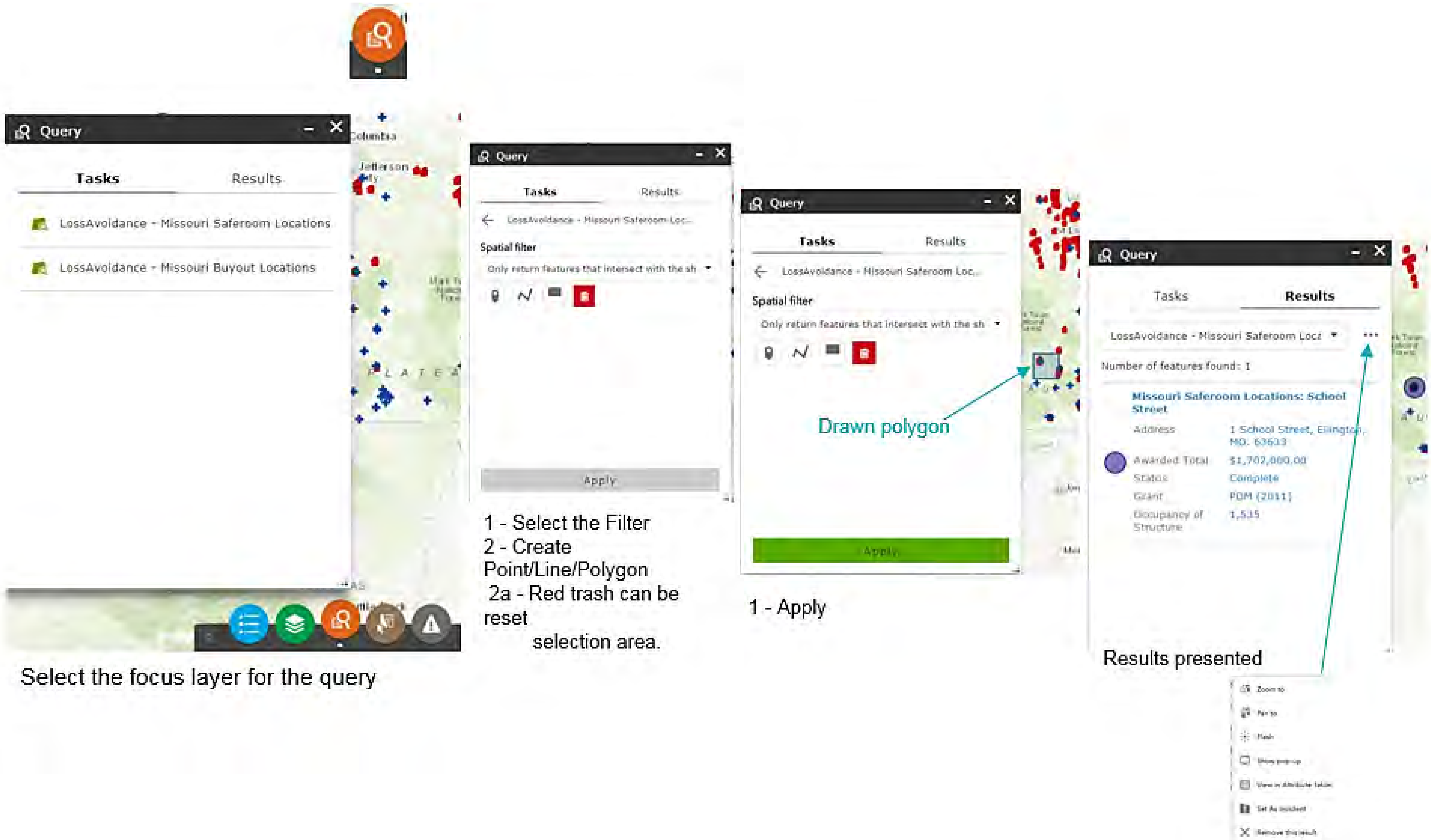
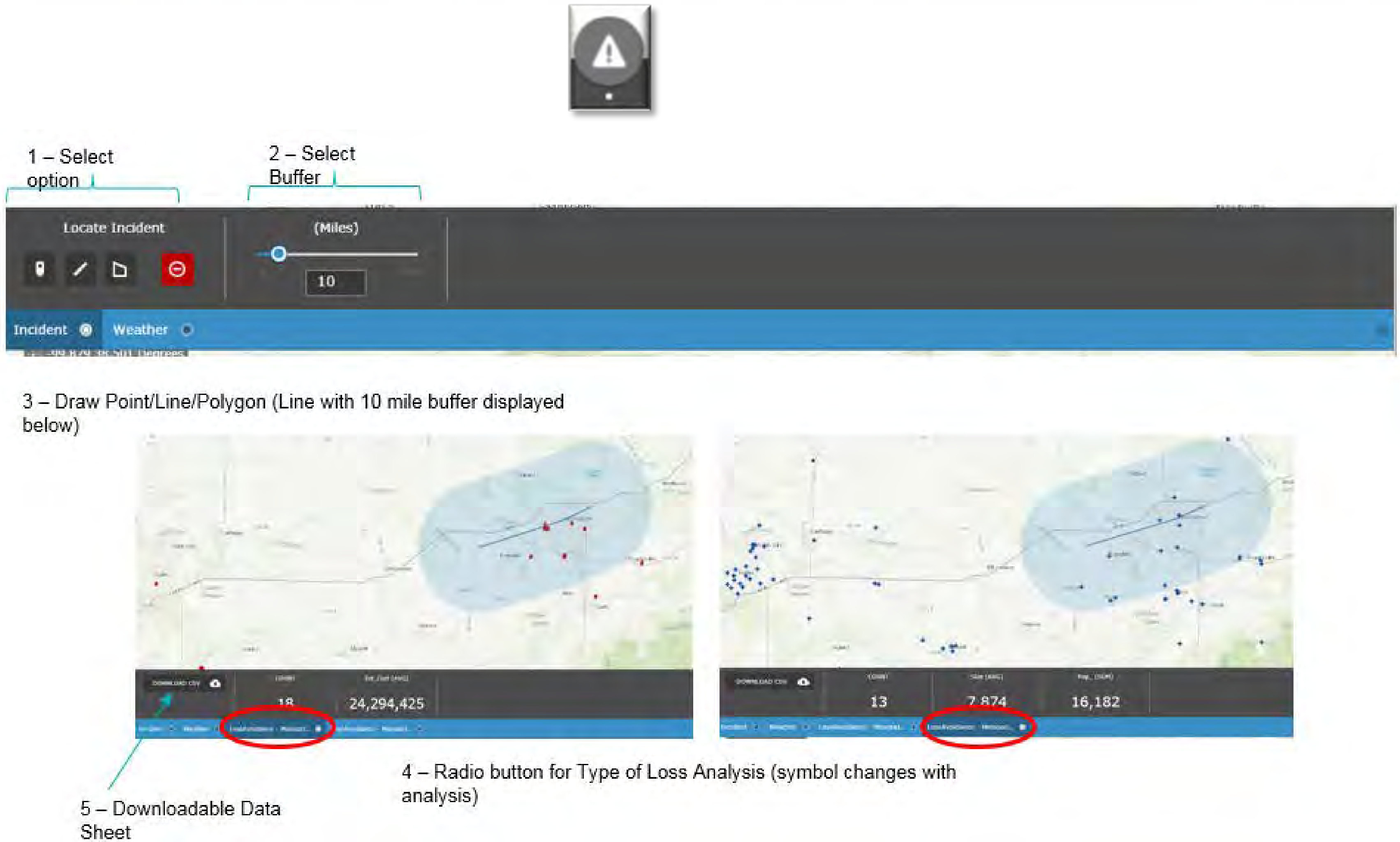


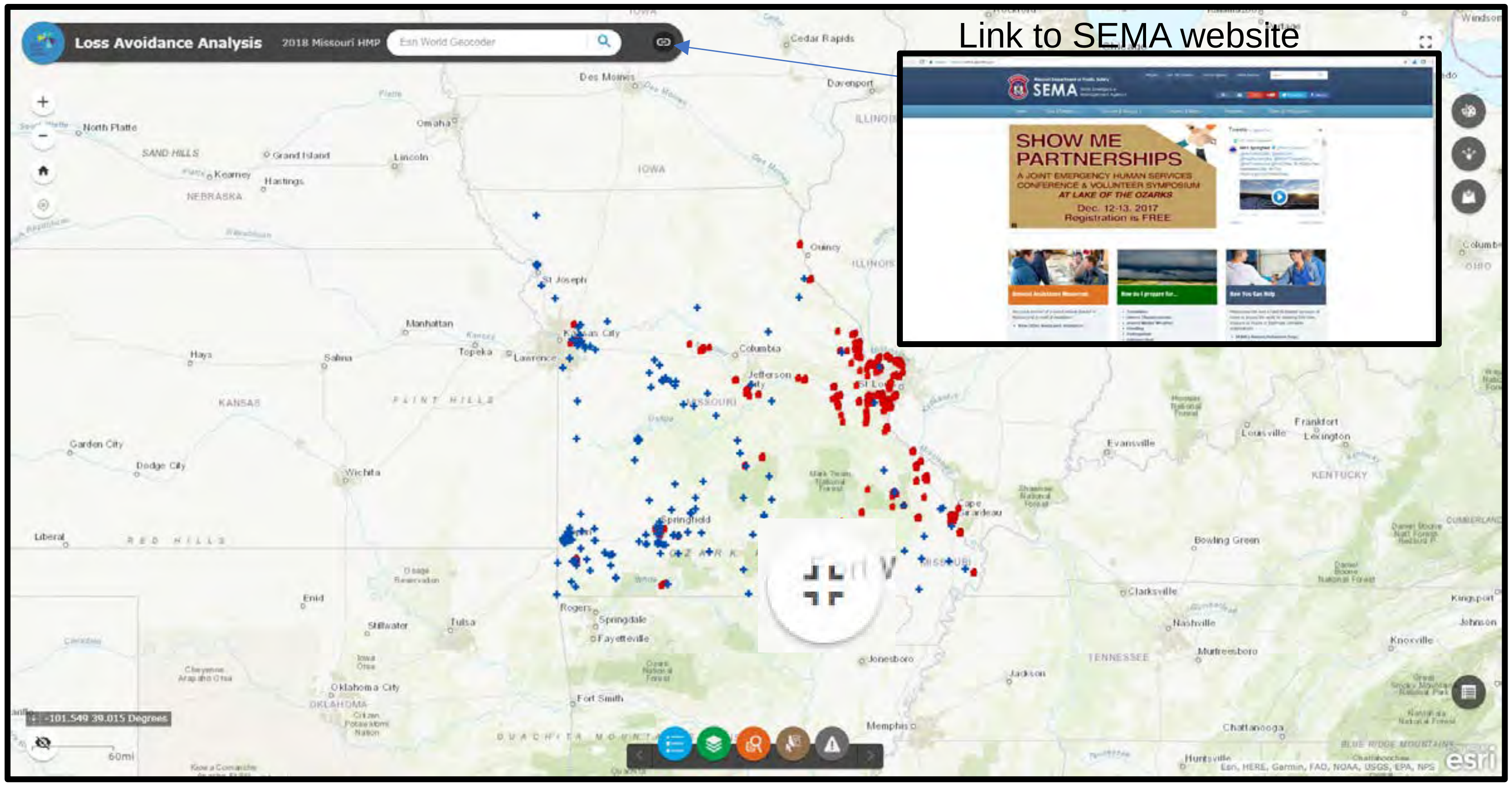
Figure 7. LAAT Website – "Incident Analysis" Tool



The initial screen looks like this. The chain link in the top banner is a link to the SEMA website.

Use the + and – buttons in the upper left of the screen or the Mouse wheel to zoom in and out.

The Home or Full Scale button will zoom to the state and center it in the screen.



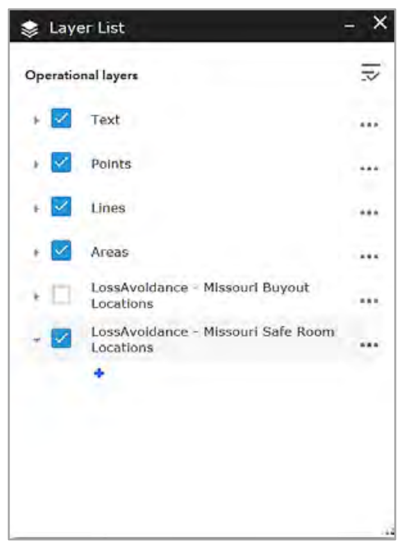
Use the Full Screen button in the upper right of the screen to make the website take up the entire screen on the window. When activated it changes to look like the button on the right. It is a toggle, so click it again to go back to normal screen.

The Attribute button in the bottom right of the screen can be clicked to view the attributes associated with the layers in the map.

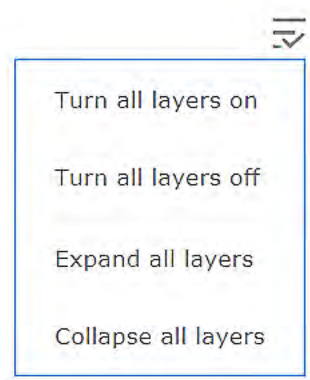
At the bottom of the page is a banner with five tool icons. From left to right they are the Legend, the Layer List, the Query, the Incident Analysis and the Select tools. The following pages describes each icon.

The blue one is the Legend icon. Clicking it will open a window explaining the symbology (symbols and color) of the active layers.

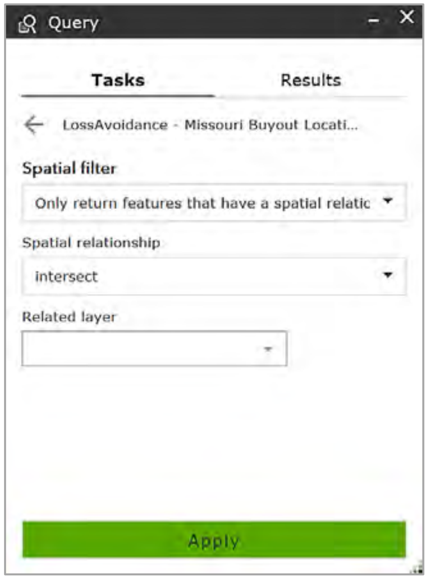
The green one is the Layers List. Clicking it will open a window indicating what Operational layers are in the map. The blue check marks indicate the layer is turned on, the empty checkbox indicates they are turned off. These are toggles and the layers can be easily activated/deactivated by clicking inside the checkboxes.



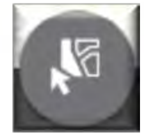
This icon in the upper right of the Layer List, when clicked will open to show options to turn on/off all layers and expand/collapse all layers.



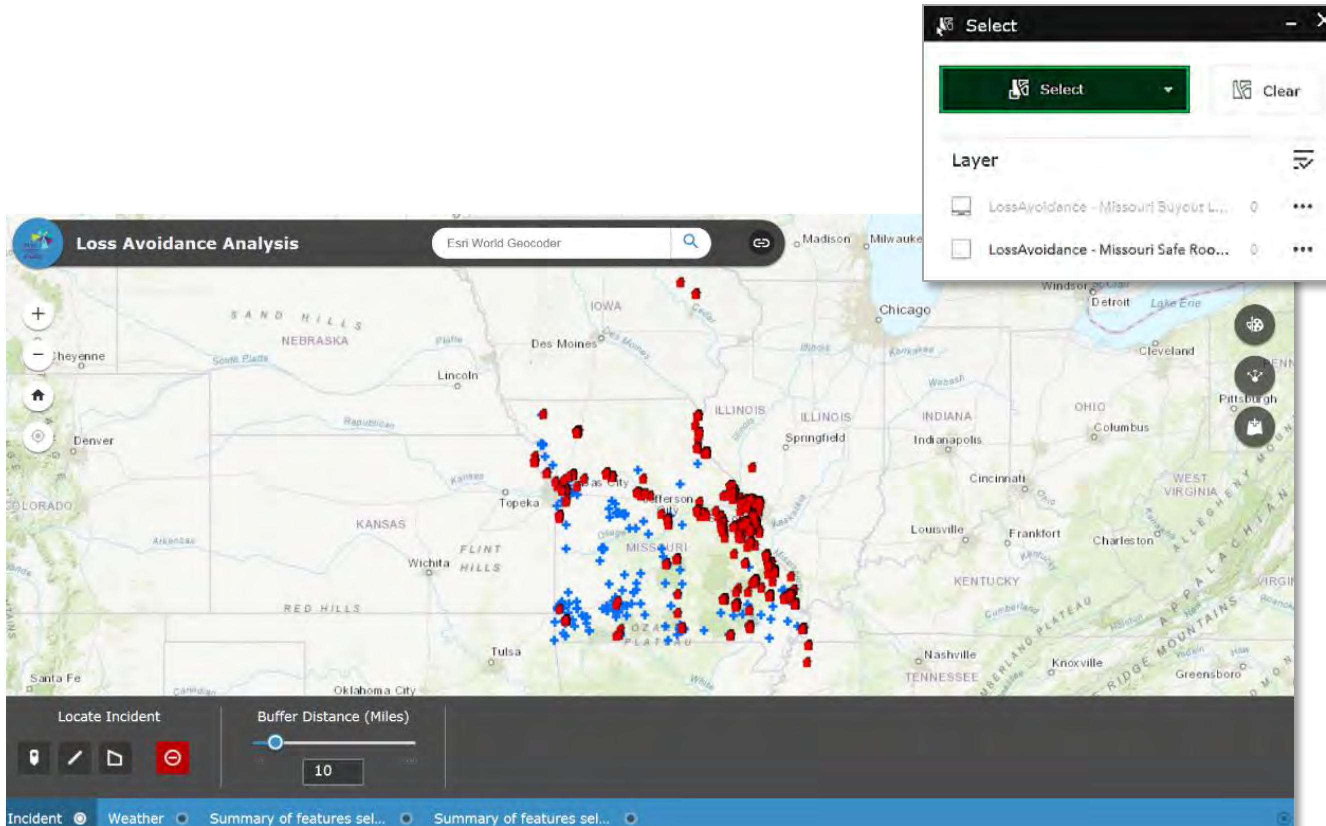
The orange one is the Query Tool. Clicking it will open a window to use in User Analysis. This functionality will be described more in Example #1 below.

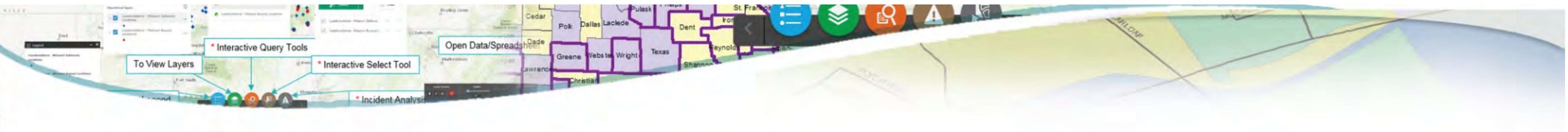


The brown one is the Incident Analysis Tool. Clicking it will open a ribbon across the bottom of the screen. Using it will be described in more detail in Example #2 below.

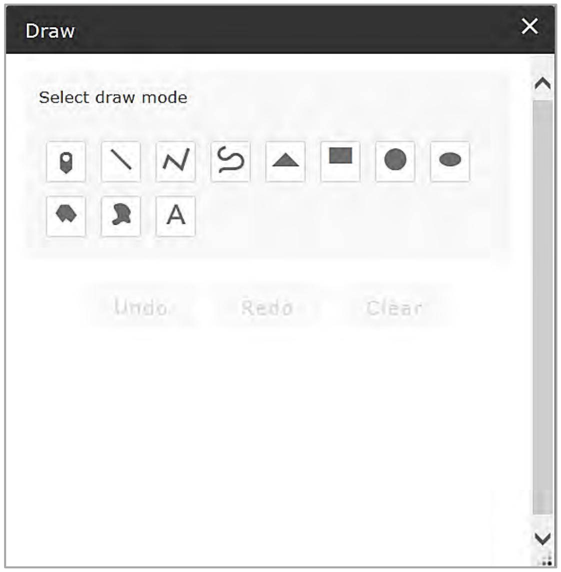


The gray one is the Select Tool. Clicking it will open the Select window to allow the user to select certain points of interest in either the Buyout locations or the Saferoom locations. More description of how to do this can be found in Example #3 below.

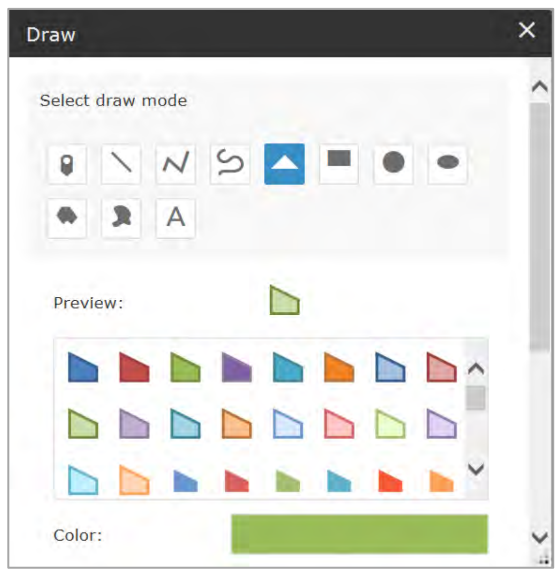


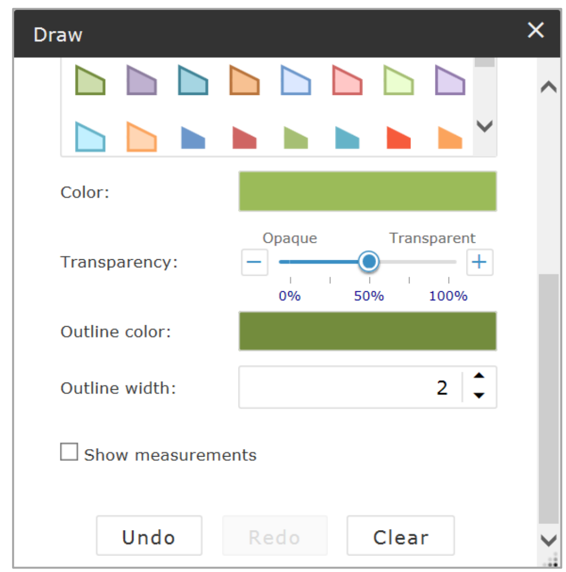


Clicking on the **Draw tool** in the upper right of the screen will activate this window.

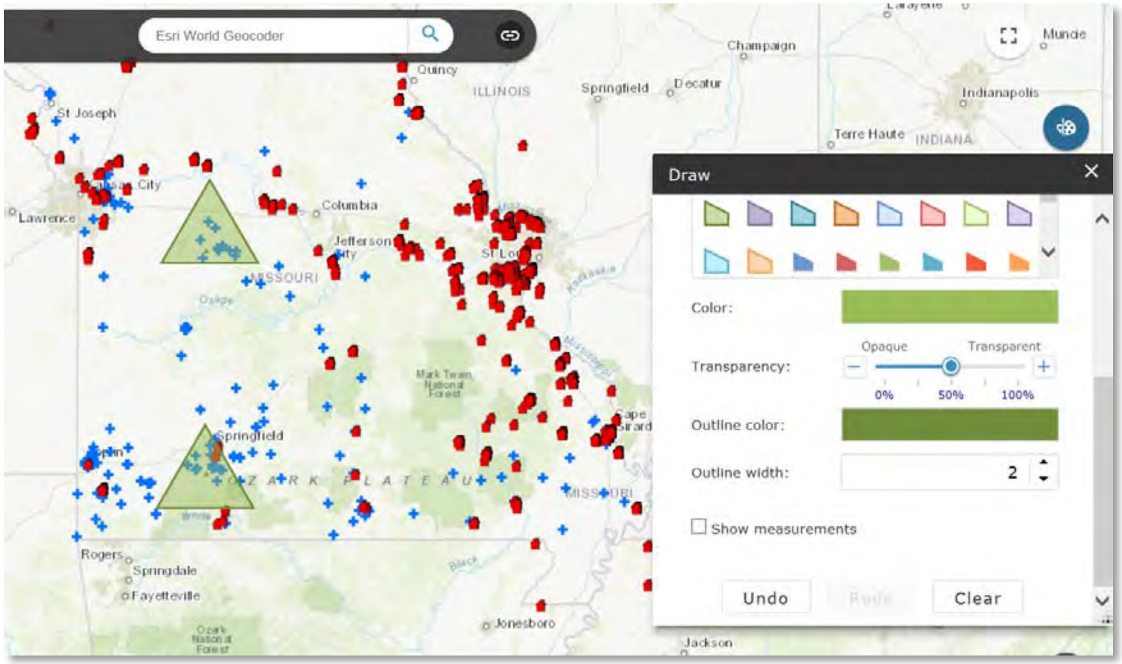


Clicking on any of the **draw mode icons** will activate a preview window with color selections. Use the scroll bar on the right to see more options to customize the color, transparency, outline color and width. Using “Undo” erases the shapes in order of creation, “Redo” will add them back in order of creation and “Clear” will erase all of them.

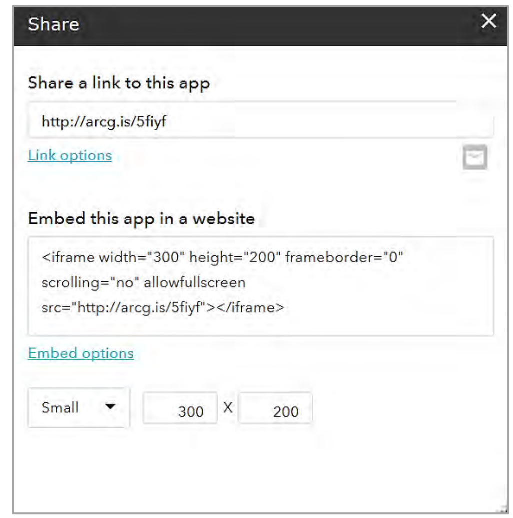




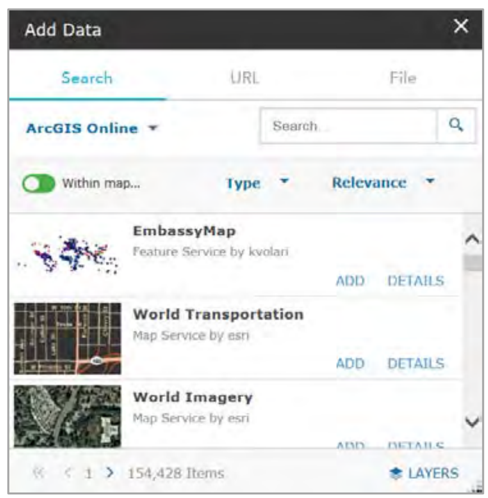
This function can be used show areas of interest on the map which can be printed or saved as a pdf for future reference.



The “**Share**” button in the upper right of the screen opens the Share window giving the user the ability to share the map with others or embed the app in a website. Clicking the envelope button on the right of the window will open an email using your default email account with the link in it.



To **Add Data** for analysis, click this icon in the upper right of the screen and the Add Data window will open. Data from web services or user input can be added here.

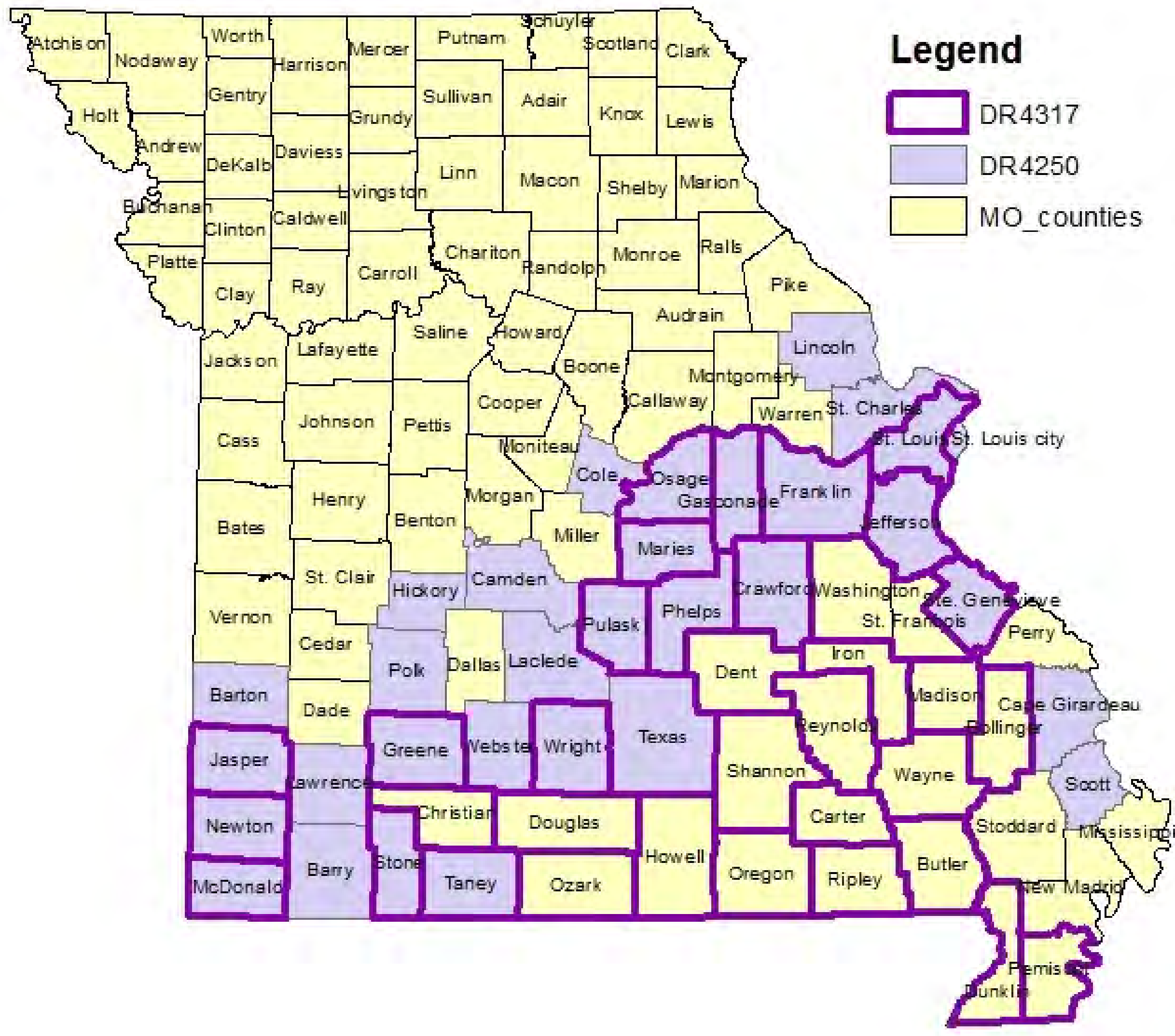


Example #1

The following is a Specific example using the LAAT for additional DR-4250 and DR-4317 for the Buyout Locations Disaster wide.

Preparation

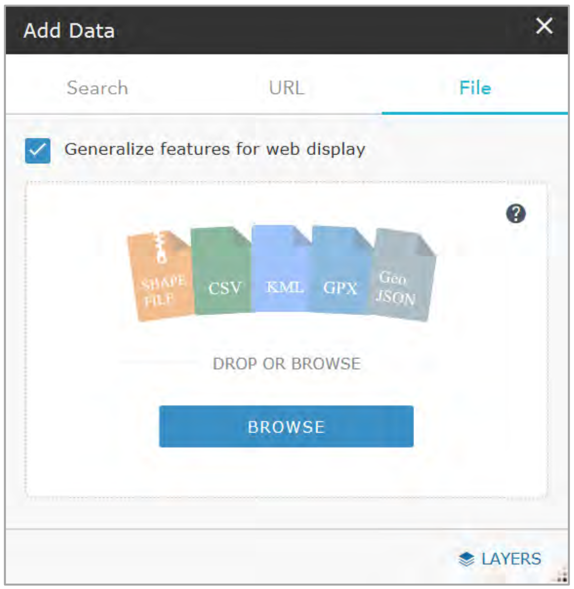
The input used is a list of the affected counties for each disaster declaration. Two shapefiles of the two disaster declared areas were used in this first example. The graphic to the right shows the affected areas.

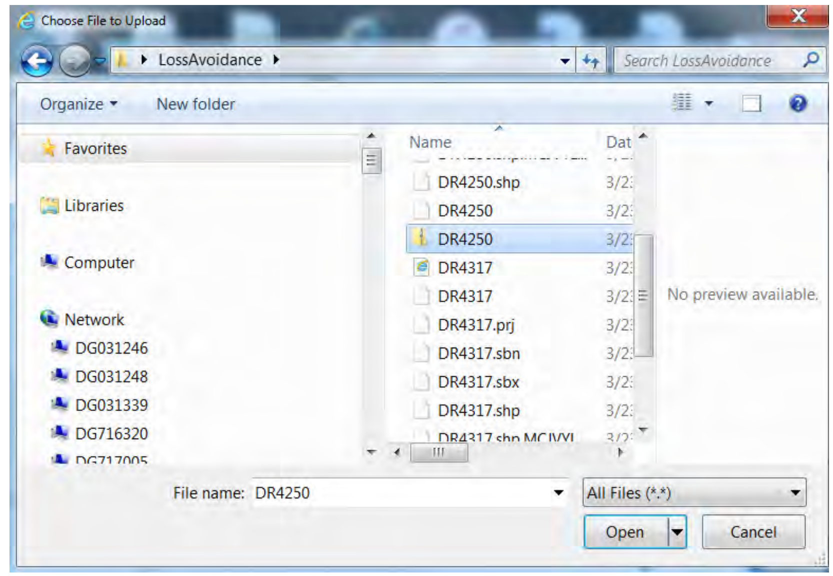


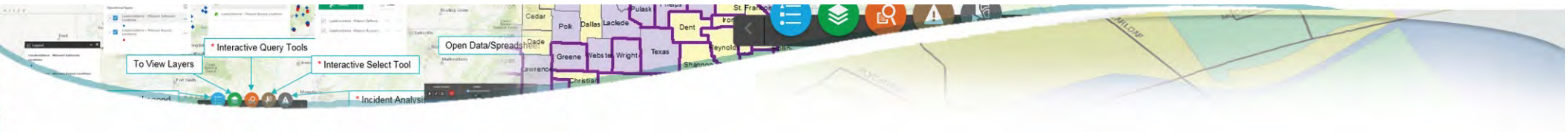
Log into the LAAT website at http://bit.ly/SEMA_LossAvoidance

In this example, we'll add the affected areas for DR4250 first. Click on the File tab. The user can either drag and drop a file or can navigate to it using the Browse button. Shapefiles, CSV, KML, GX or GeoJSON file formats may be added. If you click Browse, then another window will open for navigation. Note that shapefiles will need to be zipped for this function. Ensure that any locks on the shapefiles are not included in the zipping. Click "Open" and the website will unzip and display the files as shown in the graphic on the next page.

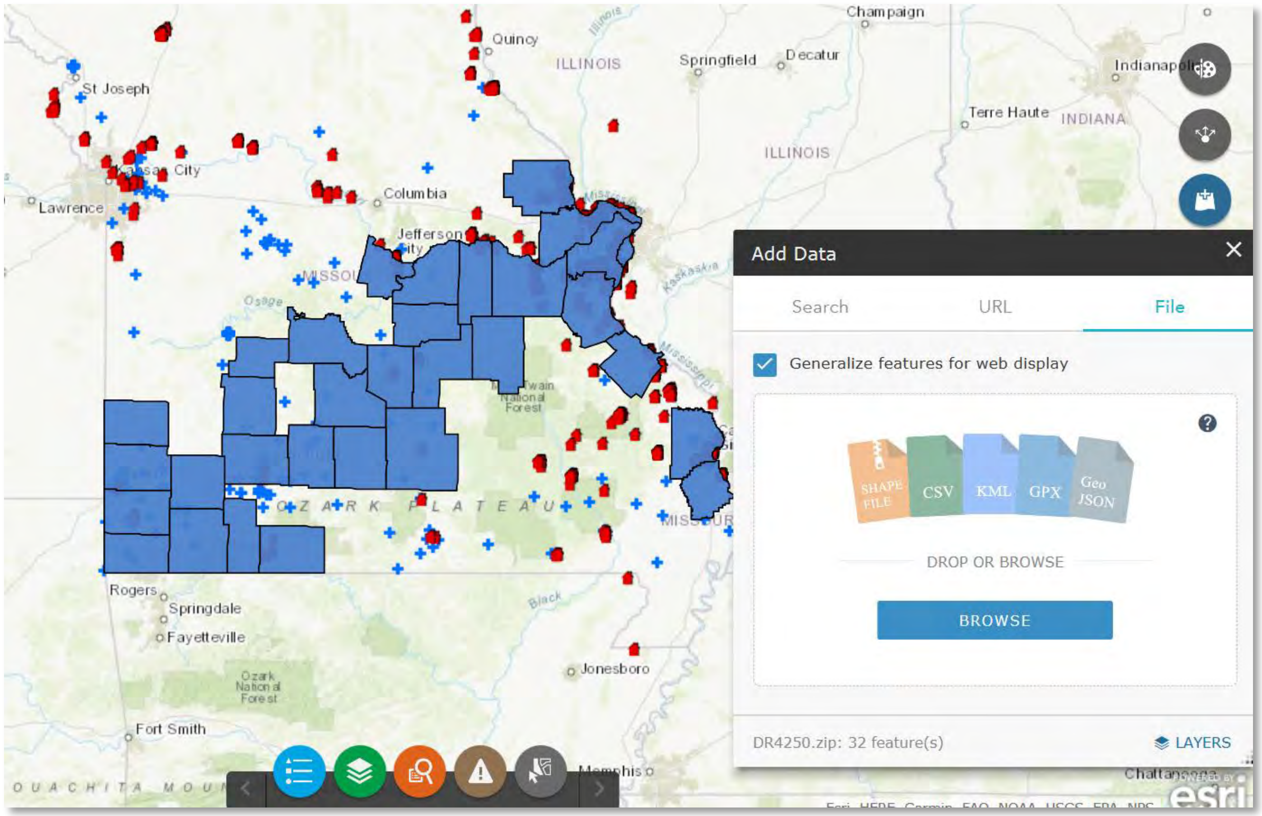
Each of the windows for Draw, Share and Add Data can be closed by clicking the X in the upper right corners.



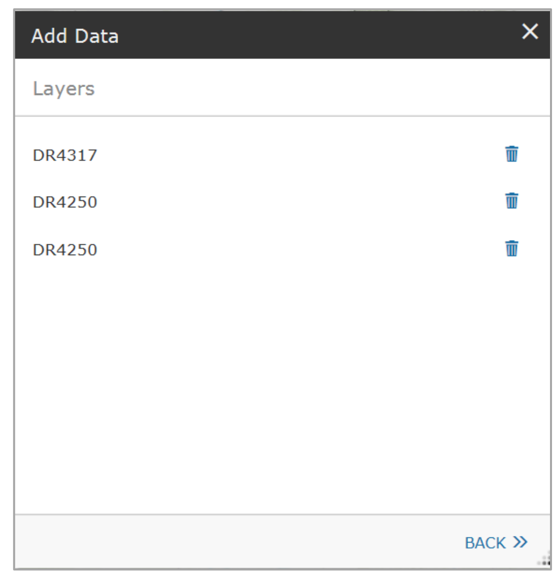




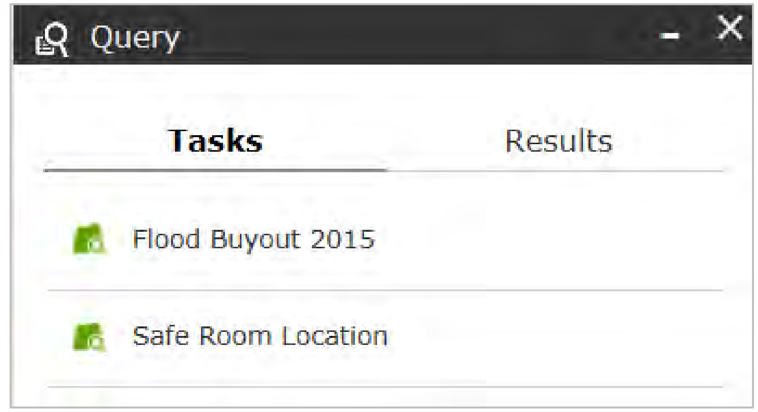
This graphic shows the addition of the DR4250 disaster declaration areas.



Layers can be removed by clicking the Layers button at the bottom right of the Add Data window. The box will activate the Layers List. Remove layers by clicking on the trashcan icon to the right of the layer. Clicking back at the bottom right will return the user to the previous screen.

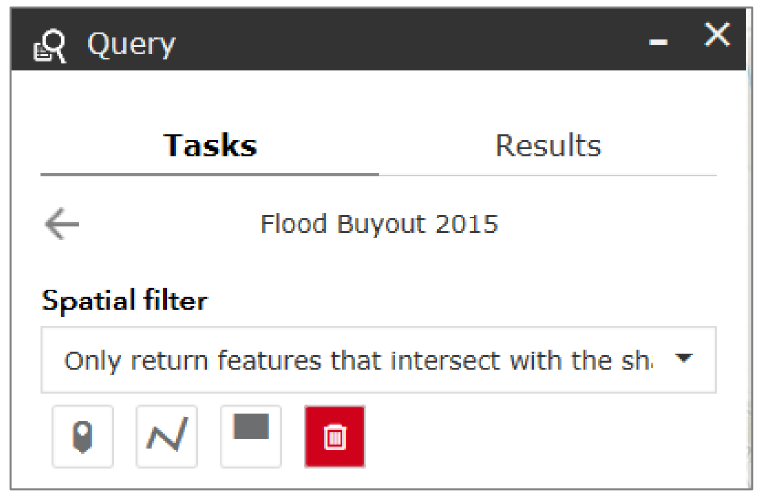


Open the Query Window and it will reveal the layers present in the tool as shown to the right. Click on the Layer wanted for the analysis. In this example, choose Flood Buyout 2015.

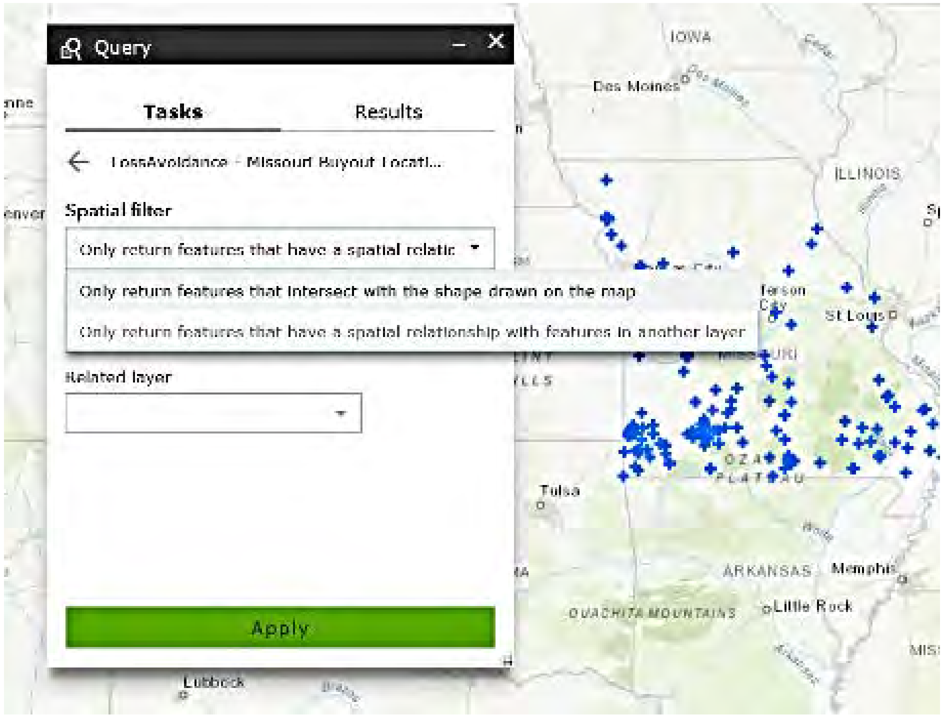


The Spatial filter dropdown menu will give the user the option to query results that have a spatial relationship (intersect or inside) with a shape drawn on the map or with features in another layer.

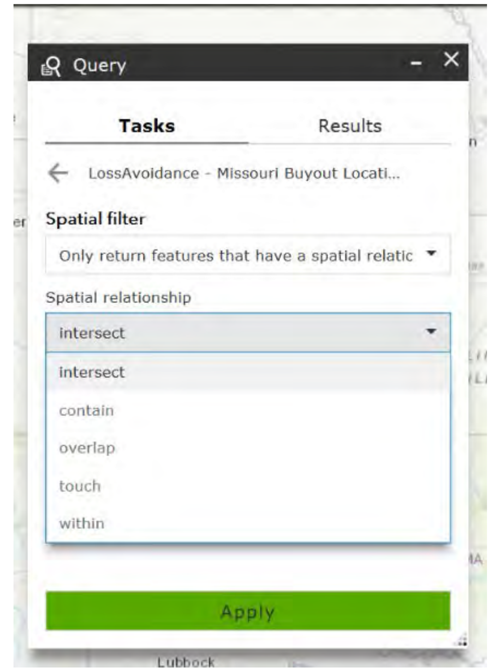
For this example, choose the second (Only return features that have a spatial relationship with features in another layer).

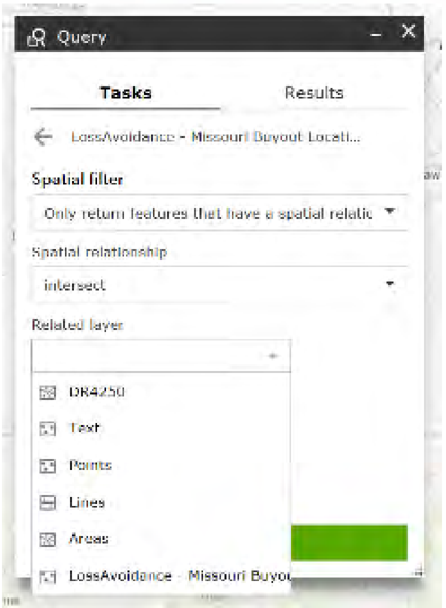


Under Spatial Relationship, the drop-down arrow allows the user to return results that intersect, contain, overlap, touch or are within the area of interest.



For this example, choose "intersect". This will be the most common choice.

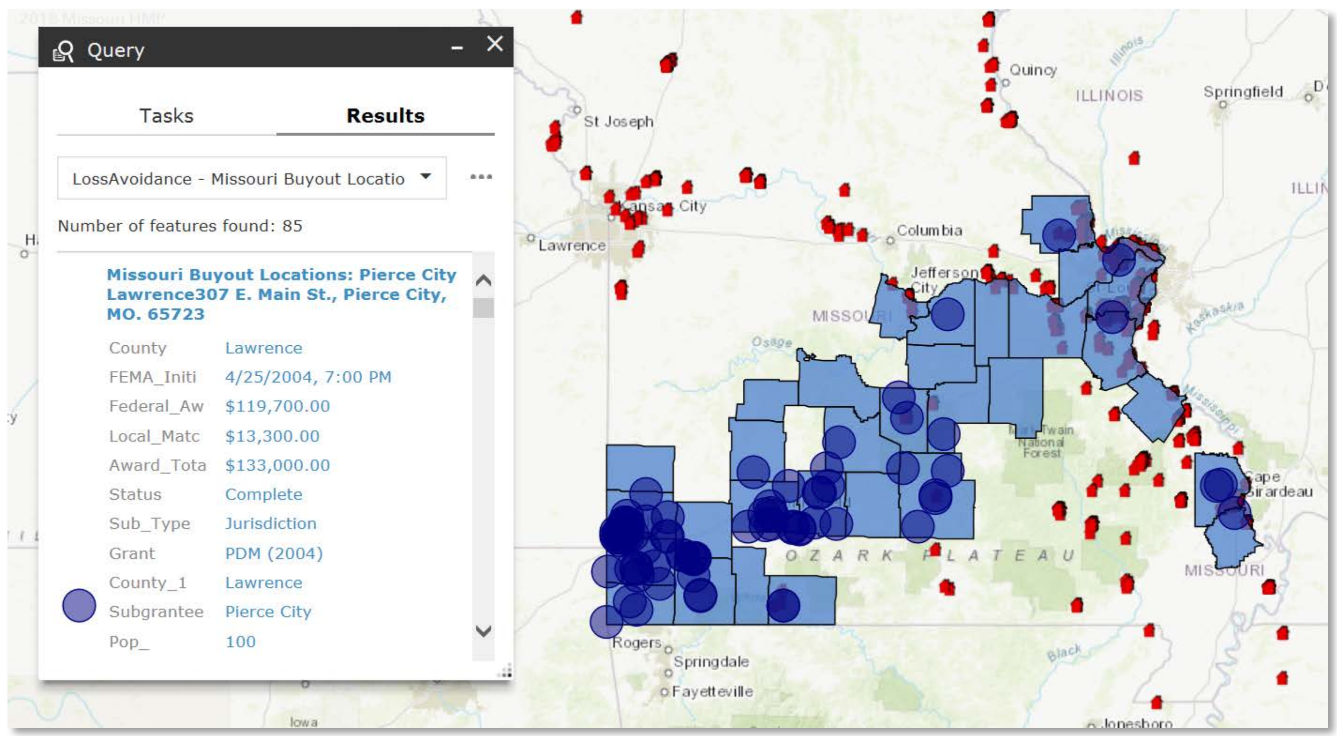




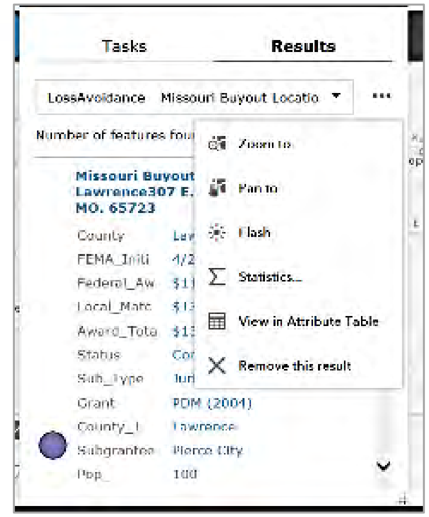
The Related layer drop-down list will allow the user to select which layer to compare against. For this example, DR4250 was chosen.

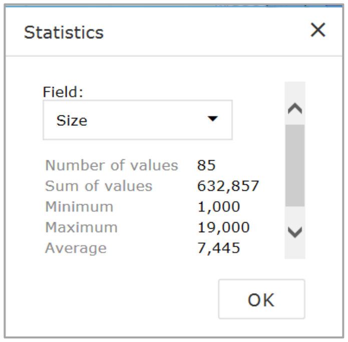
Click the green Apply button at the bottom.

The results will appear on the map as shown below. The results in this example returned 85 buyout locations within the DR4250 declaration zone.



Clicking on the three gray circles to the right of the box that says "Loss Avoidance – Missouri Buyout Location" in the graphic above will provide the user the options to Zoom to extent, Pan to, Flash (the results will flash on the screen), Statistics (run statistics on the results), View in Attribute Table or remove the result from the map.

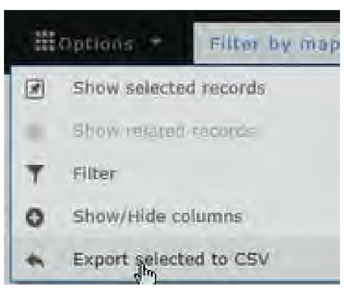


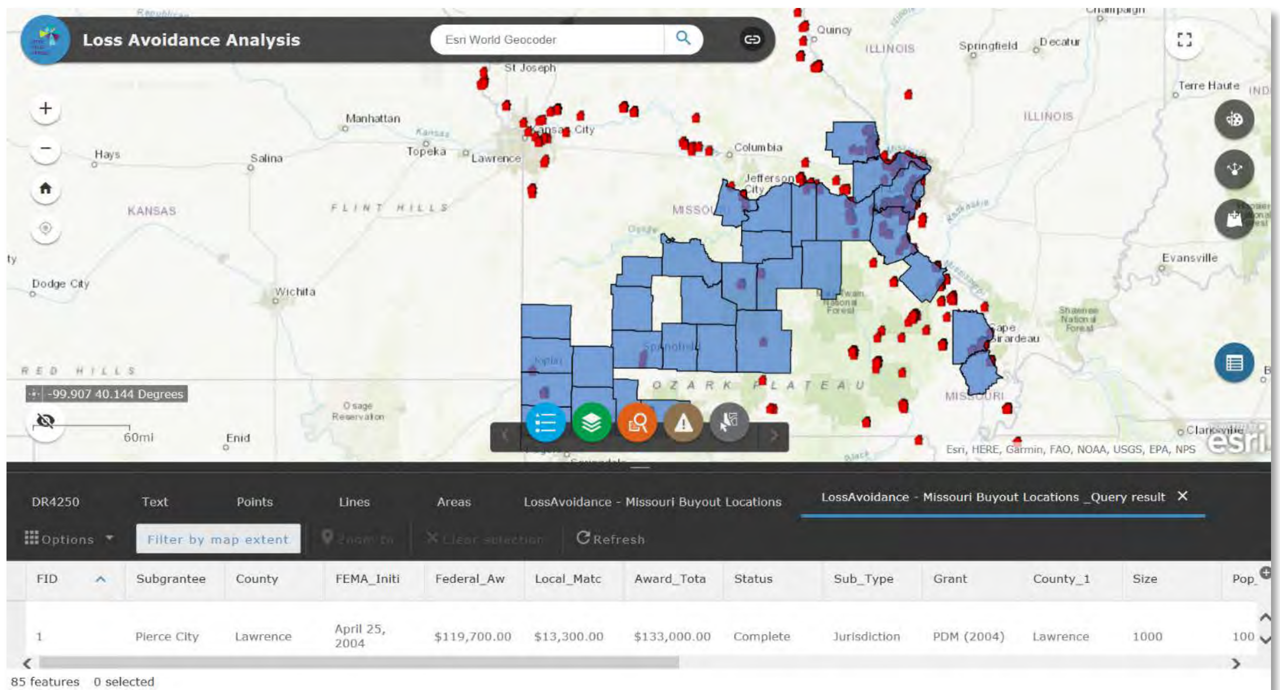


In this example, statistics were calculated for the results returned. Click "OK" to close the box.

For this example, choose the "View in Attribute Table" option. The attribute table will open at the bottom of the screen.

Clicking on the drop-down arrow on the Options tab on the right side of the black attribute header, will reveal options in the graphic to the right. Choose the "Export selected to CSV" option and navigate to a location to save the file. CSV formats files can be opened in either Excel or ArcMap. Instructions for this can be found on page 24.



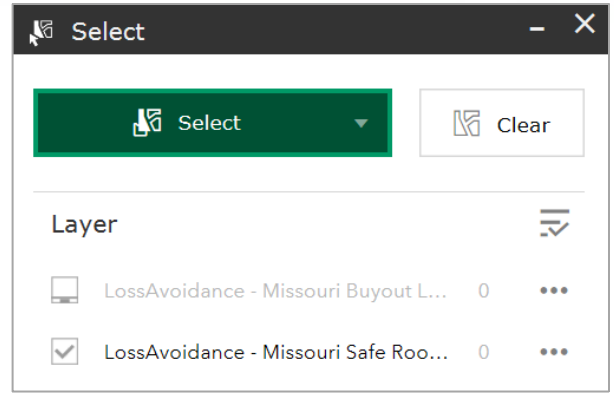


FID	Subgrantee	County	FEMA_Initi	Federal_Aw	Local_Matc	Award_Tota	Status	Sub_Type	Grant	County_1	Size	Pop_
1	Pierce City	Lawrence	April 25, 2004	$119,700.00	$13,300.00	$133,000.00	Complete	Jurisdiction	PDM (2004)	Lawrence	1000	100

*Note that if the query results in more than 1,000 locations, only 1,000 attributes will be exported. It is recommended to break the query up into smaller parts to remedy this.

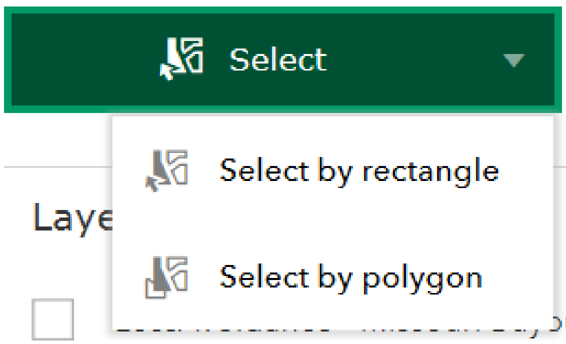
Example #2

In this example, we will mimic the path of a severe thunderstorm with tornadoes in it.

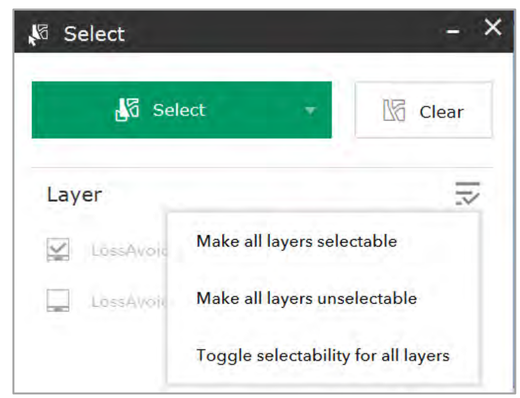


Selection can be done by using the  Select button in the bottom banner which activates the Select window.

Clicking the green Select button will reveal the Select by rectangle option or Select by polygon option.



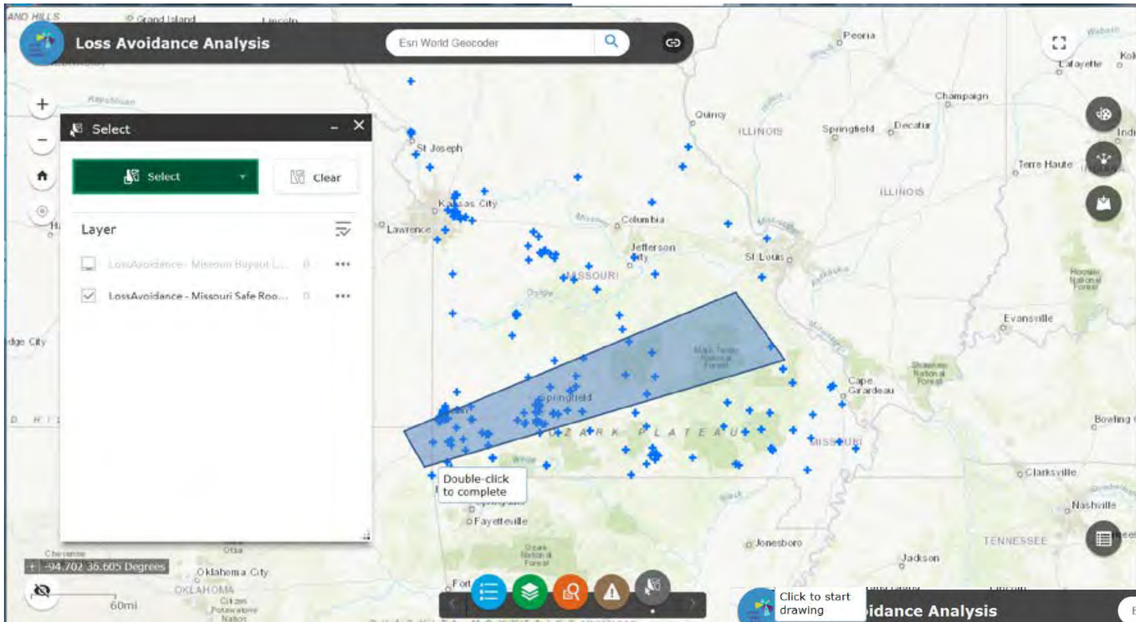
Choose either Select by rectangle or polygon. Ensure that the layer for Saferoom (or Buyout in other scenarios) is active by clicking the checkbox next to the layer name.

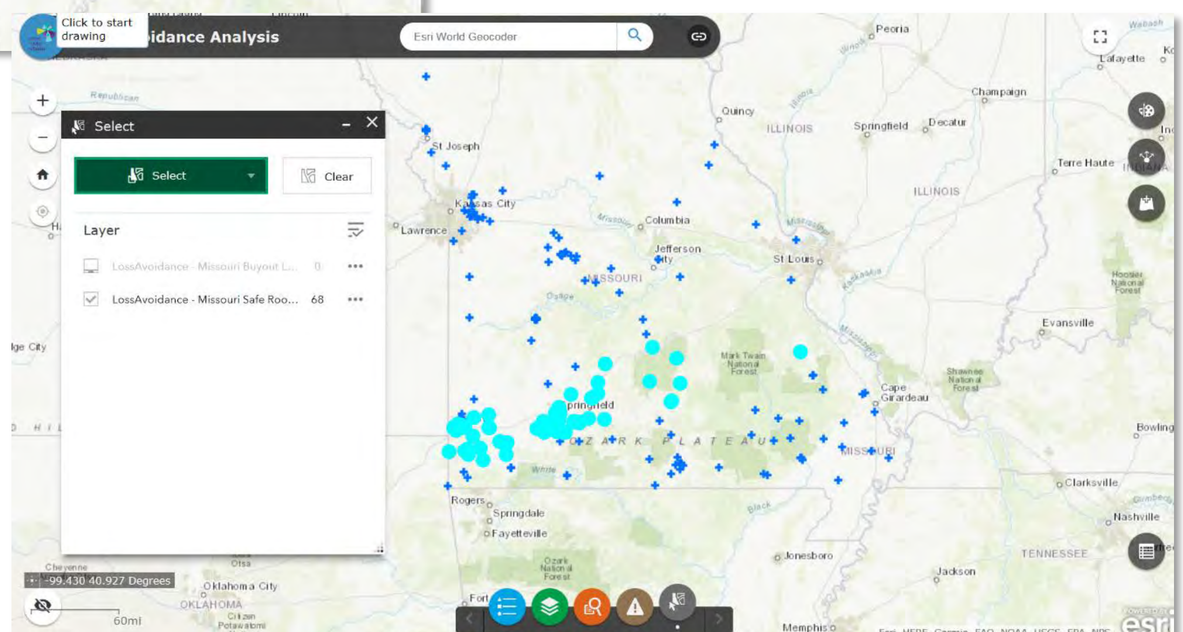


The layers can be made selectable/in-selectable by clicking the checkmark with the three bars icon in the center right and choosing one of the options that appear.

Clicking the Clear button to the right of the green button will clear out the selections.

In this example, the user will mimic the path of the storm by drawing an area of interest using the polygon. Click on the map once to start the polygon, click again to add vertices and double click to complete the polygon.

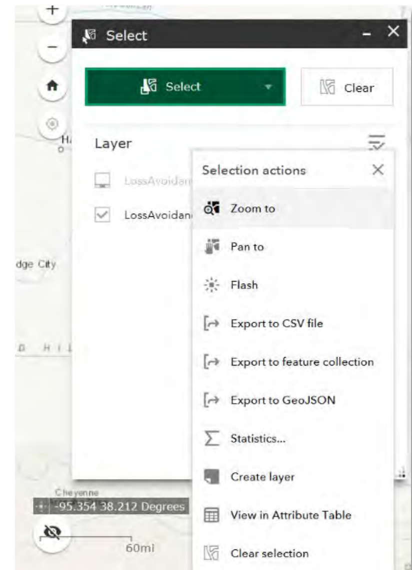


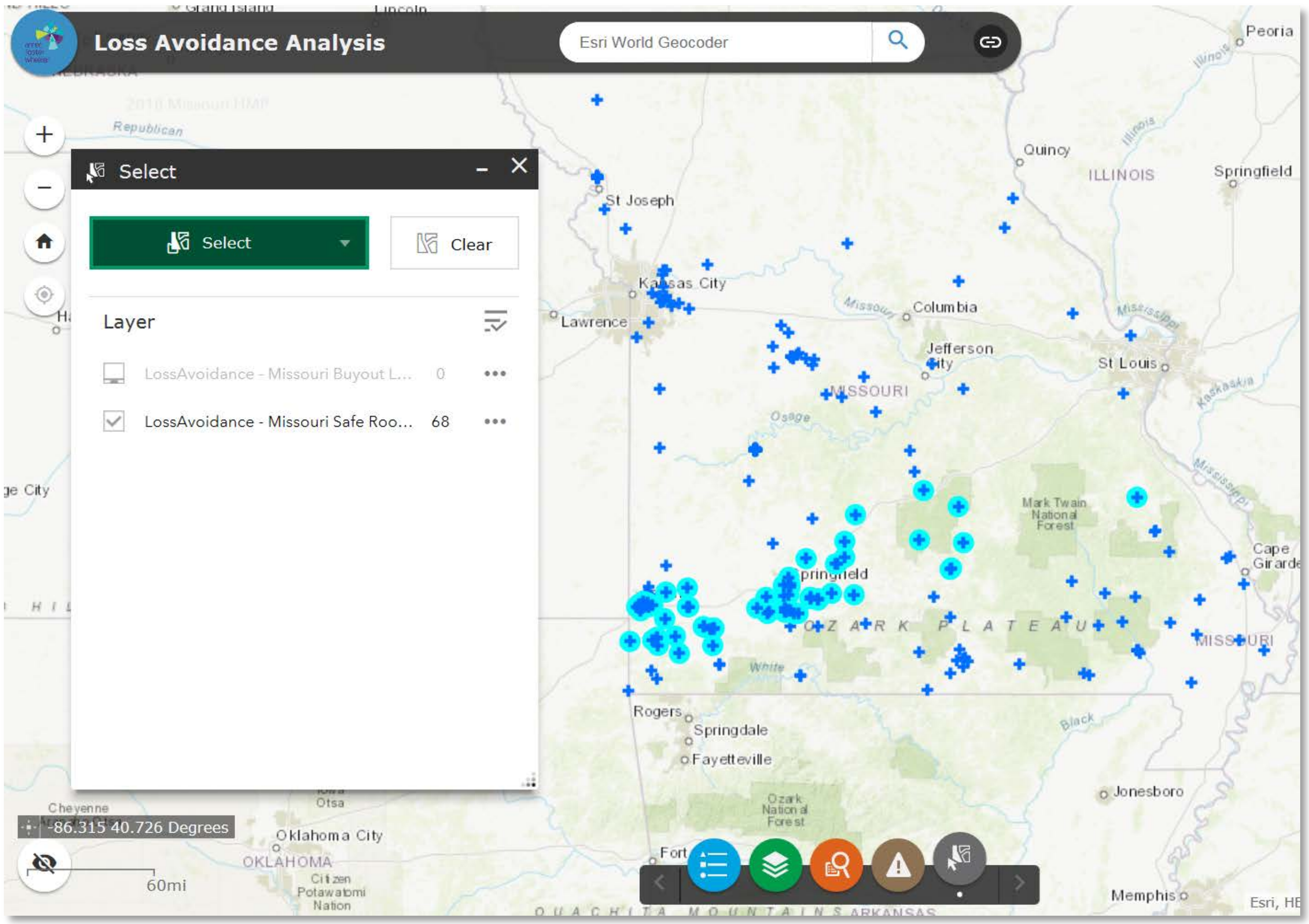


The Saferoom locations inside the polygon drawn will be selected and highlighted on the map.

The selection can be cleared by tapping the clear button to the right of the green Select button. In this example 68 saferooms were returned in the results which is also shown next to the name of the Layer in the Select Window circled in red in the graphic above.

Clicking on the three gray circles to the right of the results number, will reveal a number of options to u for viewing or exporting. In this example, “Create a Layer” was chosen. The user will be prompted to name the layer, Tornado XYZ Damage Area, in this example. This adds the selected Saferooms to the map in a new layer.

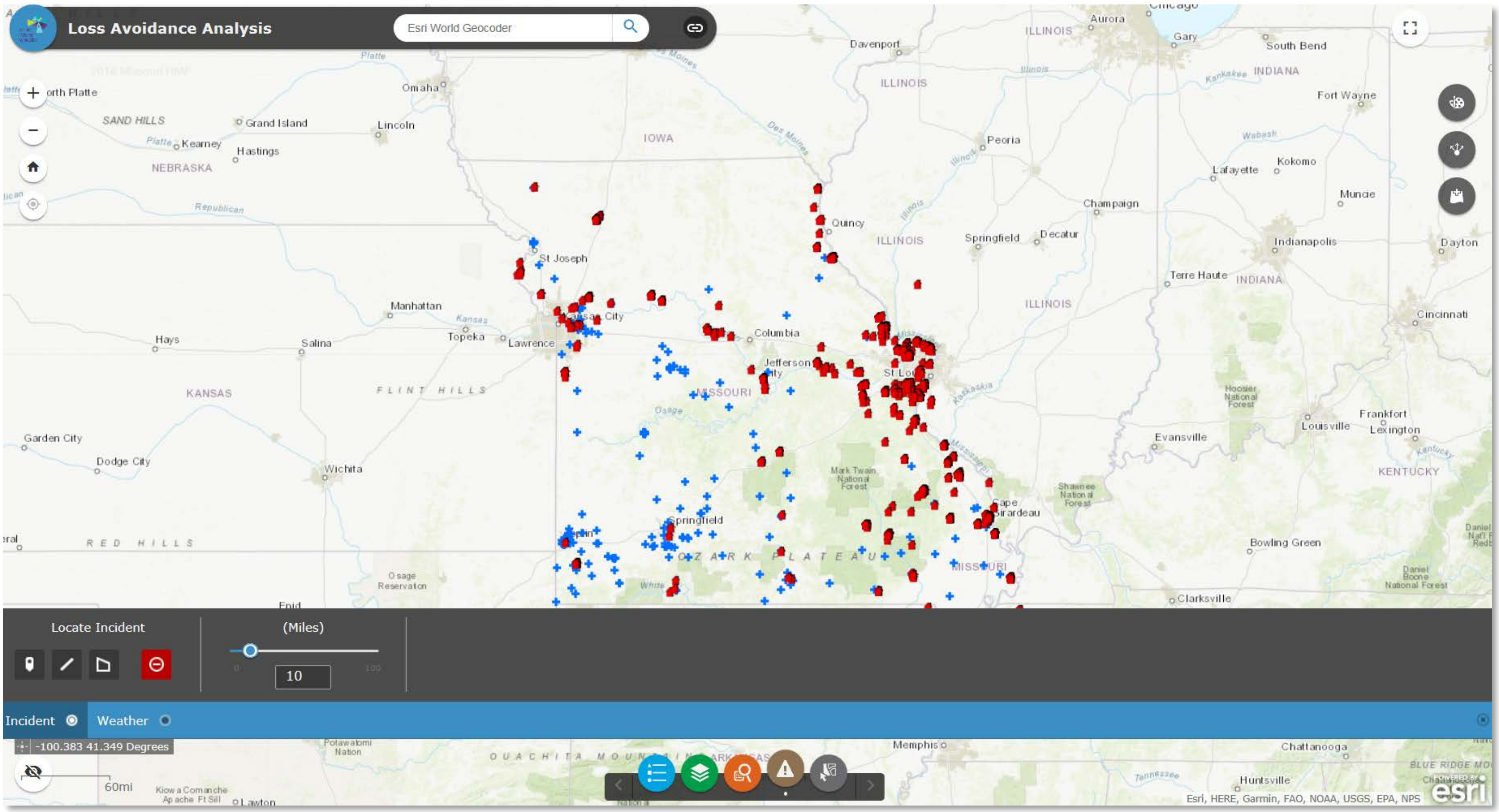


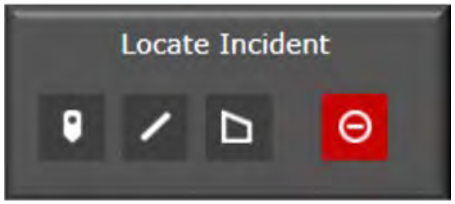


Example #3

Click the brown button on the bottom banner to activate the Locate Incident ribbon. A buffer distance in miles can be set around the incident by moving the slide bar

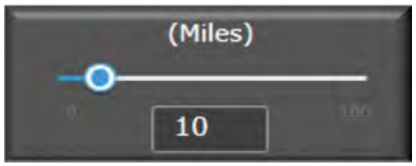
The Locate Incident ribbon can be closed by clicking the small black X at the bottom right of the ribbon.



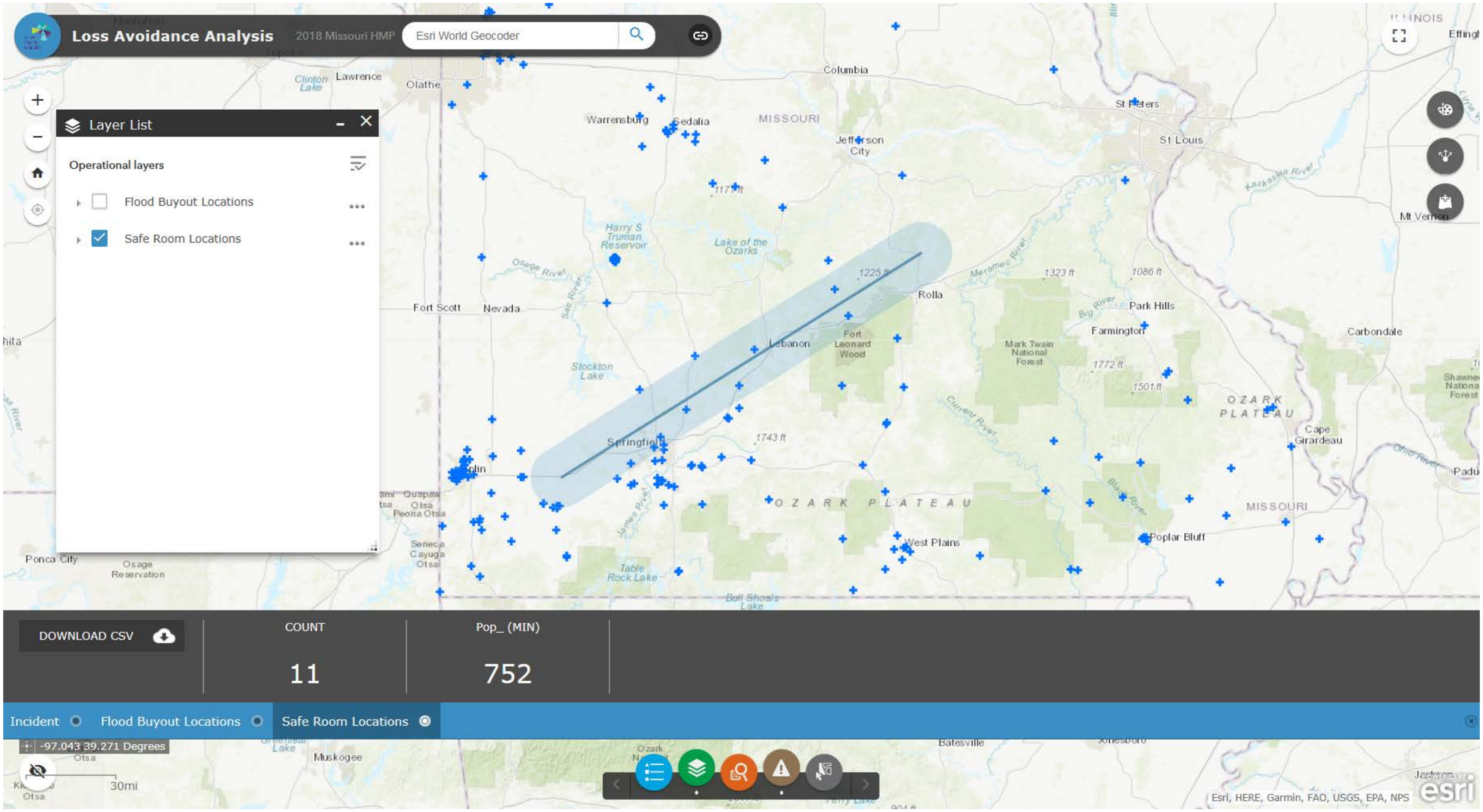


Using either the Locate Incident Buttons on the gray ribbon to simulate and incident.

The  button will all the user to draw a line simulating a storm path as shown in the graphic below.

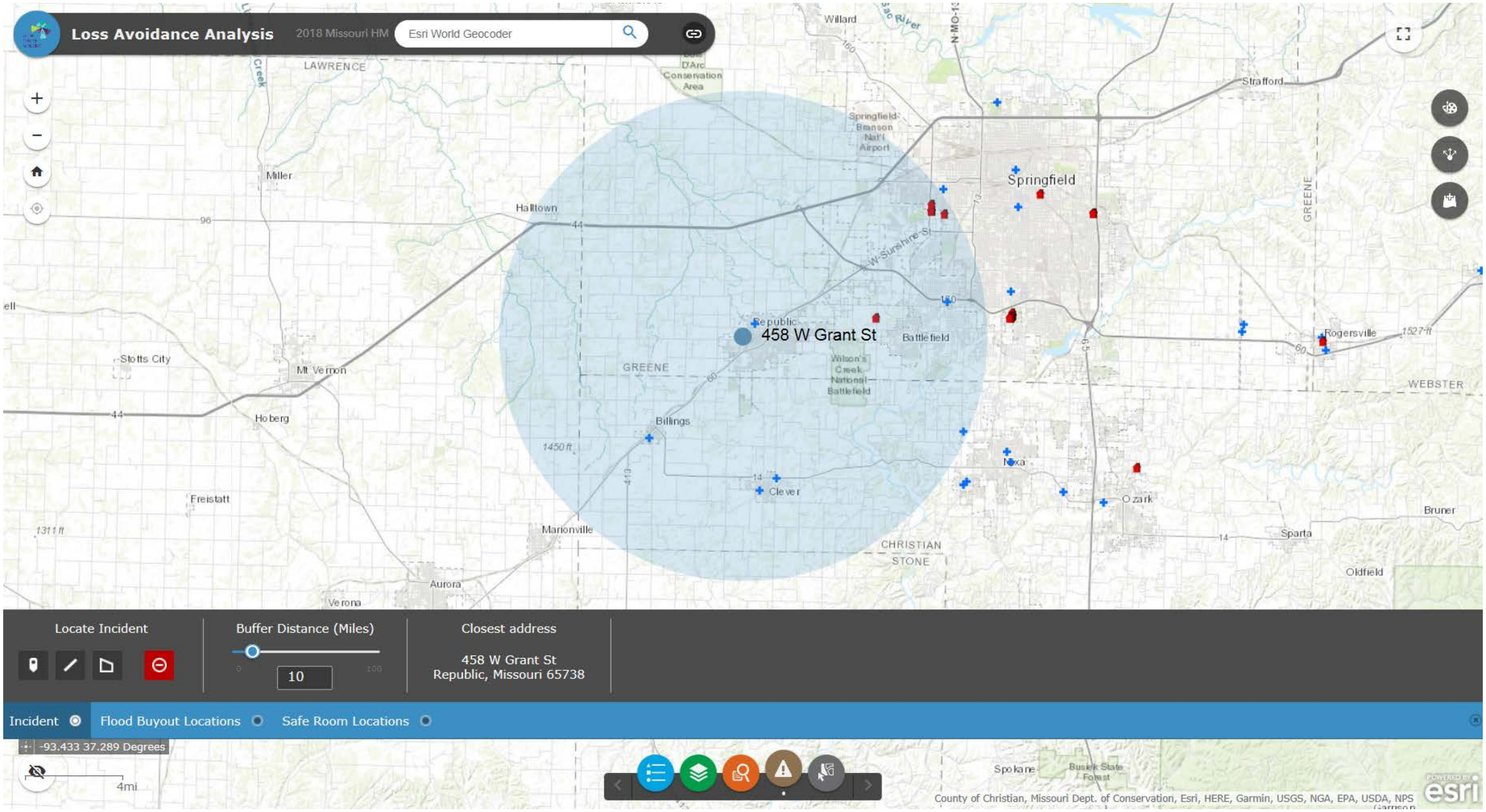
Using the 

slide bar, the area of interest on either side of line can be changed. In the example above, it is set for 10 miles. In the example below it was changed to 25 miles by sliding the blue circle to the right. Alternately, the number 25 can be insert in the number box. The display screen will automatically zoom to the extent of the incident.

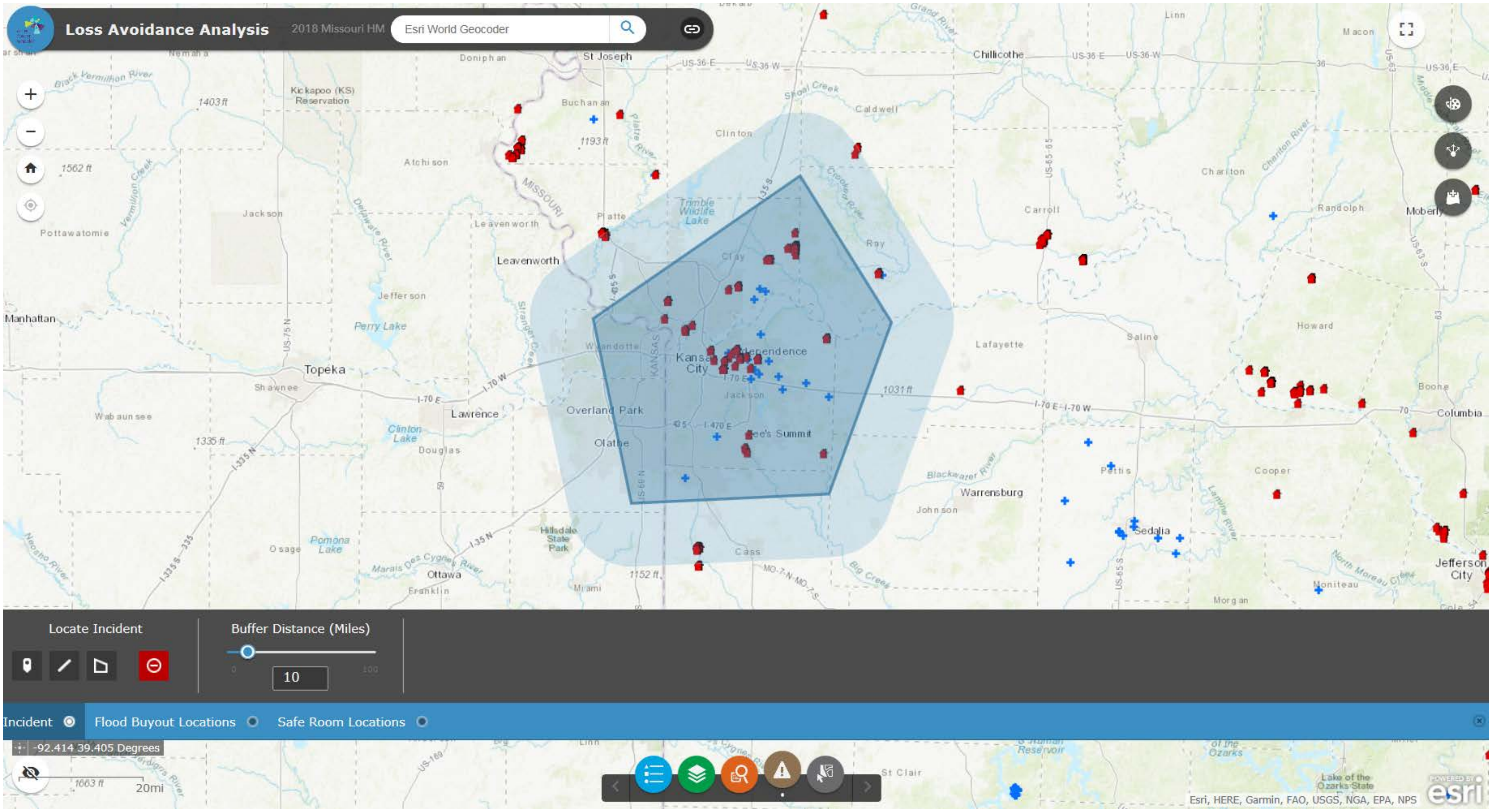


By clicking on the Layer Name in the blue ribbon along the bottom of the page, the count and population attributes for the intersection of the buffered area and the Operational Layer will be summarized in the gray ribbon. The CSV file of the selected locations can be downloaded using the Download CSV file on the gray ribbon.

The  will allow the user to drop a point on the map with the buffer applied as shown below.



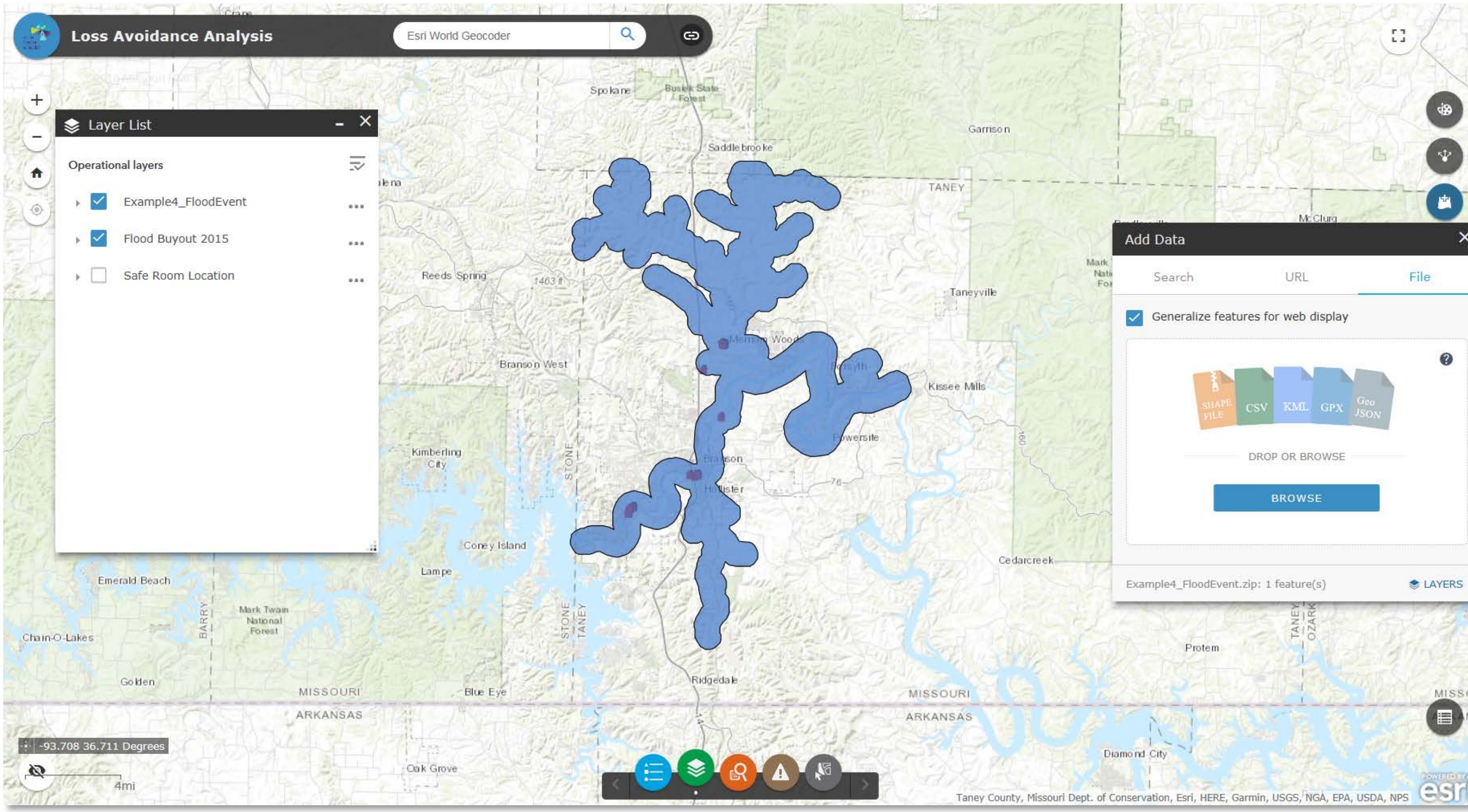
The  will allow the user to create a polygon on the map as shown below.



The  allows the user clear or remove the incident on the map.

Example #4

Another example of using the LAAT to generate Loss Avoidance estimates can be created using a polygon of flooding along a specific source as shown in the graphic below. Add the polygon of a specific flood event using the Add Data button. Then Query and Export as shown in Example 1.



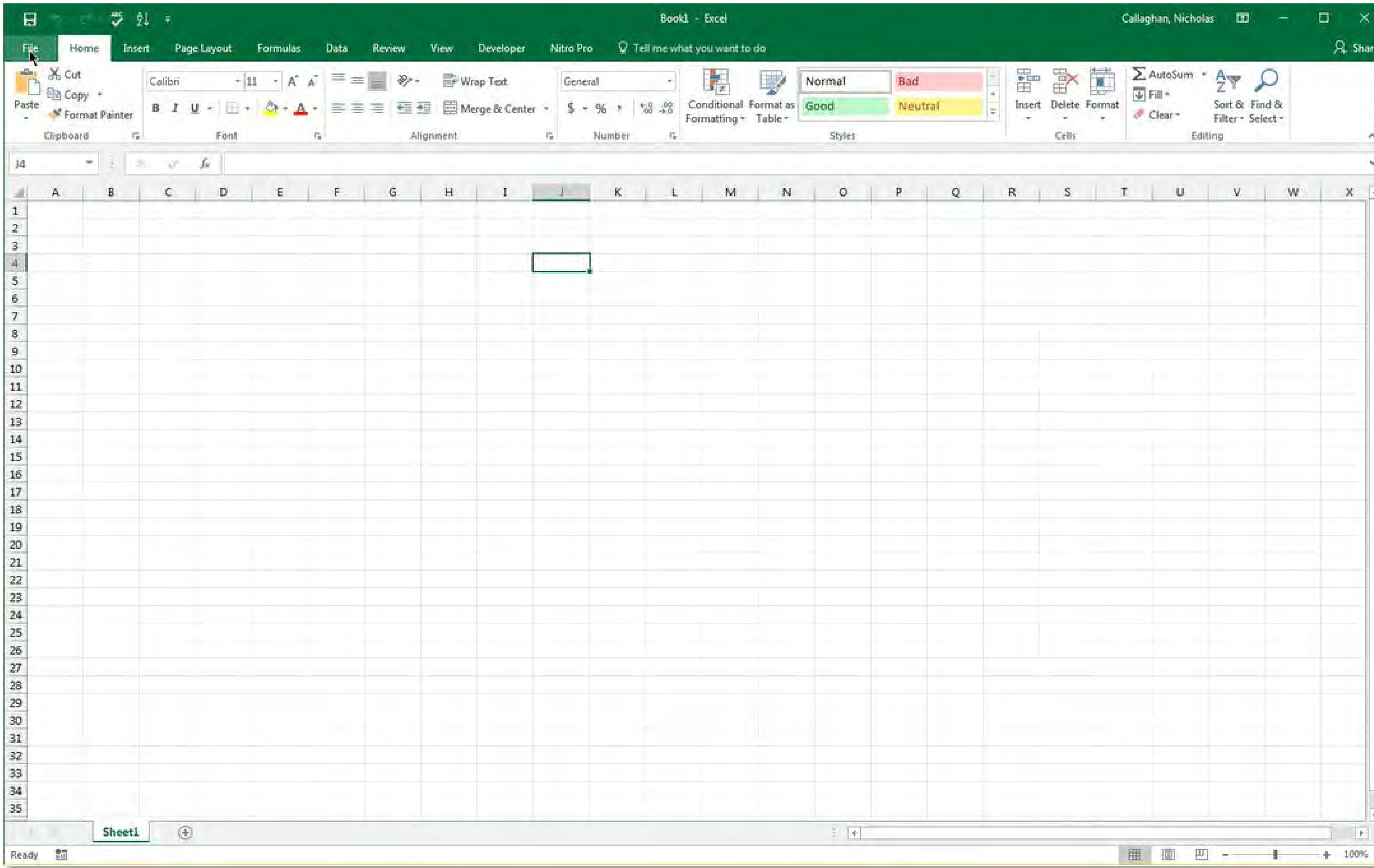
The table shown below is Table 7.11 from the Hazard Mitigation Plan and was generated from the LAAT exports utilizing the combined methods described in Examples 1 and 4 of this guide.

Community	Total # of Acquired Structures	Total # of Acquired Structures Located within the SFHA	Total Project Investment	Avoided Loss DR 4250		Avoided Loss DR 4317		Total Avoided Loss	Loss Ratio DR 4250	Loss Ratio DR 4317	Total Loss Ratio
				Structure Damage	Contents Damage	Structure Damage	Contents Damage				
Franklin	156	101	$4,103,010	$4,321,697	$2,160,849	$4,321,697	$2,160,849	$12,965,091	1.58	1.58	**3.16**
Gasconade	6	2	$556,074	$48,354	$24,177	$48,354	$24,177	$145,062	0.13	0.13	**0.26**
Greene	18	9	$1,128,880	$431,477	$215,739	$431,477	$215,739	$1,294,431	0.57	0.57	**1.15**
Jasper	3	2	$126,341	$84,228	$42,114	$84,228	$42,114	$252,684	1	1	**2**
Jefferson	517	147	$9,338,333	$3,080,801	$1,540,401	$3,080,801	$1,540,401	$9,242,403	0.49	0.49	**0.99**
Montgomery	77	4	$328,281	$96,708	$48,354	$96,708	$48,354	$290,124	0.44	0.44	**0.88**
Newton	68	53	$1,791,146	$1,375,476	$687,738	$1,375,476	$687,738	$4,126,428	1.15	1.15	**2.3**
Pulaski	19	8	$505,225	$212,728	$106,364	$212,728	$106,364	$638,184	0.63	0.63	**1.26**
St. Charles	1456	570	$15,459,051	$12,614,507	$6,307,254	$10,352	$5,176	$18,937,289	1.22	0	**1.22**
St. Louis	676	402.5	$19,598,189	$16,348,990	$8,174,495	$16,322,430	$8,161,215	$49,007,130	1.25	1.25	**2.5**
Ste. Genevieve	81	33	$1,038,091	$390,012	$195,006	$390,012	$195,006	$1,170,036	0.56	0.56	**1.13**
Taney	23	21	$3,379,541	$3,376,649	$1,688,325	$3,325,269	$1,662,635	$10,052,877	1.5	1.48	**2.97**
Grand Total	**3100**	**1353**	**$74,073,874**	**$42,381,627**	**$21,190,814**	**$29,699,532**	**$14,849,766**	**$108,121,739**	**0.86**	**0.6**	**1.46**

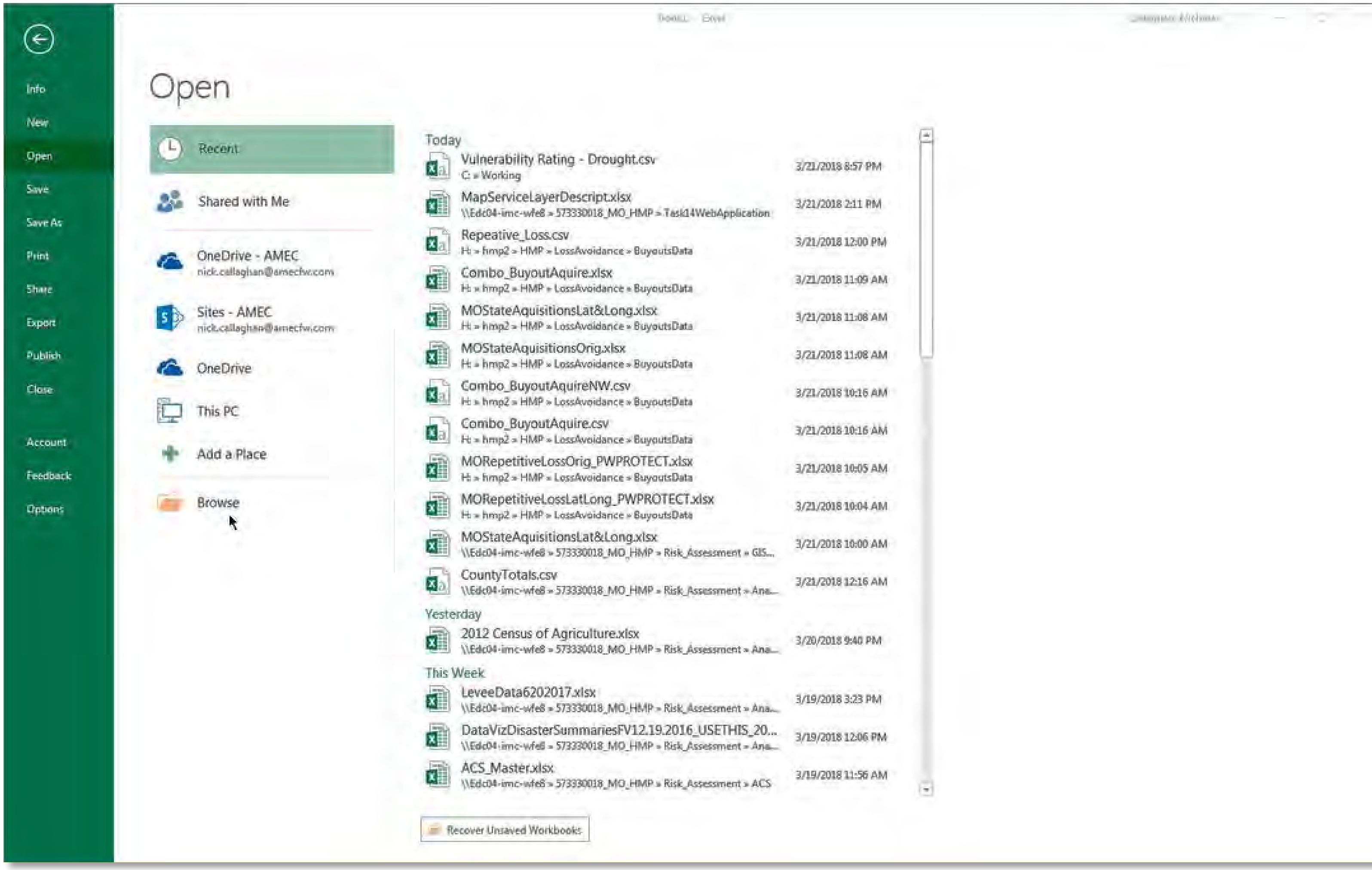
Using CSV files

To open in Excel:

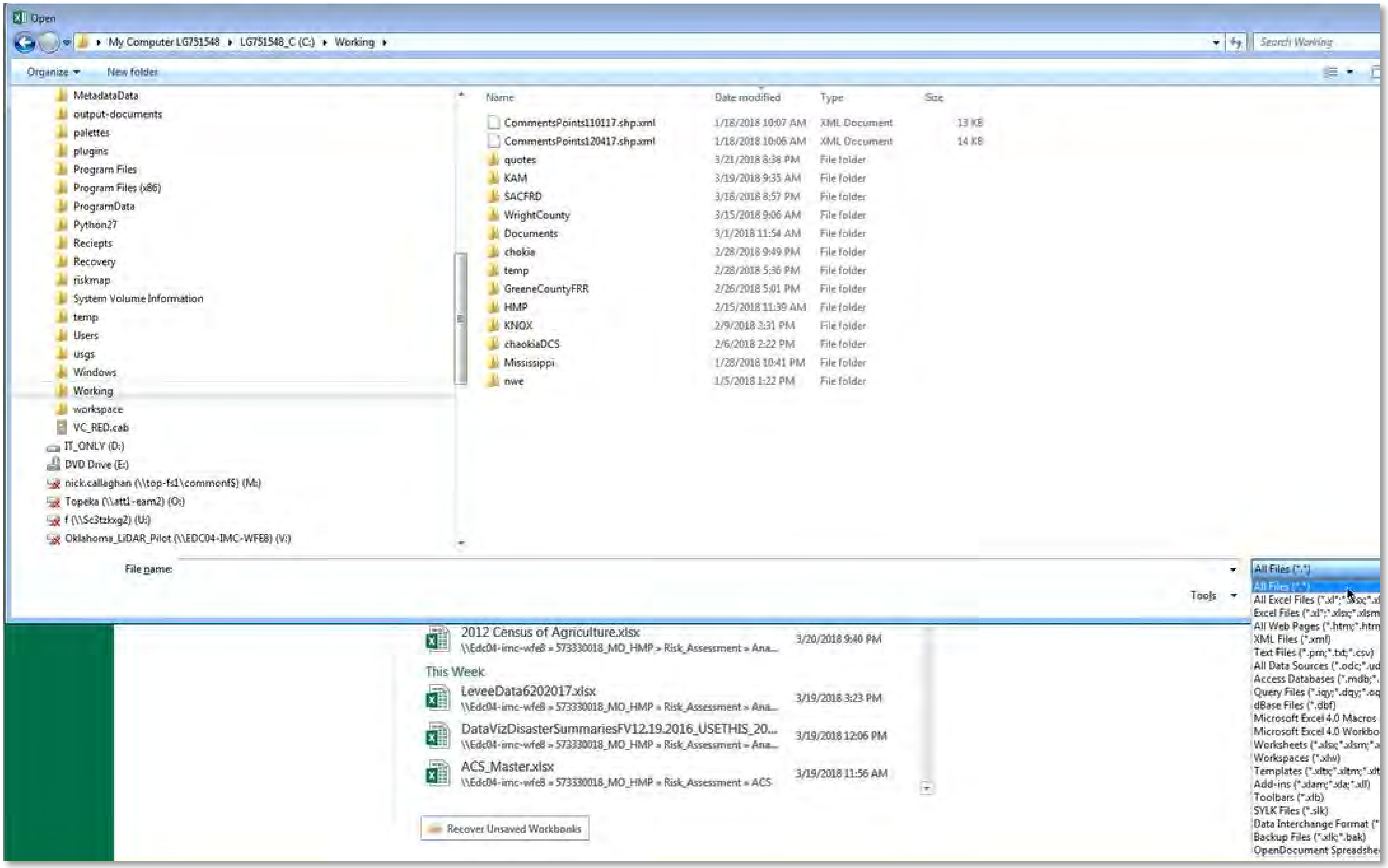
1) Open a blank Excel file.



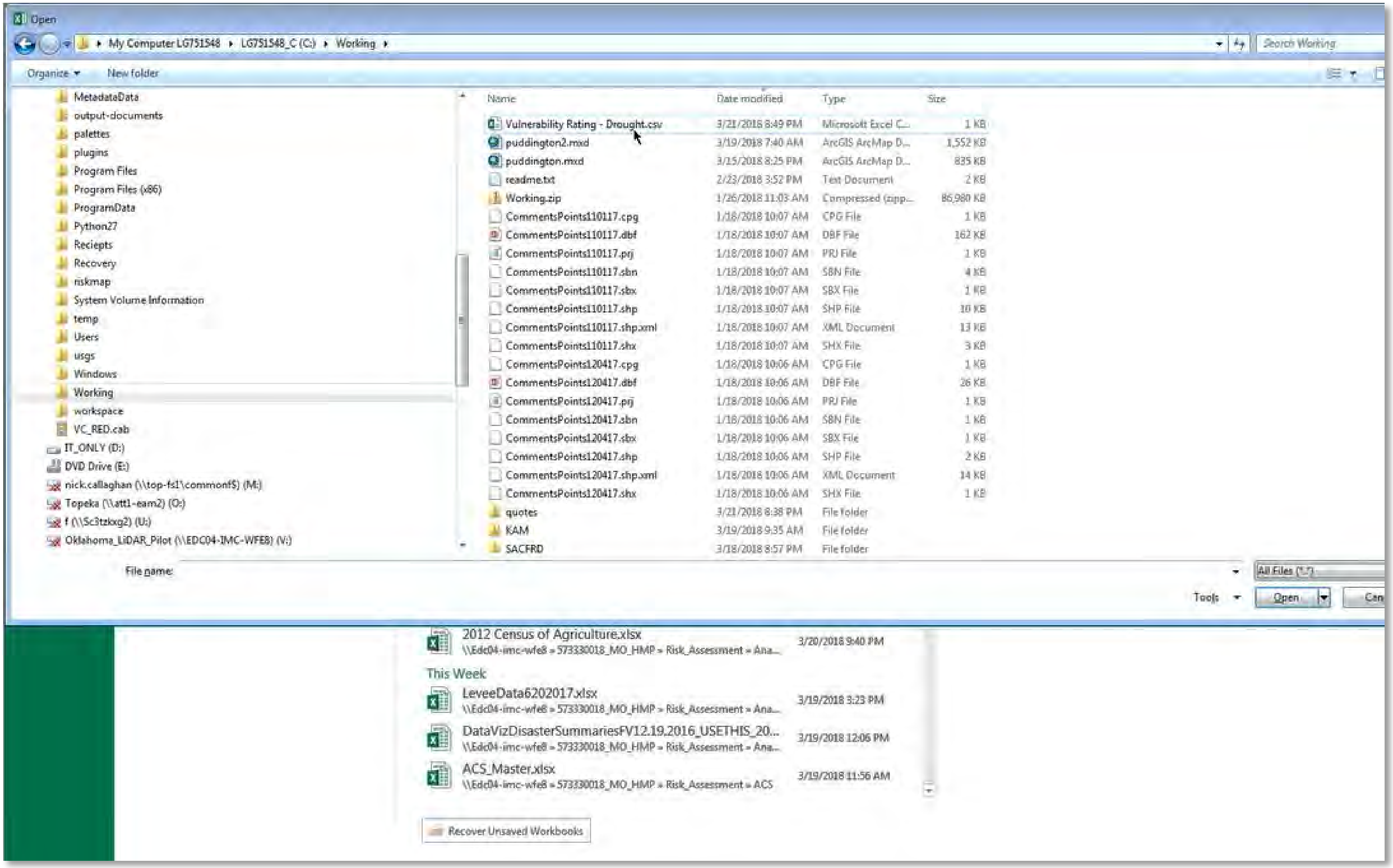
2) Click File and Browse to the CSV file



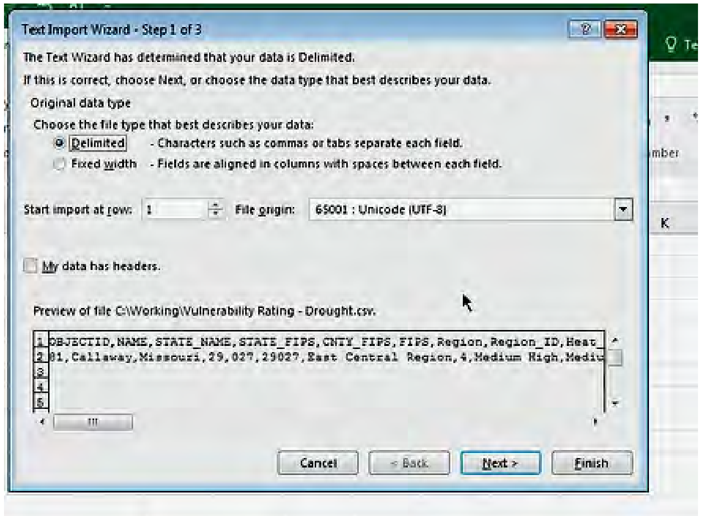
3) Navigate to the saved CSV location. Using the dropdown arrow for file types in the bottom right side of the window, choose “All Files (*.*).



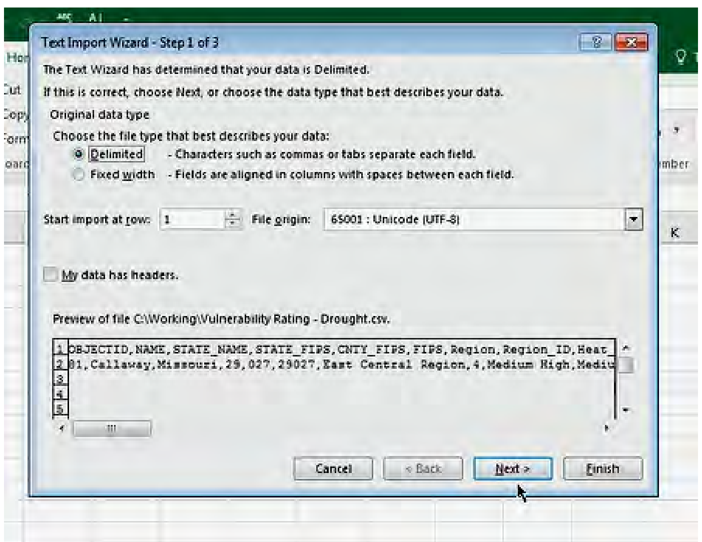
4) Click on the CSV file in the File Name window.



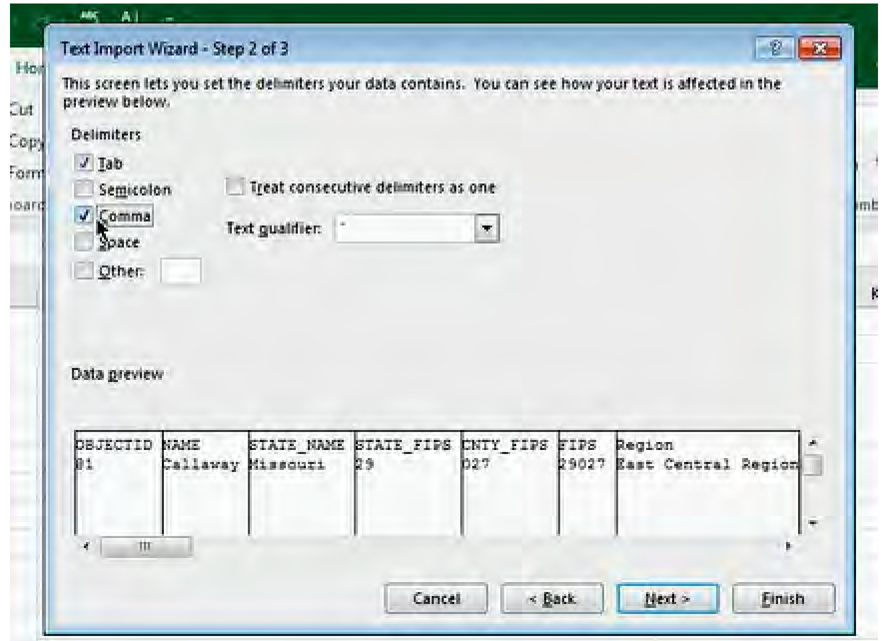
5) A Text Import Wizard window will open showing Step 1 of 3. Choose the “Delimited” radio button in the upper middle of the window.



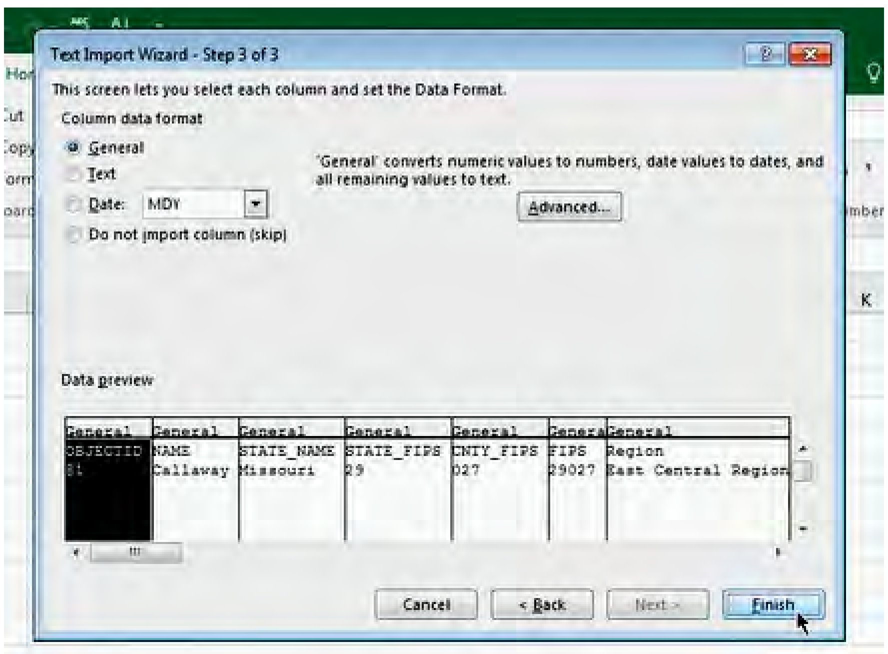
6) Then Click “Next” at the bottom right.



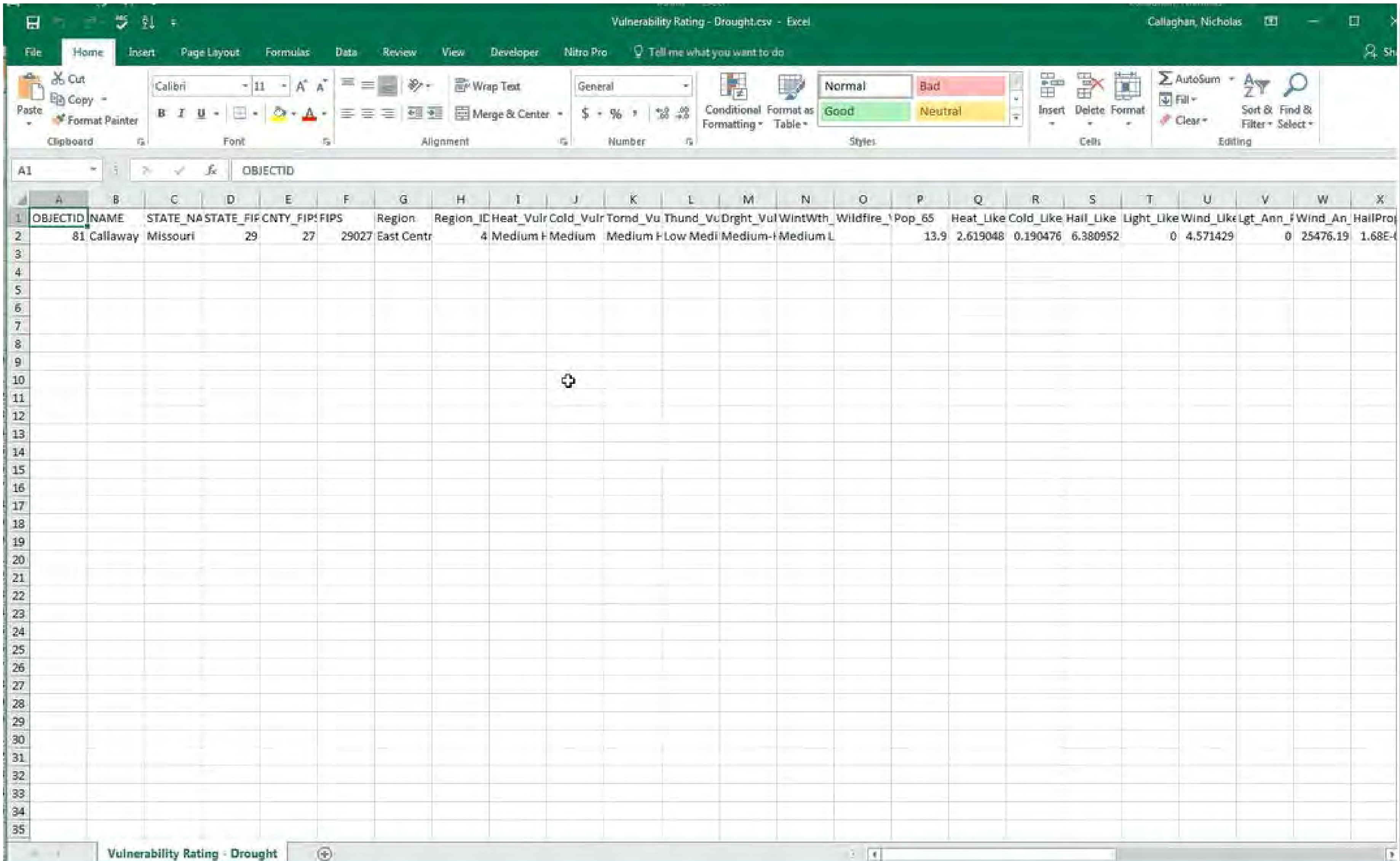
7) The Step 2 of 3 Text Import Wizard Window will open. Select the “Tab” and “Comma” check boxes on the left. Then Click “Next” at the bottom.



8) The Step 3 of 3 Text Import Wizard window will open. Click the “General” radio button on the left. Then click “Finish” at the bottom.

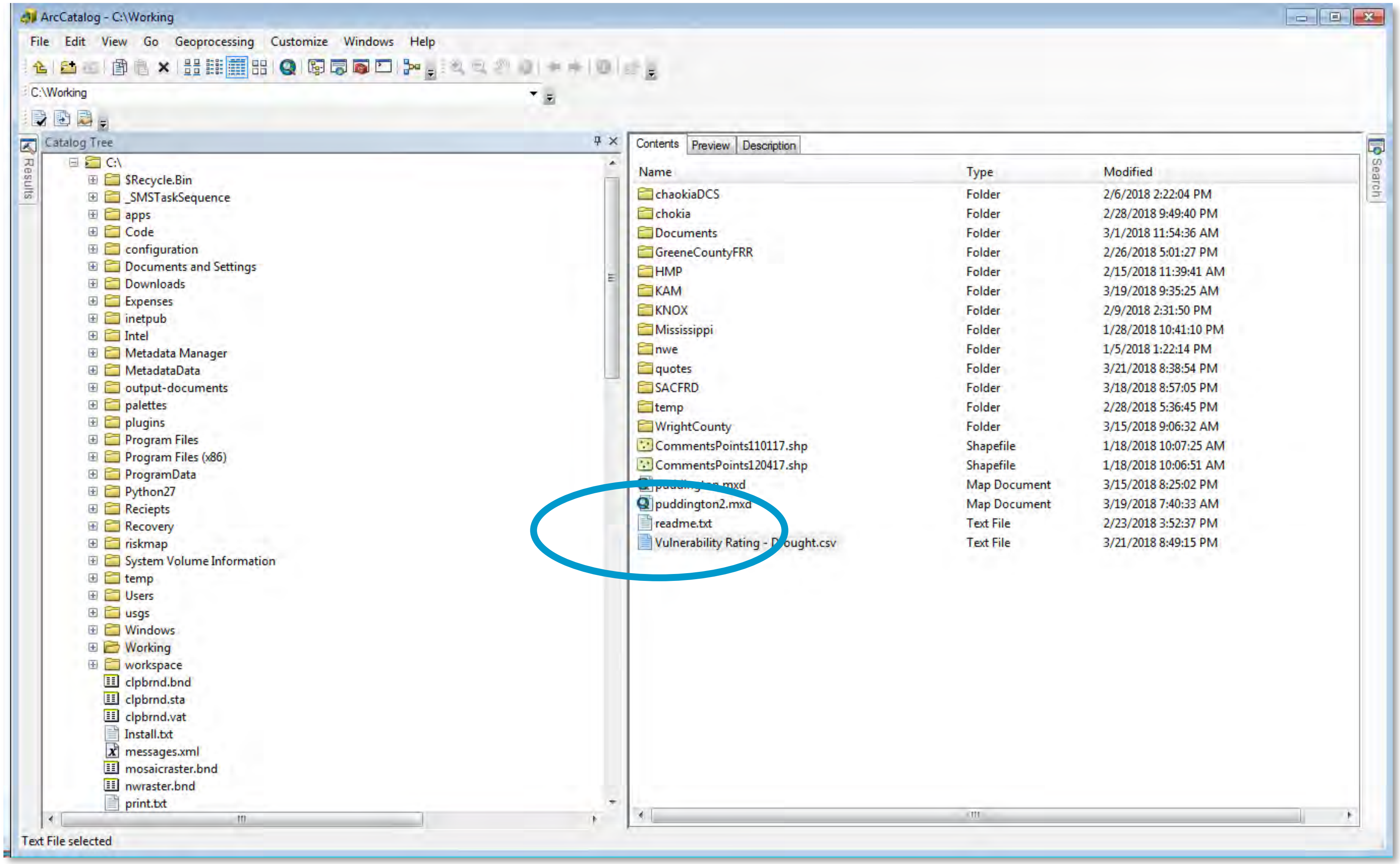


9) The Text Import Wizard window will shut and the data will appear in the Excel spreadsheet.

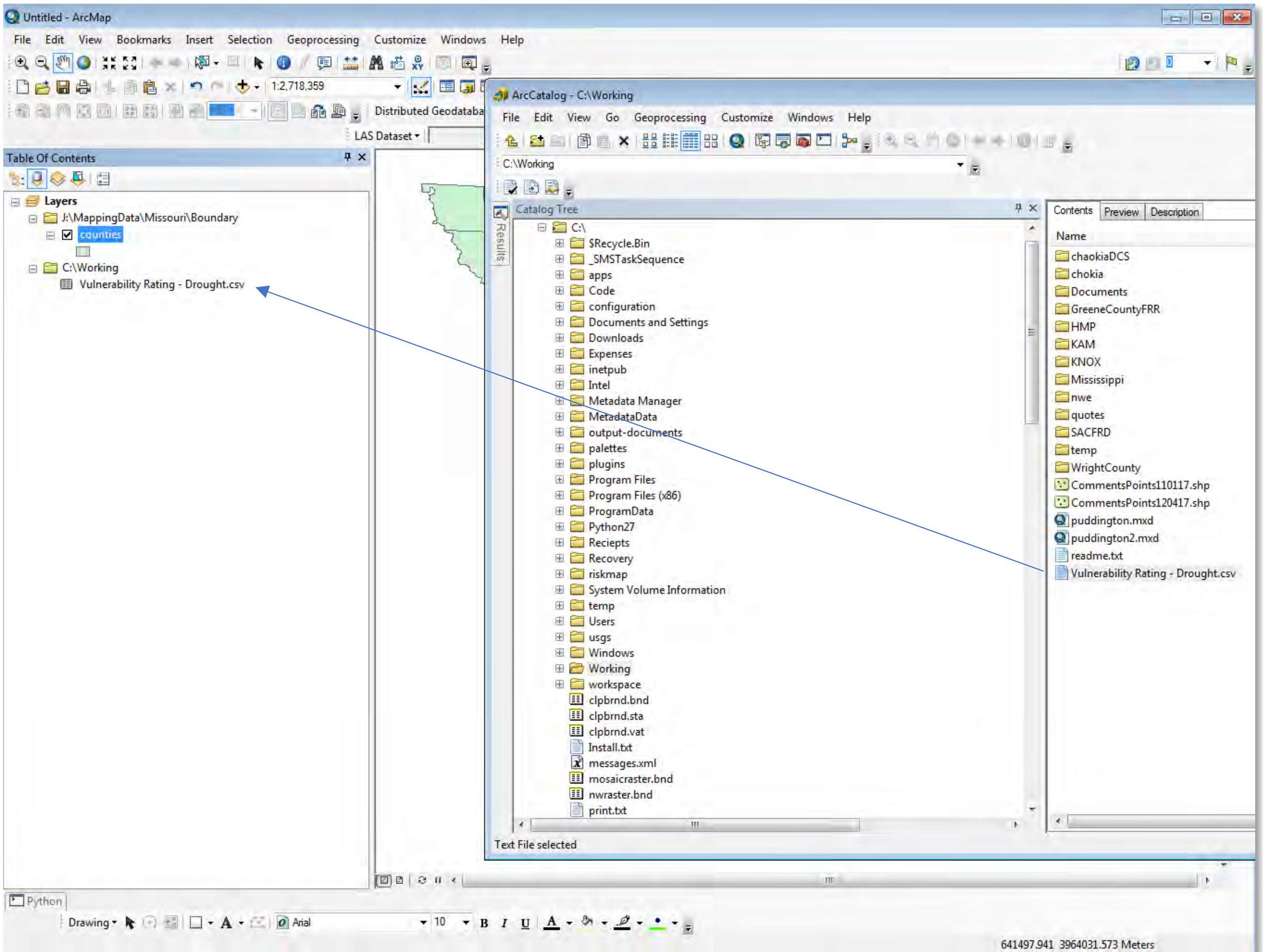


To Open the CSV file in ArcGIS:

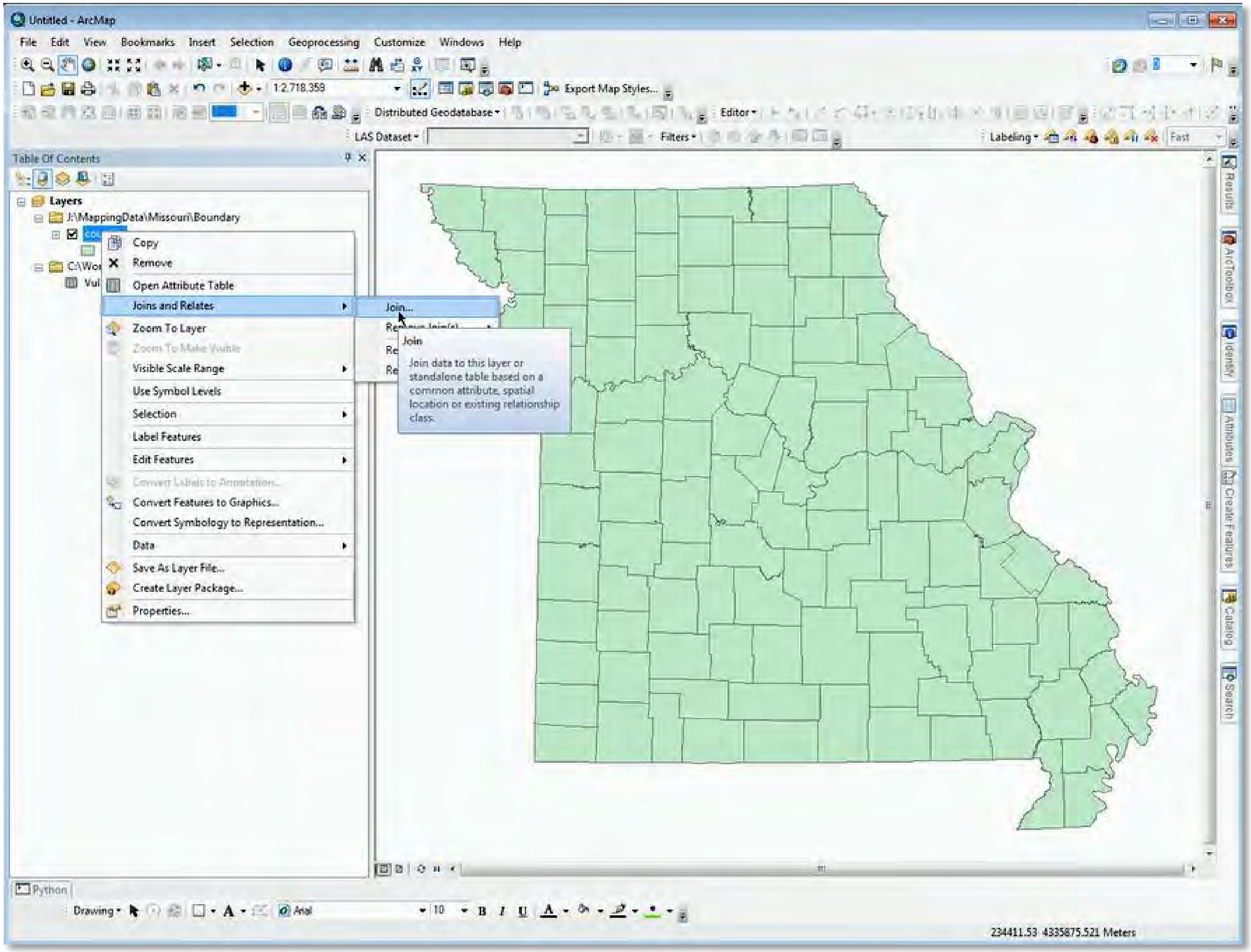
1) Open ArcMAP and then ArcCatalog. Navigate to the stored CSV file location in ArcCatalog.



2) Drag the CSV file from Catalog into ArcMAP. Also add to the ArcMap a county boundary shapefile.



3) Join the CSV file to the County shapefile by right clicking on the County shapefile in the Table of Contents window to open the options window, choosing **"Joins and Relates "**and then **"Join".**



4) A Join Data window will open. Choose the following options utilizing the drop-down arrows:

a) Join attributes from a table

b) Choose the field of the County

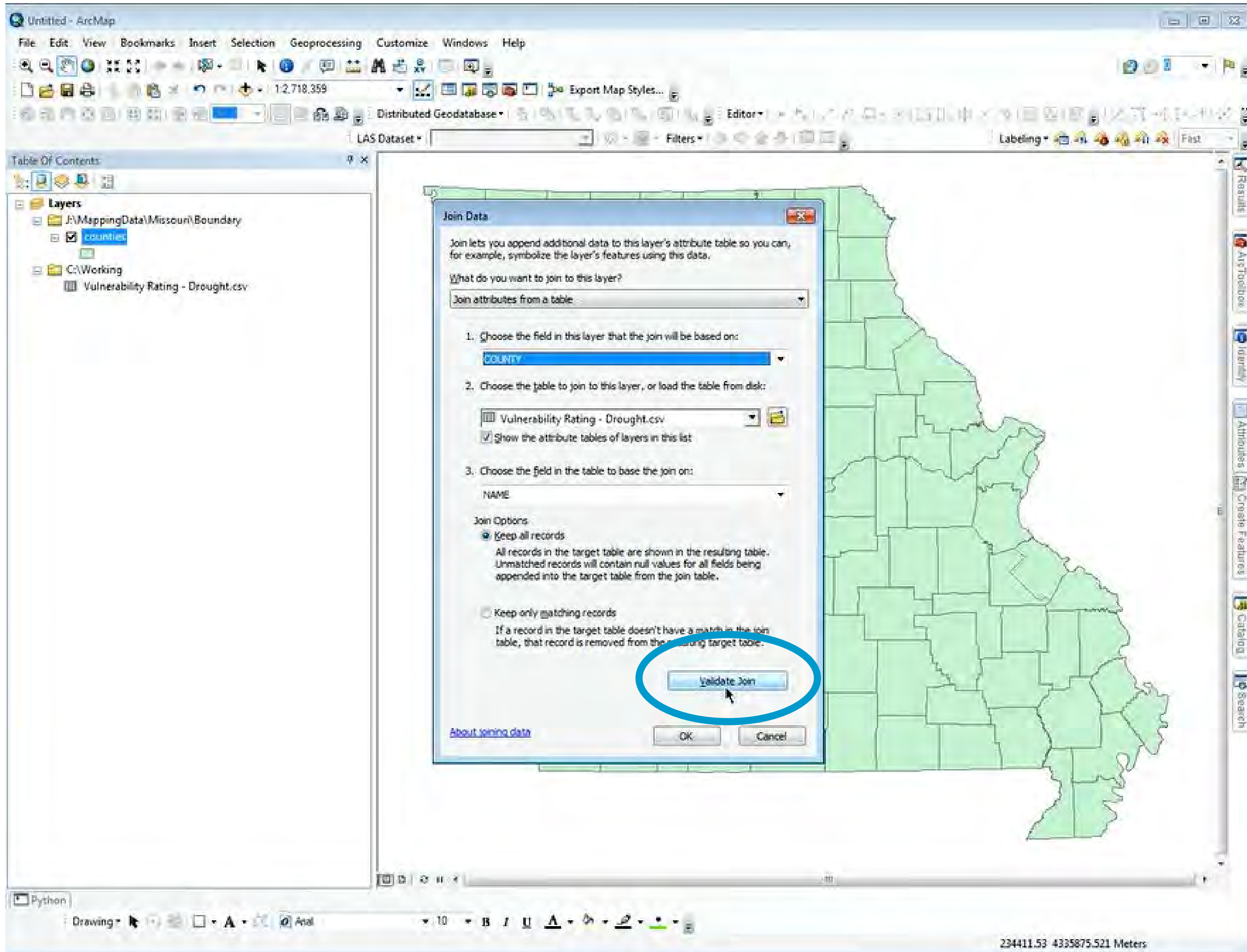
c) Choose the CSV file name

d) Choose the field with the County name in it

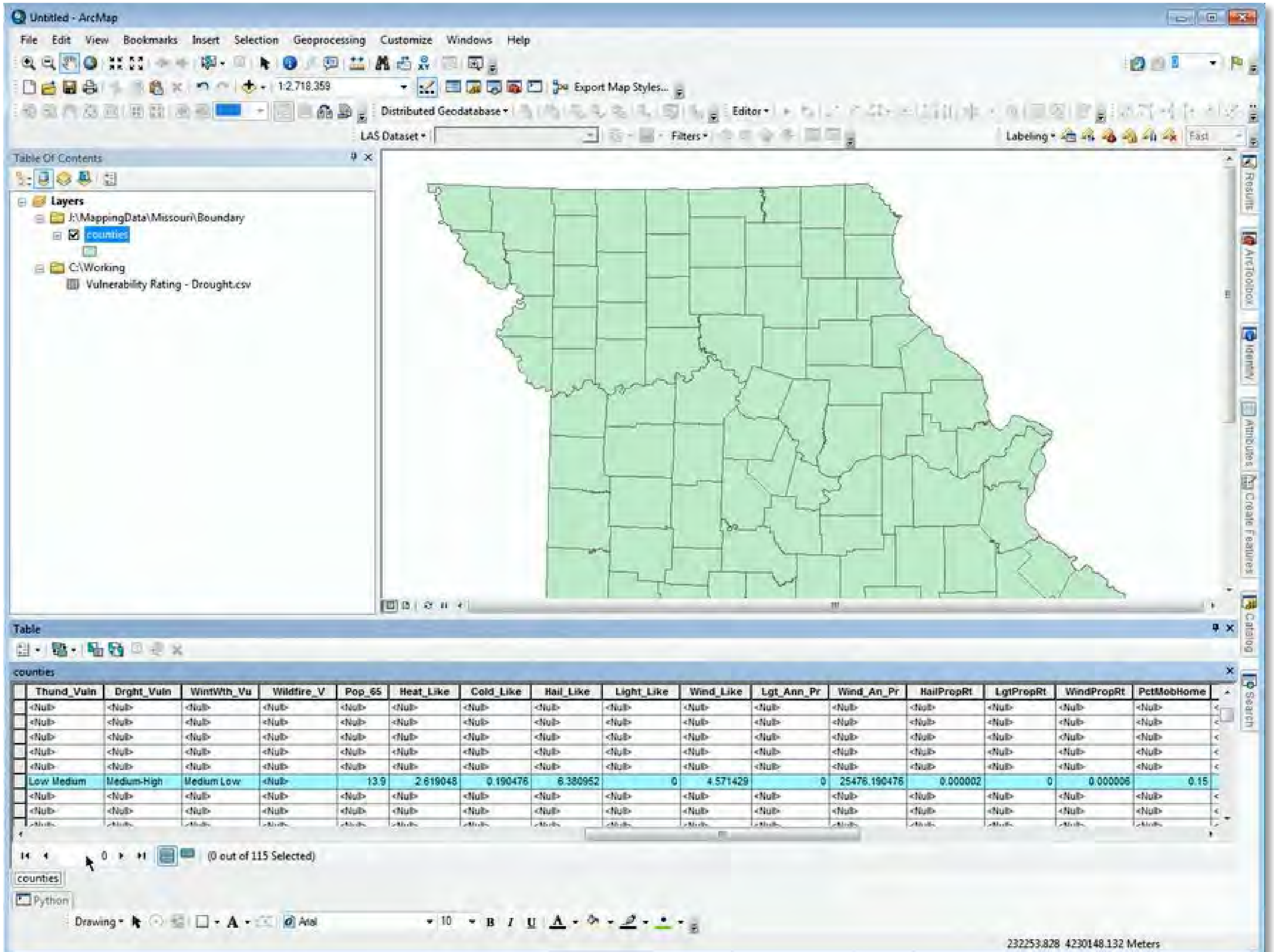
e) Choose "**Keep all records**"

f) Choose "**Validate Join**"

g) Click "**Ok**" at the bottom.



5) The data in the CSV file will now appear appended to the right of the County file attributes. For counties with no data in the CSV file, the attributes are <Null>.



Appendix F

Public Assistance Projects with Proposed Mitigation Measures Not Implemented

Disaster Number and Unique ID	Applicant Name	Applicant ID	PW #	Damage Category	Hazard Mitigation (Does the Applicant have a HM proposal or would like technical assistance with one?)	PA Mitigation Proposal Amount (Estimated 406 HM cost)	Mitigation Activity Status (Was there mitigation activity on any site in this PW?)	Mitigation Type	Was this Mitigation Policy applied to this project? List Policy	Fifteen Percent Policy	BC Policy	Codes And Standards	Construction Practices	Mitigation Proposal Scope of Work	Mitigation Comments
4130-154	POLK (TOWNSHIP OF)	211-58880-00	154	C - Roads and Bridges	Yes		Yes	Construction Practices				No	Yes	This repair / restoration project has been reviewed for mitigation opportunities. Some mitigation has been achieved by method of repair. Steven Crawford HACL 03/04/14	
4130-157	MISSOURI DEPARTMENT OF TRANSPORTATION	000-U1X28-00	157	C - Roads and Bridges	Yes	$23,338.04	Yes	Construction Practices				No	Yes	During the Incident Period May 29 to June 10, 2013, severe storms and flooding occurred at the Lincoln Shields Access Road resulting in damages to the causeway including washout of road embankment. The mitigation measures employed at this site includes stabilizing the causeway with rip-rap fill, geotextile fabric and rock blanket (rip rap) armoring of embankment in order to prevent similar damages in a future similar event. Lincoln Shields Access Road Lat. 38.52459; Long -90.11132 Mitigation measures are as follows: Work to be Completed 1) 4344 CY of Rip Rap fill material @ $8.10 per CY ($35,186.40) will be used in place of 4344 CY of pre-disaster Class A Fill @ $9.19/CY ($39,921.36) 2) 5,441 SY of geotextile fabric at $3.00 per SY will be placed on top the rip rap fill = $16,323.00 3) Two (2) foot thick of Rock blanket (250 CY) will be placed on Railroad embankment at the 12 inch CMP, at $47.00 per CY = $11,750.00. Mitigation cost = $35,186 + $16,323.00 + $11,750.00 - ($39,921.36 Class A fill) = $23,338.04 Repair Cost = $107,825.36 Ratio = Mitigation Cost/Repair Cost = $23,338.04/$107,825.36 = 21.64% Hazard Mitigation Proposal (HMP) is 21.64% of the repair and restoration cost, which is considered to be cost effective, in accordance with FEMA Recovery Policy 9526.1, Section VII, paragraph B-2, ¿Certain mitigation measures (see Appendix A) determined to be cost effective, as long as the mitigation measure does not exceed 100% of the eligible cost of the eligible repair work on the project. Therefore, HMP is cost effective.	
4130-74	BRIDGETON	189-08398-00	74	B - Protective Measures	Yes	$0.00						No	No		
4130-97	PIKE (COUNTY)	163-99163-00	97	C - Roads and Bridges	Yes		No	N/A				No	No	Total Cost of Estimate = $997,981.25 - Design engineering, $52,959.00 - Construction engineering, $57,372.25 - Borings, $5,000.00 - Mobilization of construction equipment, $35,000.00. - Unclassified excavation, $4,500.00. - Embankment in place, $20,000.00 - Compacting embankment, $5,400.00 - Installing Sheet Piling, $600,000.00 - Installing H-Pile, $189,000.00 - Installing guardrail, $22,000.00	Applicant performed mitigation prior to the the incident period by moving the road over 12 FT and giving it a different footprint. Hazard Mitigation Specialist's Comments: The primary damages to Highway 103 occurred from storms prior to the incident period and repair work was stopped on May 23, 2013 due to inclement weather. Damages were further exacerbated from rainfall and flooding during from May 23 and including the incident period May29-June 1. The Project Worksheet totals approximately $37000 of which approximately $10,300 represents work performed prior to the incident period. The applicant submitted an HMP totaling $997,981.25, which includs: 1) Installing 30,000 SF of sheet piling; 2) installing 3,000 LF of H-Piles; and reworking the embankment by compacting and adding riprap; and adding 500 FT of guard rail. This is approximately 25 times the cost of total repairs. Although the proposal may be reasonable, the applicant is aware that this is well in excess of what FEMA considers cost effective, having been given a paper copy Recovery Policy 9526.1 along with an explanation by a 406 Mitigation Engineer. It is recommended that this HMP be denied based on absence of cost effectiveness.
4144-202	OSAGE BEACH	029-55244-00	202	G - Recreational or Other	Yes	$0.00	No	N/A				No	No		
4144-228	WAYNESVILLE	169-77992-00	228	F - Public Utilities	Yes	$0.00	Yes	N/A				No	No	The applicant had earlier requested replacement and relocation of the pumps from the current Roubidoux pump station, a short distance to the existing North Street bypass pump station which is located above the flood plain. The applicant later, on September 24, 2014, revised the request for an improved project. This then disqualifies any 406 mitigation funding.	
4144-310	PULASKI (COUNTY)	169-99169-00	310	C - Roads and Bridges	Yes	$0.00	No	N/A				No	No		In Engineer's Cost Estimates did not separate the hazard mitigation from pre-existing conditions. The Hazard Mitigation costs presented in the Cost Estimates are above 100% repair costs.
4144-331	CASS (TOWNSHIP OF)	215-11854-00	331	C - Roads and Bridges	Yes	$10,000.00	Yes	CODES AND STANDARDS				Yes	No		The Mitigation Specialist inspected this particular project. Though the Applicant submitted a Hazard Mitigation Proposal, the FEMA Mitigation Specialist determined that the proposed new repair / construction are of Codes and Standards.
4144-334	CASS (TOWNSHIP OF)	215-11854-00	334	C - Roads and Bridges	Yes	$0.00	No	CODES AND STANDARDS				Yes	No		The Applicant submitted a Hazard Mitigation Proposal. The FEMA Mitigation Specialist inspected the damaged section and determined that repair / restoration of the damaged section is Codes and Standards.
4144-380	PULASKI (COUNTY)	169-99169-00	380	C - Roads and Bridges	Yes	$0.00	No	N/A				No	No		
4144-382	PULASKI (COUNTY)	169-99169-00	382	C - Roads and Bridges	Yes	$0.00	No	N/A				No	No		
4144-390	PHELPS (COUNTY)	161-99161-00	390	C - Roads and Bridges	Yes		No	N/A				No	No	awe	

Disaster Number and Unique ID	Applicant Name	Applicant ID	PW #	Damage Category	Hazard Mitigation (Does the Applicant have a HM proposal or would like technical assistance with one?)	PA Mitigation Proposal Amount (Estimated 406 HM cost)	Mitigation Activity Status (Was there mitigation activity on any site in this PW?)	Mitigation Type	Was this Mitigation Policy applied to this project?					Mitigation Proposal Scope of Work	Mitigation Comments
									List Policy	Fifteen Percent Policy	BC Policy	Codes And Standards	Construction Practices		
4144-405	PULASKI (COUNTY)	169-99169-00	405	C - Roads and Bridges	Unsure		No	N/A				No	No		This is an Engineers Estimate and Codes and Standards apply to their new Contruction Practices.
4144-78	GREASY CREEK ROAD DISTRICT	009-UZN0A-00	78	C - Roads and Bridges	Unsure		No	N/A				No	No		
4238-1003	UPTON (TOWNSHIP OF)	215-75292-00	1003	C - Roads and Bridges	Unsure		No	N/A				No	No		
4238-1037	MO. DEPT. OF NATURAL RESOURCES	000-UB2M9-00	1037	G - Recreational or Other	Yes		No	N/A				No	No		
4238-1045	WRIGHT COUNTY ROAD & BRIDGE	229-02E74-00	1045	C - Roads and Bridges	Yes	$0.00	Yes	Mitigation, List	Yes			No	No	MITIGATION: E M B A N K M E N T - Edwards Road Applicant intends to add embankment armament to the south side of the road to prevent future washout, 100 ft. X 3 ft. X 2 ft. /27 = 22.22 CY X 1.4 = 31.11 tons of large (2 ft. plus size) rip rap. Materials: 100 ft. X 3 ft. X 2ft. /27 = 22.22 CY X 1.5 = 31.11 tons Cost of material is $20/ton for hauling and $12/ton for the material = $32/ton delivered. 31.11 tons X $32/ton = $995.52 Equipment: Case 590 backhoe, CC8572, $37/hr. X 25 hrs. = $925 Labor: Mike Pasley - $16.13/hr. X 25 hrs. = $403.25 Total: $995.52 + $925 + $403.25 = $2,323.77 E M B A N K M E N T Elk Creek Road Applicant intends to add embankment armament to the north side of the road to prevent future washout, 500 ft. X 3 ft. X 2 ft. /27 = 111.11 CY X 1.4 = 155.55 tons of large (2 ft. plus size) rip rap. Place large (2 ft. plus) size rip rap along north side of Elk Creek Road, 500 ft. X 3 ft. X 2 ft./27 = 111.11 CY X 1.4 = 155.55 tons. Material: 500 ft. X 3 ft. X 2 ft. /27 = 111.11 CY X 1.4 = 155.55 tons Material cost = $12/ton, hauling cost is $20/ton, for a total of $32/ton X 155.55 tons = $4,977.60	
4238-1061	CASS (TOWNSHIP OF)	215-11854-00	1061	C - Roads and Bridges	Yes		No	N/A				No	No	Applicant is requesting to use 3 inches of turkey grit over the repaired road instead of regular surface aggregate at no additional cost 65 feet long x 12 feet wide x 3/12 FT deep /27 = 7.22 CY	
4238-1068	CASS (TOWNSHIP OF)	215-11854-00	1068	C - Roads and Bridges	Yes		Yes	Mitigation, List	Yes			No	No	Site 3.11 Replace existing CMP with Concrete Box Culvert H&H Study allowance: $1,000.00 Concrete Box Culvert (instead of 1 EA 30 FT long x 36 IN CMP): 280 SF x $35 (FEMA CC #3230) = $9,800.00 Site 3.12 Elevate the road and add 2 EA CMP Additional aggregate (12 IN aggregate) 373 CY x $13.00 (FEMA CC #3011) = $4,849.00 Additional 2 EA 24 FT long x 36 IN CMP 48 FT x $41.00 (FEMA CC #3356) = $1,968.00 The sites 3.11 and 3.12 represent the same area of water crossing. Benefit ratio: $16,387 / $16,682 x 100% = 98%	8-4-16 HMP was developed and attached. /// Reassigned to Donald Leifheit to amend and add SOW comment in mitigation tab. D Gearman Added comments to the Mitigation Scope of Work concerning the removal of the Mitigation Costs from the faceplate of the PW. D. Leifheit 6-28-2016
4238-1073	BEE BRANCH (TOWNSHIP OF)	041-03952-00	1073	C - Roads and Bridges	Yes	$0.00	No	N/A				No	No	see attached	Mitigation was proposed but applicant declined because lack of funds for local share
4238-1075	MORRIS (TOWNSHIP OF)	215-50042-00	1075	C - Roads and Bridges	Yes	$0.00	No	N/A				No	No		
4238-1082	BEE BRANCH (TOWNSHIP OF)	041-03952-00	1082	C - Roads and Bridges	Yes		No	N/A				No	No	see attached	Mitigation was proposed but applicant declined because lack of funds for local share
4238-1085	SUGAR CREEK ROAD DISTRICT	009-UBO5N-00	1085	C - Roads and Bridges	Yes	$0.00	No	N/A				No	No		

Disaster Number and Unique ID	Applicant Name	Applicant ID	PW #	Damage Category	Hazard Mitigation (Does the Applicant have a HM proposal or would like technical assistance with one?)	PA Mitigation Proposal Amount (Estimated 406 HM cost)	Mitigation Activity Status (Was there mitigation activity on any site in this PW?)	Mitigation Type	Was this Mitigation Policy applied to this project?					Mitigation Proposal Scope of Work	Mitigation Comments
									List Policy	Fifteen Percent Policy	BC Policy	Codes And Standards	Construction Practices		
4238-1146	CAMDEN COUNTY ROAD & BRIDGE	029-UNJ6E-00	1146	C - Roads and Bridges	Yes	$0.00	Yes	N/A				No	No	6-14-16 See attached mitigation proposal. D Gearman The applicant has expressed interest in mitigating this site to alleviate the numerous occurrences of the approaches washing out. The historic loss of resources at this site has totaled $31,200.00 over the last three (3) years. The Applicant would like to replace the existing LWC with a formed concrete structure according to the attached mitigation plan. The work will be completed using Force Account Labor, Equipment, and materials, according to the following estimate: FA Labor (9007): 850 hours totaling $19,144.03 FA Equipment (9008) 394 hours: $19,534.00 Grader (8332) 10 hours x $84.00 = $ 840.00 1 Tn Truck (8802) 32 hours x $26.00 = $ 832.00 ¾ Tn Truck (8802) 32 hours x $26.00 = $ 832.00 Dump (8722) 80 hours x $75.00 = $6,000.00 Backhoe (8572) 120 hours x $37.00 = $4,440.00 Vibratory Roller(8224) 40 hours x 41.75 = $1,670.00 Excavator (8282) 80 hours x 72.00 = $5,760.00 Materials: (9009) $15,805.16 1 inch base rock: 165 tons x $7.00 = $1,155.00 Concrete Mix: 45 CY x 104.75 = $4,713.75 Rebar: 1.41 Tons x $175.00 = $ 246.41 24 Inch Metal Culverts: 612 LF x $14.25= $8,721.00 Culvert Bands: 34 ea x $28.50 = $ 969.00 Total Mitigation Estimate: $54,483.19	
4238-1174	SILEX	113-67808-00	1174	F - Public Utilities	Yes		No	N/A				No	No	In lieu of exterior mounted pump controls, submersible pumps with controls integral to the pump, and within its waterproof housing, would be installed. at FAC 1, FAC 2,FAC 4,FAC 5. Remaining two WWPS, FAC 3 and FAC 6 would be candidates. Per receipts from O'Fallon Sewer Service, 2 HP submersible pumps with integral controls cost approximately $3,395.00 installed. The same size pump without the integral controls costs $3,000.00 installed. The installed cost of external controls, per Subrecipient is $1,065.00.	Applicant is seeking mitigation regarding the damages received on the main sewer treatment lagoon. Applicant is seeking also mitigation for the damaged pumps located on various lift stations. 6/13/2016 Victor Quinones 406 MIT --///-- The PW in its current state (PA total cost of $89,520.50) is incomplete and does not capture all the damages but a small portion of it. The applicant was/is interested in mitigation, and the base amount of PA is needed in order to assess the cost effectiveness of an HMP. 7/20/2016 Doron Kishoni, Victor Quinones 406 MIT --///--
4238-168	CASSVILLE	009-11890-00	168	G - Recreational or Other	Yes		No	N/A				No	No	Hazard Mitigation may be performed on both the fencing at the softball field and the foot bridge. Stronger vertical posts with larger concrete footings would strengthen the fence to prevent future damages from flooding. The wood footbridge may have stronger anchors attached to its end supports to prevent moving during future flooding.	Hazard Mitigation may be performed on both the fencing at the softball field and the foot bridge. Stronger vertical posts with larger concrete footings would strengthen the fence to prevent future damages from flooding. The wood footbridge may have stronger anchors attached to its end supports to prevent moving during future flooding.
4238-213	WINDSOR SPECIAL ROAD DISTRICT	083-U5VW0-00	213	E - Public Buildings	Yes		Yes	N/A				No	No	The applicant proposes two changes to the original structure design which they believe will strengthen the structure and make the structure less susceptable and more resistant to wind damage in the future. First, the applicant proposes using a metal framed structure instead of a wood framed structure. Second, the applicant proposes installing a concrete footing around the perimeter of the building and anchoring the metal framing to the footing which will also less susceptable and more resistant to wind damage in the future. 1. Cost to upgrade from wood framing to metal framing - Cost of wood framing per attached Part A CEF $ 10,343.00 - Cost of Metal Framing $ 14,840.00 Difference - $ 4,497.00 2. Install twelve (12) (4 FT x 4 FT x 3 FT deep) concrete pad footings to anchor the metal framing. Each concrete pad would require (4 FT x 4 FT x 3 FT / 27 = 1.78 CY) (Total = 21.36 CY) of concrete material. These concrete pads will be placed at strategic locations at the perimeter of the structure to allow for the metal framing attachment to be anchored. On 12-17-15, Public Assistance Crew Leader Chastain conversed with the applicant via telephone. The applicant advised Public Assistance Crew Leader Chastain the cost of the twelve (12) concrete pads is ($ 5,000.00). The applicant plans to utilize a Class A Structural Concrete for the placement of the concrete pads. FEMA Cost Code (3215 - Class A Structural Concrete) @ $540/CY) x 21.36 CY = $ 11,534.40. The estimated cost relayed by the applicant of $ 5,000.00 appears to be reasonable. FEMA Policy RP9526.1 1. Mitigation measures may amount to up to 15% of the total eligible cost of the eligible repair work on a particular project. $ 9,497.00 / $ 245,460.00 = 3.87%, therefore this proposal is less than 15% as authorized in FEMA Policy 9526.1.	
4238-306	RALLS (COUNTY)	173-99173-00	306	C - Roads and Bridges	Unsure		No	N/A				No	No		

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									List Policy	Fifteen Percent Policy	BC Policy	Codes And Standards	Construction Practices		
4238-337	WESTON	165-78856-00	337	C - Roads and Bridges	Unsure		No	N/A				No	No		Due to the type was work,and because the work is completed, no mitigation was considered in this project. Reviewed by : Luis F. Flores Torres; HM 406 SP; 1/14/2016.
4238-404	RALLS (COUNTY)	173-99173-00	404	C - Roads and Bridges	Unsure		No	N/A				No	No		
4238-407	RALLS (COUNTY)	173-99173-00	407	C - Roads and Bridges	Unsure		No	N/A				No	No		No mitigation opportunities have been identified. This project worksheet is for 100% completed work; therefore mitigation is not eligible. The work 100% completed then mitigation is not feasible. Reviewed by: Emily Torres HM-EASP 1/21/16/2015.
4238-409	EXCELSIOR SPRINGS	047-23086-00	409	G - Recreational or Other	Unsure		No	N/A				No	No		
4238-415	NOVINGER	001-53534-00	415	C - Roads and Bridges	Unsure			N/A				No	No		
4238-420	RAY-LAFAYETTE LEVEE DISTRICT NO 1	177-UL93B-00	420	F - Public Utilities	Unsure		No	N/A				No	No		The Subgrantee has not requested mitigation for this project. An email was forwarded to the Division F 406 HMP Specialist requesting that the Hazard Mitigation opportunities for the project be considered on 2/21/2016.
4238-452	NOVINGER	001-53534-00	452	C - Roads and Bridges	Unsure		No	N/A				No	No		
4238-453	NOVINGER	001-53534-00	453	C - Roads and Bridges	Unsure		No	N/A				No	No		
4238-483	BOWLING GREEN (TOWNSHIP OF)	041-07624-00	483	C - Roads and Bridges	Unsure		No	N/A				No	No		
4238-486	RICHMOND	177-61670-00	486	C - Roads and Bridges	Unsure		No	N/A				No	No		
4238-578	RICHMOND	177-61670-00	578	A - Debris Removal	Unsure	$0.00						No	No		
4238-585	LEWIS (COUNTY)	111-99111-00	585	C - Roads and Bridges	Unsure		No	N/A				No	No		
4238-623	SULLIVAN (COUNTY)	211-99211-00	623	C - Roads and Bridges	Unsure		No	N/A				No	No		
4238-625	SULLIVAN (COUNTY)	211-99211-00	625	C - Roads and Bridges	Unsure		No	N/A				No	No		
4238-626	SULLIVAN (COUNTY)	211-99211-00	626	C - Roads and Bridges	Unsure		No	N/A				No	No		
4238-627	SULLIVAN (COUNTY)	211-99211-00	627	C - Roads and Bridges	Unsure		No	N/A				No	No		
4238-685	COLE (COUNTY)	051-99051-00	685	C - Roads and Bridges	Yes		No	N/A				No	No	Applicant is requesting hazard mitigation. The mitigation is on private Property. PROPOSED MITIGATIONS 1.Aggregate Base/Ditch 50.00 CY $ 128.00 $ 6,400.00 2.Riprap/Embank Slope Armor 500.00 CY $ 63.00 $ 31,500.00 3.Shot Rock/Embankment Fill 2,500.00 CY $ 20.00 $ 50,000.00 4.Shot Rock/Ditch Armor 100.00 CY $ 95.00 $ 9,500.00 5.Soil/Embankment Fill 2,000.00 CY $ 9.25 $ 18,500.00 6.Drainage Aggregate Geotextile950.00SY $ 1.90 $ 1.90 7.Slope Geotextile 550.00 CY $ 2.55 $1,402.50 8.Ditch Geotextile 280.00 SY $ 2.50 $ 700.00 9.Guard Rail 7¡¦ Post 800.00 LF $ 31.00 $ 24,800.00 10.Drainage Aggregate French Drains 50.00 CY $ 83.00 $ 4,150.00 4,150.00 11.French Drains Filter Fabric 500.00 SY $ 1.75 $ 875.00 875.00 12.Temporary Erosion Control 1.00 LS $6,000.00 $ 6,000.00 6,000.00 13.Seeding, Fertilizing, Mulch 1.00 ACRE $3,500.00 $ 3,500.00 3,500.00 14.Type A Crashworthy End Terminal 1.00 Each $2,300.00 $ 2,300.00 15.Aggregate Base Riprap 130.00 CY $ 46.00 $ 5,980.00 TOTAL = $196,951.76 The cost of the Engineer Fee will be roll up in the contract cost. 8/10/2015 Engineering Fee $11,896.22 9/18/2015 Engineering Fee $17,643.04	The applicant and contractor wish to use Rip Rap in place of fill on the slopes and ditches. Please see PW for estimates.
4238-692	BUCHANAN (COUNTY)	021-99021-00	692	C - Roads and Bridges	Yes		No	N/A				No	No	-The applicant would like to have mitigation involved to raise the roadway 1.5 or 2.0 feet and deepen the ditches. The applicant has a back stock of 27,000 cubic tons of dirt that was given to them free. Applicant is requesting transportation costs. They will use their staff, nothing contracted. This mitigation project would take approximately 16,000 cubic tons of dirt. They would use the closest quarry, which is Norris Quarry in Andrew County. Applicant will provide the bid for the rock. In order to build the roadway up, the applicant will start with 3¿ base rock, then put 2¿ base rock and top it off with 1¿ base rock. The applicant is also considering adding culverts. Applicant was requested to submit the estimate for the new project proposal and road maintenance records for the past 10 years for confirmation of the flood frequency. -The applicant would like to have mitigation for the ditches along the road as well. Because the road flooded 9 times during this current incident period and has flooded severely in past disasters, the applicant would like to have six feet ditches on both sides of the road that flow into the proposed culvert that is mentioned above.	If the mitigation is deemed feasible after the review of the attached estimate, the applicant is willing to gather documentation of past flooding and it's effect on the community.
4238-722	LEBANON	105-41168-00	722	C - Roads and Bridges	Yes		No	N/A				No	No		
4238-776	CASS (TOWNSHIP OF)	215-11854-00	776	C - Roads and Bridges	Yes		Yes	N/A				No	No	Site 2.4 Applicant is requesting mitigation to increase the size of shot rock (rip rap 6 inch)aggregate to 24 inch to stop the scouring of the existing aggregate because of the weight at no additional cost.	
4238-802	PUTNAM (COUNTY)	171-99171-00	802	C - Roads and Bridges	Unsure			N/A				No	No		

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									List Policy	Fifteen Percent Policy	BC Policy	Codes And Standards	Construction Practices		
4238-804	PUTNAM (COUNTY)	171-99171-00	804	C - Roads and Bridges	Unsure		No	N/A				No	No		
4238-812	TANEY (COUNTY)	213-99213-00	812	C - Roads and Bridges	Yes		No	N/A				No	No		
4238-848	BRANSON	213-07966-00	848	F - Public Utilities	Yes		No	N/A				No	No		PROCUREMENT: The Applicant was advised by FEMA PAC and/or Project Specialist that in the seeking of proposals and letting of contracts for eligible work, the Applicant must comply with its applicable Local, State and /or Federal procurement laws, regulations, and procedures as defined in CFR 2 200.318 thru 200.326:-ENVIRONMENTAL: Applicant is responsible for obtaining all necessary permits and abiding by the provisions of the permits and any other related Federal statutes and associated State, Tribal and local laws, codes, ordinances and other statues.
4238-872	PUTNAM (COUNTY)	171-99171-00	872	C - Roads and Bridges	Yes		No	N/A				No	No	County Road 130th Bridge #0840023 over East Locust Creek - (GPS 40.544071, -93.138747) Flooding during the incident period of May 15, 2015 through July 27, 2015 caused damage to the County Road 130th Bridge #0840023. The bridge is located on County Road CR 130th Street in Putnam County, Missouri. Erosion caused damage to the bridge embankment, created a washout cavity at the bridge wing wall, and washed out (and destroyed) a 36 inch diameter CMP culvert. The applicant wishes to reduce the potential for similar erosion damage from future events by armoring the embankment and culvert ditch approach with rip rap. The applicant plans to perform the following mitigation activities in conjunction with the bridge repairs: 1.) Place geotextile fabric (add 10% for adequate overlap): 1.10 x (50 ft long x 30 ft wide) / 9 sq ft per sy = 183 sy. 2.) Place armoring rip rap on repaired embankment: 50 ft long x 30 ft wide x 3 ft deep) / 27 cu ft per cy x 1.4 tons / cy = 233 Tons. 3.) Placement of 16.7 loads of rip rap utilizing excavator: 7 hr. 4.) Labor over 6 days (Lennis Harbert): 7 hr. 5.) Labor over 6 days (David Robbins): 7 hr. 6.) Labor over 6 days (Jason Wood): 7 hr. The applicant has provided the following estimated costs for performing the mitigation activities in conjunction with the bridge repairs:	
4238-879	BUCHANAN (COUNTY)	021-99021-00	879	C - Roads and Bridges	Unsure	$0.00	No	N/A				No	No		Per FEMA correspondence of 3/18/2016 to applicant, for the 10-culvert sites, inquired if applicant desires to pursue 406 mitigation for any/all culvert sites; and to signify particular culvert sites as well as type of mitigation measures desired. To date, applicant has not signified if will pursue 406 HMP.
4238-899	WOOD HEIGHTS	177-80767-00	899	C - Roads and Bridges	Yes		No	N/A				No	No		The applicant does not have a HMP, but would like technical assistance for a HMP. One idea for a possible hazard mitigation measure is installing concrete curbs to channel storm water and protect road edges from repetitive damage. Some of the roads addressed in this sub-grant application were also damaged by DR-1847 in 2009, DR-1934 in 2010, and DR-1961 in 2011.
4238-904	STANBERRY	075-70270-00	904	C - Roads and Bridges	Yes		No	N/A				No	No		Applicant would like to mitigate and replace the box culverts with a 48 inch CMP.
4238-91	BARRY (COUNTY)	009-99009-00	91	C - Roads and Bridges	Yes		No	N/A				No	No	Site 1: Great River Engineering- Springfield, Mo provided the following information: The four wing walks should be armored with larger ¿shot rock¿ approximately 24¿ on the long side. The structure is performing as it should hydraulically and traffic-wise. The estimated cost is about $12,000. Site 2 Great River Engineering- Springfield, Mo provided the following information: The existing structure would remain in place. The east footing would be uncovered and additional concrete would remain in place. The east abutment would be armored in ¿shot rock¿ approximately 24¿ long on one side. This rock blanket would extend upstream and downstream on the bank approximately 50 feet and extend to the road elevation. Cost to do this with an outside contractor under prevailing wage law would be $30,000.	Project under review for Hazard Mitigation after consultation with Project Specialist Scott Barns and GRE Consulting Engineers 11/16/2015. James S. Smith, HM EASP
4238-932	SCOTLAND (COUNTY)	199-99199-00	932	C - Roads and Bridges	Unsure		No	N/A				No	No		
4238-987	BROOKFIELD	115-08650-00	987	E - Public Buildings	Unsure			N/A				No	No		
4238-989	CHARITON (COUNTY)	041-99041-00	989	C - Roads and Bridges	Unsure		No	N/A				No	No		
4238-991	CHARITON (COUNTY)	041-99041-00	991	C - Roads and Bridges	Unsure		No	N/A				No	No		

Disaster Number and Unique ID	Applicant Name	Applicant ID	PW #	Damage Category	Hazard Mitigation (Does the Applicant have a HM proposal or would like technical assistance with one?)	PA Mitigation Proposal Amount (Estimated 406 HM cost)	Mitigation Activity Status (Was there mitigation activity on any site in this PW?)	Mitigation Type	Was this Mitigation Policy applied to this project? List Policy	Fifteen Percent Policy	BC Policy	Codes And Standards	Construction Practices	Mitigation Proposal Scope of Work	Mitigation Comments
4250-226	KIRKWOOD	189-39044-00	226	G - Recreational or Other	Yes		Yes	N/A				No	No	(Facility #1) Site # 6 -Softball Field Fences, Greentree Park GPS Coordinates: 38.558910, -90.451151 (I) Damages Description & Dimensions (DDD): During the incident period of December 23, 2015 through January 9, 2016, severe storms, tornadoes, straight-line winds and flooding impacted St. Louis County and the city of Kirkwood, MO. Significant flooding (approximately 15-20 feet above ground level) and fast moving waters from the Meramec River caused damages on Greentree Park (GPS: 38.558793, -90.447933).This facility is owned and maintained by the applicant. An 80 foot section of fencing on field #13 was washed away, a 10 foot section of fencing on field #14 was damaged and additionally flooding compromised the structural integrity of another 80 foot and 30 foot sections of fencing. Additional damages are: one terminal was damaged on field #14, top rails at fields #13 and #14 dug-outs, backstops on fields #13 and #14 and 3rd base line fence on field #13. PW total cost to repair damaged elements to pre-disaster for this site is $6,825.00. (II) Hazard Mitigation Proposal (HMP) Scope of Work: Applicant has requested, for site #6 (softball field fences), the following mitigation to prevent future damage from flooding in a similar event. Work to be completed: The applicant want to replace the existing damaged fence sections with new ones that are removable. Once a warning of flooding is issued the applicant will disconnect/detach and remove the fence sections and lay them on the field, anchored to the ground, or store them in a safe location. This method of repair will reduce similar damages in future events. According to information in the "DR4250 189KH62G Contracts.pdf" which is located on the "comments and attachments section ¿cost and estimate": Cost of labor and material to provide repairs and replacement of backstop and safety fences and removable fence sections on Ball Diamonds #13 and #14 at Greentree Park as per specifications and drawing = $11,345.00 (bid, lump sum) Mitigation cost for Site #6 = $11,345.00 -$6,825.00 = $4,520.00 (III) Hazard Mitigation Ratio (HMR): HMP= $4,520.00 (Total Hazard Mitigation) / $6,825.00 (PW Total Cost of Damage Elements) X 100(%) = 66.23% (IV) HMP Feasibility and Cost-Effectiveness This Hazard Mitigation Proposal is 66.23% of the total cost of the eligible repair	
4250-246	SHERRILL (TOWNSHIP OF)	215-67520-00	246	C - Roads and Bridges	Yes		No	N/A				No	No		
4250-284	JOPLIN SPECIAL ROADS DISTRICT	097-UZZEI-00	284	C - Roads and Bridges	Yes	$0.00	Yes	Mitigation, List	Yes			No	No	Amy Lane Site # 1): Address/GPS Coordinates: 37.02715, -94.46120 (I) Damages Description & Dimensions (DDD): During an incident period of December 23, 2015 to January 9, 2016, severe storm and flooding occurred throughout the Joplin Special Road District in Missouri. An aggregate road, Amy Lane, experienced eroding that washed material from roadway into roadside ditches and field areas. As a result the road was unpassable until repairs could be made. During debris removal applicant hauled reclaimed creek gravel from Coffee Lane to Amy Lane. Work done to bring rock from Coffee Lane to Amy Lane could not be separated from the rest of the work done on each site based on the daily worksheets. Instead FEMA cost code 3030 was used to estimate the site cost. The PW Total Cost of Damaged Elements is $4,303.23 and can be broken down as follows: 3030 Local Borrow: 119.54 Tons x 1 CY/1.4 Ton x $1.80/CY = $153.69 3070 Ditch Cleaning and Shaping: $3,590.40 9007 Labor: $56.08 9008 Equipment: $226.00 9009 Material (Base Rock): 45.05 Tons x $6.15/Ton = $277.06 (II) Hazard Mitigation Proposal (HMP) Scope of Work: In order to prevent similar damage under a future similar event, the applicant is ing the installation of (3) 40 FT x 24 IN (dia.) culverts at GPS coordinates. EHP has reviewed this project and stated the coordinates are not in a flood plain. CMP 24 IN: 120 LF x $13.69/LF =$1,642.80 24 IN Bands: (3) x $20.53/each = $61.59 Labor (From Payroll Average): 10 Hr x $15.51/Hr = $155.10 Equipment: Backhoe Loader 8393: 10 Hr x $37.00 = $370.00 Total: $2,229.49 (III) Hazard Mitigation Ratio (HMR): HMR= (Total Hazard Mitigation Cost/PW Total Cost of Damage Elements) X 100;HMR=($2,229.49/$4,303.23)x100= 51.8% (IV) HMP Feasibility and Cost-Effectiveness The Hazard Mitigation Proposal is approved in accordance with the Appendix J (100% rule) of the FEMA PA Program and Policy Guide, Mitigation Section 7D - page 93, and Appendix J ¿ page 184. Appendix J items on this HMP include General - 1. Erosion Control.	
4250-434	LINCOLN (COUNTY)	113-99113-00	434	C - Roads and Bridges	Yes		No	N/A				No	No		After discussing the existing site conditions with the PS (turbulent water flow, depth of water, site restrictions [low water crossing]) the mutual conclusion reached was that there is no cost efficient measures that could be implemented. No cost effective mitigation opportunities identified to be incorporated. 8/15/2016 Victor Quinones 406 MIT
4250-435	LINCOLN (COUNTY)	113-99113-00	435	C - Roads and Bridges	Yes		No	N/A				No	No		After discussing the existing site conditions (slope of embankment, water flow, site restrictions) with the PS it was reached the mutual conclusion that there is no cost efficient measures that could be implemented. No cost effective mitigation opportunities identified to be incorporated. 8/15/2016 Victor Quinones 406 MIT

Disaster Number and Unique ID	Applicant Name	Applicant ID	PW #	Damage Category	Hazard Mitigation (Does the Applicant have a HM proposal or would like technical assistance with one?)	PA Mitigation Proposal Amount (Estimated 406 HM cost)	Mitigation Activity Status (Was there mitigation activity on any site in this PW?)	Mitigation Type	Was this Mitigation Policy applied to this project?						
									List Policy	Fifteen Percent Policy	BC Policy	Codes And Standards	Construction Practices	Mitigation Proposal Scope of Work	Mitigation Comments
4250-469	FRANKLIN (COUNTY)	071-99071-00	469	C - Roads and Bridges	Yes	$0.00	Yes	Mitigation, List	Yes			No	No	1- Bend Road: GPS ¿ 38.46138, -90.78219 Rip-Rap to be placed to damaged area (53.50 ft. long X 5.00 ft. wide X 2.00 ft. deep) = 535.00 CF / 27 = 19.81 CY at $35.00 per CY= $693.35 The SA cost for this site is $1,089.00. The HMP cost is $693.35. Mitigation Ratio = 63.68% 2- N. Goodes Mill Rd: GPS - 38.495331, -90.968828 Rip-Rap to be placed to damaged area (20.00 ft. long X 10.00 ft. wide X 1.50 ft. deep) = 300.00 CF / 27 = 11.11 CY at $35.00 per CY = $388.85 The SA cost for this site is $610.00. The HMP cost is $388.89. Mitigation Ratio = 63.75% 3- Walls Ford Rd.: GPS ¿ 38.287242, -90.968364 Rip-Rap to be placed to damaged area (16.50 ft. long X 10.00 ft. wide X 1.50 ft. deep) = 247.50 CF / 27 = 9.17 CY at $35.00 per CY = $320.83 The SA cost for this site is $506.00. The HMP cost is $320.83. Mitigation Ratio = 63.41%	
4250-475	VALLEY PARK	189-75472-00	475	G - Recreational or Other	Yes	$0.00	No	N/A				No	No	8-24-16 See comments in mitigation tab. The applicant is requesting as hazard mitigation measure, cover some gravel areas washed out with asphalt in the parking lots. Per as built drawings specifications, provided by the applicant (see attached drawing sheet 4.1), the "asphalt parking lot pavement detail" shows layers of 4 inches of asphalt binder course and 2 inches of asphalt base course. The applicant is requesting to place a total of 920 TON or 484 CY using a conversion factor of 1.9 TON x CY according Thomas Glover Pocket Guide. According with design specifications 920 TON would be equivalent to: 607 TON (319 CY) of Asphalt binder course, 4 inches thick. Cost estimate: 607 TON x $ 77.50 /TON, RS Means Cost Code 32 12 1613 0813 = $ 47,043 313 TON (165 CY) of Asphalt Surface course, 2 inches thick. Cost estimate: 313 TON x $ 88.50 /TON, RS Means Cost Code 32 12 1613 0852 = $ 27,701 Total HMP costs = $74,743 (W/O CEF factors).	8-24-16 Requested mitigation opportunities for the possible asphalting of the gravel parking lots in this PW was discussed with the PA Group Supervisor and the applicant. A preliminary analysis of the cost effectiveness of this mitigation method by the Mitigation TFL resulted in a determinination that the mitigation would be over 300% of the repair in kind costs for the requested sites, and not cost effective. An HMP was not developed. If there are past damages that would support a BCA, to further determine cost effectiveness, a BCA can be developed. No documentation has been provided by the applicant at this time. D Gearman -- Pending define details related to specific location of the areas to be mitigated. Mitigation Costs have been included in the CEF spreadsheet (attached), subject to approval of the Mitigation team reviewers. This Mitigation is pending revision and approval by FEMA 406 HM Division.
4250-559	SHELL KNOB SPECIAL ROAD DISTRICT #9	009-U9KH0-00	559	C - Roads and Bridges	Yes		No	N/A				No	No	Applicant (Merl Haubein - Shell Knob) has requested a permit from the USACE to raise the road. They are interested in pursuing a mitigation proposal once they have their permit. They feel they have enough historical damages and commercial impact for a BCA to be cost effective. They have been informed of the documentation requirements they will have to provide for a BCA analysis to be done (Detailed SOW, historical damages, commercial impact etc.). MLO 8-29-2016	Based on the pictures attached there are mitigation opportunities to be considered, but a scope of work for mitigation, from the applicant, is not included in the PW. Reviewed by: Luis F. Flores 406 specialist - 6/21/2016. Site1. 36.63551,-93.60694:Pre-DR replacement 70LF of rock blanket. Site2. 36.63627, -93.60385 Pre-DR replacement 95LF of rock blanket. Site3. 36.63642, -93.60703: Pre-DR replacement 50LF of rock blanket. The pre-disaster rock blanket replacement will provide erosion control measure. ~tswank08/23/2016 (response to email received 08232016).
4250-619	ST. PETERS	183-65126-00	619	G - Recreational or Other	Yes		No	N/A				No	No		
4250-660	REYNOLDS (COUNTY)	179-99179-00	660	C - Roads and Bridges	Yes		No	N/A				No	No		
4250-665	PULASKI (COUNTY)	169-99169-00	665	B - Protective Measures	Yes	$0.00						No	No		
4317-102	MCCORD BEND	209-44829-00	102	C - Roads and Bridges	Yes		No	N/A				No	No		
4317-103	BARNETT SPECIAL ROAD DISTRICT	141-UQDA6-00	103	C - Roads and Bridges	Yes		No	N/A				No	No		
4317-109	OSAGE (COUNTY)	151-99151-00	109	C - Roads and Bridges	Yes		No	N/A				No	No		
4317-112	VAN BUREN	035-75580-00	112	F - Public Utilities	Yes		No	N/A				No	No		
4317-116	VAN BUREN	035-75580-00	116	C - Roads and Bridges	Yes		No	N/A				No	No		
4317-129	REEDS SPRING	209-61112-00	129	C - Roads and Bridges	Yes		No	N/A				No	No		
4317-144	PHELPS (COUNTY)	161-99161-00	144	C - Roads and Bridges	Yes		No	N/A				No	No		
4317-145	JORDAN SPECIAL ROAD DISTRICT	181-U0OOS-00	145	C - Roads and Bridges	Yes		No	N/A				No	No		
4317-155	TANEY COUNTY REGIONAL SEWER	213-0AB03-00	155	C - Roads and Bridges	Yes		No	N/A				No	No		Damage #6944
4317-156	CO-MO ELECTRIC COOPERATIVE, INC.	000-UP2PK-00	156	F - Public Utilities	Yes		No	N/A				No	No		
4317-157	DONIPHAN	181-19792-00	157	A - Debris Removal	Yes	$0.00						No	No		
4317-16	GREASY CREEK ROAD DISTRICT #35	009-UZN0A-00	16	C - Roads and Bridges	Yes		No	N/A				No	No		
4317-163	DONIPHAN	181-19792-00	163	A - Debris Removal	Yes	$0.00						No	No		
4317-167	HOLCOMB (TOWNSHIP OF)	069-32554-00	167	E - Public Buildings	Yes		No	N/A				No	No		
4317-179	WRIGHT COUNTY ROAD & BRIDGE	229-02E74-00	179	C - Roads and Bridges	Yes	$0.00	No	N/A				No	No		
4317-197	WRIGHT COUNTY ROAD & BRIDGE	229-02E74-00	197	C - Roads and Bridges	Yes		No	N/A				No	No		
4317-199	PINEY (TOWNSHIP OF)	215-57890-00	199	C - Roads and Bridges	Yes	$0.00	No	N/A				No	No	This project was declared to be an improved project by the applicant so no mitigation was needed or requested. Verbal discussion with the PDMG.	
4317-204	CRANE	209-17074-00	204	A - Debris Removal	Yes	$0.00						No	No		
4317-21	NEOSHO SPECIAL ROAD DISTRICT	145-UV1GG-00	21	C - Roads and Bridges	Yes		No	N/A				No	No		
4317-210	PHELPS (COUNTY)	161-99161-00	210	C - Roads and Bridges	Yes		No	N/A				No	No		
4317-212	GALENA	209-26254-00	212	E - Public Buildings	Yes		No	N/A				No	No		
4317-218	BULL CREEK	213-09642-00	218	E - Public Buildings	Yes		No	N/A				No	No		
4317-225	CHRISTIAN (COUNTY)	043-99043-00	225	C - Roads and Bridges	Yes		No	N/A				No	No		
4317-247	PACIFIC	071-55910-00	247	G - Recreational or Other	Yes		No	N/A				No	No		
4317-248	PUBLIC WATER SUPPLY DISTRICT #6. OF JEFFERSON CO.	099-UC9NG-00	248	F - Public Utilities	Yes		No	N/A				No	No		
4317-249	PINEY (TOWNSHIP OF)	215-57890-00	249	C - Roads and Bridges	Yes		No	N/A				No	No		
4317-259	SUGAR CREEK ROAD DISTRICT	009-UBO5N-00	259	C - Roads and Bridges	Yes		No	N/A				No	No		Added mitigation Ratios cost data. D.Leifheit, CRC Mitigation Liaison, 11-08-2017.
4317-264	STEELVILLE	055-70576-00	264	F - Public Utilities	Yes		No	N/A				No	No		
4317-275	STEELVILLE	055-70576-00	275	C - Roads and Bridges	Yes		No	N/A				No	No		
4317-28	BARNETT SPECIAL ROAD DISTRICT	141-UQDA6-00	28	C - Roads and Bridges	Yes		No	N/A				No	No		
4317-281	STEELVILLE	055-70576-00	281	C - Roads and Bridges	Yes		No	N/A				No	No		

Disaster Number and Unique ID	Applicant Name	Applicant ID	PW #	Damage Category	Hazard Mitigation (Does the Applicant have a HM proposal or would like technical assistance with one?)	PA Mitigation Proposal Amount (Estimated 406 HM cost)	Mitigation Activity Status (Was there mitigation activity on any site in this PW?)	Mitigation Type	Was this Mitigation Policy applied to this project? List Policy	Fifteen Percent Policy	BC Policy	Codes And Standards	Construction Practices	Mitigation Proposal Scope of Work	Mitigation Comments
4317-289	ELLINGTON	179-21844-00	289	F - Public Utilities	Yes		No	N/A				No	No		
4317-299	ELLINGTON	179-21844-00	299	C - Roads and Bridges	Yes		No	N/A				No	No		
4317-303	BOONE (COUNTY)	019-99019-01	303	C - Roads and Bridges	Yes		No	N/A				No	No		
4317-325	MCDONALD COUNTY R-1 SCHOOL DISTRICT	119-UMP9N-00	325	E - Public Buildings	Yes		No	N/A				No	No		
4317-326	HOLCOMB (TOWNSHIP OF)	069-32554-00	326	C - Roads and Bridges	Yes	$0.00	No	N/A				No	No		
4317-330	CRANE	209-17074-00	330	F - Public Utilities	Yes		No	N/A				No	No		
4317-332	DONIPHAN	181-19792-00	332	B - Protective Measures	Yes	$0.00						No	No		
4317-340	PINEY (TOWNSHIP OF)	215-57890-00	340	C - Roads and Bridges	Yes		No	N/A				No	No		
4317-360	WHEATON SPECIAL ROAD DISTRICT # 29	009-U33QT-00	360	C - Roads and Bridges	Yes	$0.00	No	N/A				No	No		
4317-362	SENECA	145-66674-00	362	C - Roads and Bridges	Yes		No	N/A				No	No		
4317-363	OZARK (COUNTY)	153-99153-00	363	C - Roads and Bridges	Yes		No	N/A				No	No		
4317-371	GREEN BENEFIT SPECIAL ROAD DISTRICT	109-UHION-00	371	C - Roads and Bridges	Yes	$0.00	No	N/A				No	No		
4317-376	SEYMOUR SPECIAL ROAD DISTRICT	225-UIN7G-00	376	C - Roads and Bridges	Yes		No	N/A				No	No		
4317-383	REYNOLDS (COUNTY)	179-99179-00	383	C - Roads and Bridges	Yes		No	N/A				No	No		
4317-388	ELEVEN POINT RURAL FIRE ASSOCIATION	091-UX3LX-00	388	E - Public Buildings	Yes		No	N/A				No	No		
4317-422	PUBLIC WATER DISTRICT #2 OF JEFFERSON COUNTY	099-UHK3E-00	422	F - Public Utilities	Yes		No	N/A				No	No		
4317-424	VAN BUREN	035-75580-00	424	E - Public Buildings	Yes		No	N/A				No	No	Email from applicant stating no mitigation proposed for this site. David Pradell 12/8/2017	
4317-432	SOUTH GREENFIELD (RR NAME GREENFIELD (STA.))	057-68888-00	432	C - Roads and Bridges	Yes		No	N/A				No	No		
4317-436	COLUMBIA	019-15670-00	436	G - Recreational or Other	Yes		No	N/A				No	No		
4317-441	CRAWFORD (COUNTY)	055-99055-00	441	C - Roads and Bridges	Yes		No	N/A				No	No		
4317-442	STEELVILLE	055-70576-00	442	D - Water Control Facilities	Yes		No	N/A				No	No		
4317-445	OZARK (TOWNSHIP OF)	215-55820-00	445	C - Roads and Bridges	Yes		No	N/A				No	No		
4317-460	MILL SPRING	223-48386-00	460	C - Roads and Bridges	Yes		No	N/A				No	No		
4317-465	EUREKA	189-22834-00	465	F - Public Utilities	Yes		No	N/A				No	No		
4317-469	OZARK	043-55766-00	469	C - Roads and Bridges	Yes		No	N/A				No	No		
4317-480	WEBSTER (COUNTY)	225-99225-00	480	C - Roads and Bridges	Yes		No	N/A				No	No	Work completed on gravel roads returning them to predisaster conditions with no mitigation required by applicant. David Pradell 11/15/2017	
4317-484	RIPLEY (COUNTY)	181-99181-00	484	C - Roads and Bridges	Yes		No	N/A				No	No		
4317-487	CEDAR (COUNTY)	039-99039-00	487	C - Roads and Bridges	Yes		No	N/A				No	No		
4317-515	NOEL	119-52742-00	515	C - Roads and Bridges	Yes		No	N/A				No	No		
4317-527	CRAWFORD ELECTRIC COOPERATIVE, INC.	000-UNKYQ-00	527	F - Public Utilities	Yes		No	N/A				No	No		
4317-528	THREE RIVERS ELECTRIC COOPERATIVE	000-UL3I4-00	528	F - Public Utilities	Yes	$0.00	No	N/A				No	No		
4317-530	GREENVILLE	223-29476-00	530	G - Recreational or Other	Yes		No	N/A				No	No		
4317-541	PUBLIC WATER DISTRICT #2 OF JEFFERSON COUNTY	099-UHK3E-00	541	F - Public Utilities	Yes		No	N/A				No	No		
4317-546	MARSHFIELD	225-46388-00	546	D - Water Control Facilities	Yes		No	N/A				No	No		
4317-581	ASSOCIATED ELECTRIC COOPERATIVE, INC.	000-UOXN4-00	581	F - Public Utilities	Yes	$0.00	No	N/A				No	No		
4317-59	CORSICANA SPECIAL ROAD DISTRICT #16	009-U5CN9-00	59	C - Roads and Bridges	Yes		No	N/A				No	No	(SITE #1): Address CR 1040/ GPS Coordinates: Latitude: 36.79449/ Longitude: -93.99537 (I) Damages Description & Dimensions (DDD): During the event of April and May 2017, heavy rains caused flooding of County Road 1040 and washed out 1000 FT of the road and deposited gravel into an adjacent field. PW total cost of damage elements for this site is $8,239.27 (II) Hazard Mitigation Proposal (HMP) Scope of Work: In order to prevent future damage to this road, the Applicant proposes to install a 24 IN x 28 FT CMP metal culvert and raise the road 2 FT in height. Scope of Work: Mobilization: 1 each @ $500.00 = $500.00. Embankment fill and compaction: 1210 CY @ $15.00 per cubic yard = $18,150.00. 5 IN Aggregate road surface: 1800 SY @ $14.00 per square yard = $25,200.00. Moveable barricades: 2 EA @ $100.00 per barricade =- $200.00. Construction signs: 2 EA @ $100.00 per sign = $200.00. 24 IN x 28 FT CMP furnish and install = 1 each @ $1,680.00 = $1,680.00. Engineering standard details = 1 @ $5,500.00 = $5,500.00. Construction assistance = 1 @ $670.00 = $670.00. (All mitigation costs from Great River Engineering estimate). Net mitigation cost = $52,100.00 (III) Hazard Mitigation Ratio (HMR): HMR= (Total Hazard Mitigation Cost/PW Total Cost of Damage Elements) X 100 HMR = $52,100.00/$8,239.27 = 632.34% (IV) HMP Feasibility and Cost-Effectiveness: This Hazard Mitigation Proposal is 632.34% of the repair and restoration cost. This Hazard Mitigation Proposal is considered to be not cost effective under the 100% Rule, PAPPG FP-104-009-2/April, 2017, and Appendix J, General, Section 1, Erosion Conrol. However, if more information is provided, a BCA can be developed to futther dtermine cost effectiveness. (V) Compliances and Assurances The applicant is responsible for permits and compliance with all regulatory codes and standards of the state of Missouri and the final design and choice of the contractors and vendors. The final design must be certified by a registered Professional Engineer/Architect per 44CFR60.3. FEMA will not pay for duplication in cost between repairs and mitigation measures. FEMA will pay only the incremental	HMP Revision on 10-10-2017 identifies two sites that are not cost effective under the 100 percent rule. D.Leifheit, 11-3-2017
4317-590	RAYMONDVILLE	215-60734-00	590	C - Roads and Bridges	Yes		No	N/A				No	No		
4317-591	BURDINE (TOWNSHIP OF)	215-09766-00	591	C - Roads and Bridges	Yes		No	N/A				No	No		
4317-60	SADDLEBROOKE, VILLAGE OF	043-UKGR2-00	60	C - Roads and Bridges	Yes		No	N/A				No	No		
4317-605	RIPLEY (COUNTY)	181-99181-00	605	C - Roads and Bridges	Yes		No	N/A				No	No		
4317-622	CEDAR (COUNTY)	039-99039-00	622	C - Roads and Bridges	Yes	$0.00	No	N/A				No	No		
4317-63	OZARK FIRE PROTECTION DISTRICT	043-UFU8I-00	63	E - Public Buildings	Yes		No	N/A				No	No		
4317-631	WAYNE (COUNTY)	223-99223-00	631	C - Roads and Bridges	Yes		No	N/A				No	No		
4317-637	CRAWFORD ELECTRIC COOPERATIVE, INC.	000-UNKYQ-00	637	F - Public Utilities	Yes		No	N/A				No	No		
4317-64	SENECA SPECIAL ROAD DISTRICT	145-USS4Y-00	64	C - Roads and Bridges	Yes		No	N/A				No	No		
4317-642	CASS (TOWNSHIP OF)	215-11854-00	642	C - Roads and Bridges	Yes		No	N/A				No	No	At this site the roads and ditches were returned to predisaster conditions and the applicant did not apply for mitigation.David Pradell 11/17/2017	

Disaster Number and Unique ID	Applicant Name	Applicant ID	PW #	Damage Category	Hazard Mitigation (Does the Applicant have a HM proposal or would like technical assistance with one?)	PA Mitigation Proposal Amount (Estimated 406 HM cost)	Mitigation Activity Status (Was there mitigation activity on any site in this PW?)	Mitigation Type	Was this Mitigation Policy applied to this project? List Policy	Fifteen Percent Policy	BC Policy	Codes And Standards	Construction Practices	Mitigation Proposal Scope of Work	Mitigation Comments
4317-649	WHITE RIVER VALLEY ELECTRIC COOP, INC.	000-U5RQL-00	649	F - Public Utilities	Yes		No	N/A				No	No		11/21/2017 ¿ Applicant does not want mitigation at this time even though it was suggested to the applicant in earlier discussions and referenced in the PW. At the applicant¿s request, the damages will be returned to pre-disaster condition (see attached email). eyaun
4317-651	CRAWFORD ELECTRIC COOPERATIVE, INC.	000-UNKYQ-00	651	F - Public Utilities	Yes	$0.00	No	N/A				No	No		
4317-653	PIEDMONT	223-57422-00	653	C - Roads and Bridges	Yes		No	N/A				No	No		
4317-675	CABOOL	215-10288-00	675	C - Roads and Bridges	Yes		No	N/A				No	No		
4317-702	RIPLEY (COUNTY)	181-99181-00	702	C - Roads and Bridges	Yes		No	N/A				No	No		
4317-71	BARRY (COUNTY)	009-99009-00	71	C - Roads and Bridges	Yes		No	N/A				No	No	An HMP is attached detailing that the proposed mitigation is not cost effective.	
4317-711	MILLER (COUNTY)	131-99131-00	711	C - Roads and Bridges	Yes		No	N/A				No	No		
4317-721	SHANNON (COUNTY)	203-99203-00	721	C - Roads and Bridges	Yes		No	N/A				No	No	Applicant does not ask for mitigation, only to return to predisaster conditions. David Pradell 11/24/2017	
4317-732	REYNOLDS (COUNTY)	179-99179-00	732	C - Roads and Bridges	Yes		No	N/A				No	No		
4317-745	STE. GENEVIEVE (COUNTY)	186-99186-00	745	C - Roads and Bridges	Yes	$0.00	No	N/A				No	No		
4317-752	PUBLIC WATER DISTRICT #2 OF JEFFERSON COUNTY	099-UHK3E-00	752	F - Public Utilities	Yes	$0.00	No	N/A				No	No		
4317-754	DOUGLAS (COUNTY)	067-99067-00	754	C - Roads and Bridges	Yes		No	N/A				No	No	See email from PDMS stating that applicant had costs included in SOW and did not apply for mitigation.	
4317-755	SHANNON (COUNTY)	203-99203-00	755	C - Roads and Bridges	Yes		No	N/A				No	No	The applicant has decided they do not want mitigation for this project, according to the PDMG. David Pradell 11/292017	
4317-763	BRANSON	213-07966-00	763	G - Recreational or Other	Yes		No	N/A				No	No	As per an email from the PDMG, the applicant is no longer seeking mitigation but returning to pre disaster conditions. 11/30/17David Pradell	
4317-778	PINEVILLE	119-57818-00	778	G - Recreational or Other	Yes		No	N/A				No	No		
4317-783	RIPLEY (COUNTY)	181-99181-00	783	C - Roads and Bridges	Yes		No	N/A				No	No	Email from PDMG stating that applicant no longer wants mitigation for this project. David Pradell 12/6/2017	
4317-785	RIPLEY (COUNTY)	181-99181-00	785	C - Roads and Bridges	Yes	$0.00	No	N/A				No	No		
4317-791	DOUGLAS (COUNTY)	067-99067-00	791	C - Roads and Bridges	Yes		No	N/A				No	No	As per the email from the PDMG, the applicant is not requesting mitigation for this project and no final HMP will be needed.	
4317-795	BYRNES MILL	099-10240-00	795	C - Roads and Bridges	Yes		No	N/A				No	No		
4317-796	BRANSON	213-07966-00	796	C - Roads and Bridges	Yes		No	N/A				No	No	Email from PDMG stating that applicant has not submitted an HM Proposal but used a force account estimate to repair the site. David Pradell 12/7/2017	
4317-799	BURDINE (TOWNSHIP OF)	215-09766-00	799	C - Roads and Bridges	Yes		No	N/A				No	No		
4317-80	BAGNELL SPECIAL ROAD DISTRICT	131-UI4FN-00	80	C - Roads and Bridges	Yes		No	N/A				No	No		
4317-801	SHANNON (COUNTY)	203-99203-00	801	C - Roads and Bridges	Yes	$0.00	No	N/A				No	No	Email from PDMG stating that the work was repair and restore and no mitigation requested by applicant. David Pradell 12/15/2017 According to FEMA Consolidated Resource Center (CRC), the process to repair site at the CR 390 low water crossing (LWC) ¿ DI #8049, concrete walls and footing under the girder in which will become a toe wall will be funded under the Public Assistance (PA) program (for reference see ¿SP1701-Cost Est-2262018.xls¿ under ¿DOCUMENTS¿). Mitigation is not expected to be performed at this site nor any other sites within project #1701. E Wong 03/20/2018	
4317-802	WHITE RIVER VALLEY ELECTRIC COOP, INC.	000-U5RQL-00	802	F - Public Utilities	Yes	$0.00	No	N/A				No	No		
4317-805	EMINENCE	203-22276-00	805	F - Public Utilities	Yes		No	N/A				No	No		
4317-809	WAYNE (COUNTY)	223-99223-00	809	C - Roads and Bridges	Yes		No	N/A				No	No		
4317-825	HOWELL (COUNTY)	091-99091-00	825	C - Roads and Bridges	Yes	$0.00	No	N/A				No	No	Under the 50% Rule, the bridge will be replaced, not repaired. No mitigation opportunities for this project are listed in the SOW. David Pradell 2/22/2018	
4317-829	WEST PLAINS	091-78928-00	829	A - Debris Removal	Yes	$0.00						No	No		
4317-834	LOUISIANA	163-44174-00	834	C - Roads and Bridges	Yes		No	N/A				No	No		
4317-837	CARTER (COUNTY)	035-99035-00	837	E - Public Buildings	Yes		No	N/A				No	No	4/12/2018 ¿ Mitigation is no longer proposed for this project due to the historic nature of the courthouse. Per PA, the project will now be restored to pre-disaster condition. eyaun	4/12/2018 ¿ Mitigation is no longer proposed for this project due to the historic nature of the courthouse. Per PA, the project will now be restored to pre-disaster condition. eyaun
4317-862	LOUISIANA	163-44174-00	862	F - Public Utilities	Yes		No	N/A				No	No		
4317-863	MADISON (COUNTY)	123-99123-00	863	C - Roads and Bridges	Yes		No	N/A				No	No	Gravel roads, most work completed, mitigation not requested. David Pradell 1/26/2018	
4317-864	KIMMSWICK	099-38684-00	864	G - Recreational or Other	Yes		No	N/A				No	No		
4317-866	LOUISIANA	163-44174-00	866	D - Water Control Facilities	Yes		No	N/A				No	No	There is no mitigation in the DDD or the SOW and noted on 2/5/2018 work on the wall is completed. David Pradell 2/6/2018	
4317-88	REEDS SPRING	209-61112-00	88	C - Roads and Bridges	Yes		No	N/A				No	No		
4317-893	PULASKI (COUNTY)	169-99169-00	893	C - Roads and Bridges	Yes		No	N/A				No	No		
4317-902	ST. LOUIS (COUNTY)	189-99189-00	902	G - Recreational or Other	Yes	$0.00	No	N/A				No	No		
4317-905	COLUMBIA	019-15670-00	905	C - Roads and Bridges	Yes		No	N/A				No	No		
4317-911	METROPOLITAN ST. LOUIS SEWER DISTRICT (MSD)	189-UZX01-00	911	B - Protective Measures	Unsure	$0.00						No	No		
4317-92	SPARTA	043-69302-00	92	F - Public Utilities	Yes		No	N/A				No	No		
4317-920	DOUGLAS (COUNTY)	067-99067-00	920	C - Roads and Bridges	Yes		No	N/A				No	No	The applicant repaired and restored the road to pre disaster conditions and no mitigation was requested. David Pradell 2/7/2018	
4317-959	MO. DEPT. OF NATURAL RESOURCES	000-UB2M9-00	959	B - Protective Measures	Unsure	$0.00						No	No		
4317-976	GRANBY	145-28108-00	976	C - Roads and Bridges	Yes							No	No		
4317-981	METROPOLITAN ST. LOUIS SEWER DISTRICT (MSD)	189-UZX01-00	981	F - Public Utilities	Yes							No	No		
4317-983	TANEY (COUNTY)	213-99213-00	983	C - Roads and Bridges	Yes							No	No		
4317-985	LOUISIANA	163-44174-00	985	B - Protective Measures	Yes	$0.00						No	No		
4317-986	ST. ROBERT	169-65144-00	986	F - Public Utilities	Yes		No	N/A				No	No	Project sent back to CRC. Developmental Guide #4 states that FEMA will write the HMP Scope of Work; however, there is no true mitigation on this project as this is a relocation for the WWTP.	
4317-995	MISSOURI DEPARTMENT OF CONSERVATION	000-UIALD-00	995	G - Recreational or Other	Yes		No	N/A				No	No	Email from PDMG states no mitigaiton for this site to relocate the road.	
4317-996	DOUGLAS (COUNTY)	067-99067-00	996	C - Roads and Bridges	Yes		No	N/A				No	No	Email from PFMG states if they want mitigation in the future to apply to SEMA	