MONTGOMERY COUNTY MULTI-HAZARD MITIGATION PLAN

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Prepared for:

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EXECUTIVE SUMMARY

The Federal Emergency Management Agency (FEMA) defines the disaster life cycle as the process through which emergency managers respond to disasters when they occur; help people and institutions recover from them; reduce the risk of future losses; and prepare for emergencies and disasters. The Montgomery County Multi-Hazard Mitigation Plan (MHMP) focuses on the mitigation phase of the disaster life cycle. According to FEMA, mitigation is most effective when it's based on an inclusive, comprehensive, long-term plan that is developed before a disaster occurs. The MHMP planning process identifies hazards, the extent that they affect the municipality, and formulates mitigation practices to ultimately reduce the social, physical, and economic impact of the hazards.

In order for National Flood Insurance Program (NFIP) communities to be eligible for future mitigation funds, they must adopt either their own MHMP or participate in the development of a multi-jurisdictional MHMP. Further, it is required that local jurisdictions review, revise, and resubmit the MHMP every five years. As representatives from **Montgomery County, Alamo, Crawfordsville, Darlington, Ladoga, Linden, New Market, New Richmond, New Ross, Waveland, Waynetown, and Wingate** have provided information, attended meetings, and participated in the planning process, the planning process used to update the Montgomery County MHMP satisfies the requirements of a multi-jurisdictional plan.

During Planning Committee meetings, those in attendance revisited existing (in the 2016 MHMP) and identified new critical facilities and local hazards; reviewed the State's mitigation goals and updated the local mitigation goals and updated the local mitigation goals; reviewed the most recent local hazard data, vulnerability assessment, and maps; evaluated the effectiveness of existing mitigation measures and identified new mitigation projects; and reviewed materials for public participation. Meetings were also conducted with key groups such as city planners and various emergency responders and their information will continue to be incorporated into the MHMP update.

Risk Assessment

The risk assessment conducted for the Montgomery County MHMP is based on the methodology described in the Local Multi-Hazard Mitigation Planning Guidance published by FEMA in 2013 and is incorporated into the following sections:

1. **Hazard Identification** lists the natural, technological, and political hazards selected as having the greatest direct and indirect impact to the county as well as the system used to rank and prioritize the hazards.
2. **Hazard Profile** for each hazard, discuss the 1) historic data relevant to the municipalities where available; 2) vulnerability in terms of number and type of structures, repetitive loss properties (flood only), estimation of potential losses, and impacts based on an analysis of development trends; and 3) the relationship to other hazards identified.
3. **Hazard Summary** provides an overview of the risk assessment process; a table summarizing the relationship of the hazards; and a composite map to illustrate areas impacted by hazards.

When considering the hazards selected for study (drought; earthquake; extreme temperature; fire; flood; hail, thunder, wind; land subsidence; snow and ice storm; tornado; dam failure; and hazardous materials incidents) and the information obtained regarding the hazard profile and the hazard summary, the attached table identifies the hazards studied and ranking outcome. The ranking is completed utilizing the Calculated Risk Priority Index (CPRI), a tool by which individual hazards are evaluated and ranked according to an indexing system considering probability, magnitude, warning time, and duration for any hazard.

1. **Probability** is defined as the likelihood of the hazard occurring over a given period.

2. **Magnitude/Severity** is defined by the extent of the injuries, shutdown of critical infrastructure, the extent of property damage sustained, and the duration of the incident response.
3. **Warning Time** is defined as the length of time before the event occurs.
4. **Duration** is defined as the length of time that the actual event occurs. This does not include response or recovery efforts.

Mitigation Goals and Practices

The overall goal of the Montgomery County MHMP is to reduce the social, physical, and economic losses associated with hazard incidents through emergency services, natural resource protection, prevention, property protection, public information, and structural control mitigation practices.

As part of the planning process the Planning Committee discussed the strengths and weaknesses of existing mitigation practices and made recommendations for improvements, as well as suggested new practices. To provide further detail, information on the local status, local priority, benefit-cost ratio, project location, responsible entity, and potential funding source will be included with regard to each proposed practice. Those practices ranked by participants as a high priority are anticipated to be implemented within five years from the final Plan adoption and additional steps, or an implementation plan is included for each.

Plan Maintenance

The successful implementation of the MHMP will require the participation and cooperation of the entire Planning Committee to successfully monitor, evaluate, and update the Montgomery County MHMP. Local jurisdictions are required to update and resubmit the MHMP every five years. Information gathered following individual hazard incidents and annual meetings will be utilized along with updated vulnerability assessments to assess the risks associated with each hazard common in Montgomery County.

Type of Hazard	List of Hazards	Weighted Average CPRI
Natural	Drought	
	Earthquake	
	Extreme Temperature	
	Fire	
	Flood	
	Hail/Thunder/Windstorm	
	Landslide/Subsidence	
	Tornado	
	Winter Storm/Ice	
Technological	Dam Failure	
	Hazardous Materials Incident	

CHAPTER 1: INTRODUCTION

1.1 DISASTER LIFE CYCLE

The Federal Emergency Management Agency (FEMA) defines the disaster life cycle as the process through which emergency managers respond to disasters when they occur; help people and institutions recover from them; reduce the risk of future losses; and prepare for emergencies and disasters. The disaster life cycle, **Figure 1** includes four phases:

Figure 1 Disaster Life Cycle

- **Response** – the mobilization of the necessary emergency services and first responders to the disaster area (search and rescue; emergency relief)
- **Recovery** – to restore the affected area to its previous state (rebuilding destroyed property, re-employment, and the repair of other essential infrastructure)
- **Mitigation** – to prevent or to reduce the effects of disasters (building codes and zoning, vulnerability analyses, public education)
- **Preparedness** – planning, organizing, training, equipping, exercising, evaluation and improvement activities to ensure effective coordination and the enhancement of capabilities (preparedness plans, emergency exercises/training, warning systems)

The Montgomery County Multi-Hazard Mitigation Plan (MHMP) focuses on the mitigation phase of the disaster life cycle. According to FEMA, mitigation is most effective when it's based on an inclusive, comprehensive, long-term plan that is developed before a disaster occurs. Recent reviews of grant programs have determined for every $1 spent on mitigation efforts, between $6 and $10 are saved within the community on efforts following disasters. The MHMP planning process identifies hazards, the extent that they affect the municipality, and formulates mitigation practices to ultimately reduce the social, physical, and economic impact of the hazards.

1.2 PROJECT SCOPE & PURPOSE

REQUIREMENT §201.6(d)(3):
A local jurisdiction must review and revise its plan to reflect changes in development, progress in local mitigation efforts, and changes in priorities, and resubmit it for approval within five (5) years in order to continue to be eligible for mitigation project grant funding.

A MHMP is a requirement of the Federal Disaster Mitigation Act of 2000 (DMA 2000). According to DMA 2000, the purpose of mitigation planning is for State, local, and Indian tribal governments to identify the natural hazards that impact them, to identify actions and activities to reduce any losses from those

hazards, and to establish a coordinated process to implement the plan, taking advantage of a wide range of occurrences.

A FEMA-approved MHMP is required to apply for and/or receive project grants under the Building Resilient Infrastructure and Communities (BRIC), Hazard Mitigation Grant Program (HMGP), and Flood Mitigation Assistance (FMA). Although the Montgomery County MHMP meets the requirements of DMA 2000 and eligibility requirements of these grant programs, additional detailed studies may need to be completed prior to applying for these grants.

For National Flood Insurance Program (NFIP) communities to be eligible for future mitigation funds, they must adopt either their own MHMP or participate in the development of a multi-jurisdictional MHMP. The Indiana Department of Homeland Security (IDHS) and the United States Department of Homeland Security (US DHS)/FEMA Region V offices administer the MHMP program in Indiana. As noted above, it is required that local jurisdictions review, revise, and resubmit the MHMP every five years. MHMP updates must demonstrate that progress has been made in the last five years to fulfill the commitments outlined in the previously approved MHMP. The updated MHMP may validate the information in the previously approved Plan or may be a major plan rewrite. The updated MHMP is not intended to be an annex to the previously approved Plan; it stands on its own as a complete and current MHMP.

The Montgomery County MHMP Update is a multi-jurisdictional planning effort led by the Montgomery County EMA. This Plan was prepared in partnership with Montgomery County, the towns of Alamo, Darlington, Ladoga, Linden, New Market, New Richmond, New Ross, Waveland, Waynetown and Wingate, and the City of Crawfordsville. Representatives from these communities attended the Committee meetings, provided valuable information about their community, reviewed and commented on the draft MHMP, and assisted with local adoption of the approved Plan. As each of the communities had an equal opportunity for participation and representation in the planning process, the process used to update the Montgomery County MHMP satisfies the requirements of DMA 2000 in which multi-jurisdictional plans may be accepted.

Throughout this Plan, activities that could count toward Community Rating System (CRS) points are identified with the NFIP/CRS logo. The CRS is a voluntary incentive program that recognizes and encourages community floodplain activities that exceed the minimum NFIP requirements. As a result, flood insurance premiums are discounted to reflect the reduced flood risk resulting from community actions that meet the three goals of the CRS: (1) reduce flood losses; (2) facilitate accurate insurance rating; and (3) promote education and awareness of flood insurance. Savings in flood insurance premiums are proportional to the points assigned to various activities. A minimum of 500 points is necessary to enter the CRS program and receive a 5% flood insurance premium discount. This MHMP could contribute as many as 382 points toward participation in the CRS. At the time of this planning effort, none of the communities or the county participates in the CRS program.

Funding to update the MHMP was made available through a FEMA/DHS grant awarded to the Montgomery County EMA and administered by IDHS. Montgomery County provided the local 25% match required by the grant. Christopher B. Burke Engineering, LLC (Burke) was hired to facilitate the planning process and prepare the Montgomery County MHMP under the direction of an American Institute of Certified Planners (AICP) certified planner.

1.3 ANALYSIS PROCESS

REQUIREMENT §201.6(c)(1):
The plan shall document the planning process used to prepare the plan, including how it was prepared, who was involved in the process, and how the public was involved.

Preparation for the Montgomery County MHMP Update began in 2020, the grant request was approved by FEMA and grant funds were awarded in 2021.

Once the grant was awarded, the planning process to update the 2016 MHMP took 18 months. This included a review period by IDHS and FEMA for the draft MHMP Update, and time for Montgomery County and communities to adopt the final MHMP Update.

1.3.1 Planning Committee

In June of 2021, the EMA compiled a list of Planning Committee members to guide the MHMP update planning process. These individuals were specifically invited to serve on the Committee because they were knowledgeable of local hazards; have been involved in hazard mitigation; have the tools necessary to reduce the impact of future hazard events; and/or served as a representative on the original Planning Committee in 2016. **Table 1** lists the individuals that actively participated on the Committee and the entity they represented.

Table 1: MHMP Update Committee

Name	Office	Representing
Brandy Allen	City Planning Department	Crawfordsville
Jessica Burget	Emergency Management Agency / Fire Department	Montgomery County / New Richmond
Scott Busenbark	Fire Department	Crawfordsville
Brian Campbell	Emergency Management Agency	Montgomery County
Mike Davis	Mapping Department / Resident	Montgomery County / Ladoga
Shari Harrington	Emergency Management Agency	Montgomery County
Earl Heide	Town Superintendent	Linden
Janet Heide	Clerk – Treasurer	Linden
Tom Klein	County Administrator	Montgomery County
Jake Lough	Highway Department / Resident	Montgomery County / Darlington
Aaron Mattingly	Police Department	Crawfordsville
Chris Moore	Stormwater Department / Resident	Crawfordsville / New Market
James Peck	Engineer's Department	Montgomery County

Members of the Committee participated in the MHMP Update as a Planning Committee member or through various other group meetings. During these meetings, the Committee:

- revisited existing (in the 2016 MHMP) and identified new critical infrastructure and local hazards
- reviewed the State's mitigation goals and updated the local mitigation goals
- reviewed the most recent local hazard data, vulnerability assessment, and maps
- evaluated the effectiveness of existing mitigation measures and identified new mitigation projects
- reviewed materials for public participation.

A sign-in sheet recorded those present at each meeting to document participation. Meeting agendas and summaries are included in **Appendix 2**. Members of the Committee also reviewed a draft MHMP,

provided comments and suggestions, and assisted with adoption of the Montgomery County MHMP Update.

1.3.2 Public Involvement

A draft of the Montgomery County MHMP Update was posted to the Montgomery County website (www.montgomerycounty.in.gov) for public review and comment. A media release indicating the posting of the draft MHMP and the ability to comment was submitted for publishing to *The Journal Review* and social media sites for the EMA and *The Journal Review*. Committee members were provided with an informational flyer regarding the same information to display in their respective offices and to provide to family, friends and colleagues. No comments or corrections were received from the public or the Committee. The media release, informational flyer, and any comments received are included in **Appendix 3**.

1.3.3 Involvement of Other Interested Parties

Neighboring EMAs (Boone, Clinton, Fountain, Hendricks, Parke, Putnam, and Tippecanoe Counties) were also invited to review and comment on the MHMP update. Information related to the planning process and the availability of the draft Montgomery County MHMP was directly provided to representatives via personal conversations, informational flyer, and email correspondence. Successful implementation and future updates of the Montgomery County MHMP Update will rely on the partnership and coordination of efforts between such groups. No comments or corrections were received from the neighboring EMA offices.

1.4 PLANS, STUDIES, REPORTS, AND TECHNICAL INFORMATION

REQUIREMENT §201.6(c)(1):
The plan shall include a review and incorporation, if appropriate, of existing plans, studies, reports, and technical information.

During the development of the Montgomery County MHMP Update, several relevant sources of information were reviewed either as a document or through discussions with local personnel. This exercise was completed to gather updated information since the development of the previous Montgomery County MHMP, and to assist the Committee in developing potential mitigation measures to reduce the social, physical, and economic losses associated with hazards affecting Montgomery County.

For the purposes of this planning effort, the following materials (among others) were discussed and utilized:

- Montgomery County MHMP, 2016
- Montgomery County Comprehensive Plan, 2019
- City of Crawfordsville Comprehensive Plan, 2017
- City of Crawfordsville Stormwater Drainage Control Ordinance, 2010
- Montgomery County Zoning Ordinance
- Montgomery County GIS data

The Montgomery County Building and Zoning Department is responsible for much of the county, with the exception of the City of Crawfordsville and the two-mile jurisdiction.

In addition to local agencies and offices such as those listed above, several regional and state agencies were contacted and subsequently provided data for this planning effort. Those contacts, and the information they provided, include:

- Indiana Department of Natural Resources, Division of Water – *Flood insurance policies, claims, and payment information*
- Indiana Department of Natural Resources, Division of Water – *Dam records*
- FEMA, Region V – Repetitive loss structure counts and payments

The CRS program credits NFIP communities a maximum of 155 points for organizing a planning committee composed of staff from various departments; involving the public in the planning process; and coordinating among other agencies and departments to resolve common problems relating to flooding and other known natural hazards.

CHAPTER 2: COMMUNITY INFORMATION

Although much of the information within this section is not required by DMA 2000, this section contains important background information about the physical, social, and economical composition of Montgomery County necessary to better understand the Risk Assessment discussed in **Chapter 3**.

Montgomery County, originally established in 1822, and was named to honor Richard Montgomery, a General in the American Revolutionary War killed during the Battle of Quebec. Many of the county's original settlers arrived from Tennessee, Kentucky, and Ohio; the first earlier in 1821. Montgomery County is the 54th of the 92 Indiana counties to be organized. The total area of Montgomery County is approximately 504 square miles and the location of the county within the State of Indiana is identified in **Figure 2**.

2.1 POPULATION AND DEMOGRAPHICS

The most recent data for Montgomery County estimates that the 2020 population was 37,936, which ranks 39th in the State. Of that total, the City of Crawfordsville accounts for 16,151 or 43% of the county's population while the Town of Ladoga is the second largest community with 995 or 2.6% of the population.

Figure 2 Montgomery County Location

In 2020, the median age of the population in the county was 40.5 years of age. The largest demographic age groups in the county are older adults (45-64) with a population of 10,085 and young adults (25-44 years) with a population of 8,910. Seniors (65 and older) are the third largest age group with a population of 7,224 individuals living in Montgomery County. The approximate median household income in 2019 was reported to be $54,366 while the poverty rate in the same year was reported at 12.1% countywide. In total, 19.0% of households are married with children, and 34.3% of households are married without children.

Within the county, 89.8% of the adults older than 25, have reportedly completed a High School education. Further, 18.2% of those same adults have also completed a Bachelor of Arts or higher degree.

2.2 EMPLOYMENT

US Census data indicate that of the Montgomery County workforce, 39.0% are employed in manufacturing positions. Government and "other private" account for 12.0% and 8.8% respectively. The total resident labor force according to estimates in 2020 is 18,538 (with 958 unemployed) and a September 2021 unemployment rate of 2.8% which places Montgomery County as 54th of 92 counties in the State. **Table 2** lists the ten largest employers within Montgomery County as of 2020.

Table 2: List of Major Employers

LSC Communications (Crawfordsville)	Walmart Supercenter (Crawfordsville)
Nucor Steel (Crawfordsville)	Banjo Corp (Crawfordsville)
Random House Inc (Crawfordsville)	United Steelworkers (Crawfordsville)
Acuity Brands Lighting, Inc. (Crawfordsville)	North Montgomery School Corp (Crawfordsville)
Indiana Home Care Plus (Crawfordsville)	Bane Welker Equipment (Ladoga)

2.3 TRANSPORTATION AND COMMUTING PATTERNS

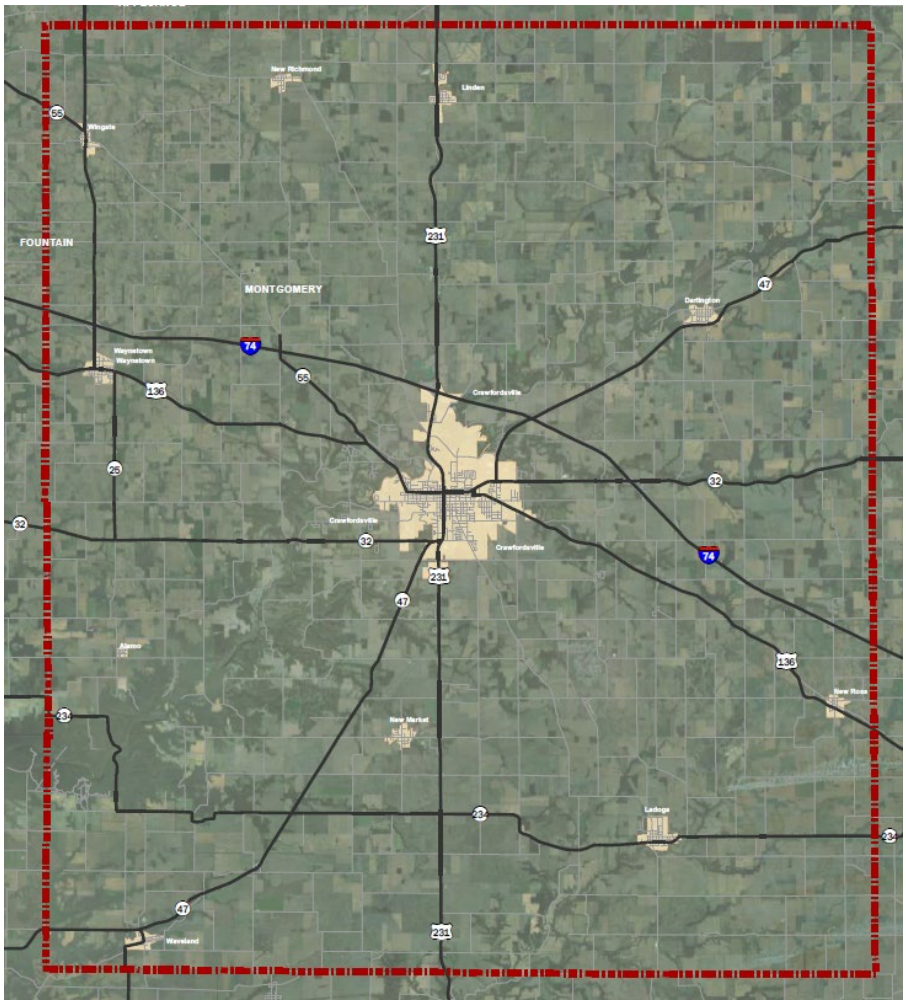


Figure 3 Montgomery County Transportation Routes

Several major transportation routes pass through Montgomery County and the municipalities within. Interstate 74, State Roads 25, 32, 47, 55, 59, 136, 231, and 234 serve as main routes between the various municipalities. CSX bisects the county from north to south and a section travels to the east from Crawfordsville to the county line near New Ross. These transportation routes are identified in **Figure 3** from the Montgomery County Comprehensive Plan.

According to STATSIndiana, approximately 3,200 people commute into Montgomery County daily. Nearly 25% of commuters travel from Fountain County. Further, approximately 3,400 Montgomery County residents commute to other counties, with the majority traveling to Tippecanoe County (32%).

Figure 4 indicates the number of workers 16 and older who do not live within Montgomery County but commute into the County for employment purposes. Similarly, **Figure 5** indicates the number of Montgomery County residents 16 and older that commute out of the county for employment.

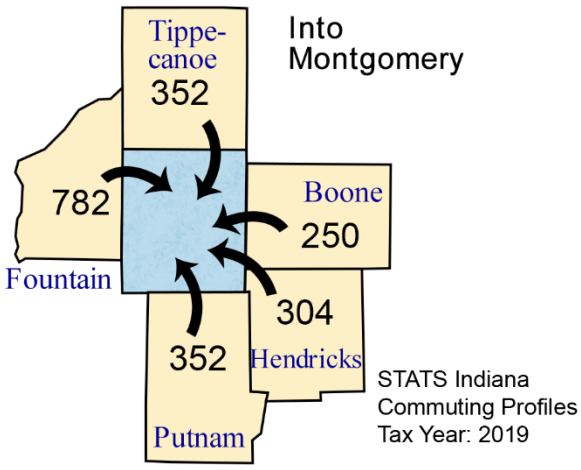


Figure 4 Workers out of Montgomery County

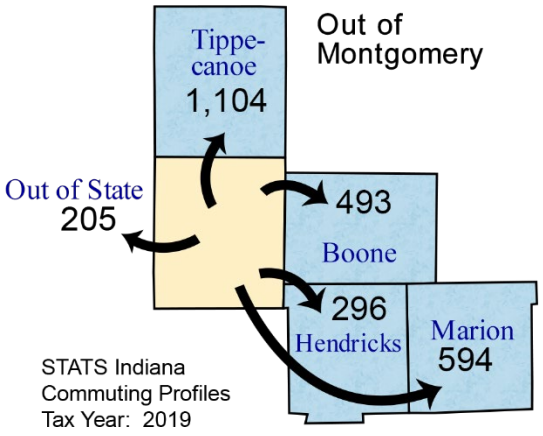


Figure 5 Workers into Montgomery County

2.4 CRITICAL AND NON-CRITICAL INFRASTRUCTURE

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

Critical facilities, or critical infrastructure, are the assets, systems, and networks, whether physical or virtual, so vital to the local governments and the United States that their incapacitation or destruction would have a debilitating effect on security, economic security, public health or safety, or any combination thereof.

These structures are vital to the community's ability to provide essential services and protect life and property; are critical to the community's response and recovery activities; and/or are the facilities, the loss of which, would have a severe economic or catastrophic impact. The operation of these facilities becomes especially important following a hazard event.

The Montgomery County EMA provided the listing and locations of the following 301 critical infrastructure points for the MHMP update:

- 1 Airport
- 26 Communication Towers
- 26 Daycare Centers
- 1 Emergency Operation Center
- 3 Emergency Medical Services
- 13 Fire Stations
- 60 Hazardous Materials Handlers
- 48 Health and Medical Facilities
- 56 Large Employers
- 1 Military Installation
- 1 Park
- 11 Police Stations
- 7 Potable Water Treatment Facilities
- 20 Power Substations
- 18 Schools
- 1 Transportation Facility
- 11 Wastewater Treatment Plants

Information provided by the EMA, GIS Department, and the MHMP Planning Committee members was utilized to identify the types and locations of critical structures throughout Montgomery County. Draft

maps were provided to the EMA, along with the Planning Committee for their review and all comments were incorporated into the maps and associated databases.

Exhibit 1 illustrates the critical infrastructure identified throughout unincorporated Montgomery County and the individual municipalities. **Appendix 4** lists the critical structures in Montgomery County by community. Non-critical structures include residential, industrial, commercial, and other structures not meeting the definition of a critical facility and are not required for a community to function. The development of this MHMP focused only on critical structures; non-critical structures are neither mapped nor listed.

2.5 MAJOR WATERWAYS AND WATERSHEDS

According to the United States Geological Survey (USGS), there are 50 waterways in Montgomery County, which are listed in **Appendix 5**. The county's main waterway is Sugar Creek and the county lies within two 8-digit Hydrologic Unit Code (HUC): Middle Wabash-Little Vermillion, and Sugar. These major waterways, and others, are identified on **Exhibit 2**.

2.6 NFIP PARTICIPATION

The NFIP is a FEMA program that enables property owners in participating communities to purchase insurance protection against losses from flooding. Montgomery County and the towns of Darlington, Waveland and Waynetown, along with the City of Crawfordsville individually participate in the NFIP. The towns of Alamo, Linden, New Market, New Richmond, New Ross, and Wingate do not individually participate in the NFIP and are considered to be covered under the county's participation. The Town of Ladoga does not participate in the NFIP. At the time of this planning effort, the Planning Director is responsible for the administration of the floodplain program in the City of Crawfordsville, while the Building Administrator for Montgomery County is responsible for the unincorporated areas of the County and Waynetown. Darlington and Waveland Clerk-Treasurer are the other offices responsible for administering the floodplain program.

Table 3 lists the NFIP number, effective map date, and the date each community joined the NFIP program. The Town of Waveland has no outlined SFHA, hence the indication of NSFHA in the table.

Table 3: NFIP Participation

NFIP Community	NFIP Number	Effective Map Date	Join Date
Montgomery County	180445#	02/02/2012	06/01/1998
Town of Alamo			
City of Crawfordsville	180171#	02/02/2012	02/01/1994
Town of Darlington	180321#	02/02/2012(M)	05/25/1978
Town of Ladoga	180172#	02/02/2012	05/24/1975 (Sanctioned)
Town of Linden			
Town of New Market			
Town of New Richmond			
Town of New Ross			
Town of Waveland	180174#	NSFHA	05/25/1984
Town of Waynetown	180175#	02/02/2012(M)	03/08/2013
Town of Wingate			

2.7 TOPOGRAPHY

Montgomery County is bordered geographically to the west by Fountain and Pike Counties, to the east by Boone and Hendricks Counties, to the north by Tippecanoe County, and to the south by Putnam County. The county is primarily a nearly level plain with many creeks and drainageways. The topography near Sugar Creek is characterized by abrupt changes especially along the waterway. In areas such as the northeastern section, and the east and south-central sections, there are little to no changes in relief. The remainder of the county could be classified as rolling. Elevation ranges from 560 feet above sea level where Sugar Creek leaves Montgomery County and enters Parke County to 930 feet near New Ross.

2.8 CLIMATE

The Midwestern Regional Climate Center (MRCC) provided climate data that includes information retrieved from a weather station located Lafayette Indiana, identified as station USC00124715. There is not a station located directly within Montgomery County. The average annual precipitation is 38.91 inches per year, with the wettest month being May averaging 4.64 inches of precipitation and the driest month being February with an average of 1.98 inches of precipitation. The highest 1-day maximum precipitation was recorded in June of 2004 with 4.51 inches of rain. On average, there are 73.2 days of precipitation greater than or equal to 0.1 inch; 26.3 days with greater than or equal to 0.5 inch; and 9.0 days with greater than or equal to 1.0 inch of precipitation.

Studies have recently been completed by the Indiana Climate Change Impacts Assessment, which is overseen by Purdue University Climate Change Research Center and comprised of a Steering Committee and several topic-oriented Working Groups. These studies indicate that average annual precipitation for Indiana is increasing seasonally during the winter and spring. Conversely, summers and autumns are trending toward less precipitation. In addition, their report shows changes in rain intensity and duration, along with frost-free days and growing seasons. These changes in climate, especially in Indiana, will impact natural hazards and how municipalities prepare for them.

CHAPTER 3: RISK ASSESSMENT

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

A risk assessment measures the potential loss from a hazard incident by assessing the vulnerability of buildings, infrastructure, and people in a community. It identifies the characteristics and potential consequences of hazards, how much of the community may be affected by a hazard, and the impact on community assets. The risk assessment conducted for Montgomery County and the communities within is based on the methodology described in the Local Multi-Hazard Mitigation Planning Guidance published by FEMA in 2011 and is incorporated into the following sections:

Section 3.1: Hazard Identification lists the natural, technological, and political hazards selected by the Planning Committee as having the greatest direct and indirect impact to the county as well as the system used to rank and prioritize the hazards.

Section 3.2: Hazard Profile for each hazard, discusses 1) historic data relevant to the county where applicable; 2) vulnerability in terms of number and types of structures, repetitive loss properties (flood only), estimation of potential losses, and impact based on an analysis of development trends; and 3) the relationship to other hazards identified by the Planning Committee.

Section 3.3: Hazard Summary provides an overview of the risk assessment process; a table summarizing the relationship of the hazards; and a composite map to illustrate areas impacted by the hazards.

3.1 HAZARD IDENTIFICATION

3.1.1 Hazard Selection

The MHMP Planning Committee reviewed the list of natural and technological hazards from the 2016 Montgomery County MHMP and discussed recent events and the potential for future hazard events. The Committee identified those hazards that affected Montgomery County and each community and selected the hazards to study in detail as part of this planning effort. As shown in **Table 4** these hazards include dam failure; drought; earthquake; extreme temperature; fire; flooding; hailstorms, thunderstorms, and windstorms; hazardous materials incident; land subsidence/landslides; snowstorms and ice storms; and tornado.

All hazards studied within the 2016 Montgomery County MHMP are included in the update.

Table 4: Hazard Identification

Type of Hazard	List of Hazards	Detailed Study	
		2016 MHMP	MHMP UPDATE
Natural	Drought	No	Yes
	Earthquake	Yes	Yes
	Extreme Temperature	No	Yes
	Fire	No	Yes
	Flood	Yes	Yes
	Hail/Thunder/Wind	Yes	Yes
	Land Subsidence/Landslide	No	Yes
	Snow / Ice Storm	Yes	Yes
	Tornado	Yes	Yes
Technological	Dam Failure	Yes	Yes
	Hazardous Material Incident	Yes	Yes

3.2 HAZARD RANKING

The Planning Committee ranked the selected hazards in terms of importance and potential for disruption to the community using a modified version of the Calculated Priority Risk Index (CPRI). The CPRI, adapted from MitigationPlan.com, is a tool by which individual hazards are evaluated and ranked according to an indexing system. The CPRI value (as modified by Burke) can be obtained by assigning varying degrees of risk probability, magnitude/severity, warning time, and the duration of the incident for each event, and then calculating as index value based on a weighted scheme. For ease of communications, simple graphical scales are used.

3.2.1 Probability

Probability is defined as the likelihood of the hazard occurring over a given period. The probability can be specified in one of the following categories:

- Unlikely – incident is possible, but not probable, within the next 10 years
- Possible – incident is probable within the next five years
- Likely - incident is probable within the next three years
- Highly Likely – incident is probable within the next calendar year

3.2.2 Magnitude / Severity

Magnitude/severity is defined by the extent of the injuries, shutdown of critical infrastructure, the extent of property damage sustained, and the duration of the incident response. The magnitude can be specified in one of the following categories:

- Negligible – few injuries OR critical infrastructure shutdown for 24 hours or less OR less than 10% property damaged OR average response duration of less than six hours
- Limited – few injuries OR critical infrastructure shut down for more than one week OR more than 10% property damaged OR average response duration of less than one day
- Significant – multiple injuries OR critical infrastructure shut down of at least two weeks OR more than 25% property damaged OR average response duration of less than one week
- Critical – multiple deaths OR critical infrastructure shut down of one month or more OR more than 50% property damaged OR average response duration of less than one month

3.2.3 Warning Time

Warning time is defined as the length of time before the event occurs and can be specified in one of the following categories:

- More than 24 hours
- 12-24 hours
- 6-12 hours
- Less than six hours

3.2.4 Duration

Duration is defined as the length of time that the actual event occurs. This does not include response or recovery efforts. The duration of the event can be specified in one of the following categories:

- Less than six hours
- Less than one day
- Less than one week
- Greater than one week

3.2.5 Calculating the CPRI

The following calculation illustrates how the index values are weighted and how the CPRI value is calculated. CPRI = Probability x 0.45 + Magnitude/Severity x 0.30 + Warning Time x 0.15 + Duration x 0.10. For the purposes of this planning effort, the calculated risk is defined as:

- **Low** if the CPRI value is between 1 and 2
- **Elevated** if the CPRI value is between 2 and 3
- **Severe** if the CPRI value is between 3 and 4

The CPRI value provides a means to assess the impact of one hazard relative to other hazards within the community. A CPRI value for each hazard was determined for each community in Montgomery County, and then a weighted CPRI value was computed based on the population size of each community. **Table 5** presents each community, population, and the weight applied to individual CPRI values to arrive at a combined value for the entire county. Weight was calculated based on the average percentage of each community's population in relation to the total population of the county. Thus, the results reflect the relative population influence of each community on the overall priority rank.

Table 5: Determination of Weighted Value for Communities

Community	Population (2021)	% of Total Population	Weighted Value
Montgomery County	16,344	42.9%	0.43
Town of Alamo	63	0.2%	0.00
City of Crawfordsville	16,096	42.3%	0.42
Town of Darlington	859	2.3%	0.02
Town of Ladoga	996	2.6%	0.03
Town of Linden	766	2.0%	0.02
Town of New Market	622	1.6%	0.02
Town of New Richmond	333	0.9%	0.01
Town of New Ross	340	0.9%	0.01
Town of Waveland	417	1.1%	0.01
Town of Waynetown	962	2.5%	0.03
Town of Wingate	265	0.7%	0.01
Total	38,063	100.0%	1.00

3.3 HAZARD PROFILES

The hazards studied for this report are not equally threatening to all communities throughout Montgomery County. While it would be difficult to predict the probability of an earthquake or tornado affecting a specific community, it is much easier to predict where the most damage would occur in a known hazard area such as a floodplain or near a facility utilizing an Extremely Hazardous Substance (EHS). The magnitude and severity of the same hazard may cause varying levels of damages in different communities.

This section describes each of the hazards that were identified by the Planning Committee for detailed study as a part of this MHMP Update. The discussion is divided into the following subsections:

- **Hazard Overview** provides a general overview of the causes, effects, and characteristics that the hazard represents
- **Historic Data** presents the research gathered from local and national courses on the hazard extent and lists historic occurrences and probability of future incident occurrence
- **Assessing Vulnerability** describes, in general terms, the current exposure, or risk, to the community regarding potential losses to critical infrastructure and the implications to future land use decisions and anticipated development trends
- **Relationship to Other Hazards** explores the influence one hazard may have upon another hazard.

3.3.1 Drought

Drought: Overview

Drought, in general, means a moisture deficit extensive enough to have social, environmental, or economic effects. Drought is not a rare and random climate incident; rather, it is a normal, naturally recurring feature of climate. Drought may occur in virtually all climactic zones, but its characteristics vary significantly from one region to another. Drought is a temporary aberration and is different from aridity, which is restricted to low rainfall regions.

Figure 6 Urban Drought Affects

There are four academic approaches to examining droughts; these are meteorological, hydrological, agricultural, and socio-economic. Meteorological drought is based on the degree, or measure, of dryness compared to a normal, or average amount of dryness, and the duration of the dry period. Hydrological drought is associated with the effects of periods of precipitation (including snowfall) shortfalls on surface or subsurface water supply. Agricultural drought is related to agricultural impacts; and focuses on precipitation shortages, differences between actual and potential evapo-transpiration, soil water deficits, reduced ground water or reservoir levels, and crop yields. Socioeconomic drought relates the lack of moisture to community functions in the full range of societal functions, including power generation, the local economy, and food source **Figure 6** shows urban grassed areas affected by drought conditions.

Drought: Recent Occurrences

Category	Description	Possible Impacts
D0	Abnormally Dry	Going into drought: ▪ short-term dryness slowing planting, growth of crops or pastures Coming out of drought: ▪ some lingering water deficits ▪ pastures or crops not fully recovered
D1	Moderate Drought	▪ Some damage to crops, pastures ▪ Streams, reservoirs, or wells low, some water shortages developing or imminent ▪ Voluntary water-use restrictions requested
D2	Severe Drought	▪ Crop or pasture losses likely ▪ Water shortages common ▪ Water restrictions imposed
D3	Extreme Drought	▪ Major crop/pasture losses ▪ Widespread water shortages or restrictions
D4	Exceptional Drought	▪ Exceptional and widespread crop/pasture losses ▪ Shortages of water in reservoirs, streams, and wells creating water emergencies

Figure 7 US Drought Monitor Severity Classification

Data gathered from the U.S. Drought Monitor indicated that between May 2015 and May 2022, there were 108 weeks where some portions of Montgomery County was considered to be in "Abnormally Dry" or D0. This is nearly 30% of the time period in consideration. According to the Drought Monitor, there were far fewer weeks in the time since 2015 where any portion of Montgomery County was in a drought state higher than a D0. Between October 2015 and January 2016, nearly 100% of the county was considered to be in a D1 drought or suffering effects such as potential water shortages developing. This occurred again for nine weeks between August and November 2017. **Figure 7**, from the U.S. Drought Monitor, describes the rationale to classify the severity of droughts.

The National Climate Data Center (NCDC) does not report any events or property or crop losses within Montgomery County during this planning period.

The Planning Committee, utilizing the CPRI, determined the overall risk of drought throughout Montgomery County is "Elevated". The probability of drought was determined to be the same for all communities and unincorporated area but the impact is anticipated to vary throughout the county due to the possible agricultural impacts and impacts to water wells. The committee agreed that a drought is "Likely" (probably within the next three years) and the magnitude of drought is anticipated to be "Negligible" to "Critical". Further it is anticipated that with the enhanced weather forecasting abilities, the warning time for a drought is greater than 24 hours and the duration will be greater than one week. A summary is shown in **Table 6**.

Table 6 CPRI for Drought

	Probability	Magnitude/ Severity	Warning Time	Duration	CPRI
Montgomery County	Likely	Critical	> 24 Hours	> 1 Week	Elevated
Town of Alamo	Likely	Negligible	> 24 Hours	> 1 Week	Elevated
City of Crawfordsville	Likely	Significant	> 24 Hours	> 1 Week	Elevated
Town of Darlington	Likely	Negligible	> 24 Hours	> 1 Week	Elevated
Town of Ladoga	Likely	Negligible	> 24 Hours	> 1 Week	Elevated
Town of Linden	Likely	Negligible	> 24 Hours	> 1 Week	Elevated
Town of New Market	Likely	Negligible	> 24 Hours	> 1 Week	Elevated
Town of New Richmond	Likely	Limited	> 24 Hours	> 1 Week	Elevated
Town of New Ross	Likely	Negligible	> 24 Hours	> 1 Week	Elevated
Town of Waveland	Likely	Limited	> 24 Hours	> 1 Week	Elevated
Town of Waynetown	Likely	Limited	> 24 Hours	> 1 Week	Elevated
Town of Wingate	Likely	Negligible	> 24 Hours	> 1 Week	Elevated

According to the National Drought Mitigation Center, scientists have difficulty predicting droughts more than one month in advance due to the numerous variables such as precipitation, temperature, soil moisture, topography, and air-sea interactions. Further anomalies may also enter the equation and create more dramatic droughts or lessen the severity of droughts. Based on the previous occurrences of significant droughts and drought related impacts felt within Montgomery County, the Committee estimated that the probability of a drought occurring in the area is "Likely"; or occurrence is probable within the next three years.

"Negligible" to "Critical" damages are anticipated throughout the county as the municipalities rely on groundwater supplies for fire response efforts and face a higher risk during times of prolonged drought. Throughout the unincorporated areas of the county, increased crop and livestock damages would also be expected during a significant drought. Communities such as Waveland, Richmond and Waynetown anticipate economic impacts due to drought effects on outdoor activities related to water levels.

Drought: Assessing Vulnerability

This type of hazard will generally affect entire counties and even multi-county regions at one time. Within Montgomery County, direct and indirect effects from a long period of drought may include:

Direct Effects:

- Urban and developed areas may experience revenue losses from landscaping companies, golf courses, restrictions on industry cooling and processing demands, businesses dependent on crop yields; and increased potential for fires
- Rural areas within the county may experience revenue losses from reductions in livestock and crop yields as well as increased field fires
- Citizens served by drinking water wells may be impacted during low water periods and may require drilling of deeper wells or loss of water service for a period of time

Indirect Effects:

- Loss of income of employees from businesses and industry affected; loss of revenue to support services (food service, suppliers, etc.)
- Loss of revenue from recreational or tourism sectors associated with reservoirs, streams, and other open water venues
- Lower yields from domestic gardens increasing the demand on purchasing produce and increased domestic water usage for landscaping
- Increased demand on emergency responders and firefighting resources

Estimating Potential Losses

Figure 8 Crops Affected by Drought

It is difficult to estimate the potential losses associated with a drought for Montgomery County because of the nature and complexity of this hazard and the limited data on past occurrences. However, for the purpose of this MHMP update, a scenario was used to estimate the potential crop loss and associated revenue lost due to a drought similar to that experienced during the drought of record from 1988. In 2021, Montgomery County produced approximately 23.6M bushels of corn and 7.9M bushels of soybeans, as reported by the United States Department of Agriculture (USDA) National Agricultural Statistics Service. Using national averages of $6.10 per bushel of corn and $14.40 per bushel of soybeans, the estimated crop receipts for 2021 would be $258.0M. Using the range of crop yield decreases reported in 1988 and 1989, just after the 1988 drought period (50%-86%) and assuming a typical year, economic losses could range between $129M-$221.9M; depending on the crop produced and the market demand. Effects of drought on corn crops can be seen in **Figure 8**.

Purdue Agriculture News reports that as of March 2013, Indiana producers received more than $1.0B in crop insurance payments for 2012 corn, soybean, and wheat losses. This amount is nearly double that of the previous record, $522M following 2008 losses, also due to drought. These losses are still considered to be record-setting in terms of drought effects, damages, and costs for Indiana.

According to a July 5, 2012 article in The Times (Noblesville, IN), "The effects of drought also could touch agricultural businesses, such as handlers and processors, equipment dealers, and see, fertilizer and pesticide providers". Additional losses associated with a prolonged drought are more difficult to quantify. Drought has lasting impacts on urban trees: death to all or portions of a tree, reduction in

the tree's ability to withstand insects and diseases, and interruption of normal growth patterns. Such effects on trees, especially urban trees can lead to additional impacts, both environmentally and monetarily in terms of the spread of Emerald Ash Borer insect and the weakening of tree limbs and trunks which may lead to increased damages during other hazard events such as wind and ice storms.

Future Considerations

Advancements in plant hybrids and development have eased the impacts from short-lived droughts. Seeds and plants may be more tolerant of dryer seasons and therefore fewer crop losses may be experienced.

As the municipal areas of the county continue to grow and expand, protocols may need to be developed which create a consistency throughout the communities and the unincorporated portions of the county for burn bans and water usage advisories.

According to the Indiana Climate Change Impacts Assessment, Indiana has experienced a rise in the average annual precipitation between 1895 and 2016; an increase of 6.5 inches for the area of Montgomery County. This increase in precipitation may lessen the likelihood or overall impact of a drought in Montgomery County. However, the assessment also notes seasonal shifts in precipitation which may lead to seasonal short-term droughts. In either scenario, changes in precipitation are not anticipated to relieve the area of a probability of a drought occurring.

Prior to municipalities expanding, provisions and considerations should be given regarding the potential additional demand for both water usage and fire response efforts. Following such expansion or development plans, alternative water sources should be explored. Since the previous MHMP was prepared and continuing through this effort, large scale industrial development has occurred southeast of the City of Crawfordsville. The Nucor steel plant is expanding capabilities and with that, potential water needs for both production and potential fire protection. To assist with this increase, a 1M gallon water tower was constructed in the area. Similar actions should be considered as other areas are slated for similar development, the SR32/I-74 interchange, the I-74/Lafayette Rd interchange, and the SR47/US 231 area.

Drought: Relationship to Other Hazards

Discussions with the Planning Committee were held regarding the similar effects of prolonged periods of extreme heat and the similar impacts that may be experienced during these times. Planning and mitigation efforts for one hazard may benefit the other. It is anticipated that rural areas of the county may be more susceptible to cropland or woodland fires during a drought, while urban areas may experience these impacts in areas where several abandoned buildings or overgrown lots exist, and this may lead to increased losses associated with a fire.

3.3.2 Earthquake

Earthquake: Overview

An earthquake is a sudden, rapid shaking of the earth caused by the breaking and shifting of rock beneath the earth's surface. For hundreds of millions of years, the forces of plate tectonics have shaped the earth as the huge plates that form the earth's surface move slowly over, under, and past each other. Sometimes the movement is gradual. At other times, the plates are locked together, unable to release the accumulating energy. When the accumulated energy grows strong enough, the plates break free, causing the ground to shake. Most earthquakes occur at the boundaries where the plates meet; however, some earthquakes occur in the middle of the plates.

Ground shaking from earthquakes can collapse buildings and bridges; disrupt gas, electric, and phone service; and sometimes trigger landslides, avalanches, flash floods, fires, and huge destructive ocean waves (tsunamis). Buildings with foundations resting on unconsolidated landfill and other unstable soil, and trailers and homes not tied to their foundations are at risk because they can move off their mountings during an earthquake. When an earthquake occurs in a populated area, it may cause deaths, injuries, and extensive property damage.

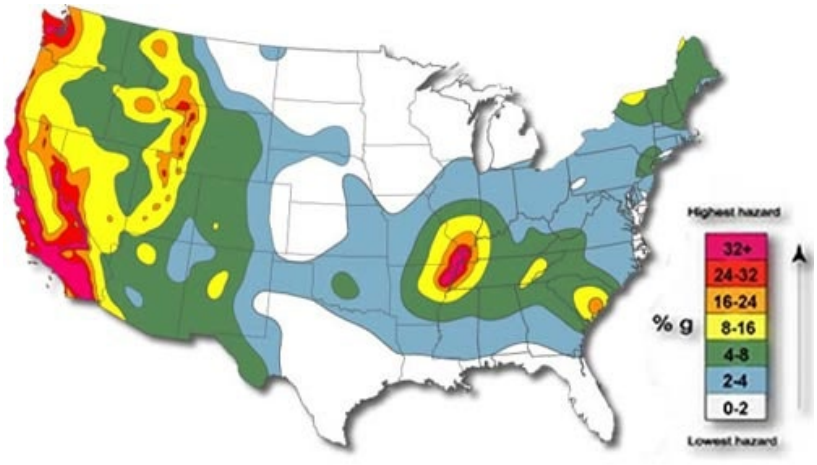


Figure 9 Earthquake Hazard Areas in the US

Earthquakes strike suddenly, without warning. Earthquakes can occur at any time of the year and at any time of the day or night. On a yearly basis, 70-75 damaging earthquakes occur throughout the world. Estimates of losses from a future earthquake in the United States approach $200B.

One method of measuring the magnitude or energy of an earthquake is the Richter Scale. This scale uses whole numbers and decimal fractions whereby each increase of a whole number represents a release of 31 times more energy than the amount associated with the previous whole number on the scale. Scientists are currently studying the New Madrid fault area and have predicted that the chances of an earthquake in the M8.0 range occurring within the next 50 years are approximately 7%-10%. However, the chances of an earthquake at a M6.0 or greater, are at 90% within the next 50 years.

There are 45 states and territories in the United States at moderate to very high risk from an earthquake, and they are located in every region of the county (**Figure 9**). California experiences the most frequent damaging earthquakes; however, Alaska experiences the greatest number of large earthquakes – most located in uninhabited areas. The largest earthquakes felt in the United States were along the New Madrid Fault in Missouri, where a three-month long series of quakes from 1811 to 1812 occurred over the entire Eastern United States, with Missouri, Tennessee, Kentucky, Indiana, Illinois, Ohio, Alabama, Arkansas, and Mississippi experiencing the strongest ground shaking.

Earthquake: Recent Occurrences

Indiana, as well as several other Midwestern states, lies in the most seismically active region east of the Rocky Mountains. Regarding Montgomery County, the nearest areas of concern are the Wabash Seismic Zone and the New Madrid Fault Zone.

On June 17, 2021 an earthquake centered near Bloomingdale, Indiana in Parke County was felt as far north as Chicago, Illinois and as far east as Cincinnati, Ohio. With a magnitude of 3.8 several localized reports included descriptions of shaking buildings and feelings of tremors. No injuries or severe damages were reported due to this incident. As reported by the NBC 5 Chicago, "Once the earthquake was confirmed, officials said the 9-1-1 phone line "started ringing immediately."" This event caused damages to the First Baptist Church in New Market. Lights were jostled, cracks were formed in the walls and ceiling, and display items were shifted. It was said that it felt like a car hit the building and the structure was shut down until cleared for worship by a structural engineer. In the Town of Linden, the doors at the water plant rattled but no damages were observed.

Previous to this event, the last earthquake to be felt in Indiana was a magnitude 5.1 centered in Sparta, North Carolina and the last event to actually occur within the state was a magnitude 2.3 earthquake centered in Haubstadt, IN on May 28, 2015. No injuries or damages were reported with either of these events.

On December 30, 2010, central Indiana experienced an earthquake with a magnitude of 3.8; rare for this area in Indiana as it is only the 3rd earthquake of notable size to occur north of Indianapolis. Even rarer is the fact that scientists believe that the quake was centered in Greentown, Indiana approximately 13 miles southeast of Kokomo, Indiana. According to The Kokomo Tribune, "113 people called 911 in a 15-minute period after the quake, which was the first tremblor centered in Indiana since 2004". Further, a geophysicist from the USGS in Colorado stated, "It was considered a minor earthquake", and "Maybe some things would be knocked off shelves, but as far as some significant damage, you probably wouldn't expect it from a 3.8".

Figure 10 Earthquake Damaged Porch

A M5.8 centered in Mineral, Virginia affected much of the East Coast on August 23, 2011. According to USA Today, 10 nuclear power plants were shutdown of precautionary inspections following the quake, over 400 flights were delayed, and the Washington Monument was closed indefinitely pending detailed inspections by engineers.

Based on historical earthquake data, local knowledge of previous earthquakes, results of HAZUS-MH scenarios, and historical earthquake impacts to Montgomery County, the Committee determined that the probability of an earthquake occurring in Montgomery County or any of the communities is "Unlikely". Should an earthquake occur, the impacts associated with this hazard are anticipated to be "Limited" to "Significant" throughout the county based on the amount of infrastructure, critical facilities, and populations. As with all earthquakes, it was determined that the residents of Montgomery County would have little to no warning time (less than six hours) and that the duration of the event would be expected to also be less than six hours. A summary is shown in **Table 7**.

Table 7 CPRI for Earthquake

	Probability	Magnitude/ Severity	Warning Time	Duration	CPRI
Montgomery County	Unlikely	Significant	< 6 Hours	< 6 Hours	Low
Town of Alamo	Unlikely	Limited	< 6 Hours	< 6 Hours	Low
City of Crawfordsville	Unlikely	Significant	< 6 Hours	< 6 Hours	Low
Town of Darlington	Unlikely	Limited	< 6 Hours	< 6 Hours	Low
Town of Ladoga	Unlikely	Limited	< 6 Hours	< 6 Hours	Low
Town of Linden	Unlikely	Negligible	< 6 Hours	< 6 Hours	Low
Town of New Market	Unlikely	Negligible	< 6 Hours	< 6 Hours	Low
Town of New Richmond	Unlikely	Negligible	< 6 Hours	< 6 Hours	Low
Town of New Ross	Unlikely	Negligible	< 6 Hours	< 6 Hours	Low
Town of Waveland	Unlikely	Limited	< 6 Hours	< 6 Hours	Low
Town of Waynetown	Unlikely	Negligible	< 6 Hours	< 6 Hours	Low
Town of Wingate	Unlikely	Negligible	< 6 Hours	< 6 Hours	Low

Per the Ohio Department of Natural Resources Division of Geological Survey, "…it is difficult to predict the maximum-size earthquake that could occur in the state and certainly impossible to predict when such an event would occur. In part, the size of an earthquake is a function of the area of a fault available for rupture. However, because all known earthquake-generating faults in Ohio are concealed beneath several thousand feet of Paleozoic sedimentary rock, it is difficult to directly determine the size of these faults." Further according to the Indiana Geological Survey, "…no one can say with any certainty when or if an earthquake strong enough to cause significant property damage, injury, or loss of life in Indiana will occur…we do indeed face the possibility of experiencing the potentially devastating effects of a major earthquake at some point in the future". The Committee felt that an earthquake occurring within or near to Montgomery County is "Unlikely" to occur within the next ten years.

Figure 11 Minor Earthquake Damages

Earthquake: Assessing Vulnerability

Earthquakes generally affect broad areas and potentially many counties at one time. Within Montgomery County, direct and indirect effects from an earthquake may include:

Direct Effects:

- Urban areas may experience more damages due to the number of structures and critical infrastructure located in these areas
- Rural areas may experience losses associated with agricultural structures such as barns and silos
- Bridges, buried utilities, and other infrastructure may be affected throughout the county and municipalities

Indirect Effects:

- Provide emergency response personnel to assist in the areas with more damage

- Provide shelter for residents of areas with more damage
- Delays in delivery of goods or services originating from areas more affected by the earthquake

Types of loss caused by an earthquake could be physical, economic, or social in nature. Due to the unpredictability and broad impact regions associated with an earthquake, all critical and non-critical infrastructure are at risk of experiencing earthquake related damages. Damages to structures, infrastructure, and even business interruptions can be expected following an earthquake. Examples of varying degrees of damages are shown in **Figure 10** and **Figure 11**.

Estimating Potential Losses

In order to determine the losses associated with an earthquake, the HAZUS-MH software was utilized in the Montgomery County MHMP update to determine the potential impacts anticipated from an arbitrary earthquake scenario. This scenario placed a magnitude 5.0 southeast of Waynetown, east of SR 25 and south of US 136. This type of modeling is useful for planning efforts such as this.

Per the HAZUS-MH scenario noted above, total economic losses are anticipated to be near $562.2M. Building related losses from the earthquake are estimated at $257.1M with moderate damages to approximately 1,777 buildings, of which 66 are anticipated to be damaged beyond repair. Further, there are no anticipated moderate damages to critical facilities, transportation segments, or utilities. Approximately 65,000 tons of debris would need to be removed from the area requiring 2,600 dump trucks. An estimated 119 households are expected to be displaced following the event with 71 residents seeking assistance with shelter.

The HAZUS-MH model computes anticipated economic losses for the hypothetical earthquake due to direct building losses and business interruption losses. Direct building losses are the costs to repair or to replace the damage caused to the building and contents, while the interruption losses are associated with the inability to operate a business due to the damage sustained. Business interruption losses also include the temporary living expenses for those people displaced from their homes.

The HAZUS-MH Earthquake Model allows local building data to be imported into the analysis. However, these local data are imported as "general building stock", meaning that the points are assigned to a census tract rather than a specific XY coordinate. HAZUS performs the damage analysis as a county wide analysis and reports losses by census tract. While the results of the hypothetical scenario appear to be plausible, care should be taken when interpreting these results.

Future Considerations

While the occurrence of an earthquake in or near to Montgomery County may not be the highest priority hazard studied for the development of the plan, it is possible that residents, business owners, and visitors may be affected should an earthquake occur anywhere within the state. For that reason, Montgomery County should continue to provide education and outreach regarding earthquakes and even earthquake insurance along with education and outreach for other hazards. As Montgomery County and the communities within the county grow and develop, the proper considerations for the potential of an earthquake to occur may help to mitigate against social, physical, or economic losses in the future.

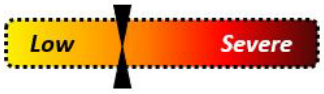
It can be anticipated that while all structures in Montgomery County will remain at-risk to earthquake damages and effects, new construction or redevelopment may reduce the overall risks. As redevelopment or growth occurs, primarily within and near Crawfordsville, the new construction may be significantly sturdier. Further, as blighted or abandoned areas are addressed, those communities

and the county as a whole, are less susceptible to economic and physical damages associated with earthquakes.

Earthquake: Relationship to Other Hazards

Hazardous materials incidents may occur as a result of damage to material storage containers or transportation vehicles involved in road crashes or train derailments. Further, dam failures and landslides may occur following an earthquake or associated aftershocks due to the shifting of the soils in these hazard areas. These types of related hazards may have greater impacts on Montgomery County communities than the earthquake itself. It is not expected that earthquakes will be caused by other hazards studied within this plan.

3.3.3 Extreme Temperature



Extreme Temperatures: Overview

Extreme heat is defined as a temporary elevation of average daily temperatures that hover 10 degrees or more above the average high temperature for the region for the duration of several weeks. Humid or muggy conditions, which add to the discomfort of high temperatures, occur when a dome of high atmospheric pressure traps water-laden air near the ground. In a normal year, approximately 175 Americans die from extreme heat.

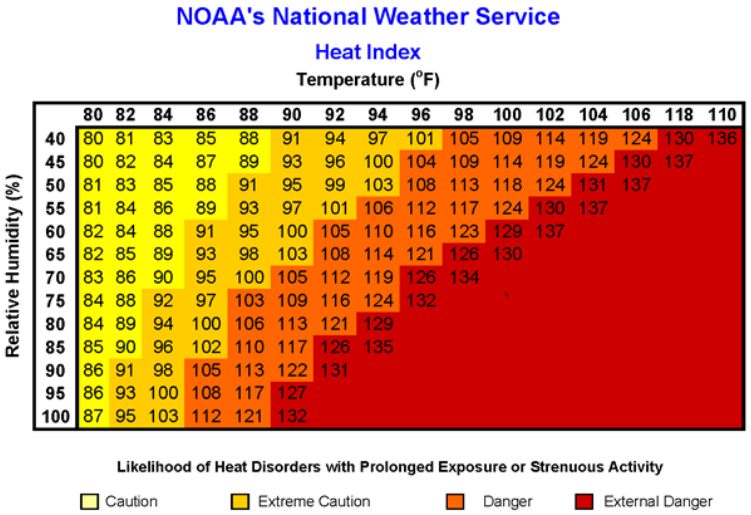


Figure 12 Heat Index Chart

According to the NWS, "The Heat Index or the "Apparent Temperature" is an accurate measure of how hot it really feels when the Relative Humidity is added to the actual air temperature". To find the Heat Index Temperature, refer to the Heat Index Chart in **Figure 12**. As an example, if the air temperature is 96°F and the relative humidity is 65%, the heat index – how hot it feels – is 121°F. The Weather Service will initiate alert procedures when the Heat Index is expected to exceed 105°-110°F for at least two consecutive days.

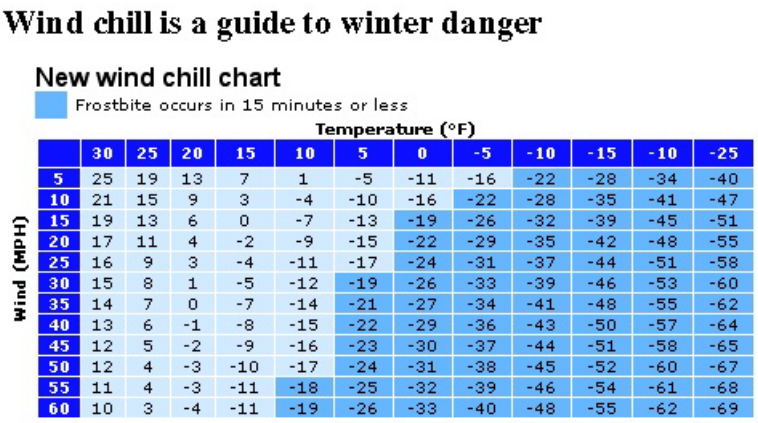
It is important to also note that these heat index values were devised for shady, light wind conditions. Exposure to full sunshine may increase heat index values by up to 15°F. Further, strong winds, particularly with very hot, dry air, can also be extremely hazardous.

As Figure 3-9 indicates, there are four cautionary categories associated with varying heat index temperatures.

- Caution: 80°-90°F: Fatigue is possible with prolonged exposure and physical activity
- Extreme Caution: 90°-95°F: Sunstroke, heat cramps, heat exhaustion may occur with prolonged physical activity
- Danger: 105°-130°F: Sunstroke, heat cramps, or heat exhaustion is likely
- Extreme Danger: >130°F: Heatstroke is imminent

Extreme cold is defined as a temporary, yet sustained, period of extremely low temperatures. Extremely low temperatures can occur in winter months when continental surface temperatures are at their lowest point and the North American Jet Stream pulls arctic air down into the continental United States. The jet stream is a current of fast-moving air found in the upper levels of the atmosphere. This rapid current is typically thousands of kilometers long, a few hundred kilometers wide, and only a few kilometers thick. Jet streams are usually found somewhere between 10-15 km (6-9 miles) above the Earth's surface. The position of this upper-level jet stream denotes the location of the strongest surface temperature contrast over the continent. The jet stream winds are strongest during the winter months when continental temperature extremes are greatest. When the jet stream pulls arctic cold air masses

over portions of the United States, temperatures can drop below 0° F for one week or more. Sustained extreme cold poses a physical danger to all individuals in a community and can affect infrastructure function as well.



	30	25	20	15	10	5	0	-5	-10	-15	-10	-25
5	25	19	13	7	1	-5	-11	-16	-22	-28	-34	-40
10	21	15	9	3	-4	-10	-16	-22	-28	-35	-41	-47
15	19	13	6	0	-7	-13	-19	-26	-32	-39	-45	-51
20	17	11	4	-2	-9	-15	-22	-29	-35	-42	-48	-55
25	16	9	3	-4	-11	-17	-24	-31	-37	-44	-51	-58
30	15	8	1	-5	-12	-19	-26	-33	-39	-46	-53	-60
35	14	7	0	-7	-14	-21	-27	-34	-41	-48	-55	-62
40	13	6	-1	-8	-15	-22	-29	-36	-43	-50	-57	-64
45	12	5	-2	-9	-16	-23	-30	-37	-44	-51	-58	-65
50	12	4	-3	-10	-17	-24	-31	-38	-45	-52	-60	-67
55	11	4	-3	-11	-18	-25	-32	-39	-46	-54	-61	-68
60	10	3	-4	-11	-19	-26	-33	-40	-48	-55	-62	-69

Figure 13 NWS Wind Chill Chart

In addition to strictly cold temperatures, the wind chill temperature must also be considered when planning for extreme temperatures. The wind chill temperature, according to the NWS, is how cold people and animals feel when outside and it is based on the rate of heat loss from exposed skin. **Figure 13** identifies the Wind Chill Chart and how the same ambient temperature may feel vastly different in varying wind speeds.

Extreme Temperature: Recent Occurrences

The effects of extreme temperatures extend across large regions, typically affecting several counties, or states, during a single event. According to the NCDC, there have been no extreme heat event or extreme cold events between May 2015 and February 2022. Local reports did not provide additional information regarding a period of excessive heat or cold during this time period.

It is difficult to predict the probability that an extreme temperature event will affect Montgomery County residents within any given year. Based on historic knowledge and information provided by the community representatives, an extreme temperature event is "Highly Likely" (possible within the next year) to occur and if an event did occur, it would result in "Significant" magnitude. **Table 8** identifies the CPRI for extreme temperature events for all communities in Montgomery County.

Table 8 CPRI for Extreme Temperatures

	Probability	Magnitude/ Severity	Warning Time	Duration	CPRI
Montgomery County	Highly Likely	Significant	> 24 Hours	>1 Week	Elevated
Town of Alamo	Highly Likely	Significant	> 24 Hours	>1 Week	Elevated
City of Crawfordsville	Highly Likely	Significant	> 24 Hours	>1 Week	Elevated
Town of Darlington	Highly Likely	Significant	> 24 Hours	>1 Week	Elevated
Town of Ladoga	Highly Likely	Significant	> 24 Hours	>1 Week	Elevated
Town of Linden	Highly Likely	Significant	> 24 Hours	>1 Week	Elevated
Town of New Market	Highly Likely	Significant	> 24 Hours	>1 Week	Elevated
Town of New Richmond	Highly Likely	Significant	> 24 Hours	>1 Week	Elevated
Town of New Ross	Highly Likely	Significant	> 24 Hours	>1 Week	Elevated
Town of Waveland	Highly Likely	Significant	> 24 Hours	>1 Week	Elevated
Town of Waynetown	Highly Likely	Significant	> 24 Hours	>1 Week	Elevated
Town of Wingate	Highly Likely	Significant	> 24 Hours	>1 Week	Elevated

As shown in the table, index values remain identical throughout each community due to the regional extent and diffuse severity of this hazard event. The anticipation of experiencing such damages is due to the amount of livestock and cropland within the county and the potential to realize impacts within the urban and municipal areas.

Extreme Temperatures: Assessing Vulnerability

As noted above, this type of hazard will generally affect entire counties and even multi-county regions at one time; however, certain portions of the population may be more vulnerable to extreme temperatures. For example, outdoor laborers, very young and very old populations, low-income populations, and those in poor physical condition are at an increased risk to be impacted during these conditions.

By assessing the demographics of Montgomery County, a better understanding of the relative risk that extreme temperatures may pose to certain populations can be gained. In total, nearly 20% of the county's population is over 65 years of age, 6% of the population is below the age of 5, and approximately 12% of the population is considered to be living below the poverty line. People within these demographic categories are more susceptible to social or health related impacts associated with extreme heat.

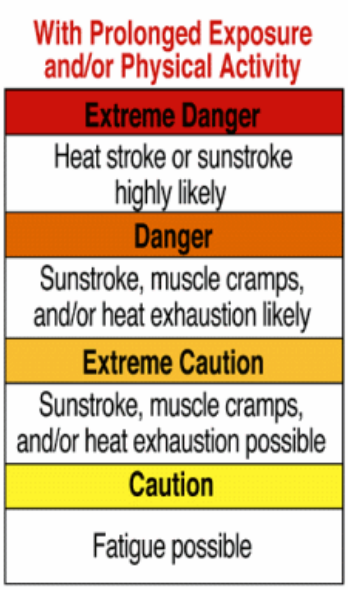


Figure 14 Danger Levels with Prolonged Heat Exposure

Extreme heat can affect the proper function of organ and brain systems by elevating core body temperatures above normal levels. Elevated core body temperatures, usually in excess of 104°F are often exhibited as heat stroke. For weaker individuals, an overheated core body temperature places additional stress on the body, and without proper hydration, the normal mechanisms for dealing with heat, such as sweating in order to cool down, are ineffective. Examples of danger levels associated with prolonged heat exposure are identified in **Figure 14**.

Extreme cold may result in similar situations as body functions are impacted as the temperature of the body is reduced. Prolonged exposure to cold may result in hypothermia, frostbite, and even death if the body is not warmed. In addition, equipment such as diesel fueled engines and fire-fighting hoses and pumps will quickly become inoperable in lower temperatures. This will increase response times associated with fires, medical emergencies, or other agencies attempting to assist during this type of hazard event.

Within Montgomery County, direct and indirect effects from a long period of extreme temperature may include:

Direct Effects:

- Direct effects are primarily associated with health risks to the elderly, infants, people with chronic medical disorders, lower income families, outdoor workers, and athletes

Indirect Effects:

- Increased need for cooling or warming shelters
- Increased medical emergency response efforts

- Increased energy demands for heating or cooling

Estimating Potential Losses

It is difficult to estimate the potential losses due to extreme temperatures as damages are not typically associated with buildings but instead, with populations and persons.

This hazard is not typically as damaging to structures or critical infrastructure as it is to populations so monetary damages associated with the direct effects of the extreme temperature are not possible to estimate. Indirect effects would cause increased expenses to facilities such as healthcare or emergency services, manufacturing facilities where temperatures are normally elevated may need to alter work hours or experience loss of revenue if forced to limit production during the heat of the day, and energy suppliers may experience demand peaks during the hottest and/or coldest portions of the day.

Future Considerations

As more and more citizens are experiencing economic difficulties, local power suppliers along with charitable organizations have implemented programs to provide cooling and heating mechanisms to residents in need. Often, these programs are donation driven and the need for such assistance must be demonstrated. As susceptible populations increase, or as local economies are stressed, such programs may become more necessary to protect Montgomery County's at-risk populations.

The Climate Change Assessment identifies several temperature related considerations of which communities should be aware and begin planning to avoid further impacts. For example, rising temperatures will increase the number of extreme heat days, thereby increasing the potential for heat related illnesses, potential hospitalizations, and medication costs to vulnerable populations. In addition, added days of extreme heat will impact agriculture, manufacturing, and potentially, water sources.

New construction associated with development of residential areas often brings upgraded and more efficient utilities such as central heating and air units further reducing vulnerabilities to the aging populations in those municipalities mentioned above. Conversely, new development associated with industrial or large commercial structures in the inner-urban centers often result in increased heat over time, which may cause additional stress to labor-related populations. Since the last planning effort, there has not been significant residential within the county. There has been commercial and industrial development within the unincorporated areas near Crawfordsville. As mentioned, newer construction allows for the installation of more energy efficient systems which are beneficial during either extreme cold or extreme heat situations.

Extreme Temperatures: Relationship to Other Hazards

While extreme temperatures may be extremely burdensome on the power supplies in Montgomery County, the Committee concluded that this type of hazard is not expected to cause any hazards studied. It is anticipated that due to prolonged extreme temperatures, primarily long periods of high temperatures, citizens may become increasingly agitated and irritable, and this may lead to a disturbance requiring emergency responder intervention.

3.3.4 Fire

Fire: Overview

Figure 15 Wildfire in Forested Area

A wildfire, also known as a forest fire, vegetation fire, or a bushfire, is an uncontrolled fire in wildland areas and is often caused by lightening; other common causes are human carelessness and arson. Small wildfires may be contained to areas less than one acre, whereas larger wildfires can extend to areas that cover several hundred or even thousand acres. Generally, ambient weather conditions determine the nature and severity of a wildfire event. Very low moisture and windy conditions can help to exacerbate combustion in forested or brush areas (**Figure 15**) and turn a small brush fire into a major regional fire event in a very short period. Wildfires can be very devastating for residents and property owners.

A structural fire is an incident where a fire starts within a structure and is largely contained to that structure. Causes of structure fires can be related to electrical shorts, carelessness with ignition sources, poor storage of flammable materials, as well as arson. These types of fires can be deadly if no warning or prevention measures are present. The most dangerous aspect of structural fires is the production of toxic gases and fumes that can quickly accumulate in enclosed areas of structures and asphyxiate those who might be in the structure.

Problems associated with structural fires are compounded when high-rise buildings catch fire. High-rise fires hinder the ability of rescue workers to fight the fire, reach impacted building occupants, and evacuate impacted occupants. Rescue efforts also become more complicated when handicapped or disabled persons are involved. Complications associated with high-rise fires typically increase as the height and occupancy levels of the buildings increase. Structural collapse is another concern associated with high-rise fires. Structural collapse often results in persons becoming trapped and severely injured. However, it is important to note that the concern associated with structural collapse, is not limited to high-rise buildings; the collapse of smaller residential buildings can also lead to severe injury and death.

Typically, a fire will incinerate all structures and objects in its path. A resident may lose all possessions and structures to a wildfire event. Additionally, combating a wildfire or a structure fire may be extremely dangerous. If weather conditions change suddenly, the wildfire may change course and overtake firefighters, causing severe injury or death. Fires can travel at speeds greater than 45 mph. Therefore, these hazard events can pose a serious threat to county residents and response agencies.

Fire: Recent Occurrences

Within the NCDC, there are no reports of wildfires occurring within Montgomery County between January 1950 and February 2022. Within the same time parameter, there were only two reported events within the State of Indiana, both within Pike County and both within 2006. During each of these events over 350 acres were burned.

The NCDC does not report structure fires; therefore, local sources were utilized to provide historical information.

According to the WISH TV, a fire caused nearly $3.0M in damages to the structure housing the Montgomery County snowplow fleet just weeks before being needed for snow removal. (**Figure 16**). A secondary concern during the fire was the exploding tires on the trucks and equipment. No injuries were reported as a result of the incident.

Figure 16 Montgomery County Highway Fire *(WISHTV.com)*

Due to the expansive acreage of cropland and wooded areas within Montgomery County, and the potential for urban areas to be at risk due to abandoned homes, blighted areas, or industrial activities, the Planning Committee determined the probability to be "Possible" in the smaller municipalities throughout the County and "Highly Likely" in the unincorporated areas and Crawfordsville. **Table 9** identifies the CPRI rankings for fire in Montgomery County.

Table 9 CPRI for Fire

	Probability	Magnitude/ Severity	Warning Time	Duration	CPRI
Montgomery County	Highly Likely	Significant	< 6 Hours	< 1 Day	Severe
Town of Alamo	Possible	Significant	< 6 Hours	< 1 Day	Severe
City of Crawfordsville	Highly Likely	Limited	< 6 Hours	< 1 Day	Severe
Town of Darlington	Possible	Significant	< 6 Hours	< 1 Day	Severe
Town of Ladoga	Possible	Significant	< 6 Hours	< 1 Day	Severe
Town of Linden	Possible	Significant	< 6 Hours	< 1 Day	Severe
Town of New Market	Possible	Significant	< 6 Hours	< 1 Day	Severe
Town of New Richmond	Possible	Significant	< 6 Hours	< 1 Day	Severe
Town of New Ross	Possible	Significant	< 6 Hours	< 1 Day	Severe
Town of Waveland	Possible	Significant	< 6 Hours	< 1 Day	Severe
Town of Waynetown	Possible	Significant	< 6 Hours	< 1 Day	Severe
Town of Wingate	Possible	Significant	< 6 Hours	< 1 Day	Severe

Information provided in **Table 10** highlights the number of fire runs in Montgomery County between 2019 and 2022. Based on this information, annual damages to structures, contents, and vehicles may be significant for each municipality on an annual basis. Social losses, such as being unable to work following a residential structure fire or losses associated with a business fire should also be considered as an impact.

Table 10 Montgomery County Fire Runs

	2019	2020	2021	2022
Aircraft Down	0	0	2	1
Arson	0	0	1	1
Bomb Threat	1	0	0	0
Chimney Fire	1	0	2	0
Confined Space Rescue	1	0	0	0
Electrical Hazard	0	0	2	0
Elevator Rescue	1	2	4	2
Fire Alarms	309	268	321	182
Grass Fire	35	45	39	28
Fire-other	208	79	100	62
Fire-smoke	41	55	74	36
Fire-structure	45	41	47	26
Vehicle Fire	39	49	33	25
Gas Leak	16	42	66	46
High Angle Rescue	0	1	1	0
Illegal Burns	0	12	24	22
Lines Down	22	8	19	10
Mutual Aid	0	0	1	0
Outside Fire	1	8	25	21
Structure Collapse	0	0	1	0
Water Rescue	0	2	1	1

Fire: Assessing Vulnerability

A fire typically affects a large regional area with potential for physical, economic, and/or social losses. Typically, a structural fire affects one or two structures, as one of the main functions of fire response is to prevent the fire from spreading to neighboring structures. This type of action works to reduce the magnitude and severity throughout the county and municipalities.

Much of the county is rural and agricultural in land use, which may be more susceptible to brush or crop fires, especially in times of drought. As most development has continued to occur within central Montgomery County (around Crawfordsville) since the last planning effort, vulnerabilities to this hazard have not shifted in location. Urbanized areas within Montgomery County are susceptible to urban and industrial fires, while the remainder of Montgomery County remains vulnerable to field, crop, and woodland fires.

Direct and indirect effects of a such an event within Montgomery County may include:

Direct Effects:

- Loss of structures
- Loss of production crop
- Loss of natural resources

Indirect Effects:

- Loss of revenue as businesses may be closed
- Increased emergency response times based on safety of roads
- Loss of income if dependent on crop production

Estimating Potential Losses

Given the nature and complexity of a potentially large hazard such as a wildfire, it is difficult to quantify potential losses to property and infrastructure. As a result, all critical and non-critical structures and infrastructure may be at some degree of risk.

Monetary damages associated with the direct effects of the fires are difficult to estimate, other than utilizing historic information as provided. Indirect effects would cause increased efforts associated with emergency response services as wildfires are difficult to contain and may accelerate very quickly. Further, multi-level business or residential structures place increased risks to those who work or live within those structures or nearby structures.

Future Considerations

As populations increase and communities continue to grow in size, the need to respond to fire will remain an important municipal effort. As new construction or re-development occurs, especially new or existing critical infrastructure, it is important to ensure that these new structures are equipped to deal with the potential risks associated with this hazard. Those may include increased risk for wooden or flammable outer structures and potential lengthy power outages.

In addition, increased populations require increased housing. Many urban communities develop large multi-family residential structures, or apartment complexes, where structures are not only in close proximity to each other, but also contain a large number of citizens. As communities age, some structures may become abandoned, significantly increasing the risk of fire due to potential vagrant populations and lack of maintenance. These areas should be considered at-risk and potentially demolished to avoid such risk and potential hazard.

Fires can also result in substantial indirect costs. Increased emergency response times, loss of work or the inability to get to work, as well as business interruption, are possible indirect effects of a fire and how it may affect those businesses directly related to cropland or natural resource areas.

Fire: Relationship to Other Hazards

Fires may certainly result in a hazardous materials incident if storage structures are within the path of the burn. Material storage containers farther away from the burn path may become damaged by high winds and embers resulting in a spill or release of materials. Fires may result from lightning associated with a thunderstorm. Typical wind speeds during a thunderstorm may also exacerbate the impacts from any ignitions from the lightning.

3.3.5 Flood

Flood: Overview

Floods are the most common and widespread of all the natural disasters. Most communities in the United States have experienced some kind of flooding, after spring rains, heavy thunderstorms, or winter snow melts. A flood, as defined by the NFIP, is a general and temporary condition of partial or complete inundation or two or more acres of normally dry land area or of two or more properties from overflow of inland or tidal waters and unusual and rapid accumulation or runoff of surface waters from any sources, or a mudflow. Floods can be slow or fast rising but generally develop over a period of days.

Flooding and associated flood damages is most likely to occur during the spring because of heavy rains combined with melting snow. However, provided the right saturated conditions, intense rainfall of short duration during summer rainstorms are capable of producing damaging flash flood conditions.

The traditional benchmark for riverine or coastal flooding is a 1% Annual Exceedance Probability (AEP), or the 100-year flood. This is a benchmark used by FEMA to establish a standard of flood protection in communities throughout the country. The 1% AEP is referred to as the "regulatory" or "base" flood. Another term commonly used, the "100-year flood", can be misleading. It does not mean that only one flood of that size will occur every 100 years, but rather there is a 1% chance of a flood of that intensity and elevation happening in any given year. In other words, the regulatory flood elevation has a 1% chance of being equaled, or exceeded, in any given year and it could occur more than once in a relatively short time period. Yet another term for this area is the Special Flood Hazard Area (SFHA).

Flood: Recent Occurrences

The NCDC indicates that between May 2015 and February 2022, there were four floods and two flash floods reported. For these events, a total of $8.5K in property damages and an additional $3.0K in crop damages were reported. No reports of injuries or deaths have been provided regarding these events.

The narrative reports through NCDC provided little more details than water overtopping local roads due to heavy rain throughout Montgomery County. For example, the May 1, 2016 event near Linden resulted in standing water at the intersection of Highway 231 and Highway 28. The water was deep enough to cause vehicles to hydroplane. The damages associated with the August 25, 2018 event were impacts to the Rocky Ridge Golf Club near Darlington and the December 11, 2021 flooding was a result of high water in fields crossing over local roadways near New Ross. Local reports did not provide additional information on these events or report on additional events impacting Montgomery County

Stream gages are utilized to monitor surface water elevations and/or discharges at key locations and time periods. Some such gages are further equipped with NWS' Advanced Hydrologic Prediction Service (AHPS) capabilities. These gages have the potential to provide valuable information regarding historical high and low water stages, hydrographs representing current and forecasted stages, and a map of the surrounding areas likely to be flooded. Within Montgomery County, there is one active USGS stream gage, the Sugar Creek at Crawfordsville. This gage currently only has the capability of issuing water level forecasts as needed during flood events.

Any property having received two insurance claim payments for flood damages totaling at least $1,000, paid by the NFIP within any 10-year period since 1978 is defined as a repetitive loss property. These properties are important to the NFIP because they account for approximately 1/3 of the country's

flood insurance payments. According to FEMA Region V, there is one single-family repetitive loss structure within the unincorporated areas of Montgomery County and an additional single-family repetitive loss structure within the City of Crawfordsville.

There have been a small number of claims made for damages associated with flooding in Montgomery County since 1978. Within the unincorporated areas of the county, there have been 13 claims resulting in slightly over $210K in payments. Further, within the City of Crawfordsville, there were 11 payments totaling approximately $160K. **Table 11** identifies the number of claims per community as well as payments made, as provided by IDNR. Information for other communities within Montgomery County was not individually reported by IDNR.

Table 11 Repetitive Properties, Claims, and Payments

Community	# of Repetitive Loss Properties	Claims Since 1978	$$ Paid
Montgomery County	1	13	$210.7K
City of Crawfordsville	1	11	$159.8K
Town of Waynetown	0	0	$0
TOTAL	**2**	**24**	**$370.6K**

Mandatory flood insurance purchase requirements apply to structures in 1% annual chance of flooding delineated areas. Total flood insurance premiums for Montgomery County and the communities is approximately $42.4K. Total flood insurance coverage for Montgomery County and the communities is slightly over $8.5M. **Table 12** further indicates the premiums and coverage totals for individual communities.

Table 12 Insurance Premiums and Coverage

Community	Flood Insurance Premiums	Flood Insurance Coverage
Montgomery County	$24.1K	$6.1M
City of Crawfordsville	$15.8K	$2.2M
Town of Waynetown	$2.5K	$0.2M
TOTAL	**$42.4K**	**$8.5M**

As determined by the Committee, the probability of a flood occurring throughout Montgomery County ranges from "Unlikely" to "Highly Likely". This is largely based on the presence or absence of rivers or water systems in or near the communities and issues associated with localized drainage. Impacts from such an event are anticipated to range from "Negligible" to "Limited". The Committee also determined that the warning time would be 12 - 24 hours based on forecasting methods, local knowledge of stream activities, and the warning provided by gages upstream. Finally, the duration of such an event is anticipated to last less than one week for all areas. A summary is shown in **Table 13**.

Table 13 CPRI for Flood

	Probability	Magnitude/ Severity	Warning Time	Duration	CPRI
Montgomery County	Highly Likely	Limited	12 - 24 Hours	< 1 Week	Elevated
Town of Alamo	Unlikely	Negligible	12 - 24 Hours	< 1 Week	Elevated
City of Crawfordsville	Highly Likely	Limited	12 - 24 Hours	< 1 Week	Elevated
Town of Darlington	Likely	Limited	12 - 24 Hours	< 1 Week	Elevated
Town of Ladoga	Highly Likely	Limited	12 - 24 Hours	< 1 Week	Elevated
Town of Linden	Likely	Limited	12 - 24 Hours	< 1 Week	Elevated
Town of New Market	Highly Likely	Limited	12 - 24 Hours	< 1 Week	Elevated
Town of New Richmond	Unlikely	Negligible	12 - 24 Hours	< 1 Week	Elevated
Town of New Ross	Possible	Limited	12 - 24 Hours	< 1 Week	Elevated
Town of Waveland	Possible	Limited	12 - 24 Hours	< 1 Week	Elevated
Town of Waynetown	Highly Likely	Limited	12 - 24 Hours	< 1 Week	Elevated
Town of Wingate	Possible	Limited	12 - 24 Hours	< 1 Week	Elevated

As mentioned within this section, there is a 1% chance each year that the regulatory flood elevation will be equaled or exceeded, and these types of events may occur more than once throughout each year. Further, based on information provided by the NCDC, and previous experiences, the Committee determined that flooding is "Unlikely" to "Highly Likely" throughout the county.

Flood: Assessing Vulnerability

Flood events may affect large portions of Montgomery County at one time as river systems and areas with poor drainage cover much of the county and several communities. In addition to riverine flooding or flooding in poorly drained areas, is the consideration of fluvial erosion hazard (FEH). This represents the risk associated with natural stream movements and losses associated with buildings and infrastructure. In some cases, this may be represented by a gradual movement of a stream across a farm field. In other, more extreme instances, homes or other infrastructure may actually be lost as steep riverbanks or bluffs sluff into the water below. This will be discussed more within the Landslide/land subsidence discussion.

Many Planning Committee members also participated in the 2018 planning effort to develop a Flood Response Plan (FRP) for the City of Crawfordsville. The FRP is developed to serve as an action plan when Action Stage flood events are detected in the City, or upstream in the unincorporated areas of the county. As a result of flood modeling, historical events, and participant knowledge, areas of concern for various flood events were identified and mapped. **Figure 17 is** an example of a Flood Impact exhibit included in the City of Crawfordsville FRP; the 1.0% AEP or 100-year Flood. Similar maps were produced for the 10-Year, 50-Year, and 500-Year events.

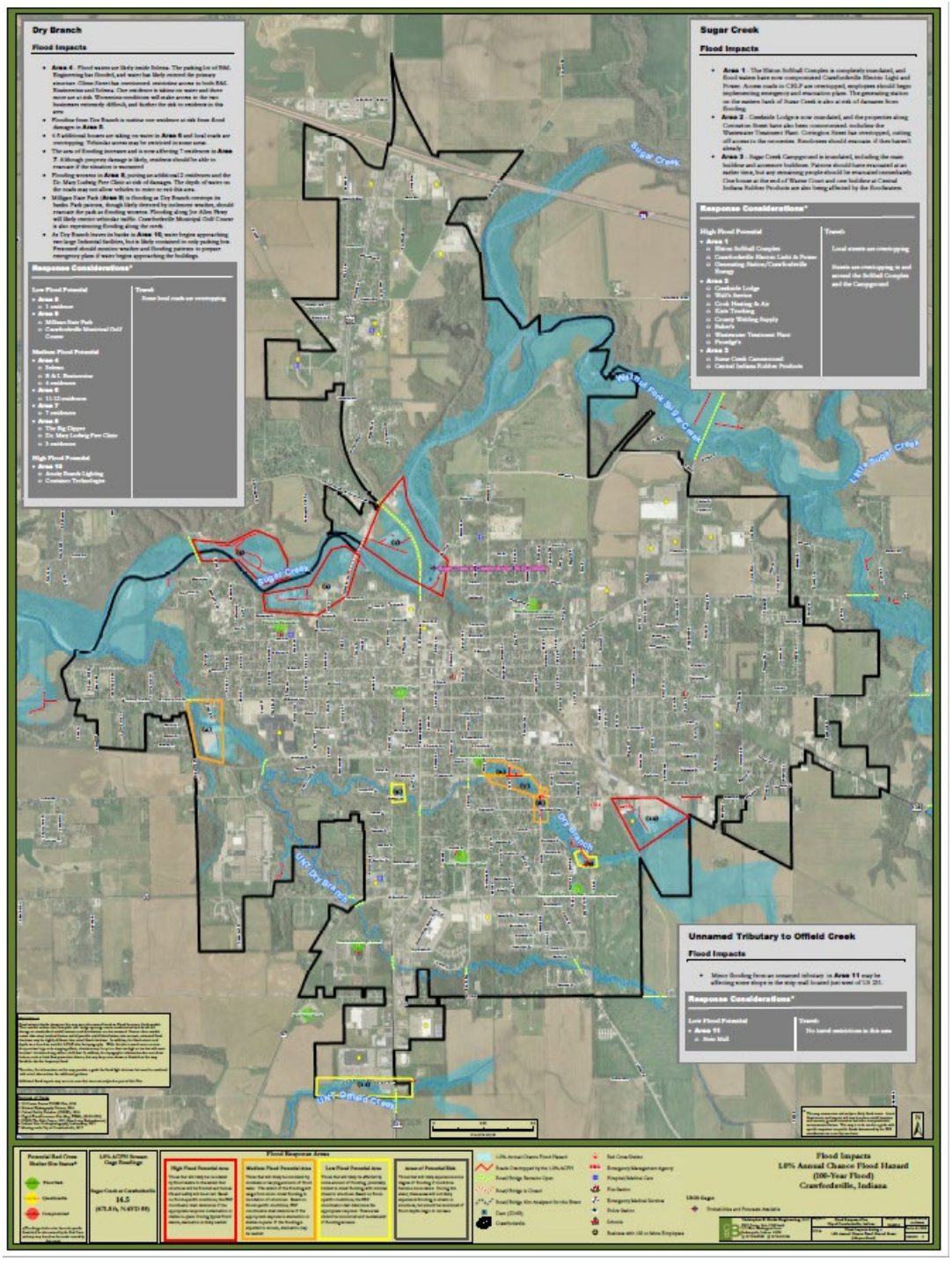


Figure 17 City of Crawfordsville FRP Flood Impacts Exhibit

Figure 18 is a closer view of the FRP Flood Impacts Exhibit in Figure 17. The areas in red are those with a High Flood Potential, areas in orange are Medium Flood Potential, and yellow are a Low Flood Potential. Additionally, the gray boxes on Figure 17 describe the anticipated flood impacts such as the number and type of structures to be flooded and transportation routes to be affected at that level of flood event.

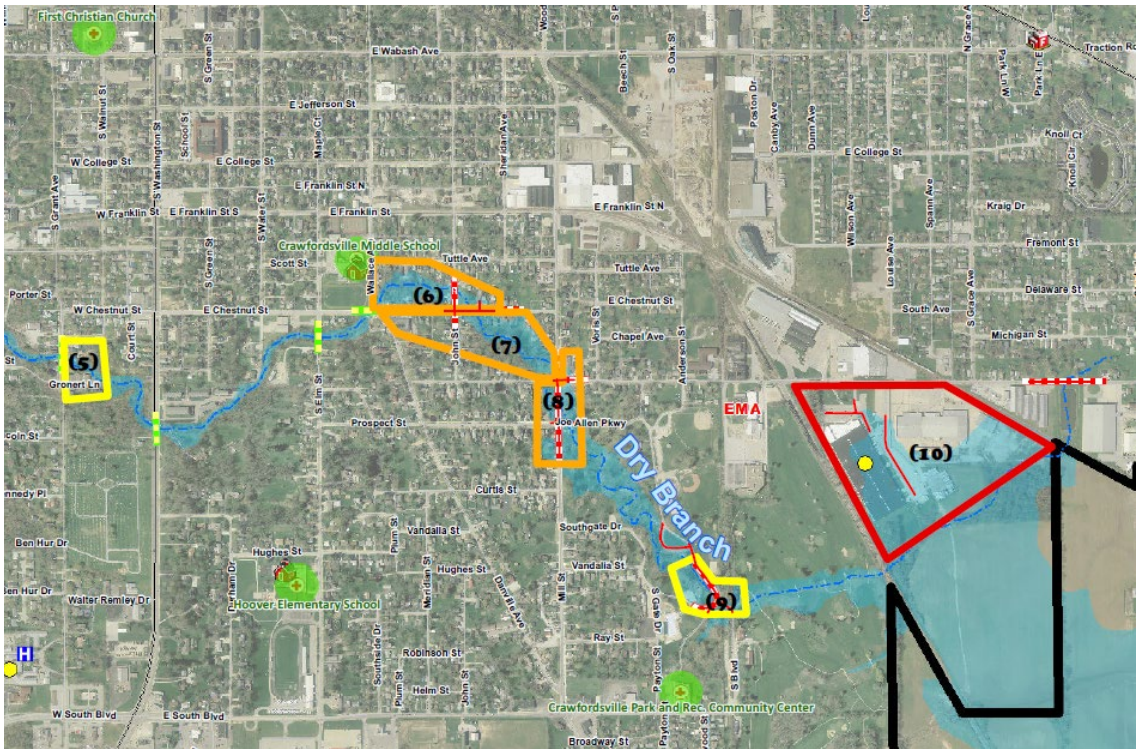


Figure 18 Potential Flood Impact Areas, Crawfordsville, IN

Within Montgomery County, direct and indirect effects of a flood event may include:

Direct Effects:

- Structural and content damages and/or loss of revenue for properties affected by increased water
- Increased costs associated with additional response personnel, evacuations, and sheltering needs
- Increased potential impacts to infrastructure and buildings located within the FEH area

Indirect Effects:

- Increased response times for emergency personnel if roads are impassable
- Increased costs associated with personnel to carry out evacuations in needed areas
- Increased risk of explosions and other hazards associated with floating propane tanks or other debris
- Losses associated with missed work or school due to closures or recovery activities
- Cancellations of special events in impacted areas or water related activities that become too dangerous due to high water

In the time period since the last planning effort, residential significant development has not occurred within the municipalities and populations have not significantly increased. The development and redevelopment that has occurred, has been directed away from the floodplains. This mitigation measure helps to reduce the countywide flood risk and vulnerability. Structures have prevented from being built in the high-risk areas while growth has been directed to more appropriate areas, less at risk from riverine flooding.

Estimating Potential Losses

Critical and non-critical structures located in regulated floodplains, poorly drained areas, or low-lying areas are most at risk for damages associated with flooding. For this planning effort, a GIS Desktop Analysis methodology was utilized to estimate flood damages.

For the GIS Desktop Analysis method, an analysis was completed utilizing the effective Digital FIRMs (DFIRMs) overlaid upon a Modified Building Inventory developed with information provided by Montgomery County. Structures located within each flood zone were tallied using GIS analysis techniques.

In the assessment, any structure listed as less than 400 ft^2 in area or classified in the Assessor's database as a non-habitable structure was assumed to be an outbuilding. It was assumed that a building was located on a parcel if the value listed in the "Assessed Value (Improvements)" showed a value greater than zero dollars. Parcels that intersected any portion of the FEMA flood zones were considered to be flood prone, and subsequently, further analyzed separately from parcels without structures. were excluded from the analysis. Structure values were calculated using:

Residential = Assessed Value x 0.5
Commercial = Assessed Value x 1.0
Industrial = Assessed Value x 1.5
Agricultural = Assessed Value x 1.0
Education = Assessed Value x 1.0
Government = Assessed Value x 1.0
Religious = Assessed Value x 1.0

In order to estimate anticipated damages associated with each flood zone in Montgomery County and communities, it was estimated that 25% of structures in the flood zones would be destroyed, 35% of structures would be 50% damaged, and 40% of structures would be 25% damaged. **Table 14** identifies the estimated losses associated with structures in the floodway, the 1% AEP (100-year floodplain), and the 0.2% AEP (500-year floodplain) areas by community within Montgomery County. The other municipalities within Montgomery County do not have 1% AEP within their jurisdictions and are therefore not included in the table.

Table 14 Manual GIS Analysis Utilizing Best Available Data and Montgomery County Building Inventory

	Floodway		1%		0.2%		Unnumbered	
	#	$	#	$	#	$	#	$
Montgomery County	4	$0.60M	16	$2.65M	0	0	178	$23.03M
City of Crawfordsville	34	$6.47M	44	$8.61M	14	$1.51M	3	$2.30M
Town of Darlington	0	0	0	0	0	0	3	$0.28M
Town of Ladoga	0	0	0	0	0	0	17	$1.87M
Town of Waynetown	0	0	0	0	0	0	12	$2.12M
Total	**38**	**$7.07M**	**60**	**$11.3M**	**14**	**$1.51M**	**213**	**$29.6M**

Utilizing the same GIS information and process, critical infrastructure within each of the flood hazard areas in Montgomery County was assessed and are included in **Table 15**. These buildings are included in the overall number of structures and damage estimate information provided in Table 14.

Table 15 Critical Infrastructure in Flood Hazard Areas in Montgomery County

Community	Floodway	1% AEP	0.2% AEP
Montgomery County			
City of Crawfordsville	Montgomery County Free Clinic	Accelplus Closure Systems International WWTP	
Town of Darlington			
Town of Ladoga			
Town of Waynetown			

Utilizing the information in Table 15 regarding the number of structures within each flood hazard area, it is also important to note the number of flood insurance policies within each area in Montgomery County. **Table 16** provides the comparison between the number of structures in the 1% AEP and the number of flood insurance policies. It is also important to note that flood insurance is voluntary unless the property owner carries a federally subsidized mortgage; insurance coverage may be discontinued when the mortgage is completed.

Table 16 Number of Structures in 1% AEP and Number of Flood Insurance Policies

COMMUNITY	# STRUCTURES IN 1% AEP	# POLICIES
Montgomery County	20	32
City of Crawfordsville	92	12
Town of Darlington	0	0
Town of Ladoga	0	0
Town of Waynetown	0	3
Total	**112**	**47**

Future Considerations

As the municipalities within Montgomery County continue to grow in population and redevelop, it can be anticipated that the number of critical and non-critical infrastructure will also increase accordingly. It will be important for recognition of potential flood impacts to residents and businesses in these areas to be coupled with proper planning for future development and redevelopment of the flood zones. This would also include utilizing the Flood Response Plan Areas developed for the City of Crawfordsville. Since the previous planning effort, no development has occurred within the flood zones of Montgomery County.

It is important to ensure that owners and occupants of residences and businesses within the known hazard areas, such as delineated or approximated flood zones and fluvial erosion hazard areas, are well informed about the potential impacts from flooding incidents as well as proper methods to protect themselves and their property.

Increased precipitation, as predicted in the Indiana Climate Change Assessment, is anticipated to come in the form of heavier, shorter events which lead to the increased potential for flooding and stress on infrastructure such as sanitary and storm sewers. Heavy precipitation events are anticipated to occur more frequently as temperatures rise, replacing rain when previously there was snow.

Despite these efforts, the overall vulnerability and monitory value of damages is expected to increase in the area unless additional measures, such as those discussed later in Chapter 4 of this report, are implemented.

Figure 19 Fire Engine in Flood Waters

Indirect effects of flooding may include increased emergency response times due to flooded or redirected streets (**Figure 20**), the danger of dislodged and floating propane tanks causing explosions, and the need for additional personnel to carry out the necessary evacuations. Additional effects may include sheltering needs for those evacuated, and the loss of income or revenue related to business interruptions. As many communities within Montgomery County are closely tied to the river systems, special events occurring near to or on these rivers and waterways may be cancelled or postponed during periods of flooding or high-water levels.

Flood: Relationship to Other Hazards

While flooding creates social, physical, and economic losses, it may also cause other hazards to occur. For example, flooding may increase the potential for a hazardous materials incident to occur. Above ground storage facilities may be toppled or become loosened and actually migrate from the original location. In less severe situations, the materials commonly stored in homes and garages such as oils, cleaners, and de-greasers, may be mobilized by flood waters. Should access roads to hazardous materials handlers become flooded, or if bridges are damaged by flood waters, response times to more significant incidents may be increased, potentially increasing the damages associated with the release.

Increased volumes of water during a flood event may also lead to a dam failure. As the water levels rise in areas protected by dams, at some point, these structures will over-top or will breach leading to even more water released. These two hazards, flood and dam failure, when combined, may certainly result in catastrophic damages.

In a similar fashion, a snowstorm or ice storm can also lead to flooding on either a localized or regional scale. When a large amount of snow or ice accumulates, the potential for a flood is increased. As the snow or ice melts, and the ground becomes saturated or remains frozen, downstream flooding may occur. Ice jams near bridges and culverts may also result in flooding of localized areas and potentially damage the bridge or culvert itself.

Repeated flooding may also create impacts associated with landslides along riverbanks and bluff areas. As floodwaters travel through the systems, saturating shorelines and increasing volumes and velocities of water, the natural process of fluvial erosion may be exacerbated. As these processes are increased, structures and infrastructure located on bluffs or in proximity to the river may be at risk.

Flooding in known hazard areas may also be caused by dams that experience structural damages or failures not related to increased volumes or velocities of water. These "sunny day failures", while not typical, may occur wherever these structures exist.

3.3.6 Hailstorms, Thunderstorms, and Windstorms

Hailstorms, Thunderstorms, and Windstorms: Overview

Hail occurs when frozen water droplets form inside a thunderstorm cloud, and then grow into ice formations held aloft by powerful thunderstorm updrafts, and when the weight of the ice formations becomes too heavy, they fall to the ground as hail. Hail size ranges from smaller than a pea to as large as a softball, and can be very destructive to buildings, vehicles (**Figure 21**), and crops. Even small hail can cause significant damage to young and tender plants. Residents should take cover immediately in a hailstorm, and protect pets and livestock, which are particularly vulnerable to hail, and should be under shelter as well.

Thunderstorms are defined as strong storm systems produced by a cumulonimbus cloud, usually accompanied by thunder, lightning, gusty winds, and heavy rains. All thunderstorms are considered dangerous as lightening is one of the by-products of the initial storm. In the United States, on average, 300 people are injured, and 80 people are killed each year by lightning. Although most lightning victims survive, people struck by lightning often report a variety of long-term, debilitating symptoms. Other associated dangers of thunderstorms included tornados, strong winds, hail, and flash flooding.

Windstorms or high winds can result from thunderstorm inflow and outflow, or downburst winds when the storm cloud collapses, and can result from strong frontal systems, or gradient winds (high- or low-pressure systems). High winds are speeds reaching 50 mph or greater, either sustained or gusting.

Hailstorm, Thunderstorm, and Windstorm: Recent Occurrences

Figure 20 Damaging Hail on Vehicles

In Montgomery County, the NCDC has recorded 15 hailstorms and 16 thunderstorms/windstorms between May 2015 and February 2022. The largest recorded hail stone was 1.75 inches in diameter and occurred on May 1, 2016 near Linden. The average diameter hail stone occurring throughout Montgomery County is approximately 1.0 inch.

Significant windstorms are characterized by the top wind speeds achieved during the incident, characteristically occur in conjunction with thunderstorms, and have historically occurred year-round with the greatest frequency and damage occurring in May, June, and July. Within Montgomery County, NCDC reports 16 instances between May 2015 and February 2022 where top wind speeds were greater than 60 mph.

Total NCDC recorded damages for hailstorms, thunderstorms, and windstorms throughout Montgomery County are $75.0K in property damages, no additional crop damages, and no injuries or deaths associated with these events. Many event reports included in the NCDC did not provide descriptive information on the social, physical, and economic losses resulting from individual storms specific to Montgomery County. Even in instances where monetary damages were reported, narrative descriptions of the event rarely extended beyond reports of damages to broken tree limbs, downed power lines, or roof damages.

Figure 21 Crop and barn damage following Montgomery County storms

During the May 23, 2019 event in Waynetown, thunderstorms and wind gusts of 60 mph and greater were reported to have caused several downed trees and power lines. Approximately $25.0K in damages were sustained due to the uprooted trees in the area. On November 18, 2017 rounds of thunderstorms passed through the Kirkpatrick area damaging several trees and two pole barns, resulting in widespread power outages and $12.0K in property damages. **Figure 21** shows damages from an August 2016 event effecting a widespread area including Montgomery County.

Appendix 6 provides the NCDC information regarding hailstorms, thunderstorms, and windstorms that have resulted in injuries, deaths, and monetary damages to property and/or crops.

According to the Institute for Business and Home Safety, central Indiana can expect to experience damaging hailstorms three to four times over 20 years; the average life of a residential roof. Further, thunderstorms and windstorms are considered a high frequency hazard and may occur numerous times per year.

The Committee determined the probability of a hailstorm, thunderstorm, or windstorm occurring anywhere throughout Montgomery County is "Highly Likely" and will typically affect broad portions of the county at one time resulting in potentially "Significant" damages. As advancements in technologies such as weather radar systems and broadcast alerts are continually made, the warning time for such incidents may increase. Currently, the Committee feels that the warning time is anticipated to be less than six hours (for weather conditions anticipated to result in storm events) and the duration is expected to last less than six hours.

Indicative of a regional hazard, the probability, magnitude, warning time, and duration of a hailstorm, thunderstorm, or windstorm are expected to be similar throughout the county. These events are highly unpredictable, and the occurrences are distributed through the county, sometimes impacting one community more often or more severely than another. Therefore, the CPRI values reflect the distributed risk and associated priority for a hailstorm, thunderstorm, or windstorm. A summary is provided in **Table 17**.

Table 17 CPRI for Hailstorm, Thunderstorm, and Windstorm

	Probability	Magnitude/ Severity	Warning Time	Duration	CPRI
Montgomery County	Highly Likely	Significant	< 6 Hours	< 6 Hours	Severe
Town of Alamo	Highly Likely	Significant	< 6 Hours	< 6 Hours	Severe
City of Crawfordsville	Highly Likely	Significant	< 6 Hours	< 6 Hours	Severe
Town of Darlington	Highly Likely	Significant	< 6 Hours	< 6 Hours	Severe
Town of Ladoga	Highly Likely	Significant	< 6 Hours	< 6 Hours	Severe
Town of Linden	Highly Likely	Significant	< 6 Hours	< 6 Hours	Severe
Town of New Market	Highly Likely	Significant	< 6 Hours	< 6 Hours	Severe
Town of New Richmond	Highly Likely	Significant	< 6 Hours	< 6 Hours	Severe
Town of New Ross	Highly Likely	Significant	< 6 Hours	< 6 Hours	Severe
Town of Waveland	Highly Likely	Significant	< 6 Hours	< 6 Hours	Severe
Town of Waynetown	Highly Likely	Significant	< 6 Hours	< 6 Hours	Severe
Town of Wingate	Highly Likely	Significant	< 6 Hours	< 6 Hours	Severe

Specific locations and frequency of hailstorms, thunderstorms, and windstorms are difficult to predict as many of these individual events are without significant warning time and may have impacts to very limited areas or may affect broader areas. However, based on NCDC data and personal experiences of the Committee, it was determined that all areas within the County are anticipated to experience a hailstorm, thunderstorm, or windstorm within the calendar year. More likely, these communities will be impacted by several of these hazard events each year. The magnitude is anticipated to be similar based on the number of critical infrastructure and populations of each of the municipalities, or "Significant".

Hailstorm, Thunderstorm, and Windstorm: Assessing Vulnerability

The effects of a hailstorm, thunderstorm, or windstorm may be minimal to extensive in nature and may affect small or broad ranges of land area. Within Montgomery County, direct and indirect effects from a hailstorm, thunderstorm, or windstorm may include:

Direct Effects:

- Damages to infrastructure (power lines)
- Damages to individual properties (homes, cars)

Indirect Effects:

- Downed power lines due to falling tree limbs
- Losses associated with power outages
- Damages sustained from blowing debris

Estimating Potential Losses

Figure 22 Home Damaged During Windstorm

Due to the unpredictability of this hazard all critical infrastructure and non-critical structures in Montgomery County are at risk of damage including temporary or permanent loss of function. For hailstorms, thunderstorms, and windstorms, it is not possible to isolate specific critical infrastructure or non-critical structures that would be vulnerable to damages. However, areas where utility lines are above ground and areas where dead or dying trees have not been removed may be at a higher risk of property damages or power outages during hailstorms, thunderstorms, and windstorms. Additionally, mobile homes and accessory buildings such as pole barns and sheds may also be at a higher risk of damages from hailstorms, thunderstorms, and windstorms if not properly anchored to the ground. Damages from falling limbs or uprooted trees such as that shown in **Figure 22**, are common.

Future Considerations

As the populations of the communities in Montgomery County continue to develop and redevelop, it can be anticipated that the number of critical and non-critical structures will also increase. To reduce the vulnerability for damages resulting from a hailstorm, thunderstorm, or windstorm, measures such as proper anchoring, enforcement of the International Building Codes, and burial of power lines should be completed. While measures can be taken to remove existing structures or prevent future structures from being built in known hazard areas such as floodplains and hazardous materials facility buffers, such measures are not applicable to hailstorms, thunderstorms, and windstorms due to the diffuse nature and regional impacts of this hazard.

Indirect effects resulting from a hailstorm, thunderstorm, or windstorm can include power outages caused by downed tree limbs or flying debris, damages resulting from prolonged power outages, and damages to structures or property as a result of debris.

Hailstorm, Thunderstorm, and Windstorm: Relationship to Other Hazards

Hailstorms, thunderstorms, and windstorms may be the precursor for other hazards. For example, hazardous materials incidents can be the result of a hailstorm, thunderstorm, or a windstorm. Material storage containers can become damaged by high winds, debris, or even lightning, and can result in a spill or release of materials. With wind speeds greater than 58 mph, tankers and other transportation vehicles carrying hazardous materials are also at risk while on the road. High winds may also cause gaseous substances to travel farther distances at a much faster rate, increasing the evacuation area necessary to protect residents and visitors of Montgomery County.

Additionally, rainfall typically occurs with a thunderstorm and this additional precipitation may lead to localized flooding or riverine flooding depending on the amount of rain during the event. Debris from a windstorm may also lead to localized flooding if debris is deposited over drains or if obstructions are created by downed limbs, trees, or other storm related debris. A similar concern due to the potential precipitation would be dam failure. High winds may also lead to structural damages to a dam or may cause damages to nearby trees or other structures, leading to indirect damages.

The risk of social losses also increases during a hailstorm, thunderstorm, or windstorm, as these hazards often result in downed power lines, utility poles, and trees. Debris such as this may impede traffic patterns and make it difficult for emergency vehicles (Fire, EMS, and Police) to pass through affected areas or people may be directly injured because of falling debris.

3.3.7 Landslide/Subsidence

Landslide/Subsidence: Overview

The term landslide includes a wide range of ground movement, such as rock falls, deep failure of slopes, and shallow debris flows. Although gravity acting on an over steepened slope is the primary reason for a landslide, there are other contributing factors. For example, erosion by rivers, glaciers, or ocean waves can cause rock to fall. Rock and soil slopes may be weakened through saturation by snowmelt or heavy rains, earthquakes can create stresses that make weak slopes fail, and excess weight from accumulation of rain or snow, stockpiling of rock or ore, from waste piles, or man-made structures that may stress weak slopes to the point of collapse.

Another important consideration is that of fluvial erosion hazard (FEH). This represents the risk associated with natural stream movements and losses associated with buildings and infrastructure. In some cases, this may be represented by a gradual movement of a stream across a farm field. In other, more extreme instances, homes or other infrastructure may actually be lost as steep riverbanks or bluffs sluff into the water below.

Land subsidence, according to the USGS, is "a gradual settling or sudden sinking of the Earth's surface owing to subsurface movement of earth materials". Further, there are three processes that attribute to subsidence: compaction of aquifer systems, drainage and subsequent oxidation of organic soils, and dissolution and collapse of susceptible rocks.

Landslide/Subsidence: Recent Occurrences

The potential for any of landslides or land subsidence within Montgomery County was discussed by the Planning Committee. To the knowledge of the Planning Committee, there are no Karst areas or underground mining operations within Montgomery County. In addition of this, to date, there has not been any typical landslides or subsidence events in Montgomery County. However, discussions were had regarding recent studies completed to assess the potential for areas along Sugar Creek to be impacted by FEH. More frequent high volume rain events lead to increased erosion along the base of the bluffs of rivers and streams, thus placing several structures at risk.

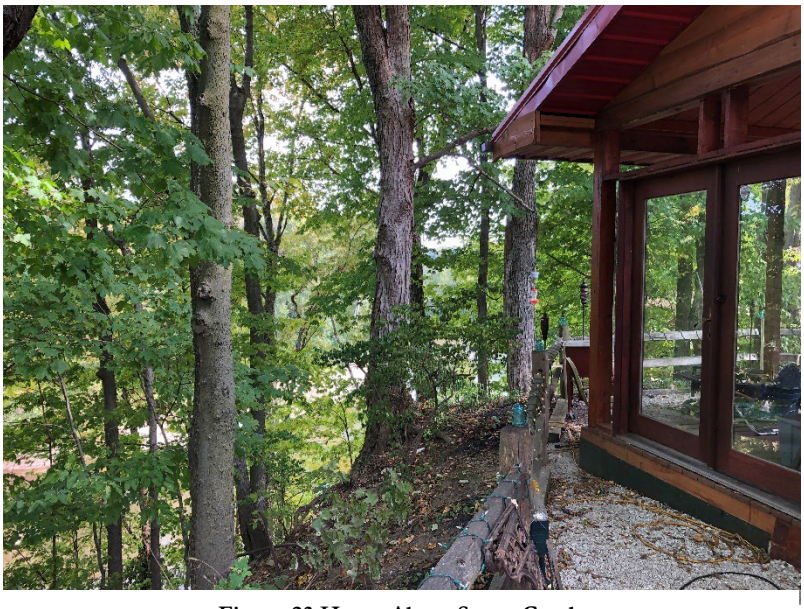


Figure 23 Home Along Sugar Creek

The study, the Sugar Creek Channel Stability and Flood Risk Assessment, was completed in 2019 to assess approximately four miles of Sugar Creek and potentially identify reasons for bank failure, locate problem areas, and develop mitigation actions for those problem areas. The assessment identified three locations (downstream of US 231, south bank at Wayne Ave, and south bank at North Sugar Cliff Dr) within Crawfordsville where measures are necessary. Two

of these critical areas have eminent danger to real property and infrastructure such as in **Figure 23**.

1) Wayne Avenue: a 1,060-foot-long and 65-foot-tall eroding bank that is unstable and migrating downstream and a large section of sand has recently been exposed. A total of 12 properties were identified as in danger of collapse.

2) North Sugar Cliff Drive: a 1,125-foot-long and 82-foot-tall eroding bank that consists of more sand and gravel than other areas and appears to be stabilizing however it could destabilize with movement in the downstream floodplain. Five properties are in danger of collapse.

In conjunction with this study, Crawfordsville and Montgomery County leaders sought assistance through the BRIC grant program. This would provide funding to implement mitigation strategies outlined within the study and provide additional protection for the residents and infrastructure in the impacted areas.

The Committee determined the probability of a landslide or subsidence occurring in Montgomery County is "Unlikely" in most areas; "Possible" within the unincorporated areas of the county; and "Highly Likely" in Crawfordsville. It is anticipated that a landslide will result in potentially "Negligible" damages except within Crawfordsville where "Critical" damages are expected due to the identified residential structures and infrastructure at risk. Currently, the Committee feels that the warning time is anticipated to be less than six hours as an event of this nature is nearly immediate and similarly, the duration is expected to last less than six hours as it is a sudden event with a short span. These events are highly unpredictable and the risk, although very low according to the Committee, is distributed throughout the county. Therefore, the CPRI values reflect the distributed risk and associated priority for a landslide or subsidence event. A summary is provided in **Table 18.**

Table 18 CPRI for Landslide/Land Subsidence

	Probability	Magnitude/ Severity	Warning Time	Duration	CPRI
Montgomery County	Possible	Negligible	< 6 Hours	< 6 Hours	Low
Town of Alamo	Unlikely	Negligible	< 6 Hours	< 6 Hours	Low
City of Crawfordsville	Highly Likely	Critical	< 6 Hours	< 6 Hours	Severe
Town of Darlington	Unlikely	Negligible	< 6 Hours	< 6 Hours	Low
Town of Ladoga	Unlikely	Negligible	< 6 Hours	< 6 Hours	Low
Town of Linden	Unlikely	Negligible	< 6 Hours	< 6 Hours	Low
Town of New Market	Unlikely	Negligible	< 6 Hours	< 6 Hours	Low
Town of New Richmond	Unlikely	Negligible	< 6 Hours	< 6 Hours	Low
Town of New Ross	Unlikely	Negligible	< 6 Hours	< 6 Hours	Low
Town of Waveland	Unlikely	Negligible	< 6 Hours	< 6 Hours	Low
Town of Waynetown	Unlikely	Negligible	< 6 Hours	< 6 Hours	Low
Town of Wingate	Unlikely	Negligible	< 6 Hours	< 6 Hours	Low

Landslide/Subsidence: Assessing Vulnerability

The effects of a landslide or subsidence event may be minimal to extensive in nature and may affect small or broad ranges of land area. As a part of the Sugar Creek assessment, areas along the study corridor were identified vulnerable developed areas, or existing developed land located within the 1%

AEP and in many cases, within the FEH area. **Figure 22** is one exhibit from the Sugar Creek assessment which identifies the vulnerable areas in red.

Figure 24 Sugar Creek Assessment Exhibit

Within Montgomery County, direct and indirect effects may include:

Direct Effects:

- Damages to infrastructure (power lines, roads, bridges)
- Damages to individual properties (homes, cars)

Indirect Effects:

- Increased response time for emergency vehicles
- Losses associated with affected land (crop loss)
- Potential contamination of groundwater resources

Estimating Potential Losses

Due to the unpredictability of this hazard all critical infrastructure and non-critical structures in Montgomery County are at risk of damage including temporary or permanent loss of function. For landslide and subsidence in general, it is difficult to isolate specific critical infrastructure or non-critical structures that would be more or less vulnerable to damages. With the assistance of the FEH mapping and the Sugar Creek assessment, information has been gathered and analyzed which does help to estimate the potential losses, at least associated with bank failures along Sugar Creek.

One of the original measures within the Sugar Creek assessment identifies several properties recommended for buyout and further restrictions regarding public safety. Utilizing rough estimations, these structures are valued at approximately $2.9M while additional costs should be considered for the infrastructure in that area. Further, there are over 50 structures identified as potentially susceptible to bank failure within the entire FEH area along the Sugar Creek study reach which would increase this value drastically.

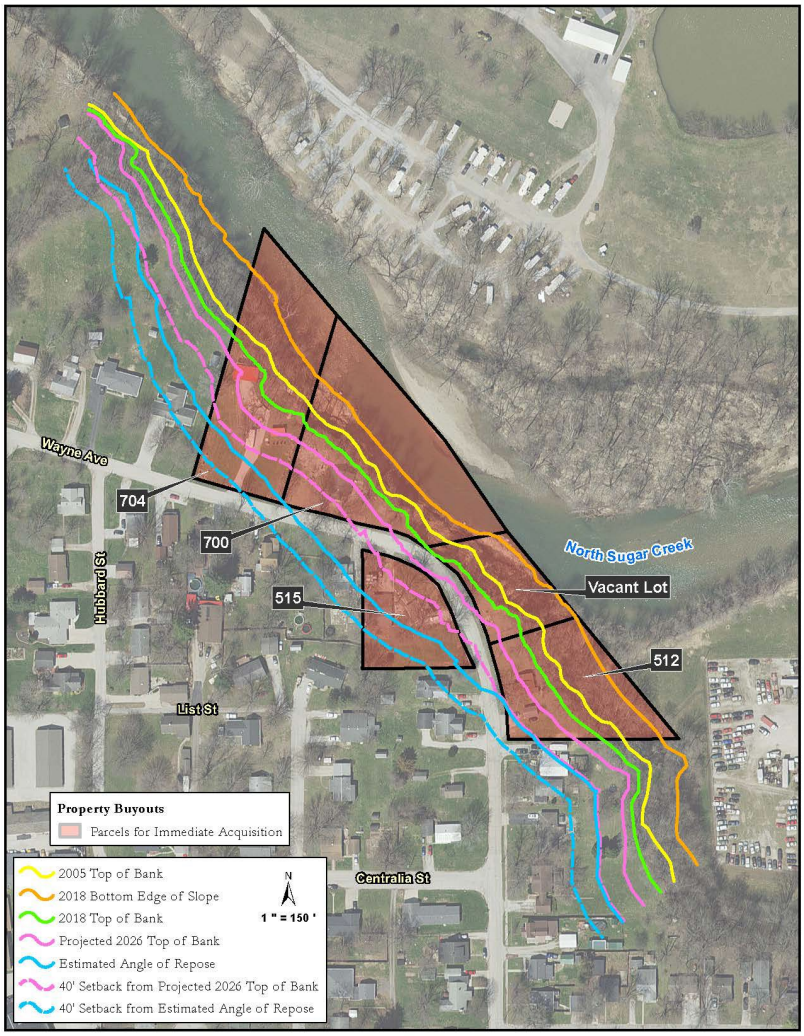


Figure 25 Historical and Predicted Sugar Creek Movement

As part of an effort to identify the properties in eminent danger of collapse within the next five years, additional analysis was conducted to the two critical areas identified in the 2019 Sugar Creek Channel Stability and Flood Risk Assessment study. This included overlaying the 2005 historical and 2026 projected top of bank as well as the slope estimated (3:1) angle of repose. A 40-foot buffer was delineated to account for the International Building Code building foundation setback from the edge of steep slopes. Based on this analysis, five properties on Wayne Avenue were identified for immediate acquisition (**Figure 25**).

A rough estimate of the cost to fully protect the three prioritized study areas of the Sugar Creek assessment is $19M. The estimated expenses of the bank repair for just one of the locations would be more than the estimated expenses of purchasing the affected properties and removing the structures; therefore, this has become the prioritized mitigation measure proposed within the Sugar Creek assessment.

Future Considerations

As the populations of the communities in Montgomery County grow, it can be anticipated that the number of critical and non-critical structures will also increase. In order to reduce the vulnerability for damages resulting from a landslide or land subsidence, soils and mining GIS layers should be integrated into the building permit or approval process. The FEH areas, and those outlined within the Sugar Creek assessment should also be considered for new and re-development proposals.

Indirect effects resulting from a landslide or land subsidence event can include power outages caused by downed tree limbs, increased response times for emergency personnel if transportation routes are damaged, and potentially shot down of businesses.

Landslide/Subsidence: Relationship to Other Hazards

A landslide or a subsidence may be the precursor for other hazards. Depending on the location of the event, material storage containers can become damaged resulting in a spill or release of materials and potentially contaminating groundwater reserves. Dam failures may occur in much the same fashion if located in the potential hazard areas, or resulting from heavy saturation following a rainstorm, heavy snow, or rapid snow melt.

Similarly, these types of events may be caused by hail, thunder, or windstorms and their effects on the soils; an earthquake may release the ground enough to set a slide in motion; or a flood may add increased soil saturation or weight to at-risk areas increasing the potential for an event and resulting damages.

3.3.8 Tornado

Tornado: Overview

Tornadoes are defined as violently rotating columns of air extending from thunderstorms to the ground. Funnel clouds are rotating columns of air not in contact with the ground. However, the funnel cloud may reach the ground very quickly – becoming a tornado. If there is debris lifted and blown around by the "funnel cloud", then it has reached the ground and is a tornado.

A tornado is generated when conditions in a strong cell are produced that exhibit a wall of cool air that overrides a layer of warm air. The underlying layer of warm air rapidly rises, while the layer of cool air drops – sparking the swirling action. The damage from a tornado is a result of the high wind velocity and wind-clown debris. Tornado season is generally April through June in Indiana, although tornadoes can occur at any time of year. Tornadoes tend to occur in the afternoons and evenings; over 80 percent of all tornados strike between 3:00 pm and 9:00 pm but can occur at any time of day or night as shown in **Figure 24** Tornadoes occur most frequently in the United States east of the Rocky Mountains. Tornadoes in Indiana generally come from the south through the east.

Figure 26 Funnel Cloud During a Lightning Storm at Night

While most tornadoes (69%) have winds of less than 100 mph, they can be much stronger. Although violent tornadoes (winds greater than 205 mph) account for only 2% of all tornadoes, they cause 70% of all tornado deaths. In 1931, a tornado in Minnesota lifted an 83-ton rail car with 117 passengers and carried it more than 80 feet. In another instance, a tornado in Oklahoma carried a motel sign 30 miles and dropped it in Arkansas. In 1975, a Mississippi tornado carried a home freezer more than a mile.

Tornado: Recent Occurrences

The classification of tornadoes utilizes the Enhanced Fujita Scale of tornado intensity and damages, described in **Table 19**. Tornado intensity ranges from low intensity (EF0) tornadoes with effective wind speeds of 65-85 mph to high intensity (EF5+) tornadoes with effective wind speeds of 200+ mph. According to the NCDC, Montgomery County has experienced two tornadoes (1-EF0 and 1-EF2), between May 2015 and February 2022.

Table 19 Enhanced Fujita Scale of Tornado Intensity

EF-Scale	Winds	Character of Damage	Relative Frequency	Typical Damages
EF0	65-85 mph	Light damage	29%	Shallow rooted trees blown over; damage to roofs, gutters, siding
EF1	86-110 mph	Moderate damage	40%	Mobile homes overturned, roofs stripped, windows broken
EF2	111-135 mph	Considerable damage	24%	Large trees snapped, light-object missiles generated, cars lifted
EF3	136-165 mph	Severe damage	6%	Severe damages to large buildings, trains overturned
EF4	166-200 mph	Devastating damage	2%	Whole houses destroyed; cars thrown
EF5	200+ mph	Incredible damage	<1%	High-rise buildings with significant damage, strong framed homes blown away

The NCDC reports approximately $75.0K in property damages and no injuries or deaths in total for the tornado events which have occurred in this reporting period. On May 1, 2017 a tornado was reported to briefly touchdown in an agricultural field near Linden, resulting in no reported damages. However, the event classified as an EF2 occurred on August 24, 2016 and traveled through the unincorporated portion of the county between Crawfordsville and Linnsburg destroying or causing major damage to approximately 30 residences. For this event, a total of $75.0K was reported.

The Committee estimated the probability of a tornado occurring in Montgomery County would be "Highly Likely" and the magnitude and severity of such an event to be "Limited" throughout the unincorporated areas of the county and range from "Significant" to "Critical" within the municipal areas. As with many hazardous events, the Committee anticipated a short warning time of typically less than six hours, and a short duration, also less than six hours. The summary is shown in **Table 20**.

Table 20 CPRI for Tornado

	Probability	Magnitude/ Severity	Warning Time	Duration	CPRI
Montgomery County	Highly Likely	Limited	< 6 Hours	< 6 Hours	Severe
Town of Alamo	Highly Likely	Significant	< 6 Hours	< 6 Hours	Severe
City of Crawfordsville	Highly Likely	Critical	< 6 Hours	< 6 Hours	Severe
Town of Darlington	Highly Likely	Significant	< 6 Hours	< 6 Hours	Severe
Town of Ladoga	Highly Likely	Significant	< 6 Hours	< 6 Hours	Severe
Town of Linden	Highly Likely	Significant	< 6 Hours	< 6 Hours	Severe
Town of New Market	Highly Likely	Significant	< 6 Hours	< 6 Hours	Severe
Town of New Richmond	Highly Likely	Significant	< 6 Hours	< 6 Hours	Severe
Town of New Ross	Highly Likely	Significant	< 6 Hours	< 6 Hours	Severe
Town of Waveland	Highly Likely	Significant	< 6 Hours	< 6 Hours	Severe
Town of Waynetown	Highly Likely	Significant	< 6 Hours	< 6 Hours	Severe
Town of Wingate	Highly Likely	Significant	< 6 Hours	< 6 Hours	Severe

The Indiana State Climate Office estimates that throughout Indiana, there is an average of 20 tornado touchdowns per year. Based on the number of tornado touchdowns previously reported through the NCDC and local weather agencies, the Committee determined the general probability of a future tornado occurring in Montgomery County is "Highly Likely" (within the calendar year).

Tornado: Assessing Vulnerability

As a path of a tornado is not pre-defined, it is difficult to isolate specific critical infrastructure and non-critical structures, or areas of Montgomery County that would be vulnerable to a tornado. Direct and indirect effects from a tornado may include:

Direct Effects:

- Damages to older construction structures, mobile homes, and accessory structures (pole barns, sheds, etc.)
- Damages to above ground utility lines and structures

Indirect Effects:

- Expenses related to debris clean-up and/or reconstruction
- Loss of revenue for affected businesses
- Loss of work if employers are affected

Estimating Potential Losses

Due to the unpredictability of this hazard, all critical and non-critical structures within the county are at risk of future damage or loss of function. Estimates of potential physical losses were determined through a hypothetical exercise where an EF2 intensity tornado traveled through portions of the county (including the Lake Holiday area) and Crawfordsville. This is intended to present a "what-if" scenario of a tornado incident and associated damages. Damage estimates were derived by assuming that 25% of all structures in the path of the tornado would be completely destroyed, 35% of the structures would be 50% damaged, and 40% of the structures would sustain 25% damage. These estimations were also determined utilizing three wind speed zones based on distance from the tornado path. Zone 1 is nearest the center of the tornado path, while Zone 3 is the farthest from the path and with a theoretically lower wind speed. **Table 21** provides summary data for the hypothetical tornado, which is identified on Exhibit 3.

Table 21 Summary of Hypothetical Tornado Damages

	Zone 1		Zone 2		Zone 3		Total	
	#	$	#	$	#	$	#	$
County	20	$2.60M	32	$4.65M	32	$4.31M	**84**	**$11.6M**
Lake Holiday	47	$4.61M	54	$5.51M	40	$3.80M	**141**	**$13.92M**
Crawfordville	371	$38.10M	300	$30.62M	305	$34.66M	**976**	**$103.4M**
Totals								

Utilizing the same GIS information and process, critical infrastructure within each of the hypothetical tornado zones are included in **Table 22**. These buildings are included in the over number and of structures and damage estimate information provided in Table 21.

Table 22 Critical Infrastructure in Tornado Zones

Community	Zone 1	Zone 2	Zone 3
County			
Lake Holiday			Kounty Kids Daycare
Crawfordsville	Andre Justice DDS Crawfordville Head Start Hose Elementary School	Crawfordsville High School Admin Bldg Happy Town Daycare Ledgewood Eye Care Wilson Kindergarten Center	First United Methodist Church Indiana Home Care Plus Witham Specialty Services

Future Considerations

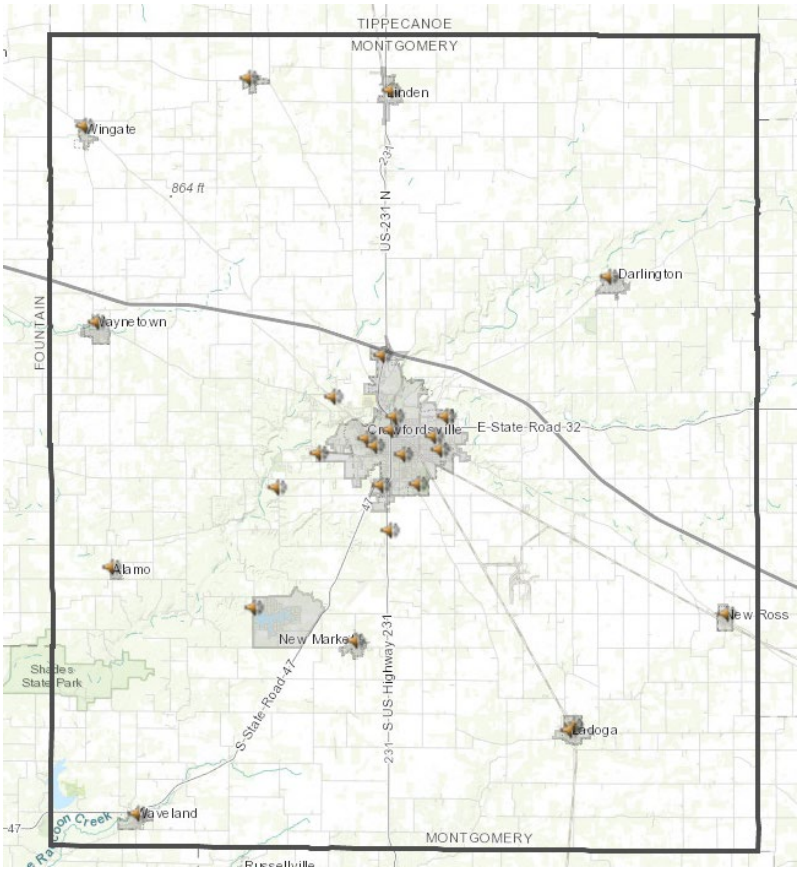


Figure 27 Montgomery County Outdoor Warning Sirens

Within Montgomery County, there are numerous events each year that draw thousands of guests. Due to this, it is imperative that the EMA place continued importance on the need to maintain, and as necessary, upgrade their outdoor warning siren coverage. Currently, much of the more populous areas of the county are not covered by the audible ranges of the existing outdoor warning sirens. The existing siren locations are provided in **Figure 27.**

While it can be anticipated that new construction associated with development may be stronger than older or existing construction, most of Montgomery County will remain vulnerable in areas left uncovered by outdoor warning sirens. It is impossible to predict the path of a tornado and therefore all current and future development will continue to be at risk for damages. However, risk to the citizens of Montgomery County has been lessened through participation in mass notification programs and outdoor warning siren activations.

There may also be indirect effects of a tornado event. For example, post-event clean-up may result in high expenses or inability to work for property owners that have experienced damages from either the tornado directly or by debris from high winds. Affected business owners may experience loss of revenue if they are unable to continue operations following the event. Similarly, if a business is affected and unable to operate, employees may experience a loss of wages during the period of recovery.

Tornado: Relationship to Other Hazards

Tornadoes may result in a hazardous materials incident. Material storage containers can become damaged by high winds and debris can result in a spill or release of materials. As wind speeds increase, the potential for damages to above ground storage containers also increases. Tankers and other transportation vehicles carrying hazardous materials are also at an increased risk while on the road or rail.

Tornadoes may also result in a dam failure as the increased wind speeds, and debris caused by the tornado, may directly impact the dam, or cause indirect damages through large debris or downed trees. In addition, tornadoes may lead to structural fires as the destruction path is sometimes long and broad, leading to an increased number of potentially damaged homes, exposed power lines, and large amounts of debris.

3.3.9 Winter Storm and Ice

Winter Storm & Ice: Overview

A winter storm can range from moderate snow over a few hours to blizzard conditions with high winds, ice storms, freezing rain or sleet, heavy snowfall with blinding wind-driven snow, and extremely cold temperatures that can last for several days. Some winter storms may be large enough to affect several states while others may affect only a single community. All winter storms are accompanied by cold temperatures and blowing snow, which can severely reduce visibility. A winter storm is defined as one that drops four or more inches of snow during a 12-hour period, or six or more inches during a 24-hour span. An ice storm occurs when freezing rain falls from clouds and freezes immediately on impact. All winter storms make driving and walking extremely hazardous. The aftermath of a winter storm can affect a community or region for days, weeks, and even months.

Figure 28 Ice Covered Power Lines

Storm effects such as extreme cold, flooding, and snow and ice accumulation (**Figure 28**) can cause hazardous conditions and hidden problems for people in the affected area. People can become stranded on the road or trapped at home, without utilities or other services, including food, water, and fuel supplies. The conditions may overwhelm the capabilities of a local jurisdiction. Winter storms are considered deceptive killers as they may indirectly cause transportation accidents, and injury and death resulting from exhaustion/ overexertion, hypothermia and frostbite from wind chill, and asphyxiation. House fires occur more frequently in the winter due to lack of proper safety precautions.

Wind chill is a calculation of how cold it feels outside when the effects of temperature and wind speed are combined. On November 1, 2001, the NWS implemented a replacement Wind Chill Temperature (WCT) index for the 2001/2002 winter season. The reason for the change was to improve upon the current WCT Index, which was based on the 1945 Siple and Passel Index.

A winter storm watch indicates that severe winter weather may affect your area. A winter storm warning indicates that severe winter weather conditions are on the way. A blizzard warning means that large amounts of falling or blowing snow and sustained winds of at least 35 mph are expected for several hours. Winter storms are common in Montgomery County and the surrounding region. Such conditions can result in substantial personal and property damage, even death.

Winter Storm & Ice: Recent Occurrences

Since May 2015, the NCDC has recorded three heavy snow events and one winter storm. NCDC reports did not include information related to monetary damages, injuries, or deaths associated with any of the events. Narrative descriptions indicated poor travel conditions, power outages and debris associated with similar events.

The most recently recorded winter storm event occurred on February 2, 2022. Snowfalls in the area ranged from eight to 12.5 inches with the heaviest amounts recorded in Waynetown and a travel advisory was issued for the county. An event resulting in 9.4 inches of snow south of Crawfordsville occurred on March 24, 2018 and it was reported that due to the ability to forecast the event and prepare, no damaging impacts were realized.

The probability, magnitude, warning times, and duration of a snowstorm or ice storm causing disruption to residents and businesses in Montgomery County, as determined by the Planning Committee, is expected to be mostly consistent throughout the county and communities. It is "Highly Likely" that this type of hazard will occur in this area and will typically affect the entire county, and possibly several surrounding counties at one time, resulting in primarily "Limited" damages due to the remoteness of some areas and the number of critical facilities in others. The warning time for severe temperatures or several inches of snow associated with a winter storm is usually 12- 24 hours while the duration of the incident is anticipated to be greater than one day for most areas. A summary is shown in **Table 23**.

Table 23 CPRI for Winter Storm and Ice

	Probability	Magnitude/ Severity	Warning Time	Duration	CPRI
Montgomery County	Highly Likely	Limited	12-24 Hours	< 1 Week	Elevated
Town of Alamo	Highly Likely	Limited	12-24 Hours	< 1 Day	Elevated
City of Crawfordsville	Highly Likely	Negligible	12-24 Hours	< 1 Day	Elevated
Town of Darlington	Highly Likely	Limited	12-24 Hours	< 1 Day	Elevated
Town of Ladoga	Highly Likely	Limited	12-24 Hours	< 1 Day	Elevated
Town of Linden	Highly Likely	Limited	12-24 Hours	< 1 Day	Elevated
Town of New Market	Highly Likely	Limited	12-24 Hours	< 1 Day	Elevated
Town of New Richmond	Highly Likely	Limited	12-24 Hours	< 1 Day	Elevated
Town of New Ross	Highly Likely	Limited	12-24 Hours	< 1 Day	Elevated
Town of Waveland	Highly Likely	Limited	12-24 Hours	< 1 Day	Elevated
Town of Waynetown	Highly Likely	Limited	12-24 Hours	< 1 Day	Elevated
Town of Wingate	Highly Likely	Limited	12-24 Hours	< 1 Day	Elevated

The Planning Committee determined that the probability for a snowstorm or ice storm to occur in Montgomery County and the communities within is "Highly Likely" or will occur within the calendar year. Based on historical data and the experience of the Planning Committee, snowstorms are frequent within Montgomery County, but actions have been taken to mitigate many impacts from snow and ice storms. The Committee considered only the larger, more detrimental event for this effort.

Winter Storm & Ice: Assessing Vulnerability

A snowstorm typically affects a large regional area with potential for physical, economic, and/or social losses. Direct and indirect effects of a snowstorm or ice storm within Montgomery County may include:

Direct Effects:

- More urban area employers may experience loss of production as employees may not be able to get to work
- Rural (County) roads may impassable

- Expenses related to snow removal or brine/sand applications

Indirect Effects:

- Loss of revenue as businesses are closed
- Increased emergency response times based on safety of roads
- Loss of income if unable to get to place of employment

Estimating Potential Losses

Given the nature and complexity of a regional hazard such as a snowstorm, it is difficult to quantify potential losses to property and infrastructure. As a result, all critical and non-critical structures and infrastructure are at risk from snowstorm and ice storm incidents.

Figure 29 Travel Impacted During Snowstorm

For planning purposes, information collected in snowstorms impacting other communities around the nation is also useful in assessing the potential social, physical, and economic impact that a winter storm could have on Montgomery County communities. For example, a March 2003 snowstorm in Denver, Colorado dropped approximately 31 inches of snow and caused an estimated $34M in total damages. In addition, a February 2003 winter storm dropped an estimated 15-20 inches of snow in parts of Ohio. The Federal and Ohio Emergency Management Agencies and U.S. Small Business Administration surveyed damaged areas and issued a preliminary assessment of $17M in disaster related costs. These costs included snow and debris removal, emergency loss prevention measures, and public utilities repair. The agencies found over 300 homes and businesses either damaged or destroyed in six counties. Snowstorms and blizzards also make road travel difficult and dangerous, as in **Figure 29.**

The Denver, Colorado area snowstorms from December 2006 through January 2007 surpassed the expenses and damages of the 2003 winter storms. In snow removal costs alone, it is estimated that over $19M was spent throughout the area, with approximately $6.4M of that allocated to clearing Denver International Airport. Additional economic expenses are realized when such a large storm closed local businesses and Denver International Airport for nearly 48 hours.

While the above examples indicate the wide-ranging and large-scale impact that winter storms can have on a community or region, winter storms generally tend to result in less direct economic impacts than many other natural hazards. According to the Workshop on the Social and Economic Impacts of Weather, which was sponsored by the U.S. Weather Research Program, the American Meteorological Society, the White House Subcommittee on Natural Disaster Relief, and others, winter storms resulted in an average of 47 deaths and more than $1B in economic losses per year between 1988 and 1995. However, these totals account for only 3% of the total weather-related economic loss and only 9% of fatalities associated with all weather-related hazards over the same period.

Future Considerations

As populations increase and communities continue to grow, the need to respond to snowstorms or ice storms will remain an important municipal effort. As new construction or re-development occurs, especially new or existing critical infrastructure, it is important to ensure that these new structures are equipped to deal with the potential risks associated with this hazard. Those may include lengthy power outages and potentially impassable transportation routes, making it difficult to obtain supplies or for passage of response vehicles. These hazard events will typically affect the entire county as a whole, perhaps multiple counties, and therefore all development, current and future, will be at risk for damages associated with snow and ice storms.

Winter storms can also result in substantial indirect costs. Increased emergency response times, loss of work or the inability to get to work, as well as business interruption, are possible indirect effects of a winter storm. According to a report by the National Center for Environmental Predictions, the cold and snowy winter in late 1977 and early 1978, which impacted several heavily populated regions of the country, was partially responsible for reducing the nation's Gross Domestic Product (GDP) from an estimated growth rate of between 6% and 7% during the first three quarters of 1977 to approximately -1% in the last quarter of 1977 and 3% during the first quarter of 1978.

Winter Storm & Ice: Relationship to Other Hazards

Figure 30 Flooding Caused by Snow Melt

Winter storms and ice storms can lead to flooding as the precipitation melts and enters local receiving waters. This increased volume of water on already saturated, or still frozen ground can quickly result in flood-related damages to structures and properties (**Figure 30**) as well as within the stream or river channel. The increased flooding may then lead to a dam failure within the same area, further exacerbating the damages.

Hazardous materials incidents may be caused by poor road conditions during winter storms or ice storms. Many hazardous materials are transported by rail or by tanker over highways and interstates. In the more rural areas of Montgomery County, or where open areas are more susceptible to snow drifts on roads, the possibility of a traffic related hazardous materials incident may increase.

Power outages and other infrastructure failures may also occur during a winter storm. Weight from snow and ice accumulations can directly or indirectly cause power lines to fail. During extreme cold temperatures, power outages may prove deadly for certain populations such as the elderly or ill.

3.3.10 Dam Failure

Dam Failure: Overview

A dam is defined as a barrier constructed across a watercourse for the purpose of storage, control, or diversion of water. Dams typically are constructed of earth, rock, concrete, or mine tailings. A dam failure is a collapse, breach, or other failure resulting in downstream flooding.

A dam impounds water in the upstream area, referred to as the reservoir. The amount of water impounded is measured in acre-feet. An acre-foot is the volume of water that covers an acre of land to a depth of one foot. As a function of upstream topography, even a very small dam may impound or detain many acre-feet of water. Two factors influence the potential severity of a full or partial dam failure: the amount of water impounded, and the density, type, and value of development and infrastructure located downstream.

Of the approximately 80,000 dams identified nationwide in the National Inventory of Dams, the majority are privately owned. Each dam is assigned a downstream hazard classification based on the potential loss of life and damage to property should the dam fail. The three classifications are high, significant, and low. With changing demographics and land development in downstream areas, hazard classifications are updated continually. The following definitions of hazard classification currently apply to dams in Indiana:

- High Hazard Dam: a structure, the failure of which, may cause the loss of life and serious damage to homes, industrial and commercial buildings, public utilities, major highways, or railroads.
- Significant Hazard Dam: a structure, the failure of which, may damage isolated homes and highways or cause the temporary interruption of public utility services.
- Low Hazard Dam: a structure, the failure of which, may damage farm buildings, agricultural land, or local roads.

A levee is a flood control structure designed to hold water away from a building. Levees protect buildings from flooding as well as from the force of water, from scour at the foundation, and from impacts of floating debris. The principle causes of levee failure are like those associated with dam failure and include overtopping, surface erosion, internal erosion, and slides within the levee embankment or the foundation walls. Levees are designed to protect against a particular flood level and may be overtopped in a more severe event. When a levee system fails or is overtopped, the result can be catastrophic and often more damaging that if the levee were not there, due to increased elevation differences and water velocity. The water flowing through the breach continues to erode the levee and increase the size of the breach until it is repaired or water levels on the two side of the levee have equalized.

Dam Failure: Recent Occurrences

Figure 31Waveland Lake and Dam

Within Montgomery County, according to the National Inventory of Dams, there is one DNR-regulated High Hazard dams (Waveland Lake Dam- **Figure 31**), one DNR-regulated Significant Hazard dam (Lake Holiday Dam), and two DNR-regulated Low Hazard dams (Lake Vista Dam and Shades Pond), shown on Exhibit 2. According to local information, there have been no dam failures within Montgomery County.

According to the National Levee Database (NLD) managed by the USACE, there are no levees systems within Montgomery County. Therefore, levees will not be considered as a hazard within this planning effort.

Based on the information provided to them and their local knowledge, experience, and expertise, the Committee determined the probability of a dam failure is "Unlikely". The magnitude of a dam failure ranges from "Limited" (areas within the potential inundation area) to "Negligible" (areas not anticipated to be within the inundation area) damages. For a dam failure that occurs on a sunny day, the warning time is anticipated to be less than six hours for those areas expected to be impacted by a dam failure; and the duration is anticipated to last less than one week. **Table 24** provides a summary of the Planning Committee's expectations during a dam failure.

Table 24 CPRI for Dam Failure

	Probability	Magnitude/ Severity	Warning Time	Duration	CPRI
Montgomery County	Unlikely	Limited	< 6 Hours	> 1 Week	Low
Town of Alamo	Unlikely	Negligible	> 24 Hours	< 6 Hours	Low
City of Crawfordsville	Unlikely	Negligible	> 24 Hours	< 6 Hours	Low
Town of Darlington	Unlikely	Negligible	> 24 Hours	< 6 Hours	Low
Town of Ladoga	Unlikely	Negligible	> 24 Hours	< 6 Hours	Low
Town of Linden	Unlikely	Negligible	> 24 Hours	< 6 Hours	Low
Town of New Market	Unlikely	Negligible	> 24 Hours	< 6 Hours	Low
Town of New Richmond	Unlikely	Negligible	> 24 Hours	< 6 Hours	Low
Town of New Ross	Unlikely	Negligible	> 24 Hours	< 6 Hours	Low
Town of Waveland	Unlikely	Negligible	> 24 Hours	< 6 Hours	Low
Town of Waynetown	Unlikely	Negligible	> 24 Hours	< 6 Hours	Low
Town of Wingate	Unlikely	Negligible	> 24 Hours	< 6 Hours	Low

Dam Failure: Assessing Vulnerability

The actual magnitude and extent of damages due to a dam failure depend on the type of breach, the volume of water that is released, and the width of the floodplain valley to accommodate the flood wave. Due to the conditions beyond the control of the dam owner or engineer, there may be unforeseen structural problems, natural forces, mistakes in operation, negligence, or vandalism that may cause a structure to fail.

Within Montgomery County, direct and indirect effects from a dam failure may include:

Direct Effects:

- Loss of life and serious damage to downstream homes, industrial and commercial buildings, public utilities, major highways, or railroads
- Loss of use of reservoirs for flood control, recreation, and water supply

Indirect Effects:

- Loss of land in the immediate scour area
- Increased response times due to damaged or re-routed transportation routes and/or bridges

Estimating Potential Losses

It is preferred that High Hazard dams have Incident and Emergency Action Plans (IEAP) developed. These plans have detailed potential dam failure inundation areas identified along with at-risk structures identified. The Waveland Lake Dam has an IEAP developed with potential dam failure inundation areas outlined. The actual magnitude and extent of damages depend on the type of dam break, the volume of water that is released, and the width of the floodplain valley to accommodate the dam break flood wave.

These potential inundation areas from the IEAP were overlaid onto recent aerial photography to estimate the number of critical and non-critical structures potentially affected by a sunny-day dam failure. As with previous hazards, damage estimates were derived by assuming 25% of all structures would be completely destroyed, 35% would be 50% damaged, and the remaining 40% of structures would have only 25% in damages. **Table 24** provides overview information of potential dam failure.

Table 25 Montgomery County Potential Dam Failure Impacts

High Hazard Dam	Potential Damages	
	# Structures	$ Damages
Waveland Lake Dam	7	$1.0M

Utilizing the same GIS process, it was determined that the only critical infrastructure which lies within the potential dam failure inundation area is the WWTP. The Committee did discuss the potential for the access road to also be damaged should a dam failure occur. Additional planning efforts may need to include the inaccessibility of the road to fully plan for such an incident.

Future Considerations

As areas near existing dams continue to grow in population, it can be anticipated that the number of critical and non-critical structures could also increase accordingly. Location of these new facilities should be carefully considered, and precautions should be taken to ensure that schools, medical facilities, municipal buildings, and other critical infrastructure are located outside of the delineated or estimated dam failure inundation areas. Also, flood-free access should be provided for these facilities. Large areas of new development have not yet occurred downstream of the high hazard dam in Montgomery County. Until such development or re-development downstream of a dam is prohibited, those areas remain vulnerable to losses and damages associated with a failure of that structure.

It is also very important to all downstream communities and property owners that dam IEAPs are developed, kept up-to-date, and routinely exercised to ensure the greatest safety to those within the hazard area. This is a good suggestion even for Significant Hazard dams as well.

Dam Failure: Relationship to Other Hazards

With the potentially large volumes and velocities of water released during a breach, it can be expected that such a failure would lead to flooding within the inundation areas downstream of the dam. Nearby bridges and roads are also in danger of being destroyed or damaged due to a dam failure. Bridges may become unstable and portions of road surfaces may be washed away, or the entire road may be undermined. Other infrastructure such as utility poles and lines may be damaged as the water flows along the surface or pipes may become exposed due to scouring; all of which may lead to utility failures within the area downstream of the dam failure.

3.3.11 Hazardous Materials Incident

Hazardous Materials Incident: Overview

Hazardous materials are substances that pose a potential threat to life, health, property, and the environment if they are released. Examples of hazardous materials include corrosives, explosives, flammable materials, radioactive materials, poisons, oxidizers, and dangerous gases. Despite precautions taken to ensure careful handling during manufacture, transport, storage, use, and disposal, accidental releases are bound to occur. These releases create a serious hazard for workers, neighbors, and emergency response personnel. Emergency response may require fire, safety/law enforcement, search and rescue, and hazardous materials response units.

Figure 32 Drums of Potentially Hazardous Waste

As materials are mobilized for treatment, disposal, or transport to another facility, all infrastructure, facilities, and residences near the transportation routes are at an elevated risk of being affected by a hazardous materials release. Often these releases can cause serious harm to Montgomery County and its residents if proper and immediate actions are not taken. Most releases are the result of human error or improper storage (**Figure 32**), and corrective actions to stabilize these incidents may not always be feasible or practical in nature.

Railways often transport materials that are classified as hazardous and preparations need to be made and exercised for situations such as derailments, train/vehicle crashes, and/or general leaks and spills from transport cars.

Hazardous Materials Incident: Recent Occurrences

During conversations with Committee members and through information provided by local news outlets, it was noted that numerous small and moderately sized incidents involving manufacturing facilities and transportation routes have occurred since the development of the original MHMP. However, the number of facilities utilizing, storing, and/or manufacturing chemicals and the number of high-volume transportation routes increase the likelihood of an incident.

According to the Committee, the probability of a hazardous materials release or incident is "Possible" within Alamo and "Highly Likely" in all other areas due to the number of facilities and transportation routes within and through these municipalities. "Limited" damages are anticipated to result from an incident regardless of the location of the event, with the exception of Alamo where the magnitude is anticipated to be "Negligible". As with hazards of this nature, a short warning time of less than six hours and a duration of less than six hours is also anticipated in the event of a hazardous materials incident. A summary is shown in **Table 26**.

Table 26 CPRI For Hazardous Materials Incident

	Probability	Magnitude/ Severity	Warning Time	Duration	CPRI
Montgomery County	Highly Likely	Limited	< 6 Hours	< 6 Hours	Severe
Town of Alamo	Possible	Negligible	< 6 Hours	< 6 Hours	Low
City of Crawfordsville	Highly Likely	Limited	< 6 Hours	< 6 Hours	Severe
Town of Darlington	Highly Likely	Limited	< 6 Hours	< 6 Hours	Severe
Town of Ladoga	Highly Likely	Limited	< 6 Hours	< 6 Hours	Severe
Town of Linden	Highly Likely	Limited	< 6 Hours	< 6 Hours	Severe
Town of New Market	Highly Likely	Limited	< 6 Hours	< 6 Hours	Severe
Town of New Richmond	Highly Likely	Limited	< 6 Hours	< 6 Hours	Severe
Town of New Ross	Highly Likely	Limited	< 6 Hours	< 6 Hours	Severe
Town of Waveland	Highly Likely	Limited	< 6 Hours	< 6 Hours	Severe
Town of Waynetown	Highly Likely	Limited	< 6 Hours	< 6 Hours	Severe
Town of Wingate	Highly Likely	Limited	< 6 Hours	< 6 Hours	Severe

Relatively small hazardous materials incidents have occurred throughout Montgomery County in the past and may, according to the Committee, occur again. As the number of hazardous materials producers, users, and transporters increase within or surrounding Montgomery County, it can be anticipated that the likelihood of a future incident will also increase.

Hazardous Materials Incident: Assessing Vulnerability

Within Montgomery County, direct and indirect effects from a hazardous materials incident may include:

Direct Effects:

- More densely populated areas with a larger number of structures, railroad crossings, and heavily traveled routes are more vulnerable
- Expense of reconstruction of affected structures

Indirect Effects:

- Loss of revenue or production while recovery and/or reconstruction occurs
- Anxiety or stress related to event
- Potential evacuation of neighboring structures or facilities

Figure 33 Fuel Tanker Fire

While the possibility of an incident occurring may be likely, the vulnerability of Montgomery County has been lowered due to the enactment of Superfund Amendments and Reauthorization Act (SARA) Title III national, state and local requirements. SARA Title III, also known as the Emergency Planning and Community Right to Know Act (EPCRA), establishes requirements for planning and training at all levels of government and industry. EPCRA also establishes provisions for citizens to have access to information related to the type and quantity of hazardous materials being utilized, stored, transported or released within their communities.

One local result of SARA Title III is the formation of the Local Emergency Planning Commission (LEPC). This commission has the responsibility for preparing and implementing emergency response plans, cataloging Material Safety Data Sheets (MSDS), creating chemical inventories of local industries and businesses, and reporting materials necessary for compliance.

In Montgomery County, 69 facilities are subject to SARA Title III provisions due to the presence of listed hazardous materials in quantities at or above the minimum threshold established by the Act. These facilities are also required to create and distribute emergency plans and facility maps to local emergency responders such as the LEPC, fire departments, and police departments. With this knowledge on hand, emergency responders and other local government officials can be better prepared to plan for an emergency and the response it would require, and to better prevent serious effects to the community involved.

Estimating Potential Losses

In addition, the very nature of these events makes predicting the extent of their damage very difficult. A small-scale spill or release might have a minor impact and would likely require only minimal response efforts. Another slightly larger incident might result in the disruption of business or traffic patterns, and in this situation, might require active control response measures to contain a spill or release. On the other hand, even small or moderate events could potentially grow large enough that mass evacuations or shelter in place techniques are needed, multiple levels of response are utilized, and additional hazards such as structural fires and/or additional hazardous materials releases (or explosions) may occur. Given the unpredictable nature of hazardous materials incident, an estimate of potential losses was not generated.

Future Considerations

Additional facilities, both critical and non-critical in nature may be affected if a hazardous materials release were to occur along a transportation route. Several routes including railways, Interstate 74; US State Routes 25, 32, 47, 55, 59, 136, 231, and 234 are traveled by carriers of hazardous materials.

By restricting development within the known hazardous materials facility buffer zones, future losses associated with a hazardous materials release can be reduced. Critical infrastructure should be especially discouraged from being located within these areas. Further, by restricting construction in these zones, the number of potentially impacted residents may also be greatly reduced, lowering the risk for social losses, injuries, and potential deaths. Future construction of hazardous materials facilities should be located away from critical infrastructure such as schools, medical facilities, municipal buildings, and daycares. Such construction would likely reduce the risk to highly populated buildings and populations with specials needs or considerations such as children, elderly, and medically unfit.

Many facilities constructed within close proximity to a hazardous materials facility are similar due to local zoning ordinances. This reduces the risk and vulnerability of some populations. However, there are several facilities and numerous transportation routes located throughout each of the communities making current and future development at risk for losses associated with a hazardous materials release.

Hazardous Materials Incident: Relationship to Other Hazards

Dependent on the nature of the release, conditions may exist where an ignition source such as a fire or spark ignites a flammable or explosive substance. As the fire spreads throughout the facility or the area, structural and/or property damages will increase. Response times to a hazardous materials incident may be prolonged until all necessary information is collected detailing the type and amount of chemicals potentially involved in the incident. While this may increase structural losses, it may decrease the social losses such as injuries or even deaths.

3.4 HAZARD SUMMARY

For the development of this MHMP, the Committee utilized the CPRI method to prioritize the hazards they felt affected Montgomery County. Hazards were assigned values based on the probability or likelihood of occurrence, the magnitude or severity of the incident, as well as warning time and duration of the incident itself. A weighted CPRI was calculated based on the percent of the county's population present in the individual communities.

Table 27 summarizes the CPRI values for the various hazards studied within this MHMP.

- "Low" hazards: Earthquake; Dam Failure
- "Elevated" hazards: Drought; Flood; Land Subsidence; Winter Storm and Ice.
- "Severe" hazards: Extreme Temperatures; Fire; Hail, Thunder, and Windstorms; Hazardous Materials Incident; Tornado

Table 27 Combined CPRI

Type of Hazard	List of Hazards	Weighted Average CPRI
Natural	Drought	
	Earthquake	
	Extreme Temperature	
	Fire	
	Flood	
	Hail/Thunder/Windstorm	
	Landslide/Subsidence	
	Tornado	
	Winter Storm/Ice	
Technological	Dam Failure	
	Hazardous Materials Incident	

It can be important to understand the cause-and-effect relationship between the hazards selected by the Committee. **Table 28** can be utilized to identify those relationships. For example, a winter storm (along the side of the table) can result in a flood (along the top of the table). In a similar fashion, a hazardous materials incident (along the top of the table) can be caused by an earthquake; flood; tornado; or a winter storm or ice storm (along the side of the table)

Table 28 Hazard Relationship Table

EFFECT → / CAUSE ↓	Drought	Earthquake	Extreme Temperature	Fire	Flood	Hailstorm/ Thunderstorm/ Windstorm	Landslide / Subsidence	Tornado	Winter Storm / Ice	Dam Failure	Hazardous Materials
Drought											
Earthquake				X			X			X	X
Extreme Temperature											X
Fire											X
Flood							X			X	X
Hailstorm/ Thunderstorm / Windstorm				X	X		X			X	X
Landslide / Subsidence					X						X
Tornado				X						X	X
Winter Storm/ Ice					X					X	X
Dam Failure					X		X				X
Hazardous Materials				X							

As a method of better identifying the potential relationships between hazards, the community exhibits can be referenced to indicate the proximity of one or more known hazard areas such as the delineated floodplains and the locations of EHS facilities. For this reason, many of the communities in Montgomery County may be impacted by more than one hazard at a time, depending on certain conditions. It can be anticipated that if a flood were to occur within these areas, there would be a potentially increased risk of a facility experiencing a hazardous materials incident. These areas may also be at a greater risk of a dam failure.

Future development in areas where multiple known hazard areas (dam failure inundation areas, floodplains and surrounding hazardous materials facilities) overlap should undergo careful design, review, and construction protocol to reduce the risk of social, physical, and economic losses due to a hazard incident. While it may certainly be difficult, critical infrastructure should not be constructed within these regions.

CHAPTER 4: MITIGATION GOALS AND PRACTICES

This section identifies the overall goal for the development and implementation of the Montgomery County MHMP. A summary of existing and proposed mitigation practices discussed by the Committee is also provided.

4.1 MITIGATION GOAL

REQUIREMENT §201.6(c)(3)(i):
[The hazard mitigation strategy shall include a] description of mitigation goals to reduce or avoid long-term vulnerabilities to the identified hazards.

The Committee reviewed the mitigation goals as outlined within the 2016 Montgomery County MHMP and determined that each of these remain valid and effective. In summary, the overall goal of the Montgomery County MHMP is to reduce the social, physical, and economic losses associated with hazard incidents through emergency services, natural resource protection, prevention, property protection, public information, and structural control mitigation practices.

4.2 MITIGATION PRACTICES

REQUIREMENT §201.6(c)(3)(ii):
[The mitigation strategy shall include a] section that identifies and analyzed a comprehensive range of specific mitigation actions and projects being considered to reduce the effects of each hazard, with particular emphasis on new and existing buildings and infrastructure.

REQUIREMENT §201.6(c)(3)(iii):
[The mitigation strategy section shall include] an action plan describing how the actions identified in section (c)(3)(ii) will be prioritized, implemented, and administered by the local jurisdiction. Prioritization shall include a special emphasis on the extent to which benefits are maximized according to a cost benefit review of the proposed projects and their associated costs.

In 2005, the Multi-Hazard Mitigation Council conducted a study about the benefits of hazard mitigation. This study examined grants over a 10-year period (1993-2003) aimed at reducing future damages from earthquake, wind, and flood. It found that mitigation efforts were cost-effective at reducing future losses; resulted in significant benefits to society; and represented significant potential savings to the federal treasury in terms of reduced hazard-related expenditures. This study found that every $1 spent on mitigation efforts resulted in an average of $4 savings for the community. The study also found that FEMA mitigation grants are cost-effective since they often lead to additional non-federally funded mitigation activities and have the greatest benefits in communities that have institutionalized hazard mitigation programs.

A more recent (2017) study by the National Institute of Building Sciences, reviewed over 20 years of federally funded mitigation grants, not only from FEMA but also from the US Economic Development Administration (EDA) and the US Department of Housing and Urban Development (HUD). From this broadened review, it has been determined that for every $1 spent on mitigation, $6 are saved on disaster costs. In addition, by designing and construction buildings which exceed select items in the 2015 International Code, $4 can be saved for every $1 invested in those changes.

Six primary mitigation practices defined by FEMA are:

- **Emergency Services** – measures that protect people during and after a hazard.
- **Natural Resource Protection** – opportunities to preserve and restore natural areas and their function to reduce the impact of hazards.
- **Prevention** – measures that are designed to keep the problem from occurring or getting worse.
- **Property Protection** – measures that are used to modify buildings subject to hazard damage rather than to keep the hazard away.
- **Public Information** – those activities that advise property owners, potential property owners, and visitors about the hazards, ways to protect themselves and their property from the hazards.
- **Structural Control** – physical measures used to prevent hazards from reaching a property.

4.2.1 Existing Mitigation Practices

As part of this planning effort, the Committee discussed the strengths and weaknesses of existing mitigation practices and made recommendations for improvements, as well as suggested new practices. The following is a summary of existing hazard mitigation practices within Montgomery County. Mitigation measures that were included in the 2016 Montgomery County MHMP are noted as such.

Emergency Services

- The County has developed a centralized system for testing and sounding the existing outdoor warning sirens.
- Maps and stream gages are utilized for flood forecasting and flood warnings for various stream levels and along Sugar Creek. *(2016 Measure)*
- Many communities have developed snow removal routes to keep primary streets clean during and after snowstorms.
- An IEAP has been developed, and is routinely reviewed, for the Waveland Lake dam. (*2016 Measure)*
- Training and table-top exercises are conducted by the LEPC and include response agencies such as police, fire, and local hospitals.
- Approximately 25-30 residents are CERT trained and monthly training is provided.
- Many response agencies have mobile data terminals and necessary software utilized by the vehicle fleet and dispatchers.
- Montgomery County EMA works with event coordinators for 13 outdoor multi-day events in Montgomery County to assist with emergency response and preparations *(2016 Measure)*
- Montgomery County has developed evacuation procedures for some known hazard areas.
- Montgomery County purchased three mobile message boards to utilize during hazard events *(2016 Measure)*
- Montgomery County EMA continues to provide weather radios to interested businesses and residents.

Natural Resource Protection

- Montgomery County, Crawfordsville, Darlington, Ladoga, Waveland, and Waynetown are in good standing with the NFIP Program and have flood protection ordinances which meets or exceeds the minimum requirements.
- Recommendations and projects proposed within the 2019 Sugar Creek Channel Stability and Flood Risk Assessment study will be implemented as funding allows and opportunities arise

- Current facility maps and response plans are on file for all Tier II HazMat facilities

Prevention

- Montgomery County utilizes GIS data collection and maintenance which may be used independently and collectively in land use planning decisions and can be utilized in HAZUS-MH "what-if" scenarios. *(2016 Measure)*
- The Montgomery County LEPC provides routine training regarding the proper storage, transport, and disposal of hazardous materials.
- The County and municipalities follow the Indiana State Building Code and enforce local zoning ordinances which discourage development within the floodplains.
- Information related to natural hazards has been incorporated into the Comprehensive Land Use Plan and other plans to better guide future growth and development (*2016 Measure)*
    - Montgomery Comprehensive Plan, 2019:
        i. The plan recommends that future development activities avoid the significant natural assets of the county such as floodplains, steep slopes, and wetlands.
        ii. One guiding principal is to "Focus investment on critical infrastructure by supporting growth and development in the proper and desired locations".
    - Crawfordsville Comprehensive Plan, 2017:
        i. Strategies noted within the plan include those to safeguard natural resources, open spaces, parks, and waterways

Property Protection

- Recommendations from completed flood protections studies are implemented as funding becomes available
- Drainage system maintenance, including repair and replacement of broken tiles and culverts occurs routinely throughout the county.

Public Information

- Outreach materials and hazard preparedness materials are routinely provided within offices and agencies throughout Montgomery County, large public events, speaking opportunities within schools, etc. *(2016 Measure)*
- The EMA and response agencies utilize websites and social media to convey messages to the public prior to, during and following hazardous events. This includes easy to understand information and easy to follow directions.

Structural Control

- Stormwater conveyances and regulated drains are maintained on a routine basis to prevent localized flooding, increased erosion, and material deposition as a result of rainfall or snowmelt. *(2016 Measure)*
- Erosion and sediment control measures included in the Storm Water Quality Management Plan (SWQMP) are implemented within the City of Crawfordsville as required. *(2016 Measure)*
- The American Red Cross has developed shelter agreements throughout the county and the EMA has worked to outfit response trailers suited to animals during disasters. In addition, the Crawfordsville Middle School has constructed a FEMA certified safe room while the Elementary Schools have established safer areas for students to congregate.

4.2.2 Proposed Mitigation Practices

After reviewing existing mitigation practices, the Committee reviewed mitigation ideas for each of the hazards studied and identified which of these they felt best met their needs as a community according to selected social, technical, administrative, political, and legal criteria. The following identifies the key considerations for each evaluation criteria:

- **Social** – mitigation projects will have community acceptance, they are compatible with present and future community values, and do not adversely affect one segment of the population.
- **Technical** – mitigation projects will be technically feasible, reduce losses in the long-term, and will not create more problems than they solve.
- **Administrative** – mitigation projects may require additional staff time, alternative sources of funding, and have some maintenance requirements.
- **Political** – mitigation projects will have political and public support.
- **Legal** – mitigation projects will be implemented through the laws, ordinances, and resolutions that are in place.
- **Economic** – mitigation projects can be funded in current or upcoming budget cycles.
- **Environmental** – mitigation projects may have negative consequences on environmental assets such as wetlands, threatened or endangered species, or other protected natural resources.

Table 29 lists a summary of all proposed mitigation practices identified for all hazards, as well as information on the local status, local priority, benefit-cost ratio, project location, responsible entities, and potential funding sources, associated with each proposed practice. The proposed mitigation practices are listed in order of importance to Montgomery County for implementation. Projects identified by the Committee to be of "high" local priority may be implemented within five years from final Plan adoption. Projects identified to be of "moderate" local priority may be implemented within 5-10 years from final Plan adoption, and projects identified by the Committee to be of "low" local priority may be implemented within 10+ years from final Plan adoptions. However, depending on availability of funding, some proposed mitigation projects may take longer to implement.

As part of the process to identify potential mitigation projects, the Planning Committee weighed the benefit derived from each mitigation practice against the estimated cost of that practice. This basic benefit-cost ratio was based on experience and professional judgement and was utilized to identify the mitigation practices as having a high, moderate, or low benefit-cost ratio. Preparing detailed benefit-cost ratios was beyond the scope of this planning effort and the intent of the MHMP.

The update of this MHMP is a necessary step of a multi-step process to implement programs, policies, and projects to mitigate the effect of hazards in Montgomery County. The intent of this planning effort was to identify the hazards and the extent to which they affect Montgomery County and to determine what type of mitigation strategies or practices may be undertaken to mitigate for these hazards. A FEMA-approved MHMP is required to apply for and/or receive project grants under the BRIC, HMGP, and FMA. Although this MHMP meets the requirements of DMA 2000 and eligibility requirements of these grant programs additional detailed studies may need to be completed prior to applying for these grants. **Section 5.0** of this plan includes an implementation plan for all high priority mitigation practices identified by the Committee.

The CRS program credits NFIP communities a maximum of 97 points for setting goals to reduce the impact of flooding and other known natural hazards; identifying mitigation projects that include activities for prevention, property protection, natural resource protection, emergency services, structural control projects, and public information.

Table 29 Proposed Mitigation Measures

Mitigation Practice	Mitigation Strategy	Hazard Addressed	Status	Priority	Benefit-Cost Ratio	Responsible Entity	Funding Source
Emergency Response & Recovery 1. Coordinate communications, documentation, and record keeping between communities and agencies including a database of accurate and community specific information following each hazard events *(2016 Measure)* 2. Develop a Standard Operating Procedure for interactions and assistance between snowplows and response vehicles to clear paths for emergencies *(2016 Measure)* 3. Establish procedures using CodeRed to alert and evacuate the populations in known hazard areas (routinely flooded areas, floodplains, dam failure areas) *(2016 Measure)* 4. Inventory needs for mobile data terminals, including software and hardware upgrades, for response vehicles and purchase as feasible *(2016 Measure)*	☒ Emergency Services ☒ Nat. Res. Protection ☒ Prevention ☐ Property Protection ☒ Public Information ☐ Structural Control	☒ Drought ☒ Earthquake ☒ Extreme Temperature ☒ Fire ☒ Flood ☒ Hail/Thunder/Wind ☒ Landslide/Subsidence ☒ Tornado ☒ Winter Storm/Ice ☒ Dam Failure ☒ HazMat Incident	**Ongoing –** 1. Post-event information is provided in varying degrees 3. CodeRed is utilized throughout Montgomery County 4. Some vehicles have terminals in place **Proposed Enhancement –** 1. Create a more consistent reporting and documentation effort following hazard events 2. Develop and train responders on procedures for snowplows to assist response vehicles as needed 3. Utilize CodeRed to develop hazard areas, pre-scripted messages and at-risk residents. 4. Inventory and prioritize all response vehicles throughout the county and purchase needed equipment as able	High	High	EMA Community Contacts *Alamo* *Crawfordsville* *Darlington* *Ladoga* *Linden* *New Market* *New Richmond* *New Ross* *Waveland* *Waynetown* *Wingate* Fire Departments *(County, Crawfordsville, Townships, Volunteers)* Police Departments *(Crawfordsville, Darlington, Waveland, Waynetown)* Montgomery County Sheriff	Existing Budget Grant
Community Rating System 1. Investigate potential to reduce flood insurance premiums through additional participation in the NFIP's CRS Program. *(2016 Measure)* *(Will assist with NFIP compliance)*	☒ Emergency Services ☒ Nat. Res. Protection ☒ Prevention ☒ Property Protection ☒ Public Information ☒ Structural Control	☐ Drought ☐ Earthquake ☐ Extreme Temperature ☐ Fire ☒ Flood ☐ Hail/Thunder/Wind ☐ Landslide/Subsidence ☐ Tornado ☐ Winter Storm/Ice ☐ Dam Failure ☐ HazMat Incident	**Ongoing –** **Proposed Enhancement –** 1. Participation from Montgomery County and/or City of Crawfordsville	High	Moderate	Floodplain Administrators *County* *Crawfordsville* *Darlington* *Waveland* *Waynetown*	Existing Budget

Mitigation Practice	Mitigation Strategy	Hazard Addressed	Status	Priority	Benefit-Cost Ratio	Responsible Entity	Funding Source
Flood Studies and Protection 1. Conduct detailed flood studies for problem areas and/or areas with repetitive flooding problems or poor drainage *(2016 Measure)* 2. Develop FEH overlay districts to further protect area and mitigate impacts from future stream movements *(Will assist with NFIP compliance)*	☐ Emergency Services ☒ Nat. Res. Protection ☒ Prevention ☒ Property Protection ☒ Public Information ☐ Structural Control	☐ Drought ☐ Earthquake ☐ Extreme Temperature ☐ Fire ☒ Flood ☐ Hail/Thunder/Wind ☒ Landslide/Subsidence ☐ Tornado ☐ Winter Storm/Ice ☐ Dam Failure ☐ HazMat Incident	**Ongoing –** 1. Studies are completed as funding becomes available 2. Base FEH areas completed for the state **Proposed Enhancements –** 1. Prioritize listing of needed studies and continue to complete as funding becomes available 2. Adopt FEH overlay districts	High	Moderate	EMA Floodplain Administrators *County* *Crawfordsville* *Darlington* *Waveland* *Waynetown* Planning Departments *County (covering all smaller municipalities)* *Crawfordsville* Montgomery County Surveyor	Existing Budget Grant Municipal Bonds
Hazardous Materials Response Team 1. Increase number of personnel for fire departments and emergency response teams as well as those certified to create a Montgomery County HazMat Response Team 2. Propose and adopt an Ordinance allowing response teams to recoup expenses following clean-ups of hazmat spills	☒ Emergency Services ☒ Nat. Res. Protection ☒ Prevention ☒ Property Protection ☒ Public Information ☒ Structural Control	☐ Drought ☐ Earthquake ☐ Extreme Temperature ☐ Fire ☐ Flood ☐ Hail/Thunder/Wind ☐ Landslide/Subsidence ☐ Tornado ☐ Winter Storm/Ice ☐ Dam Failure ☒ HazMat Incident	**Ongoing –** **Proposed Enhancement –** 1. Additional personnel should be trained to a higher response qualification as appropriate, and a county response team is developed 2. Propose and adopt the Ordinance allowing response teams to recoup expenses	High	Moderate	LEPC EMA Fire Departments *(County, Crawfordsville, Townships, Volunteers)*	Existing Budget
Building Protection 1. Inventory and prioritize structures within the FEH area for buyout or relocation 2. Relocate, buyout, or floodproof existing non-critical facilities that are subject to repetitive flooding *(2016 Measure)* 3. Protect existing critical facilities in floodplains *(2016 Measure)* *(Will assist with NFIP compliance)*	☒ Emergency Services ☒ Nat. Res. Protection ☐ Prevention ☒ Property Protection ☐ Public Information ☒ Structural Control	☐ Drought ☐ Earthquake ☐ Extreme Temperature ☐ Fire ☒ Flood ☐ Hail/Thunder/Wind ☒ Landslide/Subsidence ☐ Tornado ☐ Winter Storm/Ice ☒ Dam Failure ☐ HazMat Incident	**Ongoing –** 1. 17 structures along Sugar Creek in the fluvial erosion hazard area have been identified 2. One structure in Crawfordsville is a RepLoss structure **Proposed Enhancements –** 1. Obtain funding and purchase properties before structures are damaged 2. Create a prioritized list of structures to be relocated, bought out, or floodproofed within each municipality 3. Determine most appropriate measures to protect critical facilities located in the floodplains as well as those affected by poor drainage	High *(FEH buyouts)* Moderate *(flooding buyouts, existing critical facilities)*	High	EMA Facility Owners Floodplain Administrators *County* *Crawfordsville* *Darlington* *Waveland* *Waynetown*	Grant Existing Budget

Mitigation Practice	Mitigation Strategy	Hazard Addressed	Status	Priority	Benefit-Cost Ratio	Responsible Entity	Funding Source
Emergency Preparedness & Warning 1. Post information and/or warning signs in local parks and other public gathering places explaining outdoor warning sirens, what to do in case of a hazard event, and local radio stations that carry emergency information. *(2016 Measure)* 2. Increase awareness and following for EMA and response agency's social media accounts 3. Purchase mobile message boards to provide current hazard information 4. Inventory and prioritize needs related to cyber-security, records back-up and technology to protect systems during and following a hazardous event 5. Create bilingual notifications and hazard preparedness materials (insurance needs, warning sirens, go-kits, hazard information) as well as purchase translators for responders 6. Investigate the potential to develop a siren fund through payments made during development of a subdivision or industrial/commercial areas *(2016 Measure)* 7. Evaluate flood forecasting capabilities including stream gages, flood forecast maps, and flood alerts *(2016 Measure)* 8. Install permanent dynamic message board on I-74 to provide current hazard information *(2016 Measure)*	☒ Emergency Services ☒ Nat. Res. Protection ☒ Prevention ☒ Property Protection ☒ Public Information ☐ Structural Control	☒ Drought ☒ Earthquake ☒ Extreme Temperature ☒ Fire ☒ Flood ☒ Hail/Thunder/Wind ☒ Landslide/Subsidence ☒ Tornado ☒ Winter Storm/Ice ☒ Dam Failure ☒ HazMat Incident	**Ongoing –** 2. EMA and other response agencies utilize social media 3. The county has purchased three mobile message boards since the last planning effort 4. County IT is working to strengthen technology systems 5. Limited Spanish materials have been created **Proposed Enhancements –** 1. Post information in parks and other gathering places 2. Increase following for social media accounts and increase informational postings from agencies to the public 3. Purchase three additional message boards for use within the county 4. Continue to strengthen systems, train staff, and develop cyber-security protocols 5. Create alternate forms of printed and voiced messaging in Spanish in an attempt to reach additional residents 6. Create a fund to have developers pay into a fund for additional outdoor warning sirens 7. Install additional stream gages on Sugar Creek at Darlington and Shades 8. Install permanent message board on I-74 at heavily traveled locations	High *(post information, social media, mobile message boards, cyber security)* Moderate *(bilingual notifications, siren fund, stream gages, message board)*	High	EMA County Parks Department Indiana State Parks County IT Department USGS INDOT	Existing Budgets Grants
Geographic Information Systems 1. Update and coordinate GIS layers with location and attributes of critical infrastructure *(2016 Measure)* 2. Train GIS staff in HAZUS-MH to quantitatively estimate losses in "what if scenarios" and continue to use the most recent GIS data in land use planning efforts. *(2016 Measure)* 3. Update HAZUS-MH model with local soil data for more accurate damage estimates *(2016 Measure)*	☒ Emergency Services ☒ Nat. Res. Protection ☐ Prevention ☒ Property Protection ☒ Public Information ☐ Structural Control	☒ Drought ☒ Earthquake ☒ Extreme Temperature ☒ Fire ☒ Flood ☒ Hail/Thunder/Wind ☒ Landslide/Subsidence ☒ Tornado ☒ Winter Storm/Ice ☒ Dam Failure ☒ HazMat Incident	**Ongoing –** 1. GIS layers have been developed and are utilized by the County GIS which serves all municipalities **Proposed Enhancements –** 1. Update layers as necessary and include relevant information as new layers are created 2. Provide training opportunities for GIS staff related to HAZUS-MH. 3. Update GIS and HAZUS-MH with local soil data	Moderate	Moderate	GIS Department *County (servicing all municipalities)*	Existing Budget Grant

Mitigation Practice	Mitigation Strategy	Hazard Addressed	Status	Priority	Benefit-Cost Ratio	Responsible Entity	Funding Source
Power Backup Generators 1. Inventory presence of generators, appropriate wiring, switches, and fuel supplies at critical facilities 2. Secure a fuel reserve, or ensure contractual emergency provisions so critical infrastructure may run on power backup for extended periods of time	☒ Emergency Services ☐ Nat. Res. Protection ☒ Prevention ☒ Property Protection ☐ Public Information ☐ Structural Control	☐ Drought ☒ Earthquake ☒ Extreme Temperature ☒ Fire ☒ Flood ☒ Hail/Thunder/Wind ☒ Landslide/Subsidence ☒ Tornado ☒ Winter Storm/Ice ☒ Dam Failure ☒ HazMat Incident	**Ongoing –** 2. Many critical facilities have generators or have added since the last plan **Proposed Enhancements –** 1. Inventory generator capabilities and needs and prioritize within each community to determine needs for future purchases 2. Secure fuel reserves via contract service agreements	Moderate	Low	EMA Municipal Liaisons *Alamo* *Crawfordsville* *Darlington* *Ladoga* *Linden* *New Market* *New Richmond* *New Ross* *Waveland* *Waynetown* *Wingate* Facility Owners Fuel Providers	Existing Budget Grant
Safe Rooms and Community Shelters 1. Inventory areas of need and work to establish safer rooms and community shelters in vulnerable locations (mobile home parks, critical facilities, development without basements) *(2016 Measure)*	☒ Emergency Services ☐ Nat. Res. Protection ☐ Prevention ☐ Property Protection ☒ Public Information ☐ Structural Control	☐ Drought ☒ Earthquake ☐ Extreme Temperature ☐ Fire ☐ Flood ☒ Hail/Thunder/Wind ☐ Landslide/Subsidence ☒ Tornado ☐ Winter Storm/Ice ☐ Dam Failure ☐ HazMat Incident	**Ongoing –** 1. Many buildings have plans on where to go in the event of a hazard **Proposed Enhancement –** 1. Inventory municipal/public buildings, large employers, and vulnerable areas to determine if safest places are being utilized	Moderate	Low	EMA Large gathering liaisons Salvation Army Red Cross	Existing Budget

CHAPTER 5: IMPLEMENTATION PLAN

The following is a proposed plan for implementing all high priority mitigation practices identified in this Plan. It should be noted that implementation of each of these proposed practices may involve several preparatory or intermediary steps. However, to maintain clarity, not all preparatory or intermediary steps are included.

5.1 BUILDING PROTECTION

Inventory and prioritize areas within the county's FEH area for additional studies and actions such as buyout or relocation of properties

- Review Sugar Creek assessment and determine if any other areas need localized studies
- Implement recommendations from Sugar Creek assessment as funding is obtained
- Complete localized studies as necessary
- Prioritize areas and structures according to those most at risk
- Seek grant funding or other funding source to implement program to relocate, buyout, or floodproofing for interested property owners

5.2 COMMUNITY RATING SYSTEM

Investigate potential to reduce flood insurance premiums through additional participation (Montgomery County and Crawfordsville) in the NFIP's CRS Program.

- Review application and guidance materials and begin gathering supporting documentation
- Complete application and calculate credits
- Consult with Insurance Services Organization (ISO) representative to review application prior to submission
- Submit application for advancement within the CRS program
- Maintain and record information as necessary for annual recertification

5.3 EMERGENCY PREPAREDNESS AND WARNING

Post information and/or warning signs in local parks and other public gathering places explaining outdoor warning sirens, what to do in case of a hazard event, and local radio stations that carry emergency information.

- Identify areas where large gatherings may occur or other high visitor traffic areas
- Develop signage with clear messaging
- Prioritize areas identified and determine best signage for that specific location
- Post information or signage as appropriate for each location

Continue to utilize and increase participation in various municipal and agency-based social media outlets for preparedness and recovery efforts

- Investigate social media outlets and determine how they can be employed to provide routine updates and information.
- Establish an appropriate staff member or department responsible for coordinating social media messages
- Increase awareness and participation in the social media outlets to ensure the largest number of residents receive updates and messages

Purchase additional mobile message boards to provide current hazard information

- Review existing capabilities and maintain existing mobile message boards
- Determine needs based on areas where message boards need to be routinely deployed and how to adequately convey hazard messages
- Secure funding and procure message boards
- Store message boards at key locations throughout the county

Inventory and prioritize needs related to cyber-security, records back-up and technology to protect systems during and following a hazardous event

- Review current protocols and procedures for county and municipal backup of records
- Research options for additional securities, redundant systems, or enhanced protections
- Begin enhanced backup and protection of municipal records

5.4 EMERGENCY RESPONSE AND RECOVERY

Coordinate communications, documentation, and record keeping between communities and agencies including a database of accurate and community specific information following each hazard events

- Review current protocols for post-event communications
- Utilize existing IDHS software or develop a countywide database
- Determine a liaison from each municipality to be responsible for data collection following hazard events
- Review database with each municipality to review what information should be collected and reported in a consistent manner

Develop a Standard Operating Procedure (SOP) for interactions and assistance between snowplows and response vehicles to clear paths for emergencies

- Determine needs of response agencies to ensure vehicles are able to leave the station and respond in a timely manner
- Develop a SOP between Highway/Street Departments and Police/Fire/EMS which outlines activities to be undertaken prior to and during hazardous events
- Provide SOPs to proper response agencies and departments involved

Establish procedures using CodeRed to alert and evacuate the populations in known hazard areas (routinely flooded areas, floodplains, dam failure areas)

- Complete awareness campaign to encourage sign ups within each municipality
- Develop pre-scripted messages to utilize during hazard situation and provide for quick use and dissemination/posting
- Develop known hazard area warnings and alerts
- Provide information to municipal and agency PIO for use

Inventory needs for mobile data terminals, including software and hardware upgrades, for response vehicles and purchase as feasible

- Inventory and prioritize individual municipal equipment needs, noting maintenance or replacement dates
- Prioritize necessary purchases, including hardware and software upgrades, on a countywide basis
- Secure funding and purchase needed equipment for additional supplies throughout the year

5.5 FLOOD STUDIES AND PROTECTION

Conduct detailed flood protection studies for problem areas and/or areas with repetitive flooding or poor drainage

- Review listing of flood prone or problem areas and prioritize based on previous damages, at-risk populations, or potential for damage to critical infrastructure
- Secure funding, municipal bond, grants, or funds from existing budgets to complete floodplain studies
- Update the prioritized listing to direct future analyses

Adopt fluvial erosion hazard overlay districts to further protect area and mitigate impacts from future stream movements

- Review listing of vulnerability areas and recommendations from the Sugar Creek Assessment
- Propose and adopt recommended fluvial erosion hazard overlay districts
- Update development plans and Comprehensive Plans with relevant information
- Implement additional recommendations contained within the Sugar Creek Assessment

5.6 HAZARDOUS MATERIALS RESPONSE TEAM

Increase number of personnel for fire departments and emergency response teams as well as those certified to create a Montgomery County HazMat Response Team

- Review personnel roles and certifications to determine needs for individual Fire Departments
- Prioritize additional personnel and training on a countywide basis
- Develop training program and offer additional coursework locally
- Determine needed equipment to develop and maintain a Montgomery County Hazmat Response Team

- Obtain needed equipment and personnel to operate a Hazmat Response Team within the county

Propose and adopt an Ordinance allowing response teams to recoup expenses following clean-ups of hazmat spills

- Research and review any similar Ordinances in neighboring counties or states
- Work with response agencies to develop localized language
- Propose local Ordinance guiding recovery of expenses related to hazmat spill clean-ups
- Work with local municipalities to adopt Ordinance countywide

CHAPTER 6: PLAN MAINTENANCE PROCESS

6.1 MONITORING, EVALUATING, AND UPDATING THE PLAN

REQUIREMENT §201.6(c)(4)(i):
[The plan maintenance process shall include a] section describing the method and schedule of monitoring, evaluating, and updating the mitigation plan within a five-year cycle.

To effectively reduce social, physical, and economic losses in Montgomery County, it is important that implementation of this MHMP be monitored, evaluated, and updated. The EMA Director are ultimately responsible for the MHMP. As illustrated in Section 4.2 Mitigation Practices, this Plan contains mitigation program, projects, and policies from multiple departments within each incorporated community. Depending on grant opportunities and fiscal resources, mitigation practices may be implemented independently, by individual communities, or through local partnerships. Therefore, the successful implementation of this MHMP will require the participation and cooperation of the entire Committee to successfully monitor, evaluate, and update the Montgomery County MHMP.

The EMA Director will reconvene the MHMP Committee on an annual basis and follow a significant hazard incident to determine whether:

- the nature, magnitude, and/or type of risk have changed
- the current resources are appropriate for implementation
- there are implementation problems, such as technical, political, legal, or coordination issues with other agencies
- the outcomes have occurred as expected
- the agencies and other partners participated as originally proposed

During the annual meetings the Implementation Checklist provided in **Appendix 10** will be helpful to track any progress, successes, and problems experienced.

The data used to prepare this MHMP was based on "best available data" or data that was readily available during the development of this Plan. Because of this, there are limitations to the data. As more accurate data becomes available, updates should be made to the list of critical infrastructure, the risk assessment, and vulnerability analysis.

DMA 2000 requires local jurisdictions to update and resubmit their MHMP within five years (from the date of FEMA approval) to continue to be eligible for mitigation project grant funding. In early 2027, the EMA Director will once again reconvene the MHMP Committee for a series of meetings designed to replicate the original planning process. Information gathered following individual hazard incidents and annual meetings will be utilized along with updated vulnerability assessments to assess the risks associated with each hazard common in Montgomery County. These hazards, and associated mitigation goals and practices will be prioritized and detailed as in Section 3.0 this MHMP. Sections 4.0 and 5.0 will be updated to reflect any practices implemented within the interim as well as any additional practices discussed by the Committee during the update process.

Prior to submission of the updated MHMP, a public meeting will be held to present the information to residents of Montgomery County and to provide them an opportunity for review and comment of the draft MHMP. A media release will be issued providing information related to the update, the planning process, and details of the public meeting.

6.2 INCORPORATION INTO EXISTING PLANNING MECHANISMS

REQUIREMENT §201.6(c)(4)(ii):
[The plan shall include a] process by which local governments incorporate the requirements of the mitigation plan into other planning mechanisms such as the comprehensive or capital improvements, when appropriate.

Many of the mitigation practices identified as part of this planning process are ongoing with some enhancement needed. Where needed, modifications will be proposed for each NFIP communities' planning documents and ordinances during the regularly scheduled update including comprehensive plans, floodplain management plans, zoning ordinances, site development regulations, and permits. Modifications include discussions related to hazardous material facility buffers, floodplain areas, and discouraging development of new critical infrastructure in known hazard areas.

6.3 CONTINUED PUBLIC INVOLVEMENT

REQUIREMENT §201.6(c)(4)(iii):
[The plan maintenance process shall include a] discussion on how the community will continue public participation in the plan maintenance process.

Continued public involvement is critical to the successful implementation of the Montgomery County MHMP. Comments gathered from the public on the MHMP will be received by EMA Director and forwarded to the MHMP Committee for discussion. Education efforts for hazard mitigation will be the focus of the annual Severe Weather Awareness Week as well as incorporated into existing stormwater planning, land use planning, and special projects/studies efforts. Once adopted, a copy of this Plan will be available for the public to review in the EMA Office and the Montgomery County website.

Updates or modifications to the Montgomery County MHMP will require a public notice and/or meeting prior to submitting revisions to the individual jurisdictions for approval.

The CRS program credits NFIP communities a maximum of 37 points for adopting the Plan; establishing a procedure for implementation, review, and updating the Plan; and submitting an annual evaluation report.

CHAPTER 7: REFERENCES

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