3 RISK ASSESSMENT

The risk assessment process identifies and profiles relevant hazards and assesses the effects of exposure to these hazards on the lives, property, and infrastructure of Montgomery County residents. The process allows Montgomery County and its communities to better understand the potential risk from natural and manmade hazards and it provides a framework for developing and prioritizing mitigation actions to further reduce risk from future hazard events should they occur.

The risk assessment for Montgomery County and its jurisdictions followed the methodology described in the Local Mitigation Planning Handbook (March 2013).

This section is further divided into four parts; Hazard Identification, Assets at Risk, Land Use and Development, and Vulnerability Assessment.

Section 3.1 Hazard Identification identifies the hazards that threaten the planning area and provides a factual basis for elimination of hazards from further consideration;

Section 3.2 Assets at Risk provides the planning area's total exposure to natural hazards, considering critical facilities and other community assets at risk;

Section 3.3 Land Use and Development discusses development that has occurred since the last plan update and any increased or decreased risk that resulted. This section also discusses areas of planned future development and any implications on risk/vulnerability;

Section 3.4 Hazard Profiles and Vulnerability Analysis provides more detailed information about the hazards impacting the planning area. For each hazard, there are three sections: 1) Hazard Profile provides a general description and discusses the threat to the planning area, the geographic location at risk, potential Strength/Magnitude/Extent, previous occurrences of hazard events, probability of future occurrence, risk summary by jurisdiction, impact of future development on the risk; 2) Vulnerability Assessment further defines and quantifies populations, buildings, critical facilities, and other community/school or special district assets at risk to natural hazards; and 3) Problem Statement briefly summarizes the problem and develops possible solutions.

3.1 HAZARD IDENTIFICATION

The Montgomery County Emergency Management Director, along with members of the MPC and the Boonslick Regional Planning Commission, reviewed existing mitigation plans, researched historical disaster declaration records, and surveyed various other sources, including anecdotal information, to fairly identify hazards to be included in this plan.

3.1.1 Review of Existing Mitigation Plans

The MPC reviewed the hazards identified in the previously approved plan from 2015, as well as the hazards identified in the most recent State Plan. There were no significant differences between the lists of hazards included in the previously approved plan and this plan update. The Montgomery County plan differs from a typical Natural Hazard Mitigation plan in that it includes some manmade hazards.

Missouri requires only natural hazards to be included in county plans because federal regulations do not require manmade hazards to be included. However, as discussed above, the MPC determined some manmade hazards should be included; specifically, hazards relating to Terrorism, Transportation, Utility Disruption, and Hazardous Material Spills. These hazards were included as they are significant risks for Montgomery County due to its proximity to a nuclear power plant and several major railroads and highways bisecting the county.

3.1.2 Review Disaster Declaration History

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

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

The following table lists FEMA disaster declarations made since 1965 that include Montgomery County.

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

Disaster Number	Description	Declaration Date Incident Period	Individual Assistance (IA) Public Assistance (PA)
372	Heavy rains, tornadoes, and flooding	4/19/1973	IA, PA
407	Severe storms and flooding	11/1/1973	IA, PA
3017	Drought	9/24/1976	IA, PA

Disaster Number	Description	Declaration Date Incident Period	Individual Assistance (IA) Public Assistance (PA)
779	Severe storms and flooding	10/14/1986	IA, PA
995	Severe storms and flooding	7/9/1973	IA, PA
1054	Severe storms, tornadoes, hail, and flooding	6/2/1995	IA, PA
1463	Severe storms, tornadoes, and flooding	5/6/2003	IA
1631	Severe storms, tornadoes, and flooding	3/16/2006	IA, PA
1676	Severe winter storms and flooding	1/15/2007	PA
1736	Severe winter storms	12/27/2007	PA
3281	Severe winter storms	12/12/2007	PA
1809	Severe winter storms, flooding, and tornado	11/03/2008	IA, PA
1749	Severe storms and flooding	3/19/2008	PA
3303	Severe winter storm	1/30/2009	PA
3317	Severe winter storm	2/3/2011	PA
3325	Flooding	6/30/2011	PA
1961	Severe winter storm and snow storm	3/23/2011	PA
4130	Severe storms, tornadoes, straight-line winds, and flooding	7/18/2013	PA
4238	Severe storms, tornadoes, straight-line winds, and flooding	8/7/2015	PA
3374	Severe storms, tornadoes, straight-line winds, and flooding	1/2/2016	PA

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

3.1.3 Research Additional Sources

The following additional data sources were also consulted during the completion of this plan.

- Missouri Hazard Mitigation Plans (2013 and 2018)
- Previously approved planning area Hazard Mitigation Plan (2015)
- Federal Emergency Management Agency (FEMA)
- Missouri Department of Natural Resources
- National Drought Mitigation Center Drought Reporter
- US Department of Agriculture's (USDA) Risk Management Agency Crop Insurance Statistics
- National Agricultural Statistics Service (Agriculture production/losses)
- Data Collection Questionnaires completed by each jurisdiction
- State of Missouri GIS data
- Environmental Protection Agency
- Flood Insurance Administration

- Hazards US (Hazus)
- Missouri Department of Transportation
- Missouri Division of Fire Marshal Safety
- Missouri Public Service Commission
- National Fire Incident Reporting System (NFIRS)
- National Oceanic and Atmospheric Administration's (NOAA) National Centers for Environmental Information (NCEI);
- County and local Comprehensive Plans to the extent available
- County Emergency Management
- County Flood Insurance Rate Map, FEMA
- Flood Insurance Study, FEMA
- SILVIS Lab, Department of Forest Ecology and Management, University of Wisconsin
- U.S. Army Corps of Engineers
- U.S. Department of Transportation
- United States Geological Survey (USGS)
- Various articles and publications available on the internet (appropriate citations are provided in the plan)

The only centralized source of data for many of the weather-related hazards is the National Oceanic and Atmospheric Administration's (NOAA) National Centers for Environmental Information (NCEI). Although it is usually the best and most current source, there are limitations to the data which should be noted. The NCEI documents the occurrence of storms and other significant weather phenomena having sufficient intensity to cause loss of life, injuries, significant property damage, and/or disruption to commerce. In addition, it is a partial record of other significant meteorological events, such as record maximum or minimum temperatures or precipitation that occurs in connection with another event. Some information appearing in the NCEI may be provided by or gathered from sources outside the National Weather Service (NWS), such as the media, law enforcement and/or other government agencies, private companies, individuals, etc. An effort is made to use the best available information but because of time and resource constraints, information from these sources may be unverified by the NWS. Those using information from NCEI should be cautious as the NWS does not guarantee the accuracy or validity of the information.

The NCEI damage amounts are estimates received from a variety of sources, including those listed above in the Data Sources section. For damage amounts, the NWS makes a best guess using all available data at the time of the publication. Property and crop damage figures should be considered as a broad estimate. Damages reported are in dollar values as they existed at the time of the storm event. They do not represent current dollar values.

The database currently contains data from January 1950 to March 2014, as entered by the NWS. Due to changes in the data collection and processing procedures over time, there are unique periods of record available depending on the event type. The following timelines show the different time spans for each period of unique data collection and processing procedures.

1. Tornado: From 1950 through 1954, only tornado events were recorded.
2. Tornado, Thunderstorm Wind and Hail: From 1955 through 1992, only tornado, thunderstorm wind and hail events were keyed from the paper publications into digital data. From 1993 to 1995, only tornado, thunderstorm wind and hail events have been extracted from the Unformatted Text Files.
3. All Event Types (48 from Directive 10-1605): From 1996 to present, 48 event types are

recorded as defined in NWS Directive 10-1605.

Note that injuries and deaths caused by a storm event are reported on an area-wide basis. When reviewing a table resulting from an NCEI search by county, the death or injury listed in connection with that county search did not necessarily occur in that county.

3.1.4 Hazards Identified

The table below lists in alphabetical order the hazards that significantly impact Montgomery County that were chosen by the MPC for further analysis. Not all hazards impact every jurisdiction. An “X” in the table column indicates the jurisdiction is impacted by the hazard, and an empty cell indicates the hazard is not applicable to that jurisdiction, Each of the hazards listed have an equal likelihood of occurrence throughout the county and its communities, with the exception of dam failure, flooding, and levee failure which by natural are located in low-lying areas downstream from dams, levees, and rivers.

Table 3.2. Hazards Identified for Each Jurisdiction

Jurisdiction	Dam Failure	Drought	Earthquake	Extreme Temperatures	Flooding (River and Flash)	Hazardous Materials Release	Land Subsidence/Sinkholes	Levee Failure	Radiation Release	Severe Winter Weather	Terrorism	Thunderstorm/Lightning/Hail/High Wind	Tornado	Utility Interruptions	Wildfire
Montgomery County	x	x	x	x	x	X	x	x	X	x	X	x	x	X	x
Municipalities															
Bellflower		x	x	x		x			x	x	x	x	x	x	x
High Hill		x	x	x		x			x	x	x	x	x	x	x
Jonesburg		x	x	x		x			x	x	x	x	x	x	x
Middletown		x	x	x		x			x	x	x	x	x	x	x
Montgomery City		x	x	x		x			x	x	x	x	x	x	x
New Florence		x	x	x		x			x	x	x	x	x	x	x
Wellsville		x	x	x		x			x	x	x	x	x	x	x
McKittrick		x	x	x	x	x		x	x	x	x	x	x	x	x
Rhineland		x	x	x	x	x		x	x	x	x	x	x	x	x
Schools and Special Districts															
Gasconade County R-I School		x	x	x	x	x			x	x	x	x	x	x	x
Montgomery County R-II		x	x	x		x			x	x	x	x	x	x	x
Wellsville-Middletown R-I		x	x	x		x			x	x	x	x	x	x	x

3.1.5 Multi-Jurisdictional Risk Assessment

For this multi-jurisdictional plan, the risk assessment assesses each jurisdiction's risk where they deviate from risk's facing the entire county. Montgomery County is not geographically large at 537 square miles, and is fairly uniform in terms of climate and topography, as well as construction characteristics and development trends. Accordingly, overall hazards and vulnerability do not vary greatly across the planning area.

This is an update to the June 2015 plan. Hazards added since the last update will be noted as such. For this update, all hazards were assessed on a county-wide basis, except as noted. Some hazards, like flooding, vary in risk across the planning area. Those variations were discussed by the MPC and included in the profile where appropriate. The hazards that vary across the planning area, in terms of risk, are dam failure, flash flood, levee failure, and floods.

The county is essentially rural with more densely populated areas in and around Montgomery City, Wellsville, and Jonesburg. All of these communities have school attendance centers within their boundaries. Jonesburg, High Hill, New Florence, and Bellflower are situated near Interstate 70 and along a major railroad. Row crops and silage across the county are susceptible to drought, floods, hail, and high winds. Livestock is not as big a concern but ranching is adversely affected by flooding, drought, and extremes of heat and cold. Where appropriate, these extremes will be explained in greater detail in the vulnerability sections of each hazard.

Each hazard identified in Section 3.1, Hazard Identification, is profiled individually in this section in alphabetical order for easier reference. The level of information presented in the profiles varies by hazard based on the information available. With each update of this plan, new information will be incorporated to provide for better evaluation and prioritization of the hazards that affect Montgomery County.

The sources used to collect information for these profiles include those mentioned in Section 3.1.3. and those cited individually in each hazard section. Detailed profiles for each of the identified hazards include information on the following characteristics of the hazard.

Hazard Description

This section consists of a general description of the hazard and the types of impacts it may have on a community. It also includes a ranking to indicate typical warning times and duration of hazard events.

Historical Statistics

This section describes the geographic extent or location of the hazard in the planning area and includes the information on historic incidents and their impacts based upon the sources described in Section 3.1.4, Hazard Identification and the information provided by the MPC. Where available, maps are utilized to indicate the areas of the planning region that are vulnerable to the subject hazard.

Probability of Future Occurrence

The frequency of past events is used to gauge the likelihood of future occurrences. Where possible, the probability and severity 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. The 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 10 percent chance of drought in any given year.

Magnitude of Severity

The magnitude of the impact of a hazard event (past and perceived) is related directly to the vulnerability of the people, property, and the environment it affects. This is a function of when the event occurs, the location affected, the resilience of the community, and the effectiveness of the emergency response and disaster recovery efforts.

3.2 ASSETS AT RISK

In this section of the plan, the Montgomery County population, structures, critical facilities and infrastructure and other important assets that may be at risk to hazards are assessed. There were no changes to the planning area since the previously approved plan was adopted.

Missouri Mitigation Viewer

With the 2018 Hazard Mitigation Plan Update, SEMA now provides online access to 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.

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
- https://drive.google.com/file/d/1bPkc0jgF9ofwQLnTL9N0u-oPFWi9hkst/view - User Guide

Assets at Risk available from the Mitigation Viewer include:

- State Owned Facilities
- State Leased Facilities
- Department of Higher Education Facilities
- State Owned Bridges

Flood Risk Datasets

Data sources include:

- FEMA Flood Insurance Rate Maps (FIRM)
  https://msc.fema.gov/portal/home
- FEMA National Flood Hazard Layer
  https://hazards.fema.gov/femaportal/wps/portal/NFHLWMS
- FEMA Hazus Program
  https://www.fema.gov/hazus
- 2010 US Census Population and Housing Unit Counts
  https://www.census.gov/geo/maps-data/data/tiger-data.html

3.2.1 Total Exposure of Population and Structures

For the 2018 State Plan, SEMA utilized a structure inventory dataset developed by the University of Missouri GIS Department (MSDIS) to determine the number of structures exposed to risks. 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. This dataset was utilized throughout this section.

Unincorporated County and Incorporated Cities

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

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

Table 3.3. Maximum Population and Building Exposure by Jurisdiction (times 1,000)

Jurisdiction	2017 Annual Population Estimate	Building Count	Building Exposure	Contents Exposure	Total Exposure
Montgomery County	11,438	13,290	$ 631,489	$ 391,985	$ 1,023,474
Bellflower	362	223	$ 40,510	$ 24,083	$ 64,593
High Hill	177	128	$ 60,833	$ 73,846	$ 134,679
Jonesburg	712	378	$ 78,400	$ 56,862	$ 135,262
McKittrick	56	38	$ 5,829	$ 3,399	$ 9,228
Middletown	151	133	$ 21,181	$ 12,043	$ 33,224
Montgomery City	2,654	1,337	$ 296,362	$ 192,258	$ 488,620
New Florence	713	359	$ 89,692	$ 71,693	$ 161,385

Jurisdiction	2017 Annual Population Estimate	Building Count	Building Exposure	Contents Exposure	Total Exposure
Rhineland	130	124	$ 12,778	$ 6,459	$ 19,237
Wellsville	1,142	630	$ 134,566	$ 86,219	$ 220,785
TOTALS	17,535	16,640	$ 1,371,640	$ 918,846	$ 2,290,486

Source: U.S. Bureau of the Census, Annual population estimates/ 5-Year American Community Survey 2015; Building Count and Building Exposure, Missouri GIS Database from SEMA Mitigation Management; Contents Exposure derived by applying multiplier to Building Exposure based on Hazus MH 2.1 standard contents multipliers per usage type as follows: Residential (50%), Commercial (100%), Industrial (150%), Agricultural (100%). For purposes of these calculations, government, school, and utility were calculated at the commercial contents rate

Table 3.4. Building Values/Exposure by Usage Type (times 1,000)

Jurisdiction	Agriculture	Commercial	Education	Government	Industrial	Residential	Total
Montgomery County	$ 25,230	$ 34,785	$ 15,746	$ 2,045	$ 37,338	$ 516,344	$ 631,488
Bellflower	$ 134	$ 7,521	$ -	$ -	$ -	$ 32,855	$ 40,510
High Hill	$ 41	$ 940	$ -	$ -	$ 42,939	$ 16,913	$ 60,833
Jonesburg	$ 220	$ 18,803	$ -	$ 1,364	$ 7,468	$ 50,546	$ 78,401
McKittrick	$ 29	$ 940	$ -	$ -	$ -	$ 4,860	$ 5,829
Middletown	$ 86	$ 2,820	$ -	$ -	$ -	$ 18,274	$ 21,180
Montgomery City	$ 402	$ 76,152	$ 2,054	$ 9,545	$ -	$ 208,209	$ 296,362
New Florence	$ 151	$ 21,623	$ 685	$ 1,364	$ 14,935	$ 50,934	$ 89,692
Rhineland	$ 141	$ -	$ -	$ -	$ -	$ 12,636	$ 12,777
Wellsville	$ 201	$ 29,145	$ 4,108	$ 682	$ 1,867	$ 98,564	$ 134,567
TOTALS	$ 26,635	$ 192,729	$ 22,593	$ 15,000	$ 104,547	$ 1,010,135	$ 1,371,639

Source: Missouri GIS Database, SEMA Mitigation Management Section

Table 3.5. Building Counts by Usage Type

Jurisdiction	Residential	Residential Outbuildings	Commercial	Education	Industry	Agriculture	Government	Total
Montgomery County	2,656	4,456	37	23	20	10,551	3	17,746
Bellflower	169	214	8	-	-	56	-	447
High Hill	87	110	1	-	23	17	-	238
Jonesburg	260	349	20	-	4	92	2	727
McKittrick	25	52	1	-	-	12	-	90
Middletown	94	125	3	-	-	36	-	258

Jurisdiction	Residential	Residential Outbuildings	Commercial	Education	Industry	Agriculture	Government	Total
Montgomery City	1,071	846	81	3	-	168	14	2,183
New Florence	262	289	23	1	8	63	2	648
Rhineland	65	44	-	-	-	59	-	168
Wellsville	507	388	31	6	1	84	1	1,018
TOTALS	5,196	6,873	205	33	56	11,138	22	23,501

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

School district assets are included in the tables above. However, more discrete school district data is provided below and was taken from the School District Data Collection Questionnaire, data provided by Missouri's Department of Elementary and Secondary Education (DESE) and district-maintained websites. The number of enrolled students at the participating public school districts is provided in **Table 3.6** below. Additional information includes the number of buildings, building exposure and contents exposure. These numbers will represent the total enrollment and building count for the public school districts regardless of the county in which they are located. No building exposure is provided for the Gasconade County R-I district because the district does not own nor lease property within Montgomery County.

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

Public School District	Enrollment	Building Count	Building Exposure	Contents Exposure	Total Exposure
Gasconade County R-I School District	955	11	$36,783,697.08	$8,774,748.69	$45,558,445.77
Montgomery County R-II School District	1,225	15	$44,379,404	$6,958,088	$51,337,492
Wellsville-Middletown R-I School District	374	2	not submitted	not submitted	$ -
TOTALS	2,554	12	$81,163,101.08	$15,732,836.69	$96,895,937.77

Source: http://mcds.dese.mo.gov/quickfacts/Pages/District-and-School-Information.aspx., The Building Exposure, Contents Exposure, and Total Exposure amounts come from the completed Data Collection Questionnaires from Public School Districts. In general, the school districts obtain this information from their insurance coverage amounts.

3.2.2 Critical and Essential Facilities and Infrastructure

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

- Critical Facility: Those facilities essential in providing utility or direction either during the response to an emergency or during the recovery operation.
- Essential Facility: Those facilities that if damaged, would have devastating impacts on disaster response and/or recovery.

- High Potential Loss Facilities: Those facilities that would have a high loss or impact on the community.
- Transportation and lifeline facilities: Those facilities and infrastructure critical to transportation, communications, and necessary utilities.

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

- Interviews with County Emergency Planning Director
- Interview with County Flood Plain Manager
- Interviews with City Government Employees
- Tribal Knowledge of Regional Planning Commission employees
- Tribal Knowledge of State Office of Homeland Security Region C Planner
- Chemical Facilities (Tier II Facilities) information
- Hazus

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

Jurisdiction	Airport Facility	Bus Facility	Childcare Facility	Communications Tower	Electric Power Facility	Emergency Operations	Fire Service	Government	Housing	Shelters	Highway Bridge	Hospital/Health Care	Military	Natural Gas Facility	Nursing Homes	Police Station	Potable Water Facility	Rail	Sanitary Pump Stations	School Facilities	Stormwater Pump Stations	Tier II Chemical Facility	Wastewater Facility	TOTAL
Montgomery County				6		1			1		15	0	0	2		1		1			0	11		38
Bellflower							1	1		1	2					1	1					1		8
High Hill							1	1		1							1					2		6
Jonesburg		1	1				2	1		1	5				1	1	1		1	1		3	1	20
McKittrick																						1		1
Middletown							1	1		2	2						1		1			2	1	11
Montgomery City	1		3	2	1		2	1		2	2					1	1		1	2		9	1	29
New Florence					1		1	1		1					1	1	1		1			7	1	16
Rhineland	1						1	1			4											1		8
Wellsville			2	1			1	1		1					1	1	1		1	2		5	1	18
Gasconade County R-I		1																		N/A				1
Montgomery County R-II		1																		N/A				1
Wellsville-Middletown R-I		1																		N/A				1
Totals	2	4	6	9	2	1	10	8	1	9	30	0	0	2	3	6	7	1	5	5	0	42	0	

Source: Missouri 2018 State Hazard Mitigation Plan and Hazard Mitigation Viewer; Data Collection Questionnaires; Hazus, etc.

The two figures below show Montgomery County bridges. The first map shows all bridges and the second map shows bridge listed as Structural Deficient.

Figure 3.1. Montgomery County Bridges

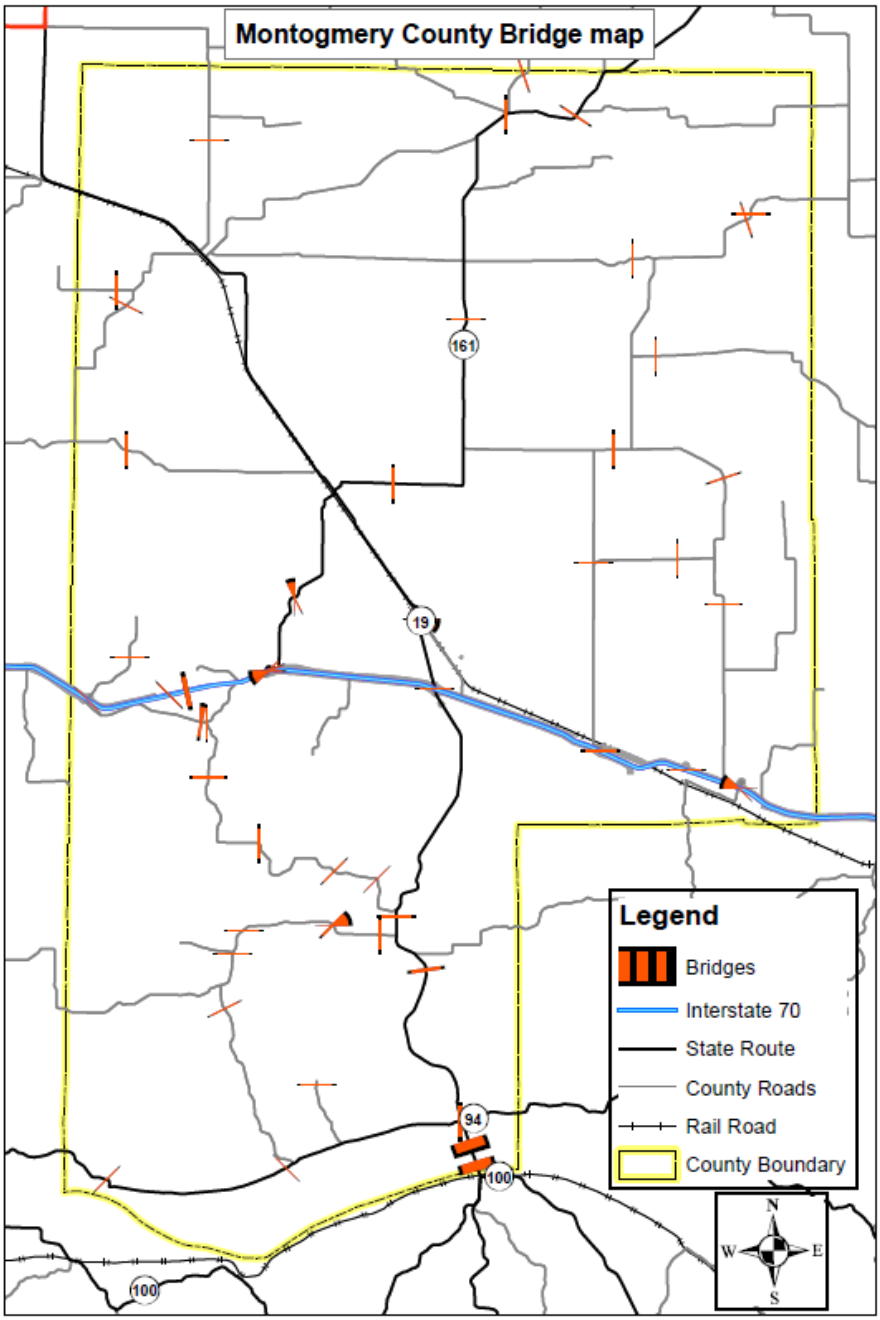
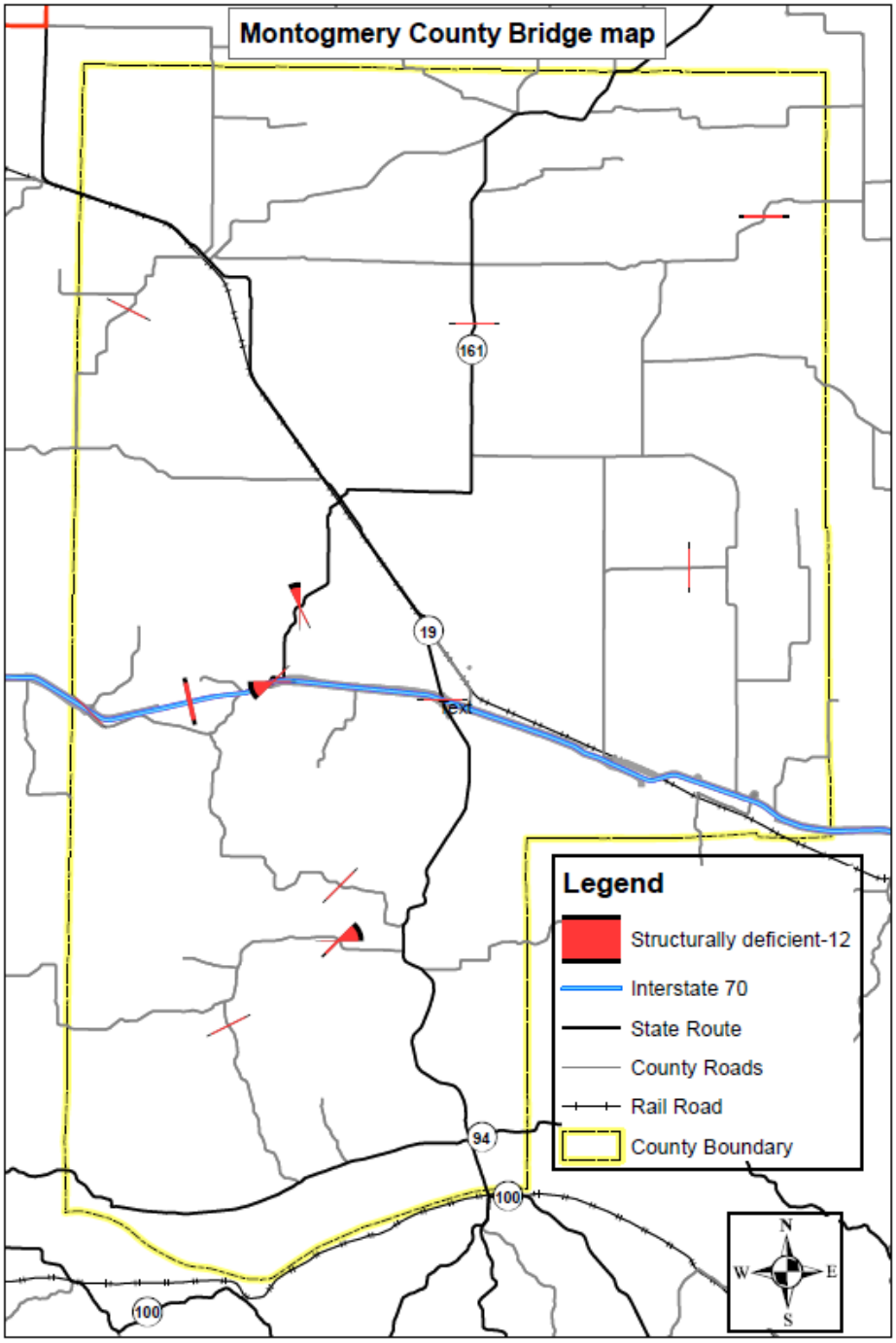


Figure 3.2. Montgomery County Structurally Deficient Bridges



The table below, taken from the National Bridge Inventory, shows the number of bridges in Montgomery County and their condition. Notice that 21 bridges are identified as “Scour D”, or scour deficient.

Table 3.8. Montgomery County Bridges – National Bridge Inventory

	Condition			
Total Bridges	**Good**	**Fair**	**Poor**	**Scour D**
187	58	92	16	21

Source: National Inventory of Dams

The table below lists the three bridges in Montgomery County that are scour critical. This term refers to one of the database elements in the National Bridge Inventory which is quantified using a "scour index"; a number indicating the vulnerability of a bridge to scour during a flood. Bridges with a scour index between 1 and 3 are considered "scour critical", or a bridge with a foundation determined to be unstable for the observed or evaluated scour condition.

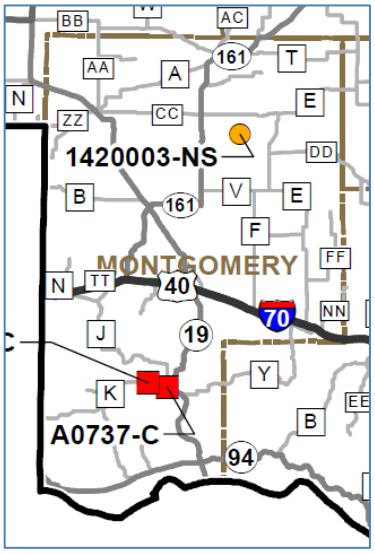
The first bridge, over Wolf Creek, is a county bridge and is not categorized although it is rated as scour critical. However, it is load posted, meaning that the weight carried by the bridge is limited. The second two bridges are state bridges. They are also scour critical. None of the three bridges are located within corporate limits of a city.

Table 3.9. Scour Critical Bridges in Montgomery County

Bridge No	Fed ID	Route	Feature	Scour Rating	Scour Type
1420003	17082	PROHIBITION RD	WOLF CR	3	NS
A0737	531	RT K E	LOUTRE RVR	3	C
L0564	6349	RT K E	DRY FORK CR	3	C

Source: Missouri Department of Transportation, 2019

Figure 3.3. Location of Scour Critical Bridges in Montgomery County



Source: Missouri Department of Transportation

3.2.3 Other Assets

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

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

Montgomery County is home to several threatened and endangered species including the bats, fish, and plants listed in the table below.

Table 3.10. Threatened and Endangered Species in Montgomery County

Common Name	Scientific Name	Status
Gray Bat	Myotis grisescens	Endangered
Indiana Bat	Myotis sodalist	Endangered
Northern Long-eared Bat	Myotis septentrionalis	Threatened
Pallid Sturgeon	Scaphirhynchus albus	Endangered
Running Buffalo Cover	Trifolium stoloniferum	Endangered

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

Natural Resources: The Missouri Department of Conservation (MDC) provides a database of lands it owns, leases, or manages for public use. These assets are listed in the table below for the Montgomery County planning area along with Graham Cave State Park.

Table 3.11. Parks in Montgomery County

Park / Conservation Area	Address	City
Danville CA	Route RB	New Florence
Graham Cave State Park	217 State Highway TT	Montgomery City
Grand Bluffs CA	MO94	Rhineland
Marshall Diggs CA	Highway ZZ and Route RA	Wellsville
Wellsville CA	Wellsville Lake Road 27	Wellsville

Source: http://mdc7.mdc.mo.gov/applications/moatlas/AreaList.aspx?txtUserID=guest&txtAreaNm=s

Historic Resources: The National Register of Historic Places is the official list of registered cultural resources worthy of preservation. It was authorized under the National Historic Preservation Act of 1966 as part of a national program. The purpose of the program is to coordinate and support public and private efforts to identify, evaluate, and protect our historic and archeological resources. The National Register is administered by the National Park Service under the

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

The table below lists the Montgomery County properties that are included in the National Register of Historic Places. The location of the Pinnacle Lake Rock Shelter is restricted to preserve the archeological integrity of the ancient site.

Table 3.12. Montgomery County Properties on the National Register of Historic Places

Property	Address	City	Date Listed
Farmers Mercantile Co. Building	872 Boones Lick Road	High Hill	6/16/2004
Graham Cave	State Route TT	Mineola	1/20/1961
Heinrich Gloe House	358 Highway P	Rhineland	2/7/2007
High Hill School	Off US 40	High Hill	11/14/1980
McKittrick Farmers Mercantile	500 Washington Street	McKittrick	6/7/2010
Mount Horeb Baptist Church	Southwest of County Road N	Mineola	9/27/1980
Pinnacle Lake Rock Shelter	Restricted	Restricted	7/29/1969
Shrine of Our Lady of Sorrows	Route P	Starkenburg	9/9/1982
Sylvester Marion Baker and Frances M. Stephens House	60 Boones Lick Road	Montgomery City	8/20/1999

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

Economic Resources The table below shows non-government (private) employers with 10 or more employees operating within Montgomery County. The table is sorted by number of employees, then by Company. Exact numbers of employees are unknown so a range of employees is cited. In some cases there are multiple locations; however, only the main location is listed.

Table 3.13. Major Non-Government Employers in Montgomery County

Company	Main Locations	Product	Employees
New Florence Wood Products	New Florence	Container Manufacturing	100-249
Bratchers Market	Montgomery City	Supermarkets/Groceries	50-99
CertainTeed Corp	Jonesburg	Roofing, Siding/Insulation Manufacturing	50-99
Jonesburg Caring Center	Jonesburg	Nursing Care Facilities	50-99
New Florence Nurse & Care Center	New Florence	Nursing Care Facilities	50-99
Porta-King Building Systems	Montgomery City	Building Construction	50-99
ADM	Montgomery City	Flour Milling	20-49
Bob Sellenriek Construction	Jonesburg	Housing Construction	20-49
Chris Minerals Co	High Hill	Minerals Mining	20-49
Dad's Junction Cafe	New Florence	Full-Service Restaurants	20-49
Duro-Flex LLC	High Hill	Industrial and Personal Service Paper Wholesalers	20-49
Dyno Nobel Inc.	Montgomery City	Chemical and Allied Products Wholesalers	20-49
Frumpy Joe's	Jonesburg	Full-Service Restaurants	20-49
Gamma Road Lodge	Wellsville	Scientific and Technical Consulting Services	20-49
Grotewiel Construction Inc.	Rhineland	Housing Construction	20-49
Hunter & Hunter Transport	Jonesburg	Building Construction	20-49
Hunter Modular Constr. Co Inc.	Jonesburg	Housing Construction	20-49

Company	Main Locations	Product	Employees
Land O'Lakes Purina Feed	Montgomery City	Animal Food Manufacturing	20-49
Loutre Market Meat Department	McKittrick	Meat Markets	20-49
Montgomery Sales	Montgomery City	Used Car Dealers	20-49
Phoenix Converting Co	Jonesburg	Stationery Product Manufacturing	20-49
Schneider Chrysler Dodge	McKittrick	New Car Dealers	20-49
Steel & Pipe Supply Co Inc.	Jonesburg	Site Preparation Contractors	20-49
Tinsley's Amusements	High Hill	Performing Arts Companies	20-49
Unique Automotive Rebuilders	Jonesburg	Automotive Repair and Maintenance	20-49
Youth In Need-Montgomery	Montgomery City	Individual and Family Services	20-49
Abel's Quik Shop	New Florence	Gasoline Stations	10-19
Americas Best Value Inn	New Florence	Hotels/Motels	10-19
Associated Medical Arts	Montgomery City	Child and Youth Services	10-19
Brandkamp Industries Inc.	Montgomery City	Residential Remodelers	10-19
Bridgeway Behavioral Health	Montgomery City	Psychiatric and Substance Abuse Hospitals	10-19
Capital Quarries	Montgomery City	Construction Sand and Gravel Mining	10-19
Cargill Inc.	Montgomery City	Farm Supplies Wholesalers	10-19
Casey's General Store	Montgomery City	Convenience Stores	10-19
Central Heating & Cooling Inc.	Montgomery City	Plumbing, Heating, and Air-Conditioning Contractors	10-19
Days Inn	New Florence	Hotels/Motels	10-19
Domino's	Montgomery City	Limited-Service Restaurants	10-19
Edge Technology	Montgomery City	Industrial Supplies Wholesalers	10-19
Fastlane Convenience Stores	Jonesburg	Convenience Stores	10-19
Forest Lawn Nursery	Jonesburg	Nursery, Garden Center, and Farm Supply Stores	10-19
Foster Farms	Montgomery City	Poultry Hatcheries	10-19
Grow2Gather	New Florence	General Merchandise Stores	10-19
Higgins Electric Inc.	Montgomery City	Electrical Contractors	10-19
Jonesburg State Bank	Jonesburg	Commercial Banking	10-19
Kaminski Home Furnishings Inc.	Jonesburg	Furniture Stores	10-19
Lorlee Transport Inc.	Jonesburg	Specialized Freight Trucking	10-19
Maczuk Chrysler Inc.	McKittrick	New Car Dealers	10-19
MFA Agri Service	Montgomery City	Miscellaneous Crop Farming	10-19
Missouri Mulch Inc.	New Florence	Nursery, Garden Center, and Farm Supply Stores	10-19
North American Carbide	Jonesburg	Industrial Supplies Wholesalers	10-19
Orchard Farm Phone Co	New Florence	Telecommunications Carriers	10-19
Peoples Savings Bank	Rhineland	Commercial Banking	10-19
Rhineland Grain Inc.	Rhineland	Farm Product Warehousing and Storage	10-19
Save-A-Lot Food Stores	Montgomery City	Supermarkets/Groceries	10-19
Scott Agency Inc.	Montgomery City	Insurance Agencies and Brokerages	10-19
Service & Supply Co Op	New Florence	Nursery, Garden Center, and Farm Supply Stores	10-19
Stone Hill Wine Co	New Florence	Wineries	10-19
SUBWAY	Montgomery City	Limited-Service Restaurants	10-19

Supreme Cuisine LLC	Montgomery City	Packaged Frozen Food Wholesalers	10-19
Tengco Inc.	Jonesburg	Hardware Wholesalers	10-19
Trailside Bar & Grill Inc.	Rhineland	Full-Service Restaurants	10-19

Source: Data Collection Questionnaires; local Economic Development Commissions, Missouri Department of Economic Development, February 2019

Agriculture According to the USDA's 2012 Census of Agriculture, there are 795 farms in Montgomery County for a total of 279,165 acres. This compares to 99,171 farms in Missouri and 28,166,137 acres. The average size farm in Montgomery County is 351 acres while the state average is smaller at 285 acres. The number of farms in Montgomery County in 2012 is down 7% from 2007.

The total value of farm products sold in Montgomery County in 2012 is $64,030,000. Crop sales account for 74% of the total sales and livestock account for the remaining 26% of sales. Beef cattle and hogs make up the majority of livestock sales and soybeans, grain corn, and forage crops account for the majority of crop sales. Average sales per Montgomery County farm is $80,540.

Agri-Business accounts for 17.3% of all jobs in Montgomery County.

Table 3.14. Agriculture-Related Jobs in Montgomery County

Farm Employment	Agriculture Related Employment	Total Agri-Business Employment	Agri-Business % of Total Employment
750	188	938	17.3%

Source: https://www.missourieconomy.org/pdfs/agribusiness_economic_contribution.pdf

3.3 Land Use and Development

3.3.1 Development Since Previous Plan Update

Population growth in Montgomery County has been in decline since the bottom fell out of the housing market in the mid-2000s. For the most-part, Montgomery County is just outside the accepted commute range for those working in St. Charles and St. Louis Counties. The county; however, remains attractive to those born and raised there and those adventurous souls looking for a quiet retirement.

The population table below shows a significant and steady loss of population across all communities during the period between 2010 and the ACS 2017 Five-Year Estimate. This is contrary to the change in housing unit table, also below, that shows a small increase in housing across all cities except for Jonesburg. This can be explained due to errors in the ACS estimates.

Table 3.15. Montgomery County Population Growth, 2010-2017

Jurisdiction	Total Population 2010	Total Population 2017	2010-2017 # Change	2010-2017 % Change
Montgomery County	12,236	11,438	-798	-6.5%
Bellflower	393	362	-31	-7.9%
High Hill	195	177	-18	-9.2%
Jonesburg	768	712	-56	-7.3%
McKittrick	61	56	-5	-8.2%

Jurisdiction	Total Population 2010	Total Population 2017	2010-2017 # Change	2010-2017 % Change
Middletown	167	151	-16	-9.6%
Montgomery City	2834	2654	-180	-6.4%
New Florence	769	713	-56	-7.3%
Rhineland	142	130	-12	-8.5%
Wellsville	1217	1142	-75	-6.2%

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

Montgomery County issued 16 building permits and Montgomery City issued one during 2015. The recent subsequent data, for 2017, was compiled during May 2018. It shows Montgomery County issued 26 building permits and Montgomery City two during 2017. No data is available for 2018 as of this plan date.

It can be argued that Montgomery County is holding its own in population and housing, however, we cannot anticipate significant growth in housing or population within the updated plan's five-year plan life span.

Table 3.16. Change in Housing Units, 2010-2017

Jurisdiction	Housing Units 2010	Housing Units 2017 (Estimate)	2010-2017 # Change	2010-2017 % Change
Montgomery County	6130	6221	91	1.5%
Bellflower	187	245	58	31.0%
High Hill	102	112	10	9.8%
Jonesburg	325	306	-19	-5.8%
McKittrick	36	38	2	5.6%
Middletown	104	113	9	8.7%
Montgomery City	1279	1383	104	8.1%
New Florence	302	316	14	4.6%
Rhineland	65	69	4	6.2%
Wellsville	564	564	0	0.0%

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

Generally, there has been no significant developmental changes to Montgomery County or to its communities outside of those listed below.

Jonesburg – Since the 2015 plan update, CertainTeed has completed a 60,000 square foot manufacturing facility in Jonesburg. The complex includes a 150,000 square foot warehouse. At peak periods, the plant may have as many as 100 employees on site who may need to be evacuated in the event of an emergency. In addition, traffic on the south service road of I70 which serves the plant has increased by approximately 125 tractor-trailers per day.

Future Land Use and Development

Several cities are attempting to make themselves more attractive to development through demolition and restoration projects. Middletown recently was awarded a Community Development Block grant that will enable the city to demolish and rake clean a small number of blighted houses. In New Florence, near the intersection of I70 and MO19 there is a possibility for a large scale fuel station.

School District's Future Development

Enrollment in the Montgomery County R-II School District for the 2018-2019 school year stands at 1,225 student. Two elementary schools, a middle school, and a high school serve the students with each located within Montgomery City except for one elementary school within the city of Jonesburg. The district employs 117 certificated staff. There are no plans in the next five years for any additions or renovations for K-12.

The Wellsville-Middletown R-I district operates an elementary school (Pre-kindergarten through 6th grade) and high school (7th grade through 12th grade), each located in Wellsville. The combined attendance centers are served by 47 certified staff and serve 374 students. The district has no plans to expand.

The Gasconade County R-I School District transports students from Montgomery County into Gasconade County attendance centers. It operates no facilities in Montgomery County has no plans to do so within the next five years.

3.4 HAZARD PROFILES, VULNERABILITY, AND PROBLEM STATEMENTS

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

Hazard Profiles

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

- **Hazard Description:** This section consists of a general description of the hazard and the types of impacts it may have on a community or school/special district.
- **Geographic Location:** This section describes the geographic areas in the planning area that are affected by the hazard. Where available, use maps to indicate the specific locations of the planning area that are vulnerable to the subject hazard. For some hazards, the entire planning area is at risk.
- **Strength/Magnitude/Extent:** This includes information about the strength, magnitude, and extent of a hazard. For some hazards, this is accomplished with description of a value on an established scientific scale or measurement system, such as an EF2 tornado on the Enhanced Fujita Scale. This section should also include information on the typical or expected strength/magnitude/extent of the hazard in the planning area. Strength, magnitude, and extent can also include the speed of onset and the duration of hazard events. Describing the strength/magnitude/extent of a hazard is not the same as describing its potential impacts on a community. Strength/magnitude/extent defines the characteristics of the hazard regardless of the people and property it affects.
- **Previous Occurrences:** This section includes available information on historic incidents and their impacts. Historic event records form a solid basis for probability calculations. Tables

are a good way to convey this data and when available. When data is available, tables showing random events for the past 20 years are included.

- **Probability of Future Occurrence:** The frequency of recorded past events is used to estimate the likelihood of future occurrences. Probability can be determined by dividing the number of recorded events by the number of years of available data and multiplying by 100. This gives the percent chance of the event happening in any given year. For events occurring more than once annually, the probability is reported as 100% in any given year, with a statement of the average number of events annually. For hazards such as drought that may have gradual onset and extended duration, probability is based on the number of months in drought in a given time-period and expressed as the probability for any given month to be in drought.
- **Changing Future Conditions Considerations:** In addition to the probability of future occurrence, changing future conditions were considered, including the effects of long-term changes in weather patterns and climate on the identified hazards.

Vulnerability Assessments

The vulnerability assessment will follow the hazard profile for each hazard. The vulnerability assessment further defines and quantifies populations, buildings, critical facilities, and other community assets at risk to damages from natural hazards. The vulnerability assessments are based on the best available county-level data available in the Missouri Hazard Mitigation plan (2018).

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

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

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

- **Vulnerability Overview:** The plan provides an overall summary of each jurisdiction's vulnerability to the identified hazards. The overall summary of vulnerability identifies structures, systems, populations or other community assets as defined by the community that are susceptible to damage and loss for hazard events.

- **Potential Losses to Existing Development:** For each participating jurisdiction, the plan describes the potential impacts of the hazard. Impact means the consequences of effect of the hazard on the jurisdiction and its assets. Assets are determined by the community and include, for example, people, structures, facilities, systems, capabilities, and/or activities that have value to the community. For example, impacts could be described by referencing historical disaster impacts and/or an estimate of potential future losses.

- **Previous and Future Development:** This section includes information on how changes in development have impacted the community's vulnerability to this hazard and describes how changes in development in known hazard prone areas since the previous plan have increased or decreased the community's vulnerability.

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

Problem Statements

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

3.4.1 Flooding (Riverine and Flash)

Hazard Profile

Hazard Description

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

Flooding caused by dam and levee failure is discussed elsewhere in this plan and will not be addressed here.

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

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

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

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

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

unpredictable nature of flash flooding in the planning area.

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

Geographic Location

Riverine flooding can occur in any low lying area of Montgomery County which is adjacent to rivers and creeks during periods of heavy rain when ground is saturated. Many rural roads within the County are dependent upon low water crossings which are not navigable during periods of high water. During times of flooding, these low water crossings can present a risk to life and property if an attempt to cross is made.

According to the National Mapping System, major rivers and creeks in Montgomery County include the Missouri River, the Loutre River, and the West Fork of the Cuivre River. Creeks include the Big Lead, Sandy, Coon, Elkhorn, White Oak, Brush, Wolf, Little Loutre, Whitestone, Prairie, Bear, and Dry Creeks, plus the Loutre Slough. The following pages show 100-Year Flood Zone maps for Montgomery County and its community.

Figure 3.4. City of Bellflower

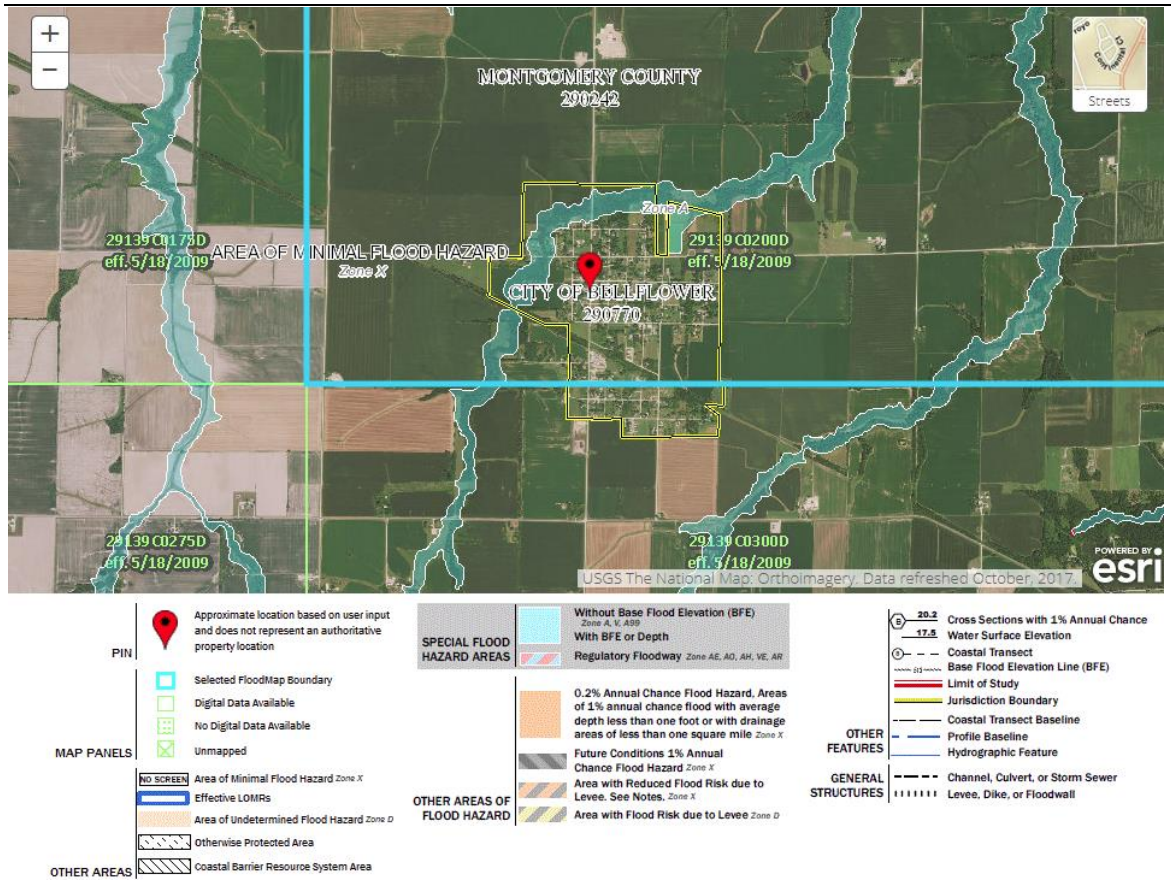


Figure 3.5. City of High Hill

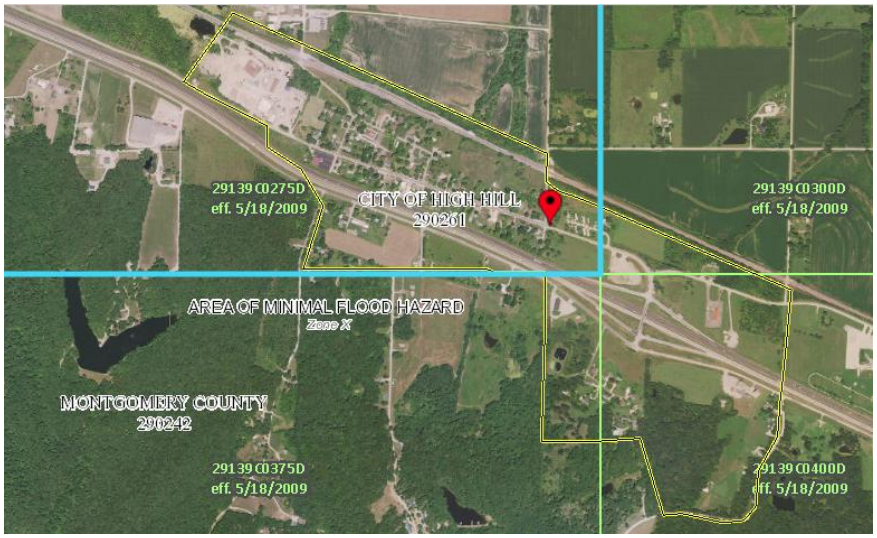


Figure 3.6. City of Jonesburg

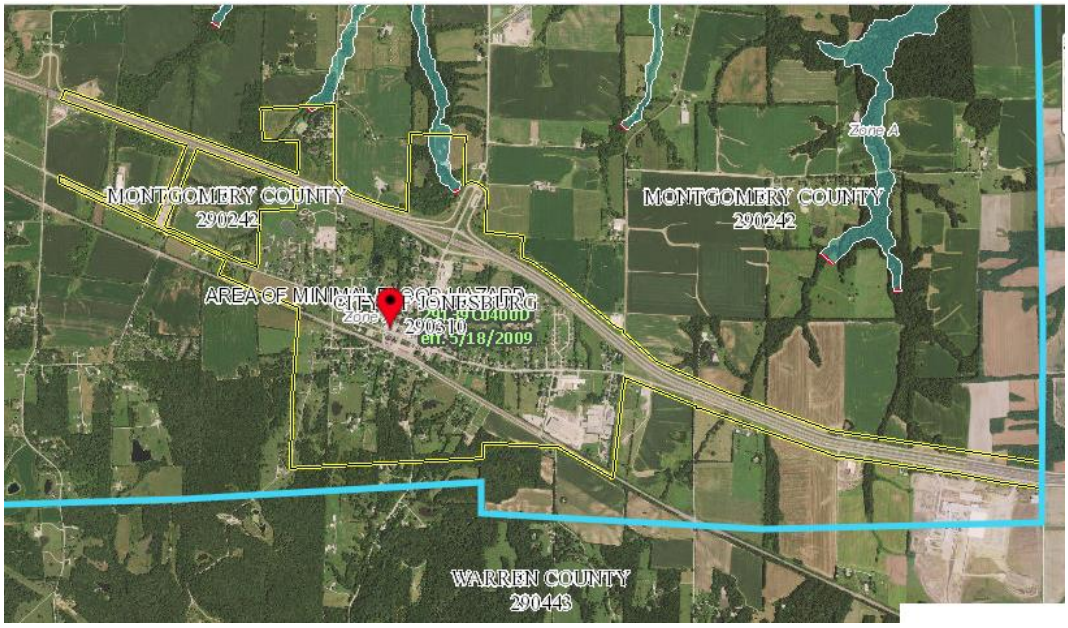


Figure 3.7. Town of McKittrick

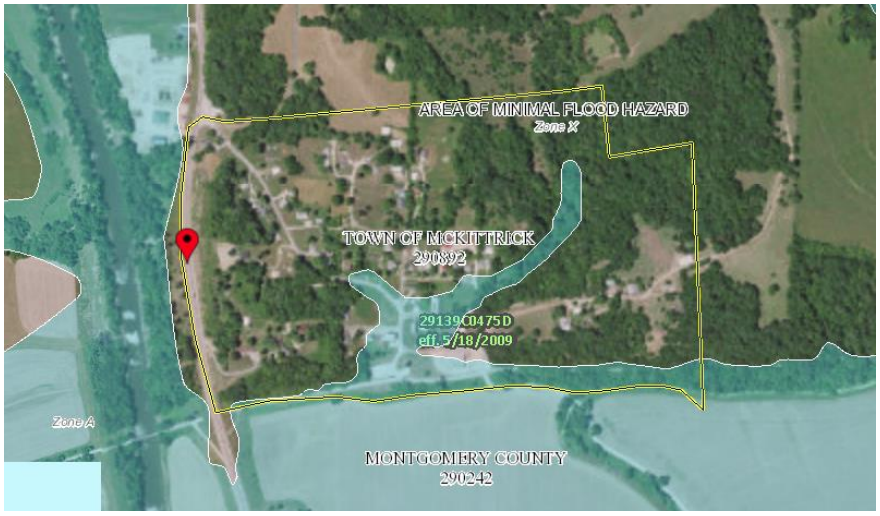


Figure 3.8. Village of Middletown

Figure 3.9. City of Montgomery City

Figure 3.10. City of New Florence

Figure 3.11. Village of Rhineland

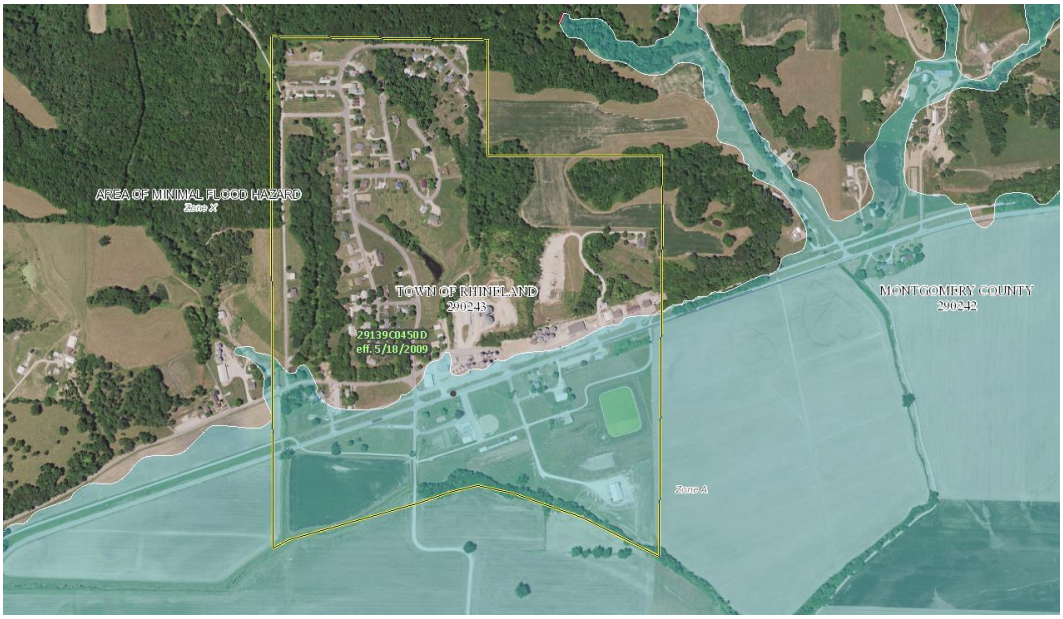


Figure 3.12. City of Wellsville

Figure 3.13. Montgomery County R-II School District, Jonesburg Elementary

Figure 3.14. Montgomery County R-II School District, Montgomery City Elementary

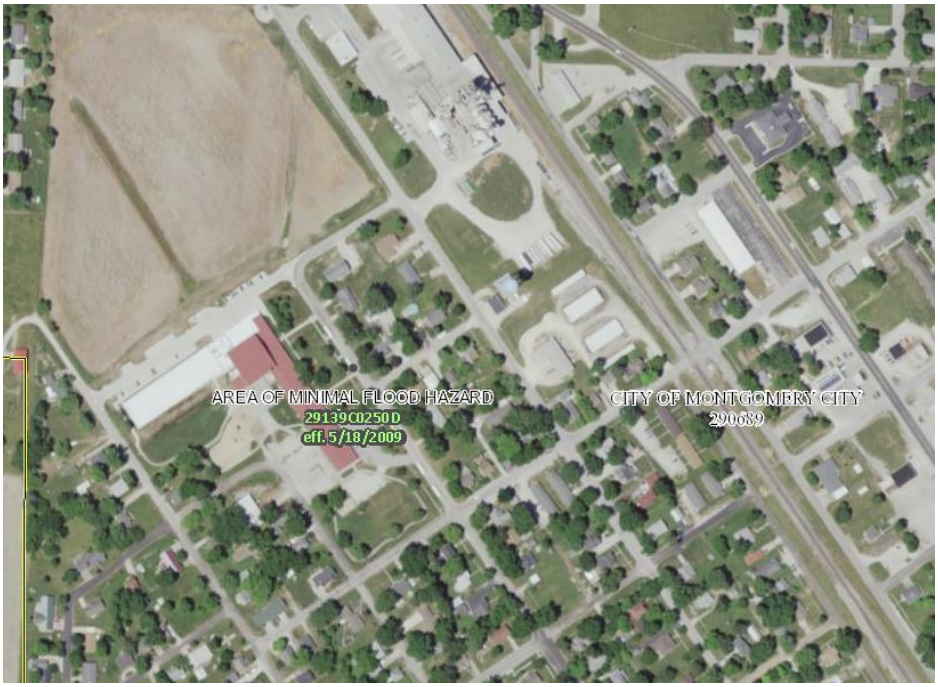


Figure 3.15. Montgomery County R-II School District, Middle and High Schools

Figure 3.16. Wellsville-Middletown R-I School District; Wellsville Elementary, Middle, and High Schools

Gasconade County R-I School district has no school buildings located in Montgomery County.

Figure 3.17. Low Water Crossings in Montgomery County

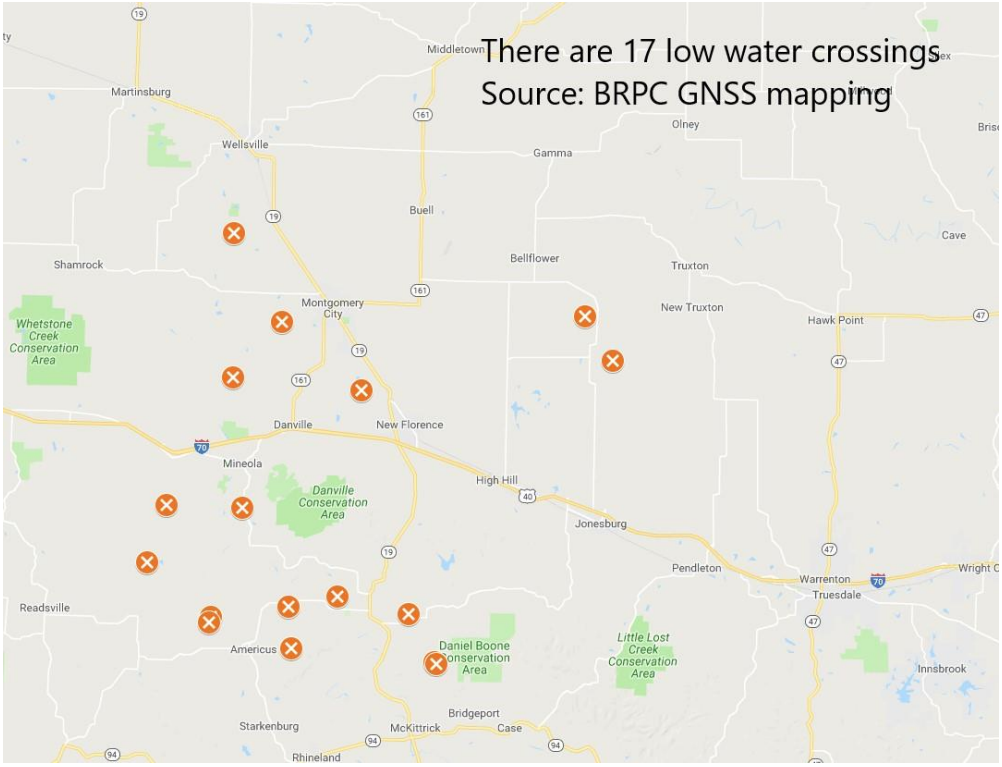
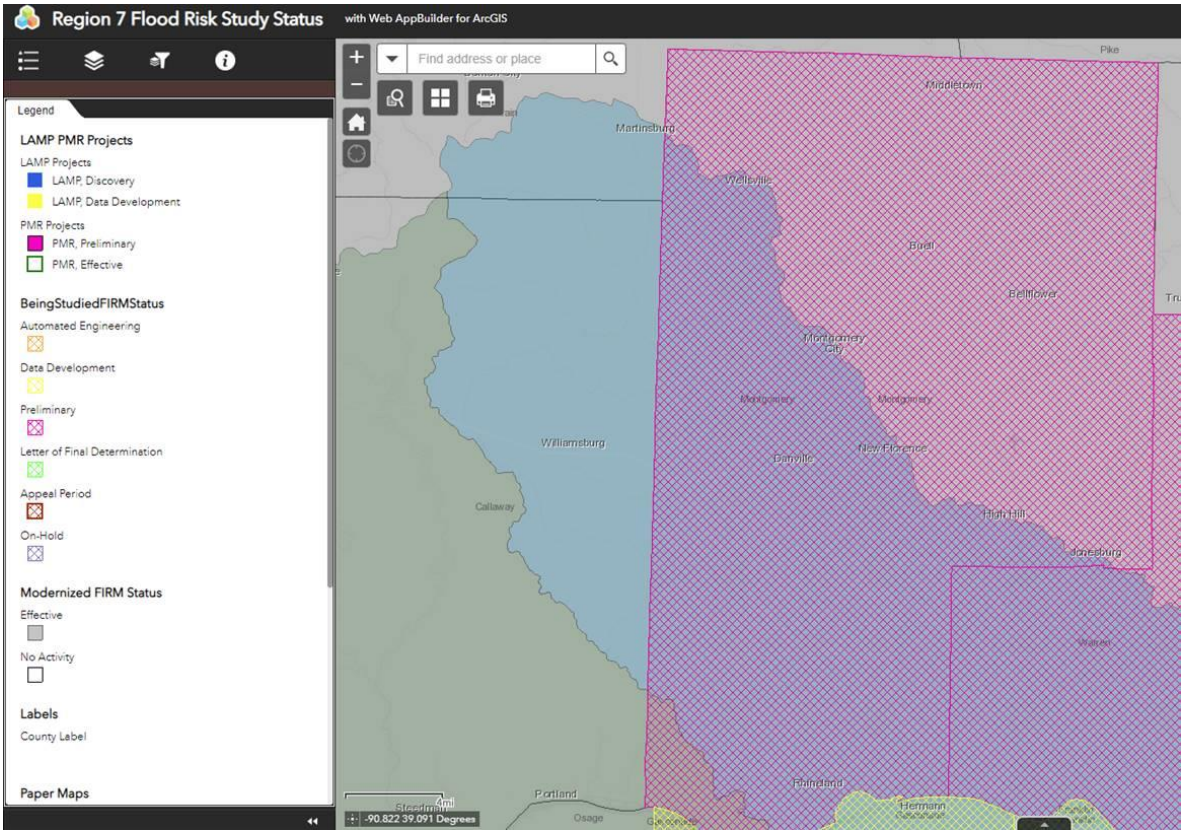


Figure 3.18. Montgomery County Flood RISK MAP



Source: http://fema.maps.arcgis.com/apps/webappviewer/index.html?id=48cfac9a9ffb4003b565aaccf464d0ac

The following National Centers for Environmental Information table shows just eight flood events from the last 20 years. The data includes events for flooding and for flash flooding. Twenty years of history is generally adequate for a trend analysis. Although only eight events are recorded for Montgomery County during the past 20 years, this is considered adequate to establish risk in Montgomery County.

Table 3.17. Montgomery County NCEI Flood Events by Location, 1998-2018

Location	# of Events
Unincorporated Montgomery County	5
Rhineland	1
McKittrick	2

Source: National Centers for Environmental Information, January 31, 2019

Special Flood Hazard Areas (SFHAs) are areas where flash flooding occurs and those locations in the planning area that are low-lying. They also occur in areas without adequate drainage to carry away the amount of water that falls during intense rainfall events. Flash flood events that occurred in those areas are listed in the table below. Montgomery County has no SFHAs.

Table 3.18. Montgomery County NCEI Flash Flood Events by Location, 1998-2018

Location	# Events
Unincorporated Montgomery County	6
North Portion	1

Location	# Events
Big Spring	1
Bluffton	1
Danville	1
McKittrick	2
Montgomery City	2
Rhineland	1
Wellsville	5

Source: National Centers for Environmental Information, Date

Strength/Magnitude/Extent

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

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

National Flood Insurance Program (NFIP) Participation

NFIP participation for the communities in the planning area is shown below and a second table shows the number of policies in force, amount of insurance in force, number of closed losses, and total payments for each jurisdiction, where applicable. Information in the charts was taken between January 1, 1978 and September 30, 2018. No community was sanctioned. Sanctioned communities are those communities that are not currently participating in the NFIP and where a Flood Hazard Boundary Map or Flood Insurance Rate Map has been issued.

Table 3.19. NFIP Participation in Montgomery County

Community ID	Community Name	NFIP Participant (Y/N/Sanctioned)	Current Effective	Regular- Emergency Program Entry Date
290261#	HIGH HILL, CITY OF	Y	(NSFHA)	03/30/09
290310#	JONESBURG, CITY OF	Y	05/18/09(M)	05/18/09
290892#	MCKITTRICK, TOWN OF	Y	05/18/09(M)	09/30/88
290568#	MIDDLETOWN, CITY OF	Y	05/18/09(M)	07/02/09
290689#	MONTGOMERY CITY, CITY OF	Y	05/18/09(M)	05/18/09
290242#	MONTGOMERY COUNTY	Y	05/18/09	03/01/87
290243#	RHINELAND, TOWN OF	Y	05/18/09(M)	10/24/1986
290652#	WELLSVILLE, CITY OF	Y	05/18/09(M)	09/02/10
290770#	BELLFLOWER, CITY OF	N	05/18/09	05/17/78
290692#	NEW FLORENCE, CITY OF	N	05/18/09	11/5/1977

Source: NFIP Community Status Book, 2019; http://www.fema.gov/national-flood-insurance-program/national- flood-insurance-program-community-status-book; M= No elevation determined – all Zone A, C, and X: NSFHA = No Special Flood Hazard Area; E=Emergency Program

Table 3.20. NFIP Policy and Claim Statistics as of 9/30/2018

Community Name	Policies in Force	Insurance in Force	Closed Losses	Total Payments
McKittrick	1	$175,000	64	$557,711
Unincorporated County	9	$2,301,800	46	$525,753

Source: NFIP Community Status Book, [insert date]; http://bsa.nfipstat.fema.gov/reports/reports.html; *Closed Losses are those flood insurance claims that resulted in payment. Loss statistics are for the period from January 1, 1979 to September 30, 2018.

There are just ten NFIP policies in force in Montgomery County, nine of which are issued to residents of unincorporated portions of the county. A single resident of McKittrick is the only NFIP insured individual within an incorporated area. Loss payments are nearly balanced between incorporated and incorporated areas of Montgomery County.

Repetitive Loss/Severe Repetitive Loss Properties

Repetitive Loss Properties are those properties with at least two flood insurance payments of $5,000 or more in a 10-year period. According to the Flood Insurance Administration, jurisdictions included in the planning area have a combined total of $725,586 in repetitive loss properties. As of January 31, 2019, 30 properties have been mitigated, leaving three un-mitigated repetitive loss properties. The table below provides a summary of the repetitive loss properties in the planning area.

Table 3.21. Montgomery County Repetitive Loss Properties

Jurisdiction	# of Properties	Type of Property	# Mitigated	Building Payments	Content Payments	Total Payments	Average Payment	# of Losses
Montgomery County	16		15	$290,503	$34,565	$282,984	$8,575	35
Rhineland	14		12	$396,028	$46,573	$442,602	$21,072	34

Source: Flood Insurance Administration as of February 2019

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

There are no validated Severe Repetitive Loss properties in Montgomery County.

Previous Occurrences

Montgomery County has been part of four Presidential Declarations for flooding between 1998 and February 2019. The most recent declaration, **FEMA-4238-DR**, involves the most counties (76) and damage assessment ($51.4M) since the Great Flood of 1993. The event began in May as a series of severe storms moved across Missouri generating tornados, straight line winds, heavy rain, hail, flooding and flash flooding. This event resulted in a per capita cost of $33.27 for Montgomery County. **FEMA-4130-DR** included 27 Missouri Counties, including Montgomery, for straight line winds, hail, tornadoes, and flooding that occurred during May and June 2013. This resulted in a per capita cost of $38.40 to Montgomery County. In September of 2008 a similar event **(Disaster 1809)** hit the state impacting 56 counties, one of which was Montgomery County where per capita cost was $3.28. Seventy-one Missouri counties were impacted by **Disaster 1749** where public assistance was offered residents of Montgomery County. It should be noted that flooding of major rivers in Montgomery County is known well in advance and impacts sparsely populated farmland

with few structures. Flash flooding, on the other hand, can impact life and property nearly anywhere in the county at a moment's notice.

Table 3.22. Montgomery County Presidential Declared Flood Events 2008-2018

Declaration Number	Declaration Date	Disaster Description	Total Estimated Damage
FEMA-4238-DR	10-Aug-15	Severe Storms and Flooding	$51,384,706
FEMA-4130-DR	17-Jul-13	Severe Storms, Flooding, and tornadoes	$9,033,804
FEMA-1809-DR	13-Nov-08	Severe Storms, Flooding, and tornadoes	$21,572,603
FEMA-1749-DR	19-Mar-08	Severe Storms and Flooding	$26,045,574

Source: FEMA.GOV, March 2019

Table 3.23. NCEI Montgomery County Flash Flood Events Summary, 1998 to 2018

Year	# of Events	# of Deaths	# of Injuries	Property Damages	Crop Damages
1998	1	0	0	0	0
1999	0	0	0	0	0
2000	1	0	0	0	0
2001	0	0	0	0	0
2002	4	0	1	0	0
2003	0	0	0	0	0
2004	1	0	0	0	0
2005	0	0	0	0	0
2006	1	0	0	0	0
2007	0	0	0	0	0
2008	1	0	0	$ 15,000	0
2009	4	0	0	0	0
2010	1	0	0	0	0
2011	0	0	0	0	0
2012	0	0	0	0	0
2013	0	0	0	0	0
2014	1	0	0	0	0
2015	3	0	0	0	0
2016	1	0	0	0	0
2017	1	0	0	0	0
2018	0	0	0	0	0

Source: NCEI, data accessed January 2019

Table 3.24. NCEI Montgomery County Riverine Flood Events Summary, 1998 to 2018

Year	# of Events	# of Deaths	# of Injuries	Property Damages	Crop Damages
1998	1	0	0	0	0
1999	1	0	0	0	0
2000	0	0	0	0	0
2001	1	0	0	0	0
2002	2	0	1	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	1	0	0	0	0
2008	0	0	0	0	0
2009	0	0	0	0	0
2010	1	0	0	0	0
2011	0	0	0	0	0
2012	0	0	0	0	0
2013	1	0	0	$ 1,000	$ 2,000
2014	0	0	0	0	0
2015	0	0	0	0	0
2016	0	0	0	0	0
2017	0	0	0	0	0
2018	0	0	0	0	0

Source: NCEI, January 2019

Probability of Future Occurrence

For flooding events, flash flooding is the most likely to occur. The flash flood chart above shows 20 flash floods occurred during the 20-year period between 1998 and 2018. Expressed mathematically, this is 20 floods divided into 20 years for one flood per year, or a 100% probability of a flash flood occurring somewhere in Montgomery County during any given year. This probability is just a measurement tool, as you can see in the chart, some years had several flash floods while other years had none.

Riverine flooding is less likely to occur. The above riverine flooding table shows eight flooding events over a 20-year period. Applying the same formula used above, this would be a 40% probability of a riverine flood occurring somewhere in Montgomery County during a 12-month period.

Changing Future Conditions Considerations

Montgomery County should begin to consider the possibility that traditional climate patterns are changing. According to the 2018 State Plan, 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 storms 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.

The expected increases in rainfall frequency and intensity are likely to put additional stress on natural hydrological systems and community storm water 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 storm water 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 storm water. 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 poor quality water. 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 storm water.

More climate information is available from the following sources:

- 2018 State Plan, see Chapter 3, Section 3.3.1, Changing Future Conditions Considerations, page 3.100
- US Climate Resilience Toolkit; https://toolkit.climate.gov/tools/climate-explorer
- National Climate Assessment; https://nca2014.globalchange.gov/

Vulnerability

Vulnerability Overview

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

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

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

home and business owners as well as present a health hazard. Refer back to the section of the plan where scour critical bridges were identified.

For Montgomery County, according to the 2018 State Plan, this can mean building exposure for a 100-year flood to range between $500K and $305M and impact as many as 600 buildings and up to 750 residents.

Potential Losses to Existing Development

Flash flooding can occur almost anywhere in Montgomery County where the terrain is hilly and the ground provides little absorption. These areas are generally well-known and development avoided when access is affected. Riverine flooding occurs within the Loutre River basin and along the Missouri River floodplain in the southern-most portions of Montgomery County. With the exception of McKittrick and Rhineland, these areas are agrarian in nature and sparsely inhabited.

Impact of Previous and Future Development

Obviously, development of the flood plain along the Loutre Basin and Missouri River will increase exposure to flooding. To date, development has been slight and has been along the perimeters of the flood plain but not in it. Continued development in other areas of the county can contribute to flash flooding if proper attention is not given to collecting pools and absorption basins. Montgomery County continues to experience a net loss of residents so development currently is not an issue.

Hazard Summary by Jurisdiction

The main origin of Montgomery County flooding is the Missouri River. As part of the Missouri River watershed, the Loutre River drains the southwestern half of the county. The upper reaches of the Cuivre River watershed drain the northeastern half of the county. Along the length of the county's southern border, the river's floodplain is 2 - 3 miles wide. The communities of Rhineland and McKittrick lie on the edge of the floodplain along State Highway 94.

Several individual communities are situated on or near small creeks. Although no reports were found of these creeks causing flooding, an inventory may be useful in the future as urban areas expand. Coon Creek runs through a corner of Middletown, East Branch Brush Creek runs through the northeast section of Bellflower, Smith Branch generally parallels State Highway 19 through New Florence, and the Modoc Creek makes up the southern boundary of the Rhineland city limits.

In the lower half of the county, drainage is a major factor in the steep hills above the floodplain. The loess-based soils covering the relatively flat northern half tend to drain well.

The Montgomery County EMD contacted the communities of Bellflower and New Florence, along with the SEMA Flood Plain manager, Linda Olsen; and encouraged the communities to become part of NFIP.

Problem Statement

Risk to Montgomery County due to flash floods and riverine floods are relatively insignificant due to geography. During the past 20 years, there are eight recorded riverine flood events. Just two events show damage claims which were insignificant. During the same period, there were 20 flash flood events, one of which records damages of $15,000. There are no severe repetitive loss properties in the planning area; however, there are 30 mitigated repetitive loss properties and three un-mitigated repetitive loss properties which accounted for $726,000 in repetitive losses during the

past 10 years. These repetitive losses could be reduced or eliminated by development of more restrictive flood plain ordinances.

3.4.2 Levee Failure

Hazard Profile

Hazard Description

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

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

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

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

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

Geographic Location

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

There are two concurrent nation-wide levee inventory development efforts, one led by the United State Army Corps of Engineers (USACE) and one led by Federal Emergency Management Agency

(FEMA). The National Levee Database (NLD), developed by USACE, captures all USACE related levee projects, regardless of design levels of protection.

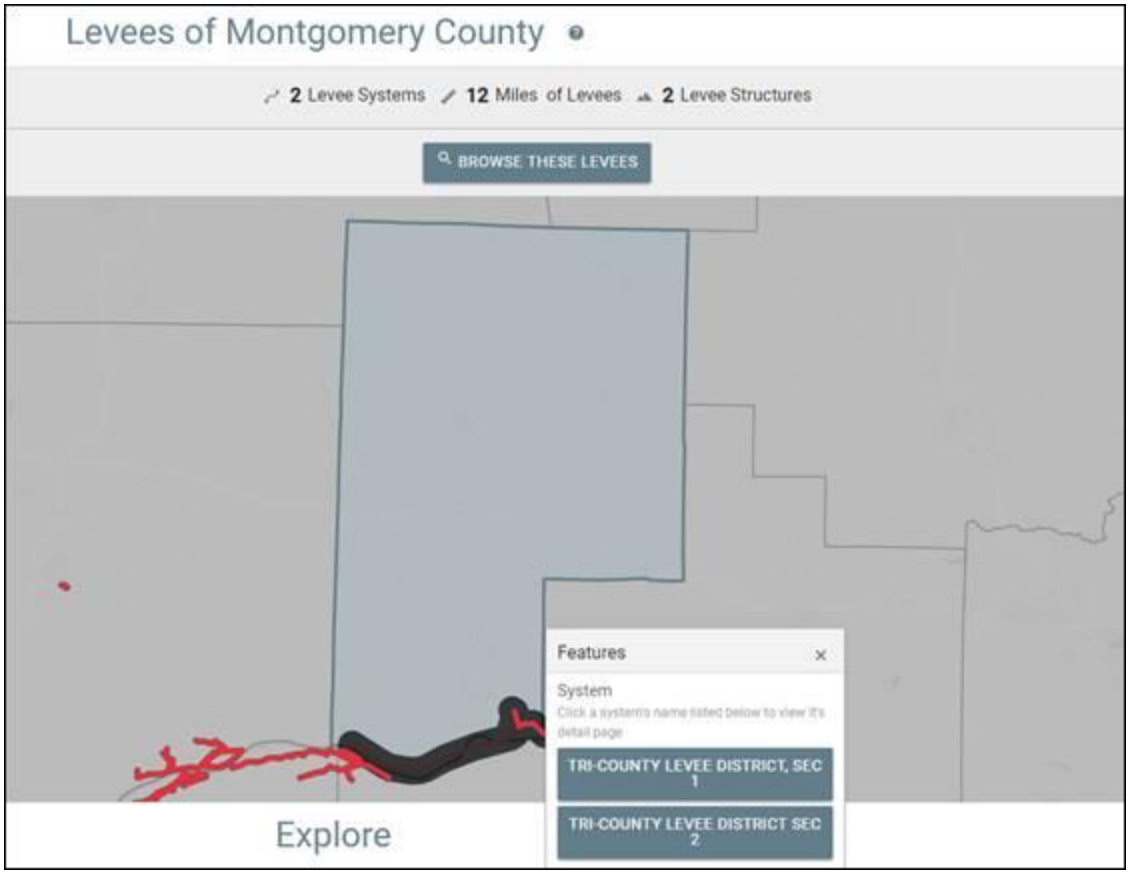
The Midterm Levee Inventory (MLI), developed by FEMA, captures all levee data (USACE and non-USACE) but primarily focuses on levees that provide 1% annual-chance flood protection on FEMA Flood Insurance Rate Maps (FIRMs).

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

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

There is just one private levee district in Montgomery County; the Tri-County Levee District, Section 1 and Section 2. Section 1 is shown in red at the lower left hand corner of the figure below and Section 2 is at the lower right of the map. The levee district is a Provisionally Accredited Levee (PAL) and is currently being mapped. Section 1 and Section 2 are USACE levees.

Figure 3.19. County Levees Shown on DFIRM as Providing Protection from the 1-Percent Annual Chance Flood



Source: FEMA Flood Insurance Rate Map, January 31, 2019

Tri County Levee District Section 1 - The Tri-County Levee District Section 1 project is a levee system that reduces flood risk to approximately 7,690 acres of Missouri River floodplain in Montgomery County, Missouri. The levee system includes 12.1 miles of earthen levee and eight gravity drains along the Missouri River. The levee is operated and maintained by the local sponsor, the Tri-County Levee District Section 1. The area behind the levee is predominately agricultural with associated farm structures and some residential development. The leveed area daytime population is four people and the estimated property value is $2.2 Million. The levee faced record flooding in 1993 when the levee overtopped and breached.

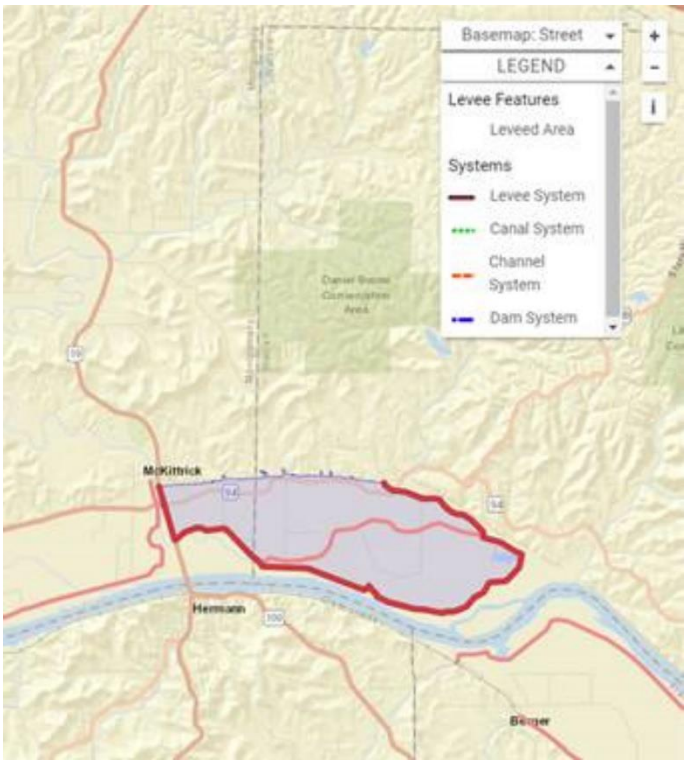
Figure 3.20. Tri-County Levee District, Section 1

Risk Characteristics; Levee safety action classification - Low; People at Risk- 11; Structures at risk - 14. Property value - $2.18 Million; assessment date - February 05, 2018

Risk Characterization Summary: The likelihood of a flood overtopping this levee in the next year has been estimated at 10% (one chance in 10). This equals a 96% likelihood of water overtopping the levee over the life of a typical 30-year mortgage. The risk assessment identified some concerns pipe inspections and emergency preparedness. Flooding of the levee could lead to flood depths up to 18 feet, which could result in life loss and economic consequences. Recommended risk management activities include continuing good operations and maintenance practices, complete pipe inspections and develop a site specific emergency preparedness plan. Efforts should be made to inform those that live or work behind the levee of their flood risk.

Tri County Levee District Section 2 - The Tri-County Levee District Section 2 project is a levee system that reduces flood risk to approximately 5,997 acres of Missouri River floodplain in Montgomery County and Warren County. The levee system includes 9.71 miles of earthen levee and seven gravity drains along the Missouri River. The levee is operated and maintained by the local sponsor, the Tri-County Levee District Section 2. The area behind the levee is predominately agricultural with associated farm structures and some residential development. The leveed area daytime population is one and estimated property value is $ 1.6 Million. The levee faced record flooding in 1993 when the levee overtopped and breached.

Figure 3.21. Tri-County Levee District, Section 2



Risk Characteristics; Levee safety action classification - not screened; People at Risk - 0; Structures at risk - 10. Property value - $3.89 Million; assessment date - N/A

Risk Characterization Summary: The likelihood of a flood overtopping this levee in the next year has been estimated at 20% (one chance in 5). This equals a 100% likelihood of water overtopping the levee over the life of a typical 30-year mortgage. The risk assessment identified some concerns pipe inspections and emergency preparedness. Flooding of the levee could lead to flood depths up to 18 feet, which could result in life loss and economic consequences. Recommended risk management activities include continuing good operations and maintenance practices, complete pipe inspections and develop a site specific emergency preparedness plan. Efforts should be made to inform those that live or work behind the levee of their flood risk.

Strength/Magnitude/Extent

Levee failure is typically an additional or secondary impact of another disaster such as flooding or earthquake. The main difference between levee failure and losses associated with riverine flooding is magnitude. Levee failure often occurs during a flood event, causing destruction in addition to what would have been caused by flooding alone. In addition, there would be an increased potential for loss of life due to the speed of onset and greater depth, extent, and velocity of flooding due to levee breach.

As previously mentioned, agricultural levees and levees that are not designed to provide flood protection from at least the 1-percent annual chance flood likely do exist in the planning area. However, none of these levees are shown on the Preliminary DFIRM, nor are they enrolled in the USACE Levee Safety Program. As a result, an inventory of these types of levees is not available for analysis. Additionally, since these types of levees do not provide protection from the 1-percent annual chance flood, losses associated with overtopping or failure are captured in the Flood Section

of this plan.

Previous Occurrences

Sections 1 and 2 of the Tri-County levee were breached during the Great Flood of 1993 which stands as an exceptional occurrence. Otherwise, there are no known instances of levee breaches or incidents reported in the state plan for the planning area, nor is there anecdotal information. We should point out that lack of a centralized database for Missouri levees limits access the data.

Probability of Future Occurrence

The Section 1 levee is operated and maintained by the local sponsor, the Tri-County Levee District Section 1. The area behind the levee is predominately agricultural with associated farm structures and some residential development. The leveed area daytime population is 4 and estimated property value is $ 2.2 Million. The levee faced record flooding in 1993 when the levee overtopped and breached. The likelihood of a flood overtopping this levee in the next year has been estimated at 10% (one chance in 10). This equals a 96% likelihood of water overtopping the levee over the life of a typical 30-year mortgage.

The Section 2 levee is operated and maintained by the local sponsor, the Tri-County Levee District Section 2. The area behind the levee is predominately agricultural with associated farm structures and some residential development. The leveed area daytime population is one and estimated property value is $ 1.6 Million. The levee faced record flooding in 1993 when the levee overtopped and breached. The likelihood of a flood overtopping this levee in the next year has been estimated at 20% (one chance in 5). This equals a 100% likelihood of water overtopping the levee over the life of a typical 30-year mortgage.

Changing Future Conditions Considerations

If we accept the climate change scenario that forecasts more dramatic periods of precipitation, we can then infer that more stress will be placed upon levees and that levees will be more prone to failure. Couple that with an infrastructure of aging, perhaps poorly maintained levees, and we have the makings of a serious problem.

Vulnerability

Vulnerability Overview

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

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

Both Routine and Periodic Inspections result in a rating for operation and maintenance. Each levee

segment receives an overall segment inspection rating of Acceptable, Minimally Acceptable, or Unacceptable.

Table 3.25. Definitions of the Three Levee System Ratings

Levee System Inspection Ratings	
Acceptable	All inspection items are rated as Acceptable.
Minimally Acceptable	One or more levee segment inspection items are rated as Minimally Acceptable or one or more items are rated as Unacceptable and an engineering determination concludes that the Unacceptable inspection items would not prevent the segment/system from performing as intended during the next flood event.
Unacceptable	One or more levee segment inspection items are rated as Unacceptable and would prevent the segment/system from performing as intended, or a serious deficiency noted in past inspections (previous Unacceptable items in a Minimally Acceptable overall rating) has not been corrected within the established timeframe, not to exceed two years.

Potential Losses to Existing Development

According to the National Levee Database, Section 1 levee was assessed February 5, 2018. Its risk characteristic is rated as “1”, and the safety action classification is “Low”. There are 11 people at risk, 14 structures at risk, and property valued at $2.18 Million. The risk assessment identified some concerns regarding pipe inspections and emergency preparedness. Flooding of the levee could lead to flood depths up to 18 feet, which could result in loss of life and economic consequences. Recommended risk management activities include continuing good operations and maintenance practices, complete pipe inspections and develop a site specific emergency preparedness plan. Efforts should be made to inform those that live or work behind the levee of their flood risk.

Section 2 is not yet assessed. However, according to the National Levee Database, there are no people at risk. The impacted property value is $3.89 million, including 10 structures. A risk assessment can be anticipated to identify the same concerns as Section 1.

Impact of Previous and Future Development

The areas protected by the levees are expected to remain largely undeveloped agricultural land with few structures.

Hazard Summary by Jurisdiction

Rhineland and McKittrick are the two communities that receive the most benefit from the levees, even though neither community is situated directly in the inundation zone. However, private and commercial transportation to and from these communities could be impacted by a breach.

Problem Statement

Flooding and potential levee breach will remain a concern for those choosing to live in or near alluvial plains. Care must be taken to ensure existing levees are well maintained and that emergency evacuation plans are in place that provide sufficient warning in the event of a pending levee breach.

3.4.3 Dam Failure

Hazard Profile

Hazard Description

A dam is defined by the National Dam Safety Act as an artificial barrier that impounds or diverts water and is at least 6 feet high and stores at least 50 acre-feet of water; or, is at least 25 feet high and stores at least 15 acre-feet. Missouri's DNR regulates the design, construction and maintenance of 4,100 non-federal, non-agricultural dams that are at least 35 feet high. Regardless of the size of the dam, dam owners have primary responsibility for the safe design, operation, and maintenance of their dams. They are responsible for providing early warning of problems at the dam, for developing an effective emergency action plan, and for coordinating that plan with local officials. The state has ultimate responsibility for public safety and many states regulate construction, modification, maintenance, and operation of dams. DNR's Dam Safety Division maintains a database of all dams regardless of federal, state, local or private ownership. Primary Levees are built and maintained by the Army Corps of Engineers while Secondary Levees; i.e., those constructed on secondary rivers and streams, are regulated by the Corps who sets design and construction standards.

The failure of dams can result in injuries, loss of life, and damage to property and the environment. While levees are built solely for flood protection, dams often serve multiple purposes, one of which may be flood control. Severe flooding and other storms can increase the potential that dams and levees will be damaged and fail as a result of the physical force of the flood waters or overtopping. Dams are usually engineered to withstand a flood with a computed risk of occurrence. If a larger flood occurs, then that structure will likely be overtopped. If during the overtopping, the dam fails or is washed out, the water behind is released as a flash flood. Failed dams can create floods that are catastrophic to life and property, in part because of the tremendous energy of the released water. The problem of unsafe dams in Missouri was underscored by dam failures at Lawrenceton in 1968, Washington County in 1975, Fredericktown in 1977, and a near failure in Franklin County in 1978. On December 14, 2005, the Taum Sauk reservoir dam owned by Ameren Missouri failed. A 600-foot breech in the northwest side of the retention facility released 1.5 billion gallons of stored water into the Johnson Shut-Ins State Park in just 10 minutes. 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 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.

The 2011 floods in Missouri led to the Corps of Engineers having to release record levels of water through the Gavin Point Dam on the upper Missouri. This release caused 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 the Corps had to breach the Bird's Point Levee late at night, in order to reduce pressure on a floodwall protecting the town.

Oversight is extremely valuable to the owners as well as those people living downstream of the dam who could be flooded in the event the dam should fail. Dams can fail for many reasons. The most common are:

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

These types of failures are often interrelated. For example, erosion; either on the surface or internal to the structure, may weaken the dam or lead to structural failure. Additionally, a structural failure may shorten the seepage path and lead to a piping failure.

The National Inventory of Dams (NID) defines three levels of hazard potential; high, significant, and low, as accepted by the Interagency Committee on Dam Safety. The definitions are:

• **High;** Failure or incorrect operation will probably cause loss of human life.

• **Significant;** Failure or incorrect operation results in no probable loss of human life but can cause economic loss, environmental damage, disruption of lifeline facilities, or impact other concerns. Significant hazard potential classification dams are often located in predominantly rural or agricultural areas but could be located in areas with population and significant infrastructure.

• **Low;** Failure results in no probable loss of human life and low economic and/or environmental losses. Losses are principally limited to the owner's property.

Information can be obtained from:

- National Resources Conservation Service: http://www.nrcs.usda.gov
- DamSafetyAction.org: https://damsafety.org/missouri

Data for dams in Montgomery County has been collected from two sources; a listing by the Missouri Department of Natural Resources (MoDNR) and the National Inventory of Dams (NID). Each has its own system of classifying dams. Neither the MoDNR nor the NID hazard potential classifications references the condition of the dam. For the Risk Analysis, data was used from all MoDNR Class I and NID High Hazard dams.

Table 3.26. MoDNR Dam Hazard Classification Definitions

Hazard Class	Definition
Class I	Represents the most severe threat to public safety, life and property. Contains ten or more permanent dwellings or any public building. Inspections must occur every two years.
Class II	Represents a moderate threat to public safety, life and property. Contains 1-9 permanent buildings or 1 or more campgrounds with permanent water, sewer, and electrical services, or one or more industrial buildings. Inspections must occur every three years.
Class III	Represents the least severe threat to public safety, life and property. Inspections must occur every five years.

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

Table 3.27. NID Dam Hazard Classification Definitions

Hazard Class	Definition
High Hazard	Loss of at least one human life if dam fails
Significant Hazard	Possible loss of human life and likely significant property or environmental destruction
Low Hazard	• Equals or exceeds 25 feet in height and exceeds 15 acre-feet in storage • Exceed 6 feet in height and equal to or exceeds 50-acre feet in storage

Source: National Inventory of Dams

Geographic Location

Dams Located Within the Planning Area

According to the Missouri Department of Natural Resources, Dam and Reservoir Safety, Montgomery County has 87 dams, of which eight are Class I, or High Hazard Dams. Of these, two are state regulated.

This contrasts to the National Inventory of Dams; NID, that lists 86 dams in Montgomery County, of which 26 are rated High Hazard and five are state regulated. The NID lists seven dams as Significant Hazard; however, none are state regulated. None are owned by the United States Army Corps of Engineers (USACE).

Table 3.28. MoDNR Class I Dams in Montgomery County

Dam Name	Class	Height	Acre-Feet Storage	State Regulated
Cates	I	22'	77	N
Zander Lake	I	18'	125	N
Golden Eagle Lake	I	33'	1,287	N
Cool Valley Lake	I	20'	519	N
Easterday	I	34'	160	N
Loutre Valley Lake	I	35'	358	Y
Allgeyer Lake	I	29'	97	N
Pinnacle Lake	I	49'	4,495	Y

Table 3.29. NID High Hazard Dams in Montgomery County

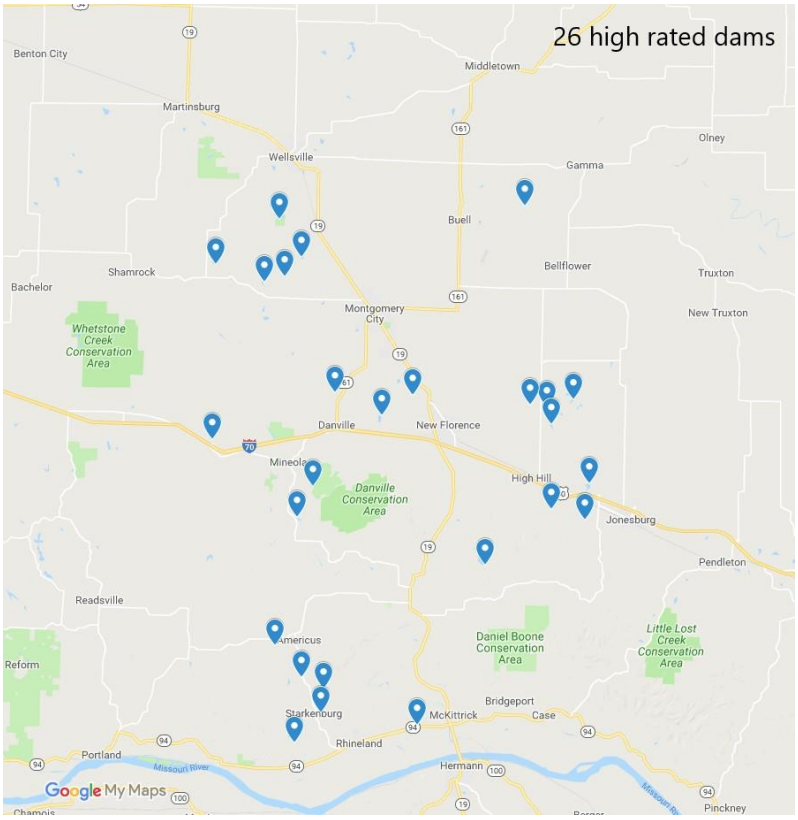
Dam Name	River	Nearest City	Miles to Nearest City	Owner's Name	Dam Height in Feet	Normal Acre-Feet Storag	EAP	Last Inspection Date
CATES DAM	TR SMITH BRANCH	MINEOLA	9	MRS. ARDINE CATES	22	58	NR	6/25/1979
ZANDER LAKE DAM	SCRATCHERS BRANCH	MONTGOMERY CITY	3	RICHARD ZANDER	18	59	NR	6/6/1980
HERON LAKE DAM UPPER	TR-BEAR CREEK	TRUXTON	12	CLAYTON COMMODITY SERVIC	16	51	NR	

Dam Name	River	Nearest City	Miles to Nearest City	Owner's Name	Dam Height in Feet	Normal Acre-Feet Storag	EAP	Last Inspection Date
GOLDEN EAGLE LAKE DAM	TR-BEAR CREEK	TRUXTON	14	CLAYTON COMMODITY SERVIC	33	990	NR	6/25/1979
COOL VALLEY LAKE DAM	PRICE BRANCH	JONESBURG	2	RAY OETTING	20	203	NR	6/28/1979
WELLSVILLE LAKE DAM	TR-LITTLE LOUTRE CREEK	MINEOLA	14	MO DEPT OF CONSERVATION	5	240	NR	8/9/1990
EASTERDAY DAM	TR-SMITH BRANCH	MINEOLA	10	EASTERDAY ESTATE	34	77	NR	6/25/1979
POINTDEXTER LAKE DAM	TR-LITTLE LOUTRE CREEK	MINEOLA	9	LARRY POINTDEXTER	30	110	NR	
GOLDEN EAGLE LAKE DAM -UPPER	TR-BEAR CREEK	TRUXTON	0	CLAYTON COMMODITY SERVIC	15	65	NR	
CASPER LAKE DAM	TR-MILLAM CREEK	MC KITTRICK	12	HAROLD CASPER	30	30	NR	
BROZ LAKE DAM	TR-OLIVER BR OF LOUTRE RIVER	MONTGOMERY CITY	0	JOHN DONALD BROZ	43	64	Y	4/5/2018
STANEK LAKE DAM	TR-WOLF CREEK	TRUXTON	0	FRANK STANER	25	64	NR	
ROY-L INC DAM (BREACHED)		NEW FLORENCE	0	CLAYTON COMMODITY SERVIC	30	900	NR	
LOUTRE VALLEY LAKE DAM	TR-LOUTRE RIVER	MCKITTRICK	16	LOUTRE VALLEY LAKE REC.	35	152	Y	2/1/2017
MUNZLINGER LAKE DAM	TR-DRY FORK-LOUTRE RIVER	AMERICUS	2	FILLMORE W MUNZLINGER	26	23	NR	
KELLY LAKE DAM	TR-BEAR CREEK	NEW HAVEN	30	MILDRED KELLY	30	80	NR	
STURGEON LAKE DAM	TR-CLEAR FK-LOUTRE RIVER	MINEOLA	5	BILLY W STURGEON	24	70	NR	
KENNY LAKE DAM	TR-WARDE BR-LOUTRE RIVER	MC KITTRICK	4	R C KENNY	21	84	NR	
ALLGEYER LAKE DAM	TR-DRY FORK,LOUTRE RIVER	AMERICUS	1	EDWARD ALLGEXER	29	43	NR	6/25/1979
PEPMILLER LAKE DAM	TR-MASSEY BR-LOUTRE RIVER	MINEOLA	4	E O PEPMILLER	30	40	NR	
PINNACLE LAKE DAM	PINNACLE CREEK	MCKITTRICK	12	PINNACLE LAKE EST. ASSOC	49	2486	Y	8/22/2016
LONE ROCK LAKE DAM	TR-LITTLE LOUTRE CREEK	MINEOLA		BARKS & VOLZ	21	83	NR	
WOHLTMAN LAKE DAM	TR-LOUTRE RIVER	NEW HAVEN	17	RANDOLPH C WOHLTMAN	30	18	NR	

Dam Name	River	Nearest City	Miles to Nearest City	Owner's Name	Dam Height in Feet	Normal Acre-Feet Storag	EAP	Last Inspection Date
LANDOLT DAM	UNAMED TRIB. OF PINCH CREEK	NA	0	NA	56	633	Y	4/5/2018
RHINE VALLEY LAKE DAM	TRIB OF QUICK CREEK	RHINELAND	1	NA	38.5	305	Y	11/10/2016
HOUSKA-VEHIGE DAM	UNNAMED TRIB OF MODAK CRK	STARKENBURG	0.3	NA	42	227	Y	9/19/2017

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

Figure 3.22. High Hazard Dam Locations in Montgomery County



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

When considering potential damage caused by a breached dam it is important to look downstream from the location of the dam. Middletown is the only jurisdiction within the planning area that rests immediately below a dam, in this case, the Ehrlich Lake Dam, just 8 miles north of town.

Table 3.30. Ehrlich Lake Dam, Middletown

Dam	City	Height in Feet	Acre-Feet Storage	Hazard	Inspection Date
EHRLICK LAKE DAM	MIDDLETOWN	23	179	S	7/8/1980

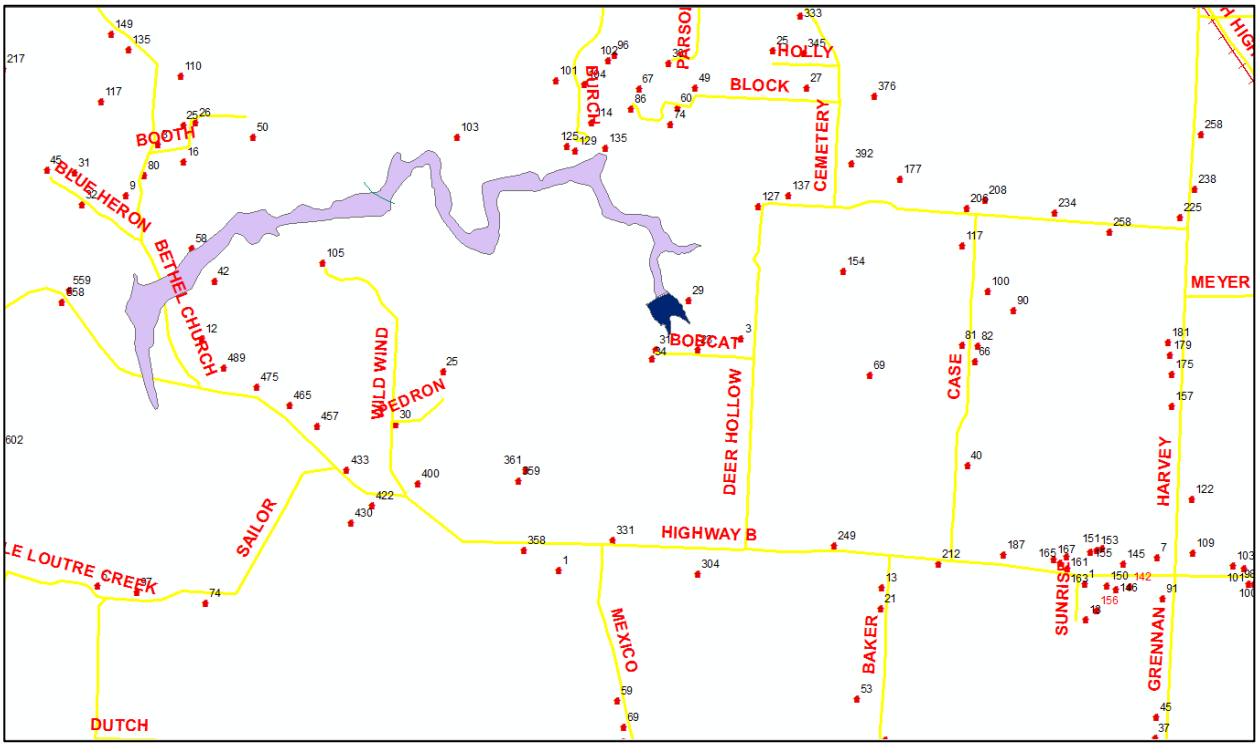
Source: National Inventory of Dams, http://nid.usace.army.mil/cm_apex/f?p=838:12

Because of its proximity to the city of Middletown, and because of its classification in the NID as a Significant Hazard, citizens from Middletown, during the 2015 planning session, suggested that consideration be given to the risk the city may face due to the dam. The Montgomery County EMD brought this issue to the attention of the Middletown City Council, who; after careful consideration, decided that the risk presented by the dam was not significant and that no further action is required. As a result, the 2019 MPC elected to remove this item from their action plan.

The inundation maps below are developed by the County Planning and Zoning. These are include the inundation areas identified by MoDNR. These dams do not pose any severe threat to properties. All these dams are located in unincorporated areas. These maps are provided as a reference for future funding opportunities.

Following each figure is a table that shows exposed properties.

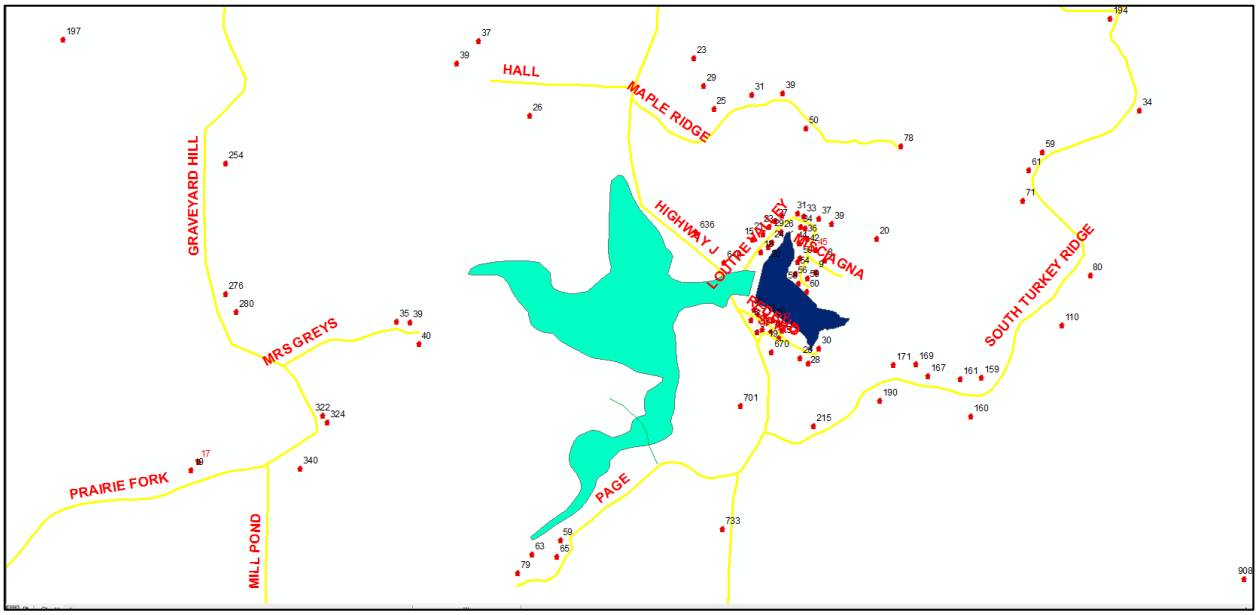
Figure 3.23. Stanek Lake Dam (MO11371) Inundation Area



Source: National Inventory of Dams

The lake is colored dark blue, the light purple is the inundation area, and the green line shows the position of water within half an hour. There are two properties located within 200 feet of the potential flood area.

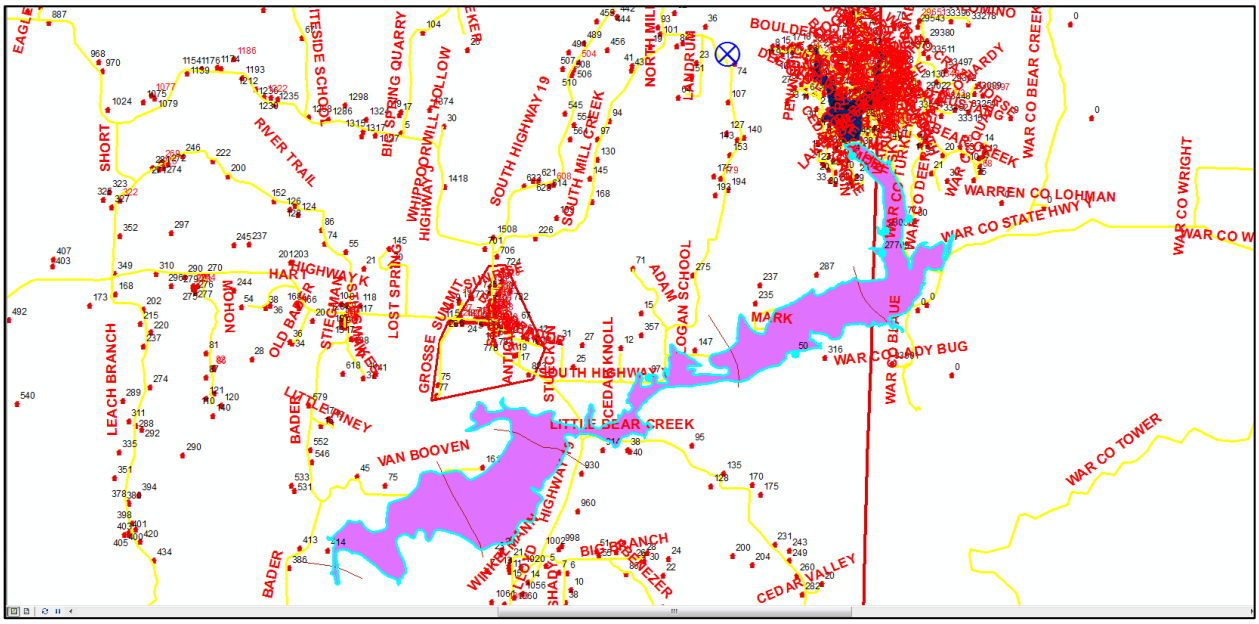
Figure 3.24. Loutre Valley Dam (MO30083) Inundation Area



Source: National Inventory of Dams

The lake is colored dark blue, the inundation area is turquoise, and the green line shows the reach of the water within half an hour. There are no structures in the inundation area.

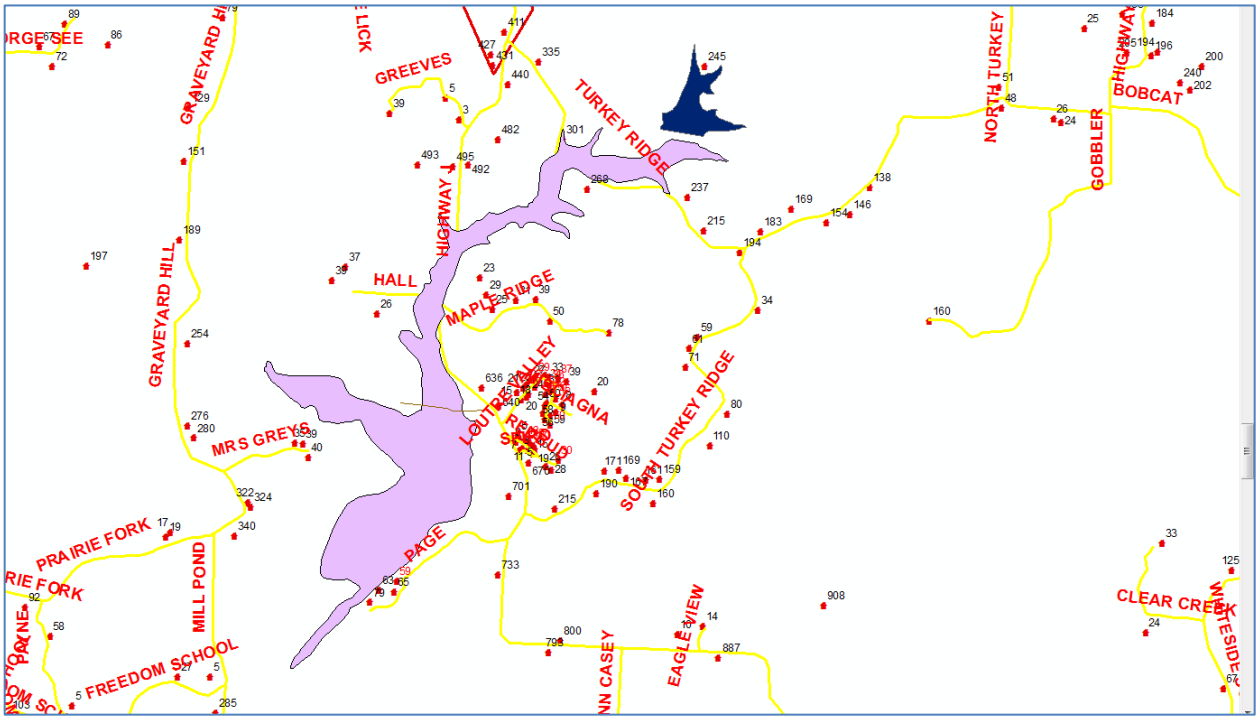
Figure 3.25. Pinnacle Lake Dam (MO30923) Inundation Area



Source: National Inventory of Dams

The lake is shown in dark blue partially obscured by red data points, purple indicates the inundation area, and the red lines show the reach of water by one-half hour increments. There are six properties within 200 feet of the flood area, two of which are directly in the path of the breach.

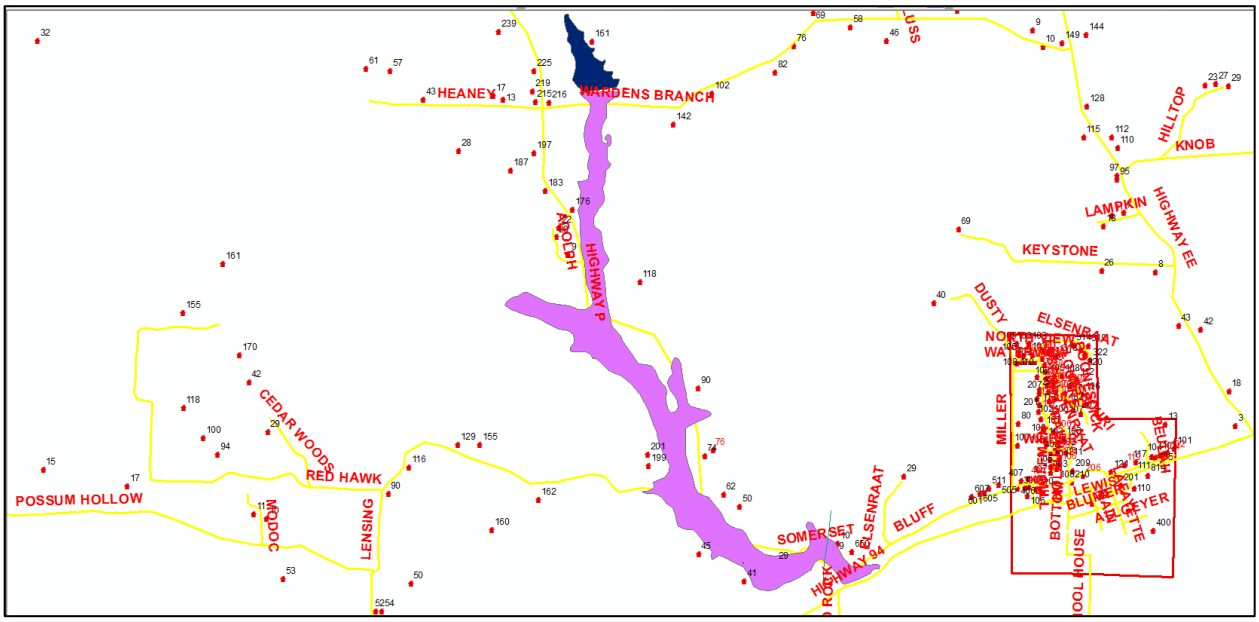
Figure 3.26. Landolt Lake Dam (MO40147) Inundation Area



Source: National Inventory of Dams

Landolt lake is shown as dark blue, the inundation area as purple, and the red line shows the position of the water one-half hour after breach. There are four properties within 200 feet of the flood area, one of which is in direct line of the breach.

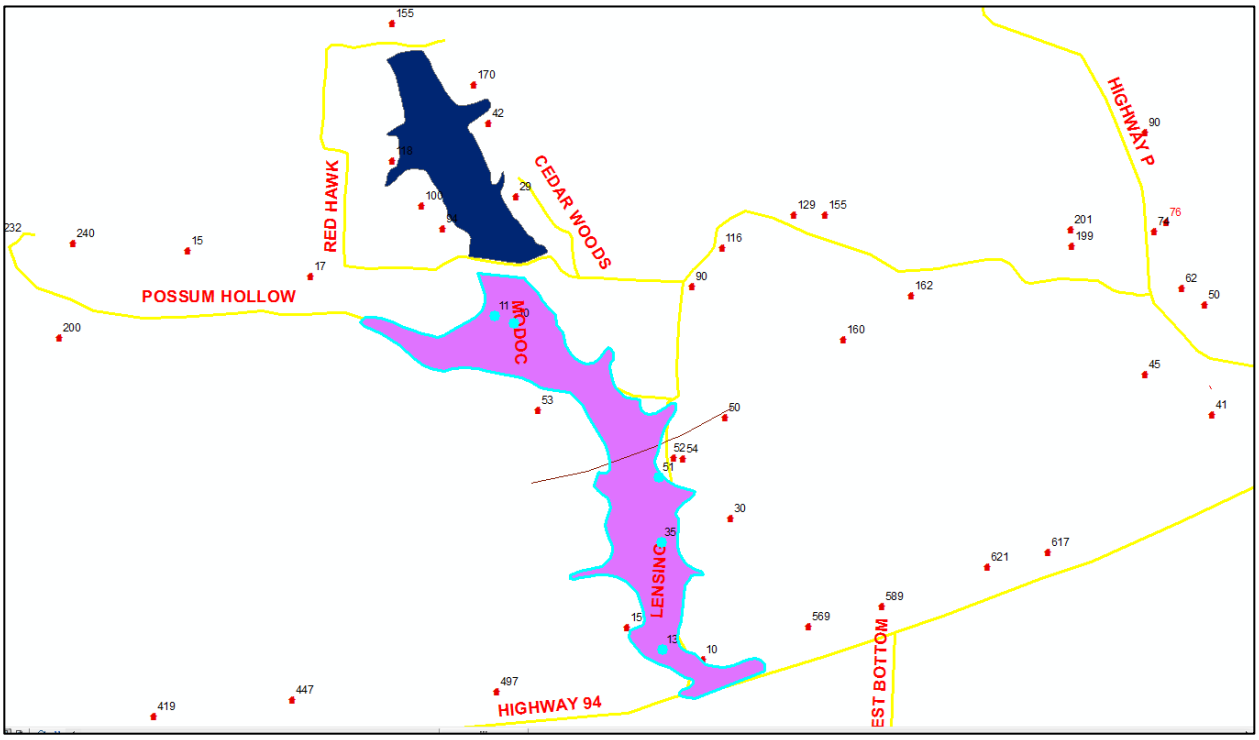
Figure 3.27. Housaka – Vehige Dam (MO40168) Inundation Area



Source: National Inventory of Dams

The lake is shown dark blue, the inundation area in purple, and the green line water arrival within half an hour. There are six properties within 200 feet of the flood area, two of which are in for a direct hit.

Figure 3.28. Lensing Lake Dam (40152) Inundation Area



The lake is shown dark blue, the inundation area in purple, and the red line water arrival within half an hour. There are seven properties within 200 feet of the inundation area, five of which are in direct line of a breach.

Upstream Dams Outside the Planning Area

The Missouri Department of Natural Resources was consulted to see if dams located outside of the county would impact it in the event of a failure. It was determined that there are no upstream dams that would place Montgomery County at risk.

Strength/Magnitude/Extent

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

Previous Occurrences

To determine previous occurrences of dam failure within Montgomery County, the 2015 Montgomery County Hazard Mitigation Plan was consulted as well as the 2018 Missouri State

Hazard Mitigation Plan and the Stanford University's National Performance of Dams Program (http://npdp.stanford.edu). Stanford's National Performance of Dams database reports an incident of high inflow into Pinnacle Lake on June 7, 1990. There were no consequences to the incident. There are no records of dam failure within the county boundaries.

Probability of Future Occurrence

There are no recorded dam failures for Montgomery County dams which make forecasting probability of failure difficult. However, there are two factors that can impact dam failure; regulation and inspection. Regulation requires regular inspections which can determine issues that contribute to failure. Of the eight MoDNR Class I dams in Montgomery County, only two are state-regulated; Pinnacle Lake Dam and Loutre Valley Lake dam.

Of the 26 High Hazard NID dams in the county, only 13 receive regular inspections and just six have published Emergency Action Plans. The impact of regular inspection and maintenance significantly reduces the probability of dam failure. We should again point out that of Montgomery County's 86 NID dams, 26 are rated High Hazard; which means failure could result in loss of life and significant property damage.

Changing Future Conditions Considerations

If we accept the climate change scenario that forecasts more dramatic periods of precipitation, we can then infer that more stress will be placed upon dams which will be more prone to failure. Couple that with an infrastructure of aging, uninspected, perhaps poorly maintained dams, and we have the makings of a serious problem for those living downstream.

Vulnerability

Vulnerability Overview

Vulnerability to dam failure is a factor due to the number of dams in the planning area, including 26 High Hazard Dams and one significant risk dam. As there are no recorded dam failures and most of them are located in unincorporated areas, the planning committee chose only to address high hazard dams when funding becomes available.

Potential Losses to Existing Development:

The two state-regulated dams with inundation maps available, if breached, could account for loss of 39 farm and residential structures valued at $8M and potential loss of life for up to 12 people.

Table 3.31. Dam Exposure for Montgomery County

County	No. Structures	Value of Structures	Population
Agriculture	34	$7,674,203	0
Residential	5	$870,357	12

Source: 2018 State Hazard Plan

Impact of Previous and Future Development

Montgomery County is largely rural with little evidence of growth within the inundation area of a dam.

Hazard Summary by Jurisdiction

The vast majority of Montgomery County is not in danger of being inundated due to a breach in a dam. No further analysis of dam failure hazard will be conducted for this plan update.

Problem Statement

Some entities in Montgomery County that own and control dams do not properly inspect and maintain them to ensure the safety of people and property that lie within the inundation area of a dam breach. Jurisdictions and residents must be informed of the proper way to inspect a dam and look for initial problems.

3.4.4 Earthquakes

Hazard Profile

Hazard Description

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

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. During the winter of 1811-1812 three earthquakes estimated to have been magnitude 7.5 or greater were centered in the New Madrid fault in the Bootheel region of southeast Missouri. Thousands of aftershocks continued for years.

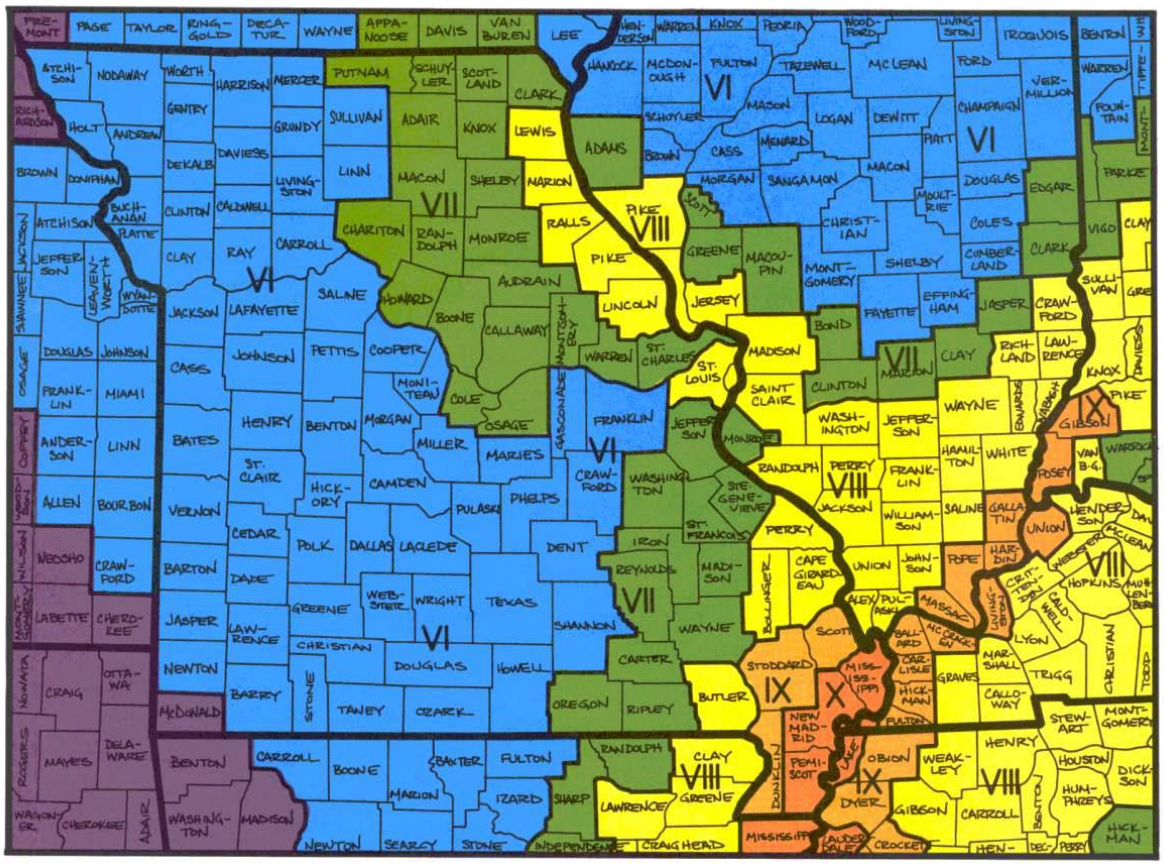
Significant earthquakes, each about magnitude 6, occurred in 1843 near Marked Tree, Arkansas, and on October 31, 1895 near Charleston, Missouri. In November 1968 a magnitude 5.5 earthquake centered in southeastern Illinois caused moderate damage to chimneys and walls at Hermann, St. Charles, St. Louis, and Sikeston, Missouri. The quake was felt in areas that include all or portions of 23 states. Other earthquakes have occurred throughout southeastern parts of Missouri. Smaller, but still destructive earthquakes are even more likely, according to the Missouri Seismic Safety Commission.

Geographic Location

Of the potential earthquake risk zones, the New Madrid Fault Zone is the most likely to impact Montgomery County. The following figure illustrates the highest projected Modified Mercalli intensities by county from a potential magnitude 7.6 earthquake whose epicenter could be

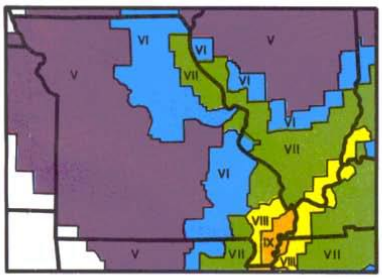
anywhere along the length of the New Madrid Seismic Zone.

Figure 3.29. Impact Zones for Earthquake Along the New Madrid Fault



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

6.7

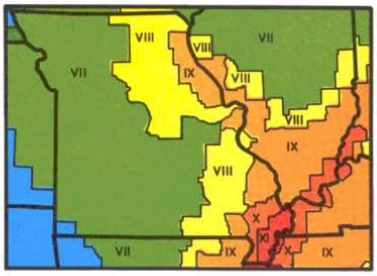


7.6

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.

8.6



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

Fortunately for Montgomery County, it lies within Category VII, meaning the effects of a New Madrid quake should be relatively minor.

Figure 3.30. Projected Earthquake Intensities

MODIFIED MERCALLI INTENSITY SCALE

I People do not feel any Earth movement.

II A few people might notice movement.

III Many people indoors feel movement. Hanging objects swing.

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

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

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

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

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

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

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

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

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

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

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