SECTION 4. RISK ASSESSMENT AND VULNERABILITY ANALYSIS

The Risk Assessment portion of this document provides a detailed description of the hazards in Montana, an assessment of the State's vulnerability to those hazards, and a basis for the mitigation goals and activities proposed in the Mitigation Strategy portion of the document. This Risk Assessment section examines natural, man-made, and technological hazards that can impact the State, determines which areas of the State are most vulnerable to each hazard, estimates potential losses to State facilities, and analyzes the potential changes in frequency and magnitude of the hazards from climate change. Supporting documentation is presented in Appendix B.

4.1 RISK ASSESSMENT METHODOLOGY

The methodology used to conduct the 2018 MHMP risk assessment involved an analysis of a number of hazard and their effect on State-owned critical facilities, the general building stock, cultural resources, and population. A description of the process used to identify and prioritize hazards is presented first, followed by a summary of the content in each hazard profile. The final sections describe the sources of data used in the risk assessment and methodology for estimating damages and structural loss.

4.1.1 HAZARD IDENTIFICATION

Hazards included in this Plan were identified and validated by the MHMP Planning Team. Review of the 2013 MHMP formed the basis of hazard discussions and new and emerging hazards were identified by subject-matter experts who comprised the Planning Team. As part of the update process, the Planning Team considering the following criteria:

- Prior knowledge of the relative risk associated with each of the hazards;
- Identification of hazard events and disasters that had occurred within the past five years;
- Identification of emerging hazards with the ability to impact public health, damage structures, and impact the State's economy;
- Changes in hazard impacts associated with climate change; and
- Review of hazards identified in local jurisdiction plans.

The natural, man-made, and technological hazards evaluated in the 2023 Montana MHMP include (in alphabetical order): Avalanche, Civil Unrest, Cyber Security, Dam Failure, Disease, Drought, Earthquake, Flooding, Hazardous Material Incidents, Landslide, Severe Weather, Terrorism, Transportation Accidents, Violence, Volcanic Ash, and Wildfire. These hazards were deemed most critical in Montana today and most likely to cause future losses.

4.1.2 HAZARD RANKING AND PRIORITIZATION

As was done for the 2018 Montana MHMP, hazards were ranked using the Calculated Priority Risk Index (CPRI). The 2018 CPRI examined five ranking criteria for each hazard (probability, magnitude/severity, warning time, duration, and economic impact). For each hazard, an index value was assigned for each CPRI category from 0 to 4 with "0" being the least hazardous and "4" being the most hazardous situation. This value was then assigned a weighting factor and the result was a hazard ranking score. The weighting factor across the five ranking criteria was adjusted, as shown in Table 4.1-1. The modified CPRI was administered through a survey to MHMP Planning Team members. Table 4.1-2 presents the results of the CPRI scoring for all hazards.

Table 4.1-1. Calculated Priority Risk Index

CPRI Category	Degree of Risk			Assigned Weighting Factor
	Level ID	Description	Index Value	
Probability	Unlikely	Rare with no documented history of occurrences of events.	1	30%
		Annual probability of less than 0.01.		
	Possible	Infrequent occurrences with at least one documented or anecdotal historic event.	2	
		Annual probability that is between 0.1 and 0.01		
	Likely	Frequent occurrences with at least two or more documented historic events	3	
		Annual probability that is between 1 and 0.1		
	Highly Likely	Common events with a well-documented history of occurrence.	4	
		Annual probability that is greater than 1		
Magnitude/ Severity	Negligible	Negligible property damages (less than 5% of critical and non-critical facilities and infrastructure).	1	25%
		Injuries or illnesses are treatable with first aid and there are no deaths. Negligible quality of life lost.		
		Shut down of critical facilities for less than 24 hours.		
	Limited	Slight property damages (greater than 5% and less than 25% of critical and non-critical facilities and infrastructure).	2	
		Injuries or illnesses do not result in permanent disability and there are no deaths.		
		Moderate quality of life lost		
		Shut down of critical facilities for more than 1 day and less than 1 week.		
	Critical	Moderate property damages (greater than 25% and less than 50% of critical and non-critical facilities and infrastructure).	3	
		Injuries or illnesses result in permanent disability and at least one death.		
		Shut down of critical facilities for more than 1 week and less than 1 month		
	Catastrophic	Severe property damages (greater than 50% of critical and non-critical facilities an infrastructure).	4	
		Injuries or illnesses result in permanent disability and multiple deaths.		
		Shut down of critical facilities for more than 1 month.		
Economic Impact	Negligible	Little to no annual economic impact.	1	20%
	Limited	<$1 million annual economic impact.	2	
	Critical	<$1 billion but >$1 million in annual economic impact.	3	
	Catastrophic	>$1 billion annual economic impact.	4	
Warning Time	Less than 6 hours	Self-explanatory.	4	15%
	6 to 12 hours	Self-explanatory.	3	
	12 to 24 hours	Self-explanatory.	2	
	More than 24 hours	Self-explanatory.	1	
Duration	Less than 6 hours	Self-explanatory.	1	10%
	Less than 24 hours	Self-explanatory.	2	
	Less than one week	Self-explanatory.	3	
	More than one week	Self-explanatory.	4	

Table 4.1-2. Calculated Priority Ranking Index Summary

Hazard	Probability	Magnitude / Severity	Economic Impact	Warning Time	Duration	CPRI Score
Wildland and Rangeland Fires	Highly Likely	Critical	Critical	<6 hours	>1 week	3.37
Flooding	Likely	Critical	Critical	6-12 hours	<1 week	2.83
Earthquake	Possible	Critical	Critical	<6 hours	<6 hours	2.93
Drought	Highly Likely	Critical	Critical	>24 hours	>1 week	2.95
Severe Weather	Highly Likely	Limited	Limited	6-12 hours	<1 week	2.75
Haz-Mat and Transportation Accidents	Possible	Limited	Limited	<6 hours	<6 hours	2.62
Disease (Public Health)	Possible	Limited	Critical	>24 hours	>1 week	2.57
Disease (Livestock and Wildlife)	Possible	Limited	Critical	>24 hours	>1 week	
Landslide	Possible	Limited	Negligible	<6 hours	>1 week	2.23
Avalanche	Possible	Limited	Negligible	<6 hours	>1 week	2.23
Dam Failure	Possible	Critical	Limited	>24 hours	>1 week	2.56
Terrorism, Violence, Civil Unrest, and Cyber Security	Possible	Limited	Limited	<6 hours	<24 hours	2.41
Volcanic Ash	Unlikely	Catastrophic	Limited	<6 hours	>1 week	2.33

The MHMP Planning Team felt that with the CPRI ranking did not accurately represent hazard priorities for the State of Montana. They, therefore, prioritized the hazards as shown in **Table 4.1-3**. Hazard profiles are arranged in the remainder of this section in this order. Changes in prioritization from the 2013 MHMP are also shown in **Table 4.1-3**.

Table 4.1-3. Prioritized Hazards for 2018 MHMP

Prioritized Rank for 2022	Hazard Profile	Comments	Prioritized Rank in 2018 Plan
1	Wildfire	Included in both 2018 and 2022 MHMP.	1
2	Flooding	Included in both 2018 and 2022 MHMP.	2
3	Earthquake	Included in both 2018 and 2022 MHMP.	3
4	Drought	Included in both 2018 and 2022 MHMP.	4
5	Severe Weather	Combined summer and winter weather hazards into one profile instead of two.	5
6	Haz-Mat & Transportation Accidents	Haz-Mat and Transportation Accidents are combined as these incidents often occur together.	6
7	Disease	Included in both 2018 and 2022 MHMP.	7
8	Landslide & Avalanche	The landslide and avalanche hazards are profiled together because they are caused by similar geologic forces.	8
9	Dam Failure	Included in both 2018 and 2022 MHMP.	9
10	Terrorism, Violence, Civil Unrest & Cyber Security	Included in both 2018 and 2022 MHMP.	10
11	Volcanic Ash	Included in both 2018 and 2022 MHMP.	11

The reorganization of the MT DES Preparedness Bureau went into effect on January 1, 2018, which combined Districts 1 and 3 into the Western District, Districts 2 and four counties in District 6 into the Central District, and Districts 4 and 5 plus four counties in District 6 into the Eastern District. This organization differs from the 2018 MHMP, as the update had already been underway when this went into effect. **Figure 4.1-1** presents a map showing the updated DES Districts.

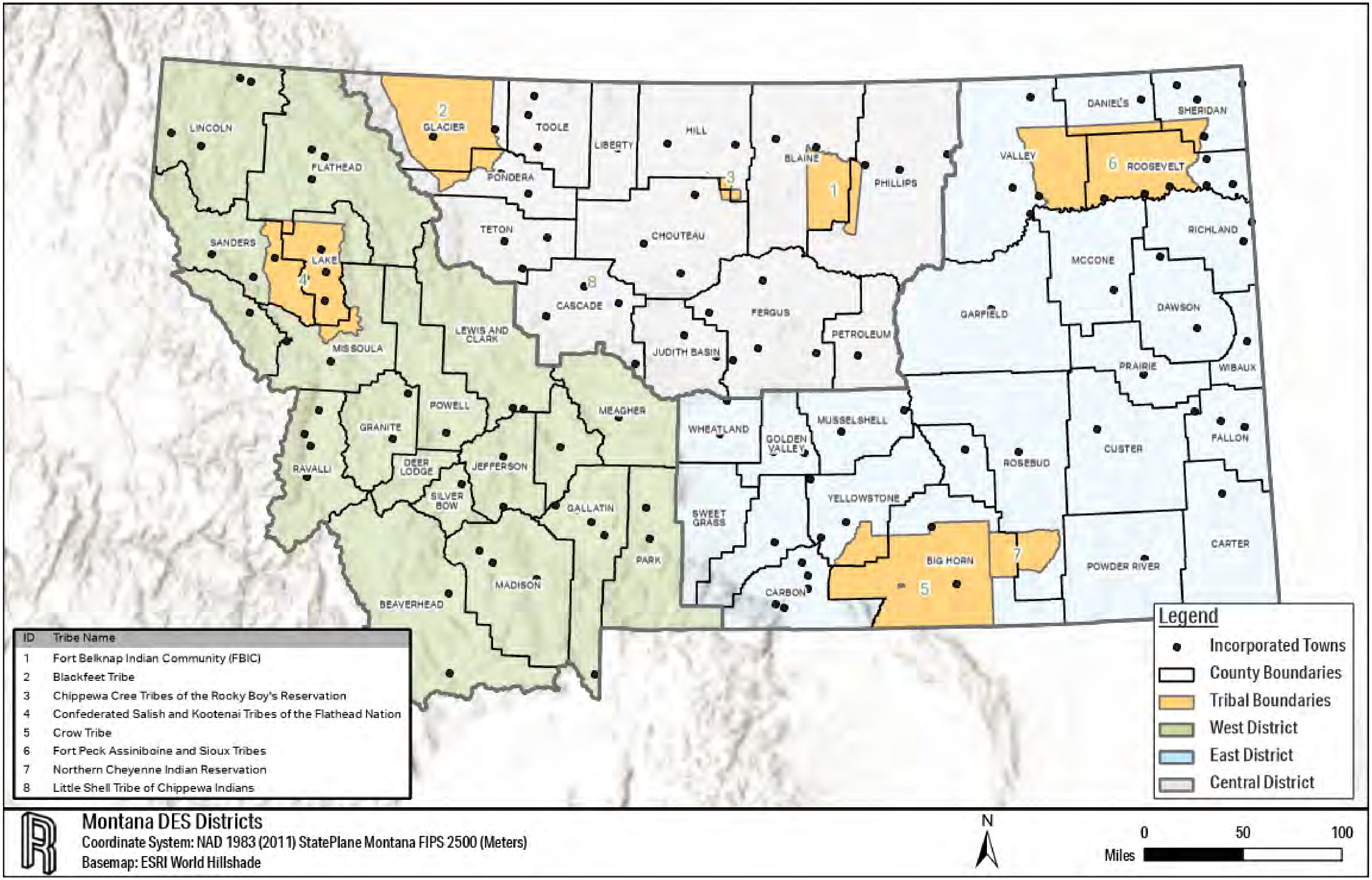

Figure 4.1-1. DES districts for the state of Montana.

In order to recognize regional differences across the State, County and Tribal Emergency Managers were asked to complete a survey identifying hazard priorities in their area. **Table 4.1-4** presents survey results by DES District. In addition, the local MHMPs were reviewed for their hazard rankings, and are presented in **Appendix B-1**. Local hazard rankings were generally consistent with the hazards ranked for the State MHMP.

Table 4.1-4. Montana Regional Hazard Priorities

Hazard Rank	West District	Central District	East District
# Survey Responses			
#1 Hazard			
#2 Hazard			
#3 Hazard			
#4 Hazard			
#5 Hazard			
#6 Hazard			
#7 Hazard			
#8 Hazard			
#9 Hazard			
#10 Hazard			

4.1.3 HAZARD PROFILES

Hazard profiles were prepared for each of the identified hazards which include a description of the hazard, history of occurrence, vulnerability and area of impact, probability and magnitude of future events, an evaluation of how future development is being managed to reduce risk, and how climate change may impact long term vulnerability to hazards. The methodology used to report each topic in the hazard profile is further described below. The level of detail for each hazard profile is generally limited by the amount of data available.

DESCRIPTION, HISTORY, AND PAST OCCURENCES

A number of databases were used to describe and compile the history of hazard events profiled in this plan. This data was supplemented by records of past Federal and State disaster declarations, newspaper accounts, and internet research. The two primary databases used included the National Climatic Data Center (NCDC) Storm Events Database and the United States Department of Agriculture (USDA) Cause of Loss Database.

The NCDC Storm Events database receives Storm Data from the National Weather Service (NWS). The NWS service receives their information from a variety of sources, including County, State and Federal emergency management officials, local law enforcement officials, skywarn spotters, NWS damage surveys, newspaper clipping services, the insurance industry, and the general public. Storm Data is an official publication of the National Oceanic and Atmospheric Administration (NOAA) which documents the occurrence of storms and other significant weather phenomena having sufficient intensity to cause loss of life, injuries, significant property damage, and/or disruption to commerce. Also used to identify climate change impacts was the NOAA Climate Explorer and the 2017 Montana Climate Assessment.

The USDA Cause of Loss Database is a county-level data set for the United States for over 30 different hazard event types. For each event, the dataset includes the date, location, and insured crop losses that affected each county. Since it is difficult to obtain all crop data since uninsured crops may often not be reported, this data source was determined to be the most reliable dataset. To compensate for inflation, all crop indemnity amounts were inflated to 2022 dollars.

VULNERABILITY AND AREA OF IMPACT

Vulnerability is discussed in terms of statewide vulnerability, potential losses in local hazard mitigation plans, and vulnerability of state facilities. Statewide vulnerability includes an analysis of the general building stock and population. Local plans were reviewed for building, societal, and economic exposure. Analysis of state facilities includes critical facilities and cultural resources. The sources of the data used to evaluate vulnerability in the 2023 MHMP risk assessment are described below.

Critical facilities used in this analysis are a subset of the state-owned buildings listed in the Property Casualty Insurance Information System (PCIIS) database of the Montana Dept. of Administration, Risk Management and Tort Defense Division. This database provides building information including location, square footage, construction type, and insured values for structures, contents, and special equipment. Critical facilities include buildings essential for continuity of government including, but not limited to, state agency buildings, Montana National Guard armories and readiness centers, aeronautic facilities, communication sites, university research facilities, and state fire facilities. Critical facilities also include those facilities that have large vulnerable populations including the state hospital, detention facilities and dormitories, dining facilities, and lecture halls associated with the universities. **Appendix B-2** presents the State-owned critical facilities included in the analysis. Digital locations were used in the analysis but are not provided for security purposes.

Cultural resources are among the other factors evaluated in the MHMP risk assessment. Information on historic properties and cultural resources is housed at the Montana State Historic Preservation Office (SHPO). However, locational information for most properties is restricted as releasing this information could undermine protection of these resources. RESPEC consulted with MT SHPO to identify state-owned historic properties and cultural resources considered significant and appropriate for inclusion in hazard analysis. A total of 907 cultural buildings, structures, sites, and districts and _ state-owned properties were identified in Montana.

Montana SHPO maintains a cultural resource database on known historic, archaeological, traditional cultural, and paleontological sites that is available for public use (http://svc.mt.gov/adsams/). The database can be accessed through online searches of spatial areas by Township, Section, Range; County; City; or Latitude/Longitude. Results indicate whether or not sites are present/absent within the search location. This tool can be used by project planners to identify cultural properties for disaster grant planning or if ground disturbance is anticipated. State-owned properties are subject to the Montana State Antiquities Act and consultation with SHPO is required.

Data used to evaluate vulnerability of the general building stock was obtained from the Montana Dept. of Revenue (MDOR) Cadastral Mapping Program and Montana State Library (MSL) Structures Framework. The cadastral dataset includes land parcel data across the state and appraised building values. The Structures Framework includes the location of buildings across the state. Details on the analysis methods are presented in *Section 4.1.4*, below.

Population data used in the statewide vulnerability analysis was from the U.S. Census, 2020 estimates. Details on the analysis methods are presented in *Section 4.1.4*, below.

Hazard impact areas describe the geographic extent to which a hazard can impact a jurisdiction and are uniquely defined on a hazard-by-hazard basis. Mapping of the hazards, where spatial differences exist, allows for hazard analysis by geographic location. Some hazards can have varying levels of risk based on location. Other hazards cover larger geographic areas and affect the area uniformly. **Table 4.1-5** below, describes the sources of data used to develop area of impact maps showing the variability of the hazards evaluated in the risk assessment.

Table 4.1-5. Area of Impact Hazard Map Data Sources

Hazard	Vulnerability Assessment Methods
Wildland and Rangeland Fires	The wildland and rangeland fire hazard area was derived from a 2021 USFS dataset. The dataset delineates U.S. Census populated places in the Unites States and their associated wildland urban interface (WUI) as part of an assessment to quantify wildfire transmission to communities. This dataset was used because, largely, there are no up-to-date community-level datasets that include the most vulnerable areas to wildfire or those areas where homes and structures are built among wildland vegetation. The USFS WUI layer was intersected with the general building stock, critical facility, and cultural resource datasets to quantify vulnerability in the WUI.
Flooding	The flood hazard area created for the current analyses represents a combination of datasets with the primary being the 2022 National Flood Hazard Layer geodatabase downloaded from the FEMA Flood Map Service Center. This geodatabase represents digital Flood Insurance Rate Maps (FIRMs) for over 20 counties in Montana. Data collected to represent missing counties come from the MT DNRC (digitized FIRMs of Golden Valley, Musselshell, and Wheatland counties), the Montana State Library (Channel Migration Zones for the Musselshell, Yellowstone, Sun, Flathead, Clark Fork, Bighorn, Ruby, Madison, Jefferson, Gallatin, East Gallatin, Bighole, and Beaverhead Rivers and Prickly Pear, Deep, and Clear Creeks), a FEMA HAZUS-derived flood risk map of Montana completed in 2010, as well as 2022 completed HAZUS-derived flood risk modeling for counties with missing data, 2021-2022 fire perimeters from the National Interagency Fire Center, and USGS modeled post-fire debris flow areas. The HAZUS scenario was for a simulated 100-year flood using National Elevation Dataset, a flood frequency discharge table that references a specific discharge per return period for a given point (stream gage derived) and regression equations used between stream gage areas. The current flood hazard area represents the 100-Year floodplain boundary. Flood hazard maps also display levee locations provided by the US Army Corps of Engineers.
Earthquake	A GIS shapefile of Peak Ground Acceleration seismic zones was downloaded from the U.S. Geological Survey. This earthquake hazard layer for 18%g and greater used in the analysis.
Drought	Drought has a variable risk across the State that changes on a monthly basis. It doesn't impact structures or the population but has significant economic consequences. The MHMP analysis evaluated Montana yields for wheat during non-drought years compared to several drought years. Additionally, several Montana DNRC drought figures are presented to reflect the variable vulnerability across the state.
Severe Weather	Vulnerability to the severe winter weather hazard is considered uniform across the state. However, severe summer weather does not present a uniform hazard. The vulnerability analysis assessed National Centers for Environmental Information data from 1952 to 2022 to map occurrences of tornadoes, hail, and severe thunderstorm wind. Based on this data, a hazard area was produced to connect regions that experience a high density of these events within a 20-mile radius. GIS was then used to intersect the hazard area with the general building stock, critical facility, and cultural resource datasets to quantify vulnerability.
Haz-Mat Incidents and Transportation Accidents	A GIS layer was created by buffering Federal interstates and highways, Montana highways, railroads, and Toxic Release Inventory (TRI) facilities by 0.25 mile. TRI data obtained from the U.S. EPA.
Disease	The disease hazard is considered to have a uniform risk across the State and was therefore, generally analyzed in the risk assessment. The hazard profile includes public health, agricultural (livestock), and wildlife disease issues.
Landslide / Avalanche	The Landslide hazard area consists of three datasets, terrain with slopes 30 degrees and greater, Quaternary mapped landslide areas from surficial geology datasets downloaded from the Montana Bureau of Mines and Geology (MBMG), and historic landslide locations from the USGS Landslide Database. The 30+ degree terrain dataset was created in GIS by downloading a Digital Elevation Model (DEM) and using a spatial analyst tool to produce a slope dataset. The DEM, downloaded from the Montana State Library (1992), has a resolution of 90 meters which is considered rather low. An attempt was made to process a dataset with a higher resolution; however, the dataset was simply too big for GIS processing. As a result, the terrain dataset represents general areas where slopes 30 degrees and greater can be found; these areas are considered susceptible to landslides. A total of 288 digital geologic maps were downloaded from the MBMG website, but were filtered down to only inlude active landslide ar eas (5) and not dormant ones. USGS historic landslide locations were buffered 750 feet to include potential damage area of the landslides. These datasets were filtered for areas mapped as Quaternary Landslide and merged together. The resulting dataset also has some limitations as the entire state of Montana is not represented by digital geologic maps. Additionally, different specialists mapped landslides over a number of years and it is likely the criteria for identifying past landslides varied.
Dam Failure	A GIS layer was created of the inundation areas, digitized from EAPs, associated with federal, state, local and private high hazard dams. High hazard dam data provided by MT DNRC.

Terrorism, Violence, Civil Unrest, and Cyber Security	The terrorism hazard is considered to have a uniform risk across the State. Montana DES completed a Threat Hazard Identification Risk Assessment (THIRA) on May 15, 2018. The THIRA is included in Appendix B-12 to address the Terrorism hazard.
Volcanic Ash	The volcanic ash hazard was generally analyzed in the risk assessment. Counties located adjacent to Yellowstone Park are considered vulnerable to impacts from volcanic eruptions, mudflows, and ashfall. Counties west of the Continental Divide are considered vulnerable to impacts from volcanic eruptions in the Cascade Range in Washington State.

Local plans were completed by various authors using different methods making it difficult to compare risk assessment results. As such, local plans were reviewed with details captured in a spreadsheet for each hazard in terms of their effect on buildings, society, and the economy, as outlined below:

- Building exposure is presented either as a dollar value or high-moderate-low rating and typically refers to the vulnerability of residential structures and/or critical facilities from the hazard.
- Societal exposure is presented either as the number of lives at risk or as a high-moderate- low rating representing the vulnerability of human life from the hazard.
- Economic exposure is presented as a dollar value or high-moderate-low rating referring to the potential impact to the economy from the hazard.

FREQUENCY/LIKELIHOOD OF OCCURRENCE

Included in the risk assessment was how often disaster events occur. To assess this aspect, recent records/events were examined, as well as recent averages of yearly occurrences. This section did not specify an exact frequency, but rather provided the information to give readers a sense of how often and in what capacity these events may occur.

In some of the risk assessments, a summary is provided of the likelihood of future hazard events that includes projected changes in occurrences for each natural hazard in terms of location, extent, intensity, frequency, and/or duration. Likelihood of a hazard event was assessed based on hazard frequency over a 100-year period. Hazard frequency was based on the number of times the hazard event occurred divided by the period of record. If the hazard lacked a definitive historical record, the likelihood was assessed qualitatively based on regional history and other contributing factors. Probability or likelihood was broken down as follows:

- Highly Likely – greater than 1 event per year (frequency greater than 1)
- Likely – less than 1 event per year but greater than 1 event every 10 years (frequency greater than 0.1 but less than 1)
- Possible – less than 1 event every 10 years but greater than 1 event every 100 years (frequency greater than 0. 01 but less than 0.1)
- Unlikely – less than 1 event every 100 years (frequency less than 0.01)

Likelihood also included consideration of changing future conditions, including the effects of long- term changes in weather patterns and climate on the identified hazards.

CLIMATE CHANGE CONSIDERATIONS

An essential aspect of hazard mitigation is predicting the likelihood of hazard events occurring in a planning area. For hazards that are affected by climate conditions, the assumption that future behavior will be equivalent to past behavior is not valid if climate conditions are changing. As flooding is generally associated with precipitation frequency and quantity, for example, the frequency of flooding will not remain constant if broad precipitation patterns change over time. Specifically, as hydrology changes, storms currently considered to be a 1 percent annual chance event (100-year flood) might strike more often, leaving many communities at greater risk. The risks of landslide, severe storms, extreme heat, and wildfire are all affected by climate patterns as well. For this reason, an understanding of climate change is pertinent to efforts to mitigate natural hazards.

FEMA's Climate Change Adaptation Policy (2011-OPPA-01) directs FEMA programs and policies to integrate considerations of climate change adaptation. As such, FEMA requires States to consider changes in weather patterns and climate in their MHMPs in order to reduce risk from changes that may affect and influence long-term vulnerability to natural hazards. The FEMA Region VIII publication for Montana entitled "*Assessing Future Conditions, Meeting FEMA's State* Mitigation Plan Requirement" was used in the risk assessment, including temperature and precipitation projections by NOAA for mid- and end-of century for low- and high-emission scenarios. The low-emissions scenario assumes that global emissions of the greenhouse gases than cause changes in climate conditions peak in the year 2040 and then decline. The high-emissions scenario assumes that global emissions of greenhouse gases remain largely unabated through the 21st century.

At the end of each hazard profile there is a discussion on climate change. The information provides insight on how the hazard may be impacted by climate change and how these impacts may alter current exposure and vulnerability for the population, property, and critical facilities. The risk assessment provides further analysis, as appropriate, to project the changes in frequency and magnitude to hazard events in Montana due to climate change.

POTENTIAL MAGNITUDE AND SEVERITY

Magnitude is a measure of the strength of a hazard event and is usually determined using technical measures specific to the hazard. Magnitude was calculated for each hazard where property damage data was available. Magnitude is expressed as a percentage according to the following formula:

- (Property Damage / Number of Incidents) / $ of Building Stock Exposure

Severity was examined as the potential economic or social impact of a disaster or event occurring. The severity is most often presented as a dollar amount, or a number of individuals impacted.

FUTURE DEVELOPMENT

The impact to future development was assessed based on potential opportunities to limit or regulate development in hazardous areas such as zoning and subdivision regulations. The impacts were assessed through a narrative on how future development could be impacted by the hazard. Plans, ordinances and/or codes currently in place were identified that protect future development in the State from damage caused by natural and man-made hazards.

4.1.4 ASSESSING VULNERABILITY – ESTIMATING POTENTIAL LOSSES

The 2023 MHMP risk assessment builds on what was presented in 2018 Plan and has been updated to provide an updated methodology for assessing vulnerability and estimating potential losses. Enhancements made for the 2023 MHMP include expanding the State's cultural resources in the analysis, updating hazard areas, and creating community engagement with the tribal regions. Further details are presented below.

Methodologies for assessing vulnerability depended upon the hazard, the type of losses, and available data. For some hazards, models have been developed to assess potential exposure and calculate loss. For others, vulnerability was qualitatively assessed, and loss estimates are general in nature. Potential losses were estimated at both the state and local level. The state vulnerability assessment presents the exposure of State-owned critical facilities, total exposure of general building stock and population, and cultural features. The local vulnerability assessment also presents exposure of the general building stock and population. Data is reported according to the three Montana DES Districts described in *Section 4.1.2* above and shown in **Figure 4.1-1**. **Appendices B-3 through B-13** present results of the analysis for each county and incorporated community.

Risk assessment results from the local MHMPs were reviewed and are compiled for each hazard for structure, population, and economic exposure. The local plans did not use a common methodology, so results are not necessarily comparable. **Appendix D-**

2 summarizes the local plan references and loss estimation methodology. **Appendices B-3 through B-13** present risk assessment results from the local MHMPs for each hazard.

Methods used in this risk assessment represent the best readily available statewide data. For hazards that are not uniform across the State and occur in specific areas (e.g. wildfire, flooding, severe weather hazardous material incidents, landslide, dam failure) the area of impact factored into the loss estimation calculations (see **Table 4.1-5** for a description of the sources used to develop the area of impact hazard maps). Building stock data from the MDOR Cadastral Mapping Program was linked to the MSL Structures Framework, based on parcel number. This enabled the location of structures to be connected to their appraised value. Using GIS, hazard impact areas were intersected with the Structures dataset to identify the number of structures and exposure due to each hazard.

The Structures dataset consists of over 670,000 entries and includes information on parcel identification numbers, addresses, owners, and structure types. This dataset was reviewed to eliminate multiple entries. Due to the large number of records, it was not possible to visually inspect each structure against an aerial background in GIS to assess information accuracy, so the database was filtered to identify duplicate parcel numbers and addresses. However, duplicate entries could not be automatically deleted as one parcel number or address could contain more than one primary building. For this analysis, primary building refers to principal structures (e.g., residential dwelling or farmstead dwelling) and not any associated outbuildings. Many structures in question were viewed in GIS but errors undoubtedly exist in the dataset as not all structures were visually examined for accuracy.

The structure types found within the Structures Framework dataset include 80 different categories ranging from single-family dwelling to restaurants, radio facilities, post offices, hospitals, colleges, and power substations. **Table 4.1-6** presents a list of structure types and the eight different structure classes assigned to each type for GIS analysis purposes.

Table 4.1-6. Structure Types within Structures Framework Dataset

Structure Type	Structure Class	Structure Type	Structure Class
Agriculture, food, or livestock facility	Commercial	Federal Government facility	Government
Airport	Commercial	Fire station	Government
Ambulance Service	Commercial	Government or military facility	Government
Automobile Rental/Service	Commercial	Information or communications facility	Government
Banking or finance facility	Commercial	Law Enforcement	Government
Bus station/dispatch facility	Commercial	Library	Government
Cabin/Guest House	Commercial	Local Government facility	Government
Cemetery	Commercial	Military facility	Government
Commercial or retail site	Commercial	Museum	Government
Daycare Facility	Commercial	Park/Recreation Area	Government
Farm/Ranch	Commercial	Post Office	Government
Funeral Home	Commercial	Rest stop/Roadside Park	Government
Gas Station	Commercial	State capitol	Government
Grain Elevator	Commercial	State Government facility	Government
Grocery Store	Commercial	Tribal government facility	Government
Hotel/Motel	Commercial	Church/Place of worship	Institutional
Industrial or manufacturing facility	Commercial	Institutional residence/dorm/ barrack	Institutional

Lumber Products facility	Commercial	Public Attraction or Landmark	Institutional
Mail or shipping facility	Commercial	Health or medical facility	Medical
Office Building	Commercial	Heliport	Medical
Parking Site	Commercial	Hospital/Medical Center	Medical
Pharmacy	Commercial	Outpatient Clinic	Medical
Railroad Facility	Commercial	Public Health Office	Medical
Restaurant/Bar	Commercial	Rehabilitation Center	Medical
Shopping Mall/Center	Commercial	Dwelling, Multi-Family	Residential
Sports facility	Commercial	Dwelling, Single Family	Residential
Veterinary Hospital/Clinic	Commercial	Mobile Home	Residential
Communication Tower	Communication	Nursing Home/Long Term Care	Residential
Radio/TV Broadcast facility	Communication	College/University facility	School
Telephone facility	Communication	Education Facility	School
Border crossing/port of entry	Government	School (K-12)	School
City/Town Hall	Government	Dam Site	Utility
Civic/Community Center	Government	Electric Facility	Utility
Correctional Facility	Government	Energy or utility facility	Utility
Courthouse	Government	Hydroelectric facility	Utility
Disposal Site	Government	Oil/Gas facility	Utility
Emergency Operations Center	Government	Power Substation	Utility
Emergency services/law enforcement	Government	Water Supply/Treatment facility	Utility
Emergency Shelter	Government	Water tower/tank	Utility
Fairgrounds	Government	Wind facility	Utility

As previously described, the Structures dataset was linked to the MDOR Cadastral Mapping Program to provide building values. However, a small percent of the parcels displays a zero building value. As this could deflate the dollar exposure of buildings in the hazard analyses, average residential and commercial building values were calculated for each county and this value was assigned to zero value properties.

Percent exposure for each county and town by summing the commercial and residential building values within the designated hazard areas and dividing that total structure risk value by the total amount of commercial and residential structures within the county or town.

In addition to the Structures dataset, hazard impact areas were also intersected with critical facility data and cultural resources using GIS to determine the number and exposure to each hazard.

Using the number of residential structures in each hazard impact area, estimated exposure population values were assigned based on structure type, as guided by the DNRC Dam Exposure calculations. For example, hospitals were assigned a population of 100 persons, while residences were assigned a population of 2.5 persons.

4.1.5 DATA LIMITATIONS

Risk assessment and vulnerability analysis results are only a general representation of the potential loss that may be experienced from a hazard event and there are many inherent inaccuracies with the methodology used. Output is only as good as the data sources used and the State may wish to consider alternate data for future MHMP updates.

Data limitations identified in the 2018 MHMP suggested that the risk assessment analysis may have over-reported building exposure when parcel size was large because the spatial location of structures within each parcel was not provided. The enhanced approach for the 2018 MHMP risk assessment attempted to correct this deficiency by joining the MDOR Cadastral Parcel dataset with the MSL Structures Framework dataset. This approach was again taken in the 2023 MHMP risk assessment to increase accuracy of reported data.

There are, however, limitations with this method of estimating societal exposure as well. The 2023 MHMP risk assessment method of estimating vulnerable population assumes that all residential structures are occupied, and that all residential structure types are occupied in accordance with 2020 U.S. Census estimates. This method could lead to over-reporting vulnerable populations where seasonal-use structures exist, or under-reporting vulnerable population where more than the county average number of people reside in each structure. It is most appropriate when hazard areas are small (flooding) or linear (haz-mat).

Another limitation still existing in the 2023 MHMP update is the assumption that the whole value of a structure is at risk if within the hazard area. For example, all structure values within the designated floodplain and flood hazard areas were calculated using the structure value. This assumption may not always be accurate because flood depths on that structure could be minimal and incurred damages may be small. This method could lead to over-reporting vulnerability costs and factoring depths into future analysis may provide more accurate estimates.

The remainder of this section presents hazard profiles organized in general accordance with State priority followed by a risk assessment summary. Further data limitations are presented in the hazard profiles.

4.2 WILDLAND AND RANGELAND FIRE CPRI SORE =3.37

DESCRIPTION

A wildland or rangeland fire may be defined as any fire that occurs on grassland or forestland, regardless of ignition sources. Three factors influence wildland fire behavior: weather, topography, and fuel. These components can increase the likelihood of a fire starting, its intensity, the speed and direction in which it travels, and the ability to control and extinguish it.

Wildland fire fuels consist of live and dead vegetation in the form of trees, shrubs, grasses, and their debris. In western Montana, fire potential is high in many areas along the wildland-urban interface (WUI) due to the quantity of forest fuels in close proximity to urban areas. Conversely, dry grass and sagebrush associated with agricultural areas and rangeland are the primary fuels for eastern Montana wildfires. From 1992 to 2021, 40 percent of wildfires were naturally caused and 60 percent were human-caused [DNRC, 2022]. The primary sources of human-caused fires include debris burns, campfires, equipment-caused fires, and railroad starts [DNRC, 2018]. Burning coal seams are a frequent cause of wildfire ignition in eastern Montana, and are difficult to extinguish. Embers play a large role in spreading wildfires because they easily become airborne. During a large fire with strong winds, embers can start spot fires several miles away from the fire-front.

Wildland and rangeland fires occur every year; they are considered part of the normal vegetative cycle for forests and grasslands. Fire frequency depends on the forest vegetation type and weather conditions. Historically, vegetation types influenced fire recurrence intervals. However, intervals have been anthropogenically changed through fire suppression practices and landscape alterations. Fire suppression has increased the density of fuels available to burn, resulting in greater undergrowth and denser vegetation. These changes have increased fire severity and frequency when compared to the pre-20th century fire regime. An added factor in fire recurrence is climate change, which causes extended periods of low precipitation that may lead to low fuel moisture content, insect infestation, and extreme heat. Climate change is expected to increase the occurrence and severity of fires.

Dry, hot, and windy weather increases the likelihood of a major wildfire occurring because these conditions make ignition easier and allow fuels to burn more rapidly. In mountainous regions, slope relief greatly influences fire behavior and speed. Slopes with south and southwest aspects tend to be drier and more prone to ignition. Further, steep, narrow drainages and canyons act like chimneys when wildfires occur [FireSafe Montana, 2009]. Red flag warnings are issued when conditions exist that could sustain extensive wildfire activity in conjunction with "Very High" or "Extreme" fire danger.

When people choose to build or buy homes in high-hazard fire areas their homes can act as fuel. The WUI is defined as the zone where structures and human development meet or intermingle with undeveloped wildland or vegetative fuel. Fires meeting the WUI has become more commonplace over the years. Between 2005 and 2020, wildfires have destroyed more than 89,000 structures in the United States, including homes and businesses. The most damaging wildfires have occurred in the last few years, accounting for 62% of the structures lost over the last 15 years. Wildfires in the United States inflict an estimated economic loss of between $77.4 to $378.7 billion each year. This includes everything from fire suppression to evacuations to property loss and recovery efforts [FEMA, 2022].

PAST OCCURENCES

In Montana, wildfires have burned approximately 1.3 million acres since 2018 [NIFC, 2022[1]], threatening lives, destroying dozens of homes, and costing millions of dollars. Wildland fires near communities impact public health and safety, water quality, transportation infrastructure, regional economies, and quality of life.

By all historical records, the Great Idaho fire of 1910 in northern Idaho and western Montana was the largest forest fire in American history. The fire burned 3 million acres, killed 86 people, and destroyed numerous towns in northern Idaho and western Montana.

By some accounts, most of the destruction occurred in 6 hours. The hurricane winds of August 20 and 21, 1910 turned numerous fires scattered throughout the region into a blow-torch. The fire occurred when the U.S. Forest Service was a fledgling agency that lacked the personnel, equipment, and communications to effectively address wildfire. Even with today's technology and resources devoted to wildland firefighting, that magnitude of fire could occur again, given similar conditions.

Grassland fires in eastern Montana have been equally devastating historically. In July 1999, the Fishel Creek Fire threatened the town of Musselshell. The fire burned 33,000 acres, one home and threatened the evacuation of Musselshell. Later that same year, a grassfire burned 18,000 acres and a portion of the town of Outlook, causing $4 million in damages. In all, about 105,000 acres burned in five hours in eastern Montana that night. In July 2003, the Missouri Breaks Complex in eastern Garfield County burned 125,927 acres and destroyed eight structures and 610 miles of fence.

During the early summer of 2012, extremely hazardous wildland fire conditions existed throughout the entire State of Montana, including near-record temperatures, continual wind and low relative humidity. Statewide there were 2,206 fires that burned 1,174,691 acres. The 2013 Montana State MHMP describes many of these wildfires.

More recently, 2017 was a historic year for drought and fire in Montana that brought about 2,422 fires that burned approximately 1,366,498 acres. The Lodgepole Complex fire in Garfield County was the second largest fire in Montana history. It burned Over 270,000 acres and caused massive devastation to local landowners. 32 structures, including 16 homes, were destroyed. The 2018 Montana State MHMP details the impacts of this fire and others in the 2017 wildfire season.

In 2021, the second worst fire year since 2017, there were a total of 2,573 fires [NIFC, 2022[1]]. The worst fire of which was the Richard Spring fire in Rosebud County which burned approximately 170,000 acres, and lead to the destruction of 12 secondary structures. The 2021 fires season is detailed extensively in the proceeding sections.

The 2018 Montana State MHMP details the most serious wildfires in Montana history from 1910 to 2013. With a focus on current events, **Table 4.2-1** lists the most destructive fires from 2005 to 2022 based on the number of structures destroyed [Headwaters Economics, 2022]. In the past 30 years, Montana has experienced an increase in the size and intensity of fires due to changes in land management practices, forest health, and changing climate conditions. At the same time, the number of homes in moderate to high wildfire hazard areas has almost doubled since 1990. The rate of housing growth in moderate and high hazard areas far outpaces home development in low hazard areas. Currently, 16,683 homes are in high hazard areas, and 99,988 homes are in moderate hazard areas, with these numbers expected to increase. Wildfire activity is very common in the western part of Montana, with the highest risk in and around Missoula. New home development in high wildfire hazard areas increased by 72% in Missoula County, 97% in Ravalli County, and 69% in Mineral County. The top 5 counties in order of number of existing homes in wildfire hazard areas from 1990 to 2018 includes Flathead County, Missoula County, Ravalli County, Yellowstone County, and Gallatin County [Headwaters Economics, 2020].

Table 4.2-1. Top Ten Most Destructive Fires Since 2005

Wildfire	Year	Structures Destroyed
Dahl	2012	223
Bridger Foothills	2020	68
Roaring Lion	2016	65
West Wind	2021	51
Bobcat	2020	48
Derby Fire	2006	47
Chi Chi	2007	42
Caribou	2017	40
Ash Creek	2012	39
Nineteen Mile	2012	34

Table 4.2-2 builds off data presented in the 2018 Montana State MHMP and includes documented wildfire statistics from 2018 to 2021 for fires located on land managed by the Bureau of Indian Affairs (BIA), BLM, U.S. Forest Service (USFS), U.S. Fish and Wildlife Service (FWS), National Park Service (NPS), State, Tribal, and County (C&L). Supporting data for the table is taken from NIFC data for historical year-end fire statistics by state [NIFC, 2022[1]]. Fires as small as 0.01 acres are reported. Data indicates that during this 4-year period there was an average of 1,564 fires per year, that burned an average of 255,992 acres per year.

Table 4.2-2. Interagency Statistics for Montana Wildfires; 2018-2021

Year/ Agency	# Wildland Fires	# Wildland Acres	Year/ Agency	# Wildland Fires	# Wildland Acres
2018			2019		
BIA	335	5,025	BIA	293	9,124
BLM	60	959	BLM	50	915
C&L	423	16,950	C&L	544	32,157
FS	328	52,020	FS	335	8,395
FWS	3	2,937	FWS	12	8,590
NPS	10	17,439	NPS	4	0
ST	183	2,484	ST	236	5,654
TOTAL	1,342	97,814	TOTAL	1,474	64,835
2020			2021		
BIA	1,054	125,696	BIA	673	1
BLM	82	11,670	BLM	99	37,063
C&L	566	181,264	C&L	954	340,261
FS	447	49,072	FS	564	257,401
FWS	2	42	FWS	8	850
NPS	2	5	NPS	5	0
ST	280	1,884	ST	270	4,731
TOTAL	2,433	369,633	TOTAL	2,573	747,678

The 2021 Fire Season

Since the last MHMP was completed in 2018, the fire seasons of 2018, 2019, and 2020 were relatively quiet. However, the severity of the 2021 fire season is notable. Nearly 940,000 acres burned in the 2021 fire season, the highest total since 2017. The severity of the 2021 wildfire season is partly attributable to the intense drought, that by September, had seen 69 percent of the state under severe drought. These dry conditions led to an early start and late finish to the fire season. By July 14th, Governor Gianforte had issued both drought and wildfire emergency declarations to FEMA. Only July 22nd he was forced to call in 549 National Guard personnel to aid in the state's fire response. In late July and early August, fire activity increased, and the total number of acres burned across the state nearly doubled in one week. Coal seam fueled fires burned eastern Montana rangeland and grassland, while forest-fuel fires affected western Montana. The largest fire of the season, named the Richard Spring Fire, occurred in Rosebud County and burned about 170,000 total acres. Even Montanans who weren't directly affected by flames experienced smoky, below-average air quality from July until late September. According to EPA monitoring, Billings recorded only one day in July when air quality wasn't designated as at least moderately poor. Bozeman only recorded four good air quality days in all of July. In 2021, 52% of the state's total 2,555 wildfires were determined as human caused. According to the governor's office, the state spent $47.5 million on fire suppression efforts through October 13th, not including $9.2 million in federal cost-share reimbursements that have been secured by the state. The busy fire season of 2021 mostly abated when cool, wet weather was experienced in late October [Montana Free Press, *Fire season 2021: Early to start, late to finish, and smoky in the middle*, 2021]. 2021 fires that exceeded 50,000 acres include the Richard Springs Fire, Trail Creek Fire, Woods Creek Fire, and the PF Fire. Several significant wildfires that occurred in 2021 are described below.

Source: **Wildfire Today, 2021.** Richard Spring Fire suppression.

Richard Spring Fire - The Richard Spring fire was discovered August 8, 2021. By the following day it had grown to 35,000 acres. Its growth led to the immediate closure of Highway 39 between Colstrip and Jimtown in Rosebud County. Land on the Northern Cheyenne Reservation were also immediately scorched. At the end of the day on August 10th, the fire had grown to an estimated 160,00 acres and jumped the highway in two other locations. This caused the mandatory evacuation of the Lame Deer Community, as thirteen engines, four helicopters, and 131 personnel began expanded efforts to suppress the blaze. On August 14th, the cause of the fire had been determined to be coal seams as it grew in excess of 170,000 acres. On this day, crews achieved 53 percent containment, allowing the evacuation status to be lowered. A week later, on August 21st, the fire was 100 percent contained due to the help of one-inch of rain. In total, the fire burned approximately 170,000 acres and 12 secondary structures were lost [KULR8, *Richard Spring Fire 100% Contained,* 2021]. Due to the expansive damage of this fire, Montana's second largest since 2017, Governor Gianforte requested a disaster declaration for this event on September 17th, allowing for $1.35 million in federal aid to help restore electrical service to 3,500 homes and commercial buildings. The funds also aided repairs to tribal fencing, powerlines, and utilities [FEMA, 2022]. Although suppressed in less than 2 weeks, this fire exemplifies the speed at which brush-fueled rangeland fires grow.

Boulder 2700 Fire - The most destructive fire of 2021 was the Boulder 2700 Fire detected in the Mission Mountains on Saturday, July 31st. An initial evacuation order was enforced and later lifted that same night, as teams had the fire under control. However, strong winds then changed direction, funneling the fire to the banks of Flathead Lake, 8 miles away from Polson. By the next morning Lake County officials estimated that 15 to 20 structures had been destroyed. In reality, 25 structures had been destroyed with additional 250 still considered under threat. A total of 500 people were evacuated. Also damaged were power utilities and road infrastructure in the area. This left many homes in the area without power even as evacuations were underway. Some of those affected were able to return home after three days. By August 5th, the fire encompassed 1,844 acres along Flathead Lake near the Finley Point area [8KPAX, *Boulder 2700 Fire Grows to 1,800 Acres Near Polson,* 2021]. It was reported that many residents expressed frustration with a slow and spotty rollout of fire and evacuation information — especially given the fact that initial orders were lifted by Saturday evening only to be reinstated late at night [Missoula Current, *Montana Wildfires: 600 People Displaced from Homes; Boulder 2700 Fire Top Priority*, 2021]. This fire serves as an example of the continual need for improved communication between decision makers and stakeholders. Additionally, it exemplifies the unpredictability of natural conditions coupled with difficult topography that leads to the most destructive and costly fires. It also demonstrates that small fires can often create the most property damage based on environmental conditions.

Source: **Flathead Beacon, 2021.** Aftermath of Boulder 2700.

<u>Trail Creek Fire</u> - The trail creek fire was discovered on July 8th of 2021, approximately 20 miles west of Wisdom in Beaverhead County. Its cause was determined to be lightning. By July 18th, strong winds had caused the fire to reach 19,848 acres, prompting the closure of Highway 43 along the Montana-Idaho border, threatening the historic Big Hole National Battlefield. Although 147 personnel were fighting the fire at this time, the difficult terrain prompted fire officials to admit that the fire would be a long-term event that would not end until moisture brings an end to the fire season [KRTV, *Trail Creek Fire Grows to More Than 19,000 Acres in SW Montana*, 2021]. Managing this fire to ensure no structure damage to surrounding cabins lasted until October 11th, when cool and wet temperatures led fire crews to dismantle their camp [KXLF, *Snowfall Helps Knock Down Wildfires in Southwest Montana*, 2021]. The long duration of this fire, which reached a maximum size of about 62,000 acres, lead to suppression costs that may be approximated at $40 million, tied with the most expensive of the 2021 fire season [NIFC, 2022[2]].

Source: **NBC Montana, 2021.** USFS personnel manage the Trail Creek Fire.

PF Fire - The second largest fire of the 2021 season was the PF (Poverty Flats) Fire near Hardin in Big Horn County and the Crow Reservation. It was deemed to be of human cause via a coal seam. Like the Richard Spring fire in its rangeland fuel types, the PF Fire burned approximately 66,000 acres in total. It was discovered on July 27th, and fully suppressed on August 4th [NIFC, 2022[2]]. The day after its discovery, FEMA authorized the use of federal funds to help battle the blaze because "Poverty Flats Fire was threatening more than 1,240 homes in and around the Crow Agency and the town of Hardin in Big Horn County. The fire is also threatening buildings, infrastructure, utilities, equipment, and roads in the area. The fire started yesterday, July 27, 2021 and has burned more than 65,000 acres of state and private land. The fire is zero percent contained" [FEMA, 2021]. Such immediate aid was granted because strong winds caused this fire to grow at a rapid pace, even jumping roads and rivers. Due to quick response and a skilled Type II incident management team, the only structure damaged was a power transmission line [NBC Montana, Crews Continue to Hold Perimeter on PF Fire, 2021]. This fire was suppressed quickly and cheaply compared to fires in western Montana, such as the Trail Creek Fire.

Source: **Billings Gazette, 2021.** Crews replace power poles destroyed by PF Fire.

Alder Creek Fire - The Alder Creek fire was discovered on July 8th, 2021, near Wise River in Beaverhead County and was caused by lightning. By July 14th, eight homes were evacuated near Wise River, south of Highway 43. A week later, the fire experienced minimal growth as it slowly moved towards the Pioneer Scenic Byway corridor. Crews focused on stopping the fire by removing burnable fuels, but rain slowed their efforts. Crews continued to improve containment lines and protect structures [ABC Fox Montana, Evacuations North of Alder due to Fire Scaled Back to Stage One, 2021]. By August 9th, many of the surrounding communities were under stage 1 and 2 fire warnings. This fire spurred "on-again, off-again" fire evacuation orders from local authorities until the fire was officially declared as contained on November 4th. The duration of this fire, which burned a total of 37,000 acres, lead it to become one of the costliest of the 2021 fire season at $40 million [NIFC, 20222].

Source: **KRTV, 2021.** Woods Creek Fire in the Big Belt Mountains.

Woods Creek Fire - This lightning-sparked fire in the Big Belt Mountains near Townsend was discovered July 10th, 2021. Almost immediately, a Type III Incident Management team assigned 30 personnel to the fire, with pre-evacuations placed for homes near Camas Creek Road. It was reported that the fire, "driven by an atypical east wind, made a significant run to the west late on July 30 but was stopped short of homes and other structures in the Confederate Gulch area. Firefighters have taken advantage of helicopters and air tankers assigned to the incident, including water drops on spot fires and retardant drops on critical resources in front of advancing fire. Local ranchers have contributed greatly to the suppression efforts, using their own heavy equipment in coordination with firefighters assigned to the fire" [KRTV, Woods Creek Fire in the Big Belt Mountains has Burned 3,700 Acres, 2021]. By August 17th, the fire had grown to its maximum size of just over 55,000 acres. This fire, which wasn't fully contained until November 22nd of that year, cost a total of $27 million [NIFC, 20222].

Declared Disasters

Requests for public assistance for wildland and rangeland fires comes from the State and/or Federal level. The Governor of Montana may declare an Executive Order (EO) that will permit the use of State funds or activate the Montana National Guard. FEMA may authorize Fire Management Assistance Grants, formerly known as Fire Suppression Assistance (FSA), to local and State agencies for fire suppression. These funds are exclusive of other firefighting costs on Federal land by Federal agencies. In extreme fire years, the Governor may request a Presidential-Declared Disaster for a wildland fire. In addition, the U.S. Small Business Administration (SBA) can make declarations to aid businesses that are directly affected by forest fires. **Table 4.2-3** shows wildfire disasters or emergencies declared in Montana since 2018 based on data from the Governor's office [Executive Orders, 2022].

Table 4.2-3. Montana Disaster Declarations from Wildfire; 2018-2022

Year	Event	County/City/Town
2019	FEMA-5286-FM-MT North Hills Fire	Lewis and Clark County
2020	FEMA-5324-FM-MT Falling Star Fire	Stillwater County
2020	FEMA-5344-FM-MT Bobcat Fire	Musselshell County
2020	FEMA-5343-FM-MT Huff Fire	Garfield County
2020	FEMA-5345-FM-MT Snider/Rice Fire Complex	Custer, Powder River, and Rosebud Counties
2020	FEMA-5346-FM-MT Bridger Foothills Fire	Gallatin County
2020	EO-8-2020 Statewide fire emergency declaration.	All counties
2021	FEMA-5392-FM-MT Robertson Draw Fire	Carbon County
2021	FEMA-5399-FM-MT Buffalo Fire	Yellowstone County
2021	FEMA-5403-FM-MT Poverty Flats Fire	Bighorn County and the Crow Agency
2021	FEMA-4623-FM-MT Richard Spring Fire	Rosebud County and Northern Cheyenne Indian Reservation
2021	EO-12-2021 Statewide fire emergency declaration.	All Counties

PROBABILITY/LIKELIHOOD OF OCCURRENCE

Probability for this MHMP was assessed based on hazard frequency over a 10-year period. The Planning Team rated the frequency of wildland and rangeland fires has a “Highly Likely” probability rating; an event that will occur more than once each year. The probability of wildfire is expected to increase due to Montana’s changing climate.

CLIMATE CHANGE CONSIDERATIONS

Montana has been on a steady warming trend for decades, up over 3 degrees F since 1950, and all projections are that it will continue. The summer of 2017 was the second warmest on record since 1950 at 4 degrees F above average, and the persistent high temperatures coupled with the record lowest rainfall in July and August shifted the relatively wet conditions of spring into extreme drought by mid-summer followed by a severe wildfire season (Whitlock et.al., 2017).

The climate future with respect to wildfire will include additional warming with less precipitation in the summer months which set the stage for drier conditions and more fires. Over the next century, extreme heat days (above 90 degrees F) are projected to increase by an additional 5-35 days across the state (See **Table 4.6-13** in the *Severe Weather* section). And, as a result of greater drought, forest fires will likely increase in size, frequency, and possibly severity.

In a given year, warmer weather and less precipitation dries out fuel loads and creates conditions for rapid fire spread. Fire records dating back decades to millennia show a clear link between warmer temperatures, lower precipitation, and an increase in the number of fires and acres burned. Since 1986, wildfire seasons are nearly 80 days longer, with increases in large fires and fires at high wildfires are burning up to 10,000 feet (Whitlock et.al., 2017).

Larger, more severe, and more frequent fires may impact the people, property, and critical facilities by increasing the risk from ignition from nearby fire sources. Climate change also may increase winds that spread fires. Faster fires are harder to contain, and thus are more likely to expand into residential neighborhoods.

Secondary impacts, such as air quality concerns and public health issues, will likely increase due to smoke from wildfire. Wildfire smoke generates a lot of particulate matter 2.5 microns or less in diameter. Those particles are so small, they easily bypass most of the human body’s defenses and move directly from the lungs into the bloodstream. A recent study demonstrates that smoke waves are likely to be longer, more intense, and more frequent under climate change, which raises health, ecologic and economic concerns.

POTENTIAL MAGNITUDE AND SEVERITY

Since 1933, 45 wildland fire fatalities occurred in Montana. Twenty-five (25) of these deaths were from burnovers (such as the Mann Gulch Tragedy), seven were associated with aircraft crashes, and the others were from falling snags, training accidents, motor vehicle accidents, hypothermia, and heart attacks [National Interagency Fire Center, 2018].

Wildfire losses are also measured in terms of acres burned. **Table 4.2-4** displays the top fifteen counties that have sustained the greatest cumulative wildfire losses from NIFC data from 2010 to 2022 in both acres and cost-to-date (not inflated to 2022 dollars) [NIFC, 2022[2]]. Based on the data, interagency federal and local costs for wildland fire control in Montana totaled over $1.288 billion from 2010 to 2022. Nationally, the federal interagency 5-year average fire suppression costs are estimated as $2.862 billion per year [NIFC, 2022[1]]. **Table 4.2-5** displays data from the U.S. Forest Service and DNRC indicating wildfire losses for the National Forests in Montana from 1992 to 2021 [DNRC, 2022]. It may be observed that the Custer Gallatin National Forest has seen the most acreage burn since 1992.

Table 4.2-4. Counties with Highest Wildfire Losses in Acres and Cost-to-Date

County	Acres Burned (Since 2010)	County	Cost-to-Date (Since 2010)
Rosebud	255,153	Missoula	$149,733,000
Big Horn	212,357	Sanders	$143,372,383
Flathead	179,223	Lincoln	$138,668,030
Beaverhead	156,556	Beaverhead	$117,797,175
Sanders	86,792	Flathead	$85,897,035
Broadwater	74,844	Granite	$85,192,318
Lewis And Clark	64,210	Mineral	$74,043,000
Garfield	62,659	Lewis And Clark	$66,636,200
Lincoln	51,585	Rosebud	$44,666,660
Jefferson	44,512	Ravalli	$42,774,743
Phillips	42,529	Broadwater	$35,998,000
Cascade	40,297	Cascade	$34,439,579
Fergus	39,937	Meagher	$24,838,710
Carbon	35,054	Lake	$23,012,917
Musselshell	26,779	Carbon	$22,699,000

Table 4.2-5. U.S. Forest Service Wildfire Statistics in National Forests1992 to 2020

National Forest	Acres Burned Between 1992 and 2020
Custer Gallatin National Forest	753,924
Flathead National Forest	684,986
Lolo National Forest	684,284
Helena - Lewis and Clark National Forest	479,491
Bitterroot National Forest	442,707
Beaverhead-Deerlodge National Forest	295,532
Kootenai National Forest	238,330
Total	**4,703,717**

Montana's wildfire suppression costs for the 2021 fire season were less than what was observed in 2017, a year which saw $70 million spent. According to the governor's office, Montana spent $47.5 million on fire suppression up until October 13th. However, $9.2 million in federal cost-share reimbursements will lessen this toll [Montana Free Press, Fire season 2021: Early to start, late to finish, and smoky in the middle, 2021]. Fires in the wildland interface continue to pose costly challenges. Community preparedness and homeowner risk reduction efforts continue to be a priority to better protect life, property, natural resources and reduce suppression costs. **Table 4.2-6** displays the largest fires in Montana since 2010 [DNRC, 2022]. **Table 4.2-7** shows the most costly fires in Montana since 2010 [NIFC, 2022[2]].

Table 4.2-6. Largest Wildfires Since 2010

Fire Name	County	Discovery Date	Cause	Acres
Lodgepole Complex	Garfield	7/19/2017	Natural	270,723
Ash Creek	Rosebud	6/25/2012	Natural	249,562
Richard Spring	Rosebud	8/8/2021	Natural	170,000
Rosebud Complex	Rosebud	8/2/2012	Natural	152,261
Rice Ridge	Missoula	7/24/2017	Natural	147,529
Sartin Draw	Powder River	8/30/2017	Natural	99,714
East Sarpy	Big Horn	8/1/2012	Natural	82,127
Bear Creek	Flathead	8/12/2015	Natural	69,435
P F	Big Horn	7/27/2021	Human	66,134
Taylor Creek	Powder River	7/3/2012	Natural	62,111
Meyers	Granite	7/14/2017	Natural	62,034
Trail Creek	Beaverhead	7/8/2021	Natural	62,013
Woods Creek	Broadwater	7/10/2021	Natural	55,449
Lolo Peak	Missoula	7/15/2017	Natural	53,902
Spotted Eagle	Pondera	8/12/2015	Natural	53,640

Table 4.2-7. Costliest Wildfires Since 2010

Fire Name	County	Discovery Date	Cause	Cost-to-Date
Rice Ridge	Missoula	7/24/2017	Natural	$49,251,000
Lolo Peak	Missoula	7/15/2017	Natural	$48,500,000
Alder Creek	Beaverhead	7/8/2021	Natural	$40,000,000
Trail Creek	Beaverhead	7/8/2021	Natural	$40,000,000
Sapphire Complex	Granite	7/24/2017	Undetermined	$35,406,736
Meyers	Granite	7/14/2017	Natural	$32,800,000
Sunrise	Mineral	7/17/2017	Natural	$31,700,000
West Lolo Complex	Mineral	7/8/2021	Undetermined	$28,228,000
Thorne Creek	Sanders	7/7/2021	Natural	$28,228,000
Woods Creek	Broadwater	7/10/2021	Natural	$27,000,000
Tongue River Complex	Rosebud	7/9/2017	Undetermined	$26,500,000
Copper King	Sanders	7/31/2016	Undetermined	$26,467,287
Burnt Peak	Lincoln	7/7/2021	Natural	$24,000,000
Divide Complex	Meagher	7/9/2021	Undetermined	$22,125,000
Balsinger	Cascade	7/8/2021	Natural	$22,125,000

VULNERABILITY ASSESSMENT

All of Montana is vulnerable to wildland and rangeland fires. The probability and severity of fires is dependent on weather and fuel conditions, and will change from year to year. Montana's forests and rangeland are more capable of supporting fires following and during drought years. Longer fire seasons caused by changing climate, lower precipitation, and reduced snowpack have also contributed to the increased level of fire activity in Montana.

Anthropogenic factors also increase fire probability and intensity. More than 100 years of practices excluding fire from forested areas, combined with past land-use practices, have altered the landscape. The resulting changes include a heavy buildup of dead vegetation, dense stands of trees, introduction of species that have not evolved and adapted to fire, and an increase in non-native fire-prone plants.

Increased fuel loads are also attributable to infestations of Spruce Budworm and Mountain Pine Beetle in Montana's forests. These factors have increased tree mortality since 2005, when central and southwestern Montana forests faced the largest known Mountain Pine Beetle epidemic on record. Luckily, a 2011 aerial check showed signs that the State's beetle infestation has abated. Further, between 2020 and 2021, the observed affected area of Mountain Pine Beetles dropped by 64%. Similarly, defoliating species such as the Bark Beetle and Douglas Fir Beetle saw affected forest areas drop by 69% and 8% respectively. However, the Douglas-fir beetle is still considered ubiquitous throughout north-western Montana and is projected to continue to cause tree mortality. The Western Spruce Budworm also continues to deforest Montana. In 2021, the Western Spruce Budworm damaged 11,640 acres, followed by Pine Needle and Shoot Disease, which contributed to 8,409 damaged acres. Lincoln, Flathead, Mineral and Sanders Counties in northwestern Montana were the counties with the highest number acres affected. Tree mortality causes fires to be larger, burn hotter, and move faster, making them more severe, more dangerous, and costlier in human, economic, and ecologic terms [DNRC, 2021].

In central and eastern Montana, rangelands are also vulnerable to wildfires. Most fires use grass and sagebrush as fuel. These fires are typically larger in size, but they are suppressed more quickly. The USDA Farm Service Agency's (FSA) Conservation Reserve Program (CRP) is a voluntary program available to agricultural producers to help them safeguard environmentally sensitive land. Producers enrolled in CRP establish long-term, resource-conserving covers to improve the quality of water, control soil erosion, and enhance wildlife habitat. In return, FSA provides participants with rental payments and cost-share assistance. Generally, CRP acreage may not be hayed or grazed during the primary nesting season for certain wildlife unless under emergency or managed conditions. Although the CRP may benefit the environment in many respects, the program may also increase the fire risk in nearby communities [FSA, 2007].

Homes located in the WUI are extremely vulnerable to wildfire. Untreated wood shake and shingle roofs, narrow roads, limited suppression access, and poorly planned subdivisions increase the risk of wildfire to people and their property.

Wildland fires are also a source of airborne particulate matter that can lead to serious health problems. A 2016 study suggests that smoke days will increase by almost two-thirds as the climate warms through the end of the century. Further, fires in California, Oregon, and Idaho often send smoke to Montana because continental wind patterns move in an easterly and northeasterly path. The study demonstrated that wind-blown smoke waves are likely to be longer, more intense, and more frequent. It predicts that western Montana counties could see smoke ranging from 25 to 69 days a year. Wildfire smoke raises health, ecological and economic concerns. Children, the elderly, and those with pre-existing conditions encounter increased respiratory problems during wildfires. Smoke also affects road safety, tourism, and property values as lingering smoke lowers visibility [Independent Record, *Wildfire Smoke Affecting Montana,* August 21, 2016].

Post wildfire conditions that lead to degraded and burned lands can also pose risks to human life and property. Loss of vegetation causes more erosion, leading to an increase in flash flooding and landslides. Sediments may move downstream and damage houses or fill reservoirs, putting native species and water resources at risk. The Forest Service Burned Area Emergency Response (BAER) program addresses these situations with the goal of protecting life, property, water quality, and deteriorated ecosystems.

Statewide Vulnerability

In 2020, a wildfire risk assessment for the state of Montana (MWRA) was conducted by Pyrologix for DNRC [DNRC, 2020] . The purpose of the project was to provide foundational information about wildfire hazard and risk to highly valued assets across the state with the aim of supporting response efforts and resource management planning. The project quantifies average wildfire risk, measured as eNVC (expected net value change), for each county. This parameter captures the relative likelihood for wildfire disturbance in each county based on weighted raster calculations of various environmental and community factors. An abbreviated table of results from the MWRA are shown in **Table 4.2-8**. The analysis shows the three most susceptible counties to wildfire risk are Ravalli, Gallatin, and Missoula counties, due to their high percentage of populations inhabiting the WUI.

Table 4.2-8. Results of Montana Wildfire Risk Assessment [Pyrologix, 2020]

County	Burnable Acres/ 100 Acres	Total (All HVRA) Mean eNVC	Rank by Mean eNVC
Ravalli	14,140	-0.567	1
Gallatin	15,345	-0.383	2
Missoula	16,143	-0.363	3
Silver Bow	4,504	-0.258	4
Lake	8,260	-0.256	5
Yellowstone	15,666	-0.251	6
Carbon	11,400	-0.178	7
Flathead	30,659	-0.166	8
Lewis and Clark	21,091	-0.158	9
Granite	10,805	-0.156	10

Increased population growth over the past two decades in Montana has resulted in an expanded WUI. Fires in WUI areas have become much larger and burned with greater intensity. According to the 2020 Headwaters Economics study, more than a third of montana homes have a moderate to high wildfire risk, with this number doubling since 1990 due to construction in the WUI. The report states that Madison County has seen a 580% housing growth rate in high hazard areas, followed by Gallatin County at 367%. In general, there has been an 87% increase in new homes constructed in high hazard areas, and a 100% increase in moderate hazard areas [Headwaters Economics, 2020].

Structures are also susceptible to the effects of wildfires. From 2005 to 2022 there have been a total of 142 wildfires that have accounted for 1,398 total structures destroyed in Montana [Headwaters Economics, 2022]. Fires in WUI areas pose extreme risk to human life and property, increase the cost of fire suppression activities, endanger the lives of firefighters that must contain and prevent losses in these areas, and have significant social, economic, and natural resources impacts.

Federal and state wildfire management agencies, as well as public non-profit wildfire organizations were involved in the planning process for the 2022 Montana MHMP. Their cohesive wildfire strategy is defined by three objectives that include creating fire adapted communities, fire resilient landscapes, and safe and effective fire response. A fire adapted community consists of informed and prepared citizens that collaboratively plan to safely coexist with wildland fires. These communities stay knowledgeable and engaged in relation to infrastructure, buildings, landscaping and the surrounding ecosystem to lessen the need for protection actions. This enables the communities to safely accept fire as part of the surrounding landscape. Because every community is unique, strategies to improve wildfire resilience will vary from place to place.

Creating fire resilient landscapes is a new approach to achieve fire resiliency goals. This approach uses partnerships among programs, activities, and organizations to increase resilience. Collaboration between wildland fire and resource management programs are essential to address land health and the role of fire adapted ecosystems.

The wildfire hazard is not considered a uniform hazard across the State. Therefore, three GIS layers were created compare the wildfire hazard impact area of the WUI, where each layer reflects a different data source. These layers are depicted in **Figures 4.2-1A-I.** It was determined that providing a side-by-side comparison of how different entities define the WUI would be informative to stakeholders fire planning process.

As such, the first set of figures depicts the Community Wildfire Protection Plan (CWPP) for each county in comparison to other resources at risk, including agricultural land (cultivated crops and pasture/hay) acreage CWPPs and WUI GIS data were gathered from counties that completed CWPPs. WUI parcels were mapped using Montana Cadastral data and the various WUI categories or levels determined by individual counties. Some counties did not have a WUI mapped by their CWPP. DNRC worked with those counties individually to designate WUI parcels. CWPPs portray WUI boundaries using a variety of methods. Some counties consider nearly their entire county as some type of WUI, while others only recognize small buffers around certain communities. WUI parcel delineation was completed from January 2010 through December 2011, Cadastral fields were kept as part of the WUI data. Since the cadastral data that the WUI parcels are based upon is updated regularly, the WUI parcels are out-of-date. There is no current plan to update WUI parcels [MSL, 2011].

The second set of figures reflects WUIs as defined by USFS. This dataset delineates U.S. Census populated places in the Unites States and their associated wildland urban interface (WUI) as part of an assessment to quantify wildfire transmission to communities. The USFS research data used to create this dataset showed that less than 20% of buildings in non-WUI areas are exposed to wildfire yet there are no community-level datasets that include the most vulnerable areas to wildfire, those areas where homes and structures are built among wildland vegetation. Local and regional risk planning processes, including engagement with communities, can use these boundaries to better define and map the scale of wildfire risk from large fire events and incorporate wildfire network and connectivity concepts into risk assessments [USDA, 2021].

The third set of figures shows WUIs as defined by the United States Geological Survey (USGS). This dataset maps the intermix and interface WUI that were generated using a range of circular neighborhood sizes, based on radius distances from 100 – 1,500 m, to determine building density and vegetation cover on a pixel-by-pixel basis. A composite was also generated by combining the combined WUI maps (both interface and intermix WUI) for all neighborhood sizes, with field values indicating the radius distances for which pixels are included in the WUI classification [USGS, 2022].

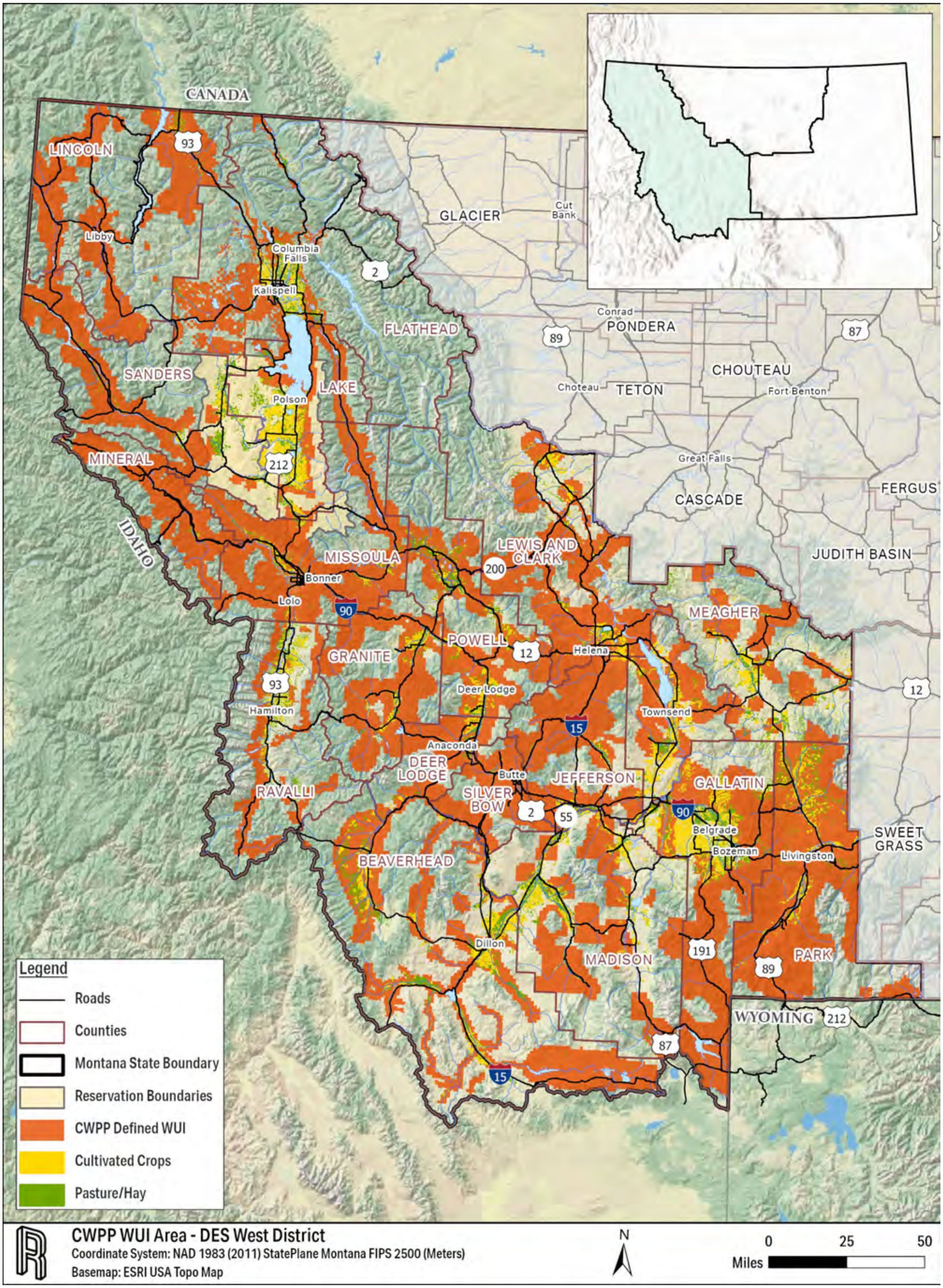

Figure 4.2-1A. Wildland and Rangeland Fire Hazard Areas for DES West District based on CWPP.

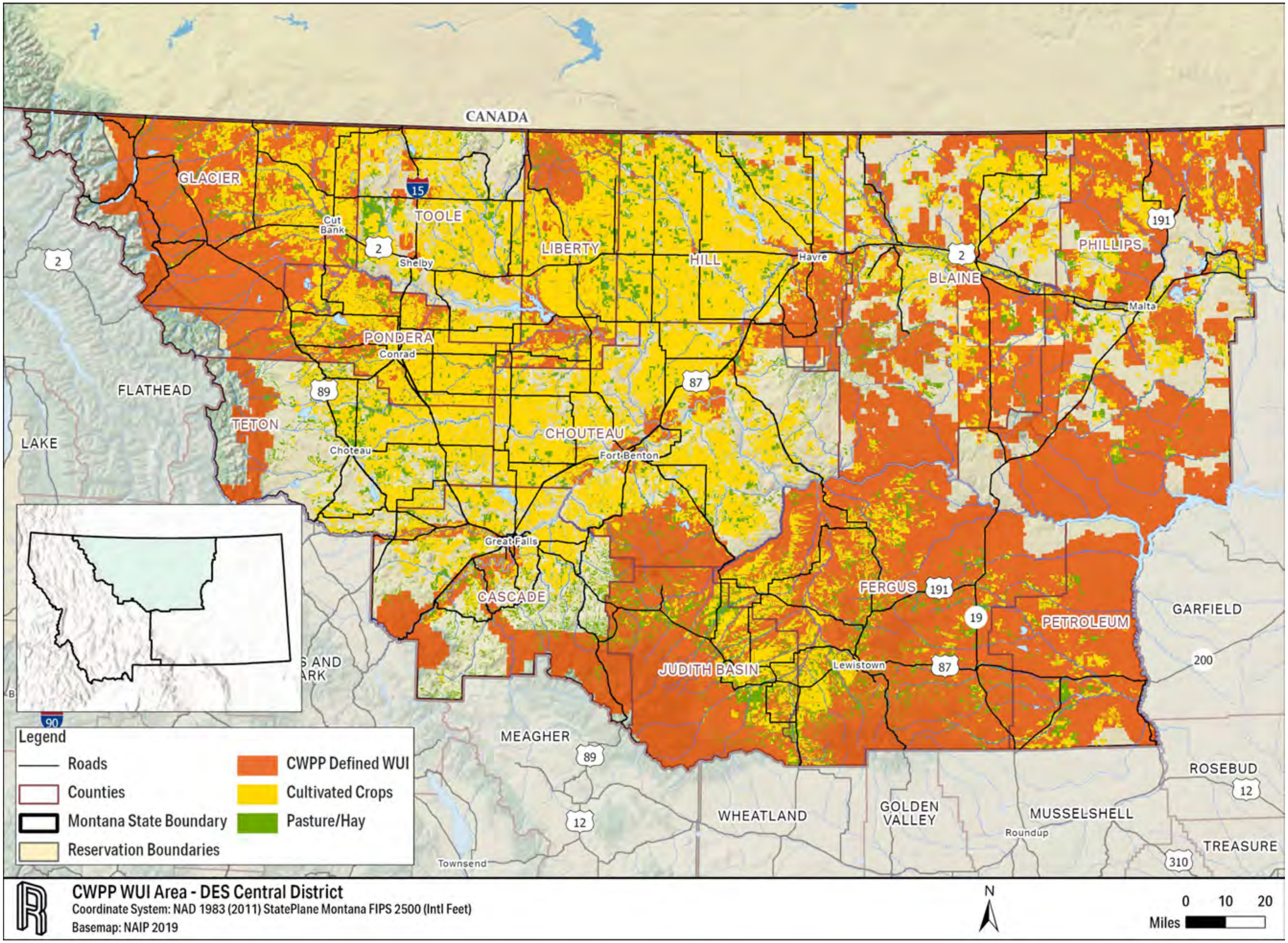

Figure 4.2-1B. Wildland and Rangeland Fire Hazard Areas for DES Central District based on CWPP.

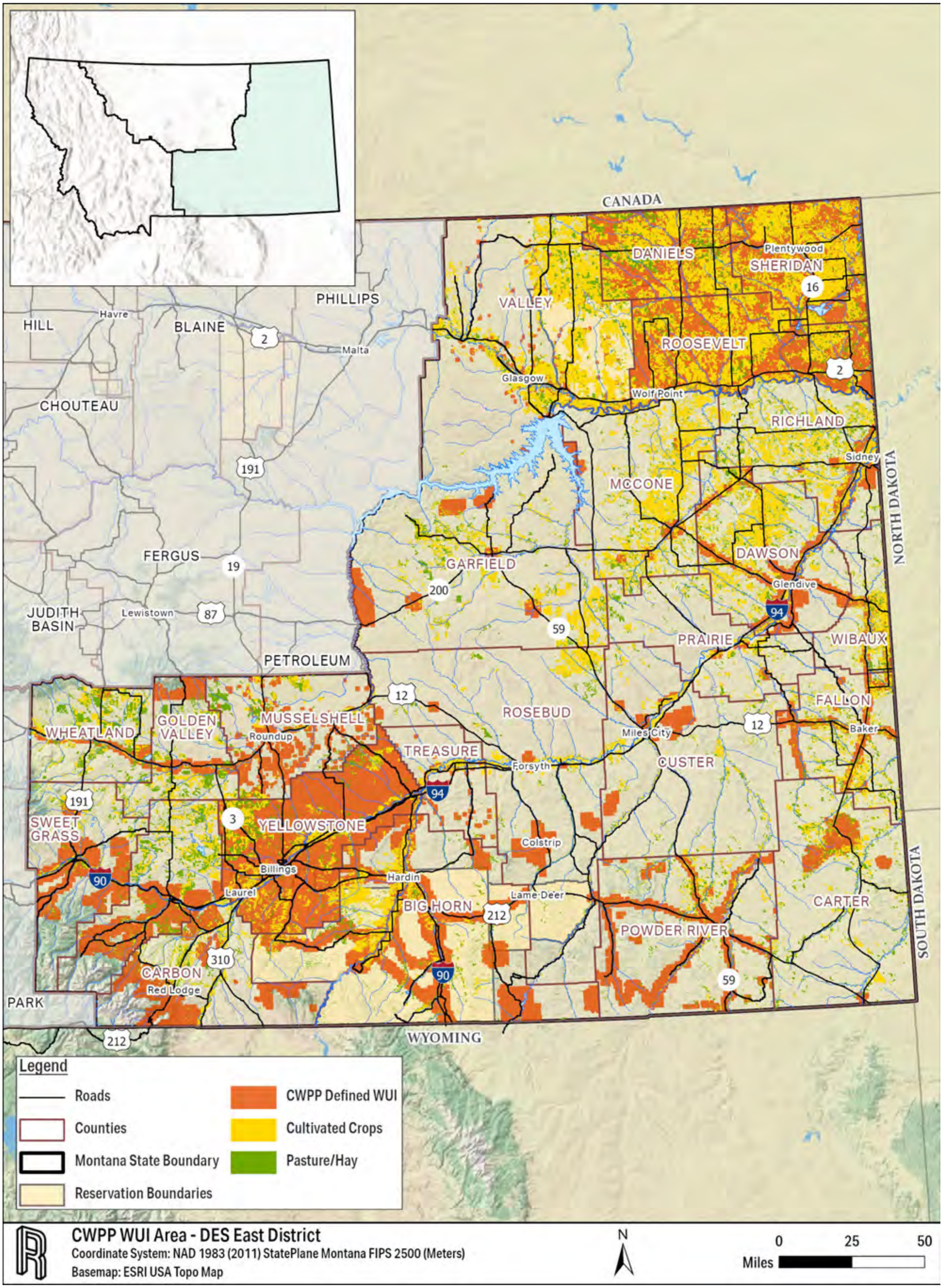

Figure 4.2-1C. Wildland and Rangeland Fire Hazard Areas for DES East District based on CWPP.

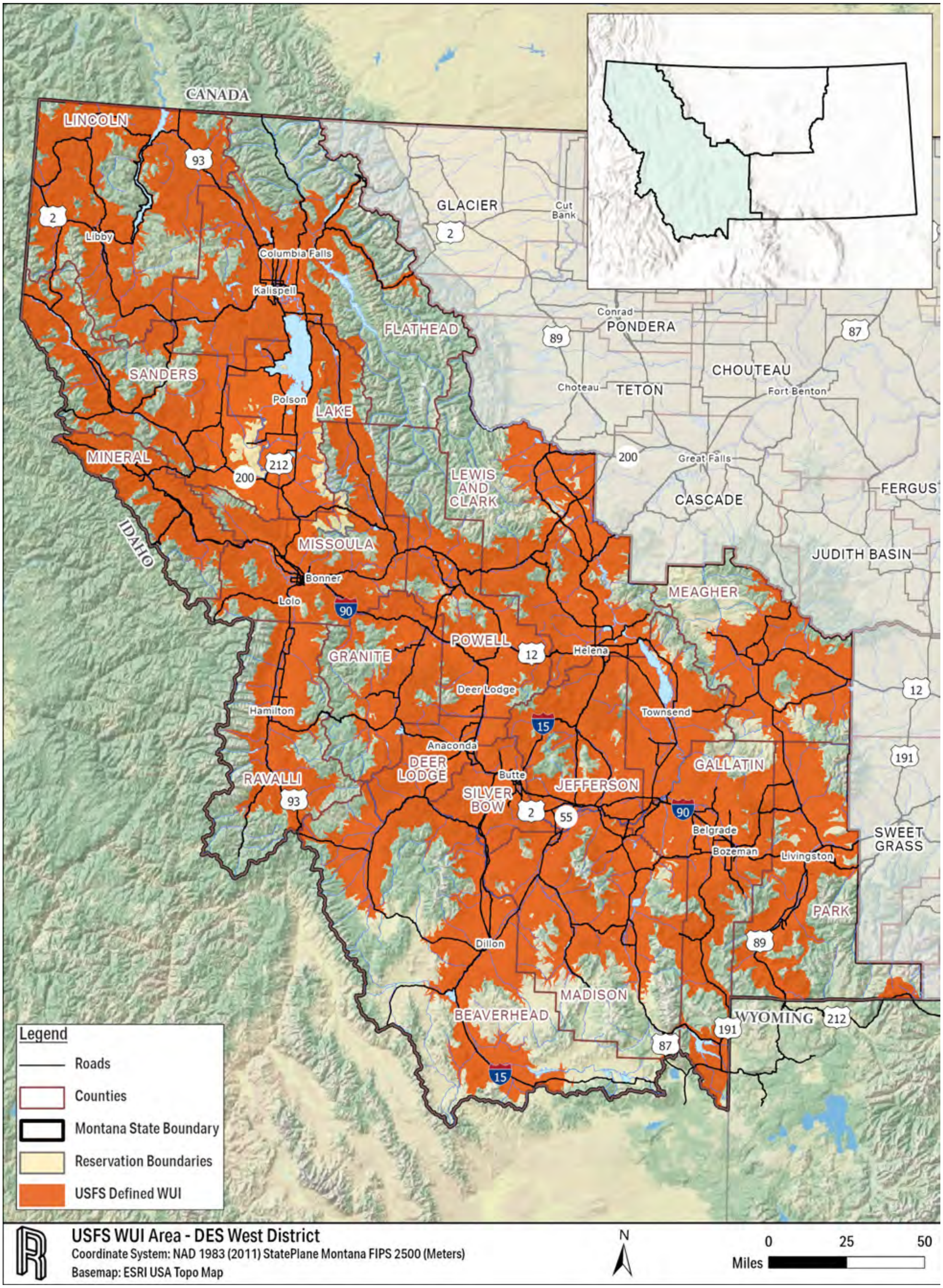

Figure 4.2-1D. Wildland and Rangeland Fire Hazard Areas for DES West District based on USFS.

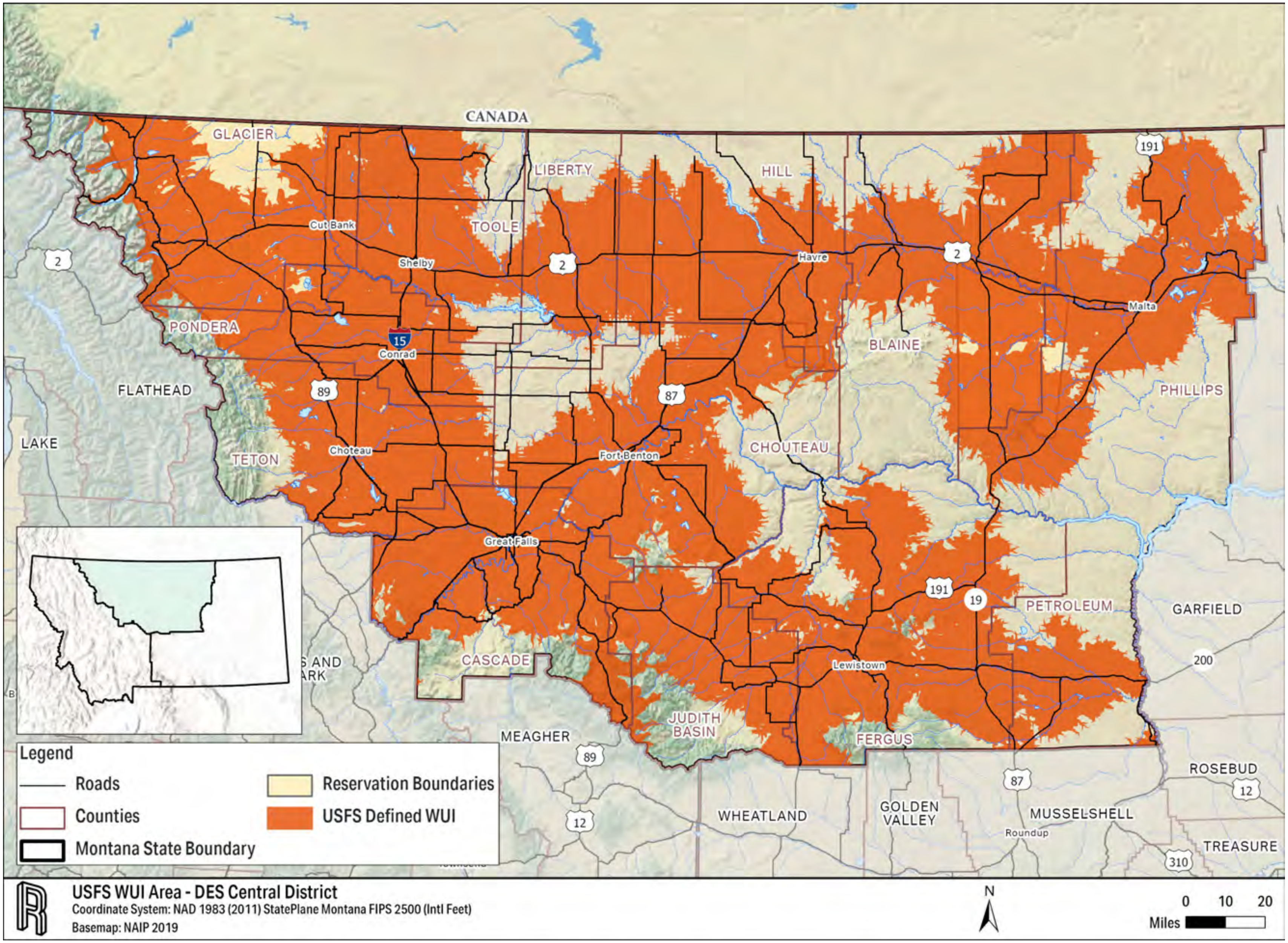

Figure 4.2-1E. Wildland and Rangeland Fire Hazard Areas for DES Central District based on USFS.

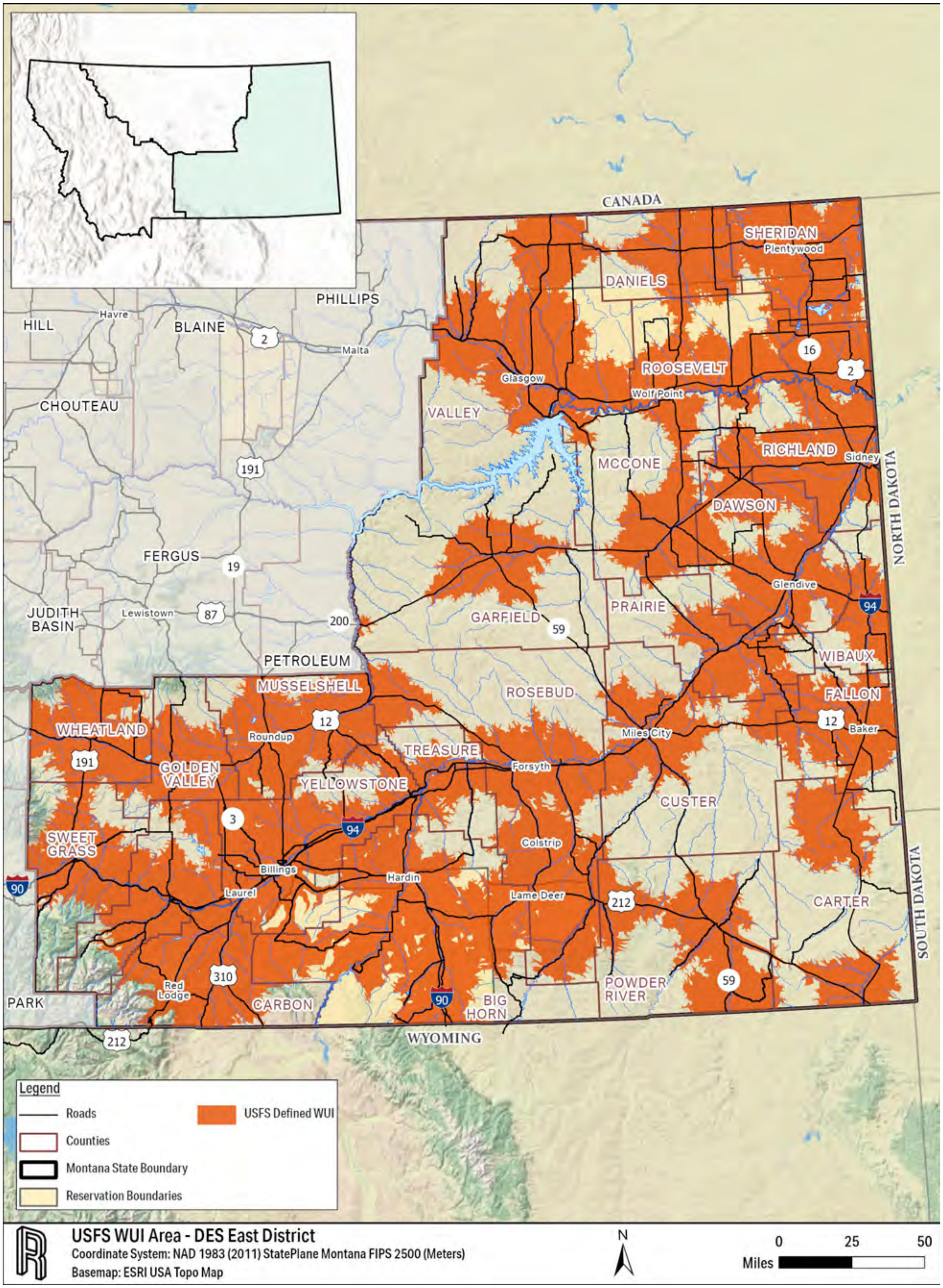

Figure 4.2-1F. Wildland and Rangeland Fire Hazard Areas for DES East District based on USFS.

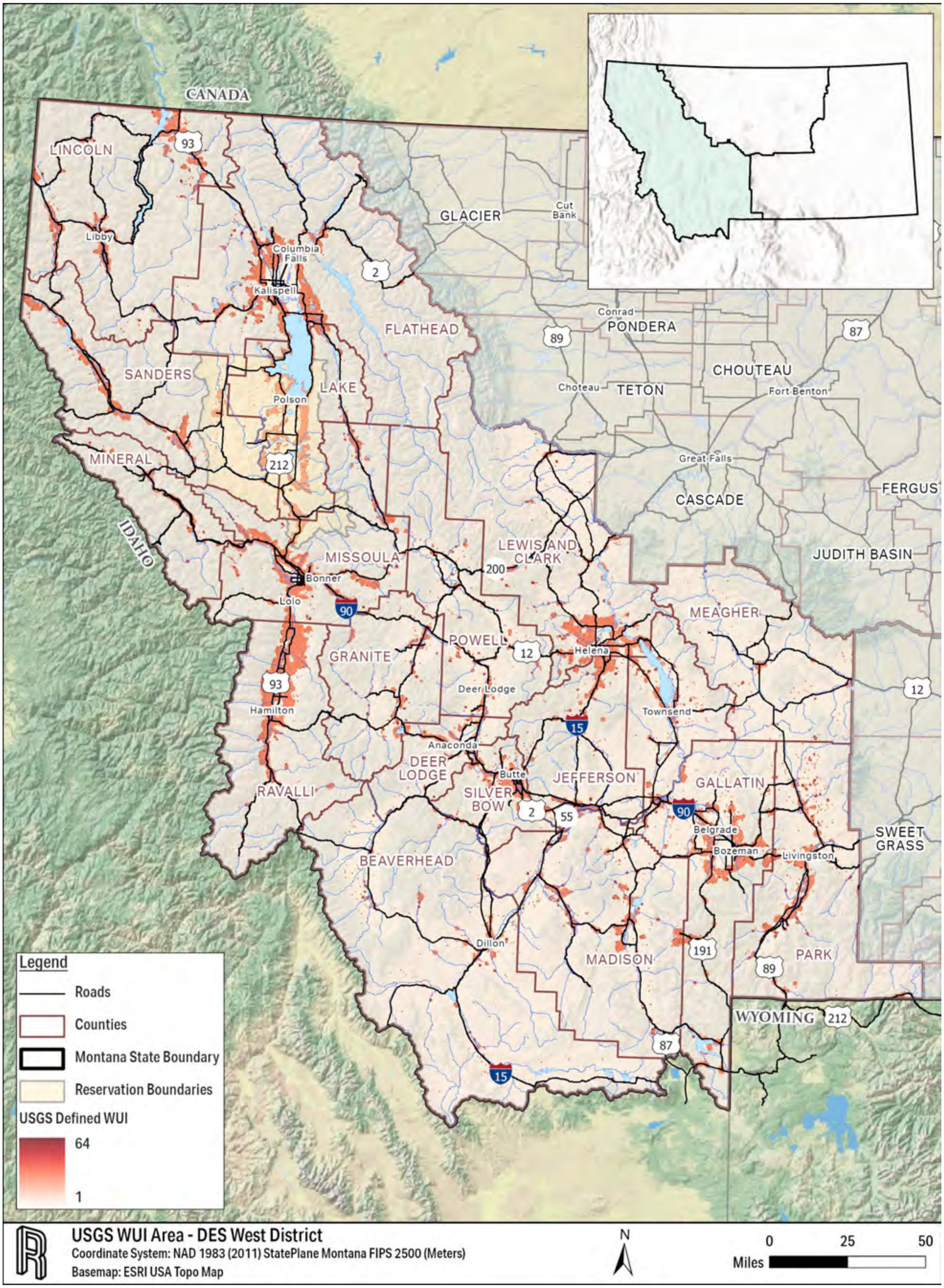

Figure 4.2-1G. Wildland and Rangeland Fire Hazard Areas for DES West District based on USGS.

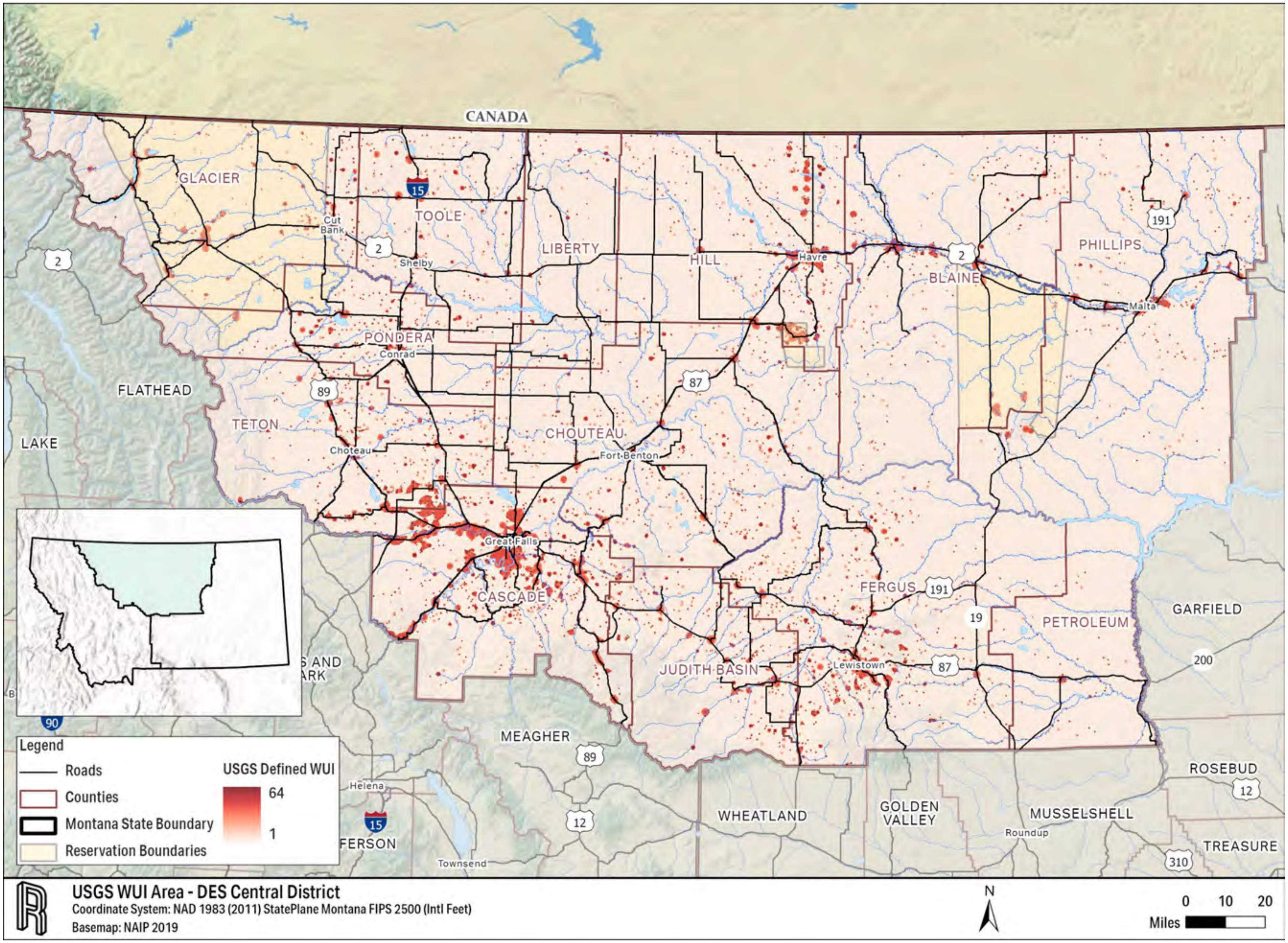

Figure 4.2-1H. Wildland and Rangeland Fire Hazard Areas for DES Central District based on USGS.

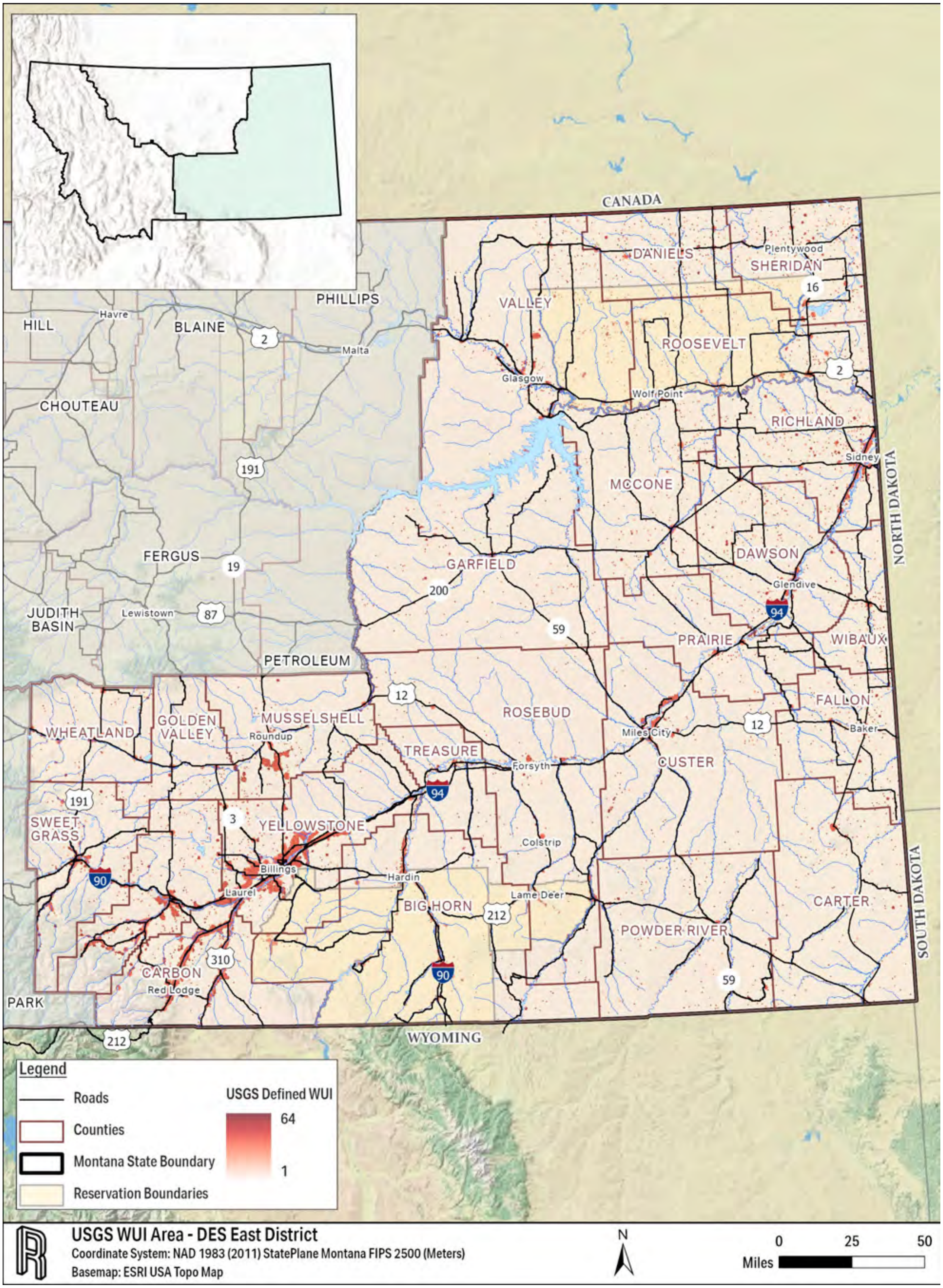

Figure 4.2-1l. Wildland and Rangeland Fire Hazard Areas for DES East District based on USGS.

To complete the vulnerability analysis for the wildfire hazard, GIS was used to intersect the USFS WUI layer with both the general building stock, critical facility, and cultural resource datasets. It was determined that the USFS dataset would provide a more complete picture of the fire risks presented across the state, as the CWPP omits the WUIs of several counties. Estimates of vulnerable population were calculated by assigning a population to a structure type, a technique DNRC used when estimating vulnerable populations downstream of dams and is based on US Census Data. Exposure values are presented in **Table 4.2-9**. **Appendix B-3** presents supporting documentation from the risk assessment including a list of critical facilities in the wildfire hazard area and loss estimates by county.

Table 4.2-9. Fire Exposure Summary by DES District

Item	West District	Central District	East District
Severe Weather Hazard Area (Square Miles)	29955	24343	35432
Severe Weather Hazard Area Percent of District	61.74%	65.26%	57.98%
Residential Building Exposure ($)	$60,160,304,123	$8,369,576,398	$17,642,558,165
Residential Building Exposure (# structures)	214,563	49,785	93,950
Commercial, Ag, Industrial Building Exposure ($)	$6,599,669,354	$1,808,657,532	$827,880,148
Commercial, Ag, Industrial Building Exposure (# structures)	7,229	2,135	2,178
Essential Facility Exposure ($)			
Essential Facility Exposure (# structures)			
Cultural Resources (# features)	474	181	100
Persons Affected in Hazard Area	675,915	165,110	271,883

Risk assessment results indicate that DES West District has the highest building stock exposure in terms of number of structures at risk from fires. District _ has the highest number of critical facilities and cultural resources at risk from flooding, while the West District has the most population at risk.

Table 4.2-10 presents a vulnerability summary of the wildfire hazard as it relates to percent exposure in Montana's counties, cities and towns. Percent exposure was derived by dividing the value of residential and commercial/agricultural/industrial building stock exposed to the hazard into the total value of the building stock. Percent exposure is a more accurate way of displaying vulnerability than presenting jurisdictions with the highest exposure because it reflects areas with the greatest risk opposed to those with high value real estate. A complete ranking is presented in **Appendix B-3**.

Table 4.3-10. Fire Exposure Summary for Top Counties, Cities and Towns

County	% Wildland Fire Exposure	$ Residential Exposure	# Residences at Risk	$ Commercial/ Ag/Industrial Exposure	# Commercial/ Ag/Industrial Buildings at Risk	$ Critical Facilities Exposure	# Critical Facilities at Risk
Counties with Highest Percent Exposure ($ Residential + $ Commercial-Ag- Industrial Exposure in Hazard Area / Total Exposure)							
Silver Bow	98.12%	$2,351,477,673	14,136	$188,628,105	446		
Missoula	97.34%	$9,239,850,874	35,830	$1,878,514,766	1,920		
Broadwater	96.03%	$163,662,977	918	$9,826,280	23		
Carbon	95.78%	$1,075,817,120	4,740	$92,663,872	293		
Gallatin	95.19%	$13,464,698,894	33,158	$2,073,294,089	1,864		
Ravalli	94.66%	$4,677,138,939	18,216	$103,978,051	67		
Madison	94.27%	$4,365,659,268	5,149	$136,803,226	176		
Cities/Towns with Highest Percent Exposure (Towns with Pop. > 500) ($ Residential + $ Commercial- Ag- Industrial Exposure in Hazard Area / Total Exposure), towns with 100% exposure sorted by population							
Lolo	100.00%	$476,000,972	2,204	$32,222,323	68		
Alberton	100.00%	$105,241,586	125	$16,780	1		
Walkerville	99.86%	$21,637,070	274	$412,458	7		
Trego	99.58%	$24,981,070	125	$40,170	1		
Missoula	98.87%	$7,342,362,945	27,581	$1,779,392,527	1716		
Stevensville	98.29%	$1,158,655,005	4,607	$2,436,080	7		
Terry	98.17%	$25,212,070	401	$3,335,720	26		

Counties with the highest wildfire exposure include: Silver Bow, Missoula, Broadwater, Carbon, Gallatin, Ravalli, and Madison counties; while the top cities/towns (with population over 500) include: Lolo (Missoula Co.), Alberton (Mineral Co.), Walkerville (Silver Bow Co.), Trego (Lincoln Co.), Missoula (Missoula Co.), Stevensville (Ravalli Co.), and Terry (Prairie Co.). **Figure 4.2-2** presents percent exposure for the top counties and cities/towns showing regional vulnerability.

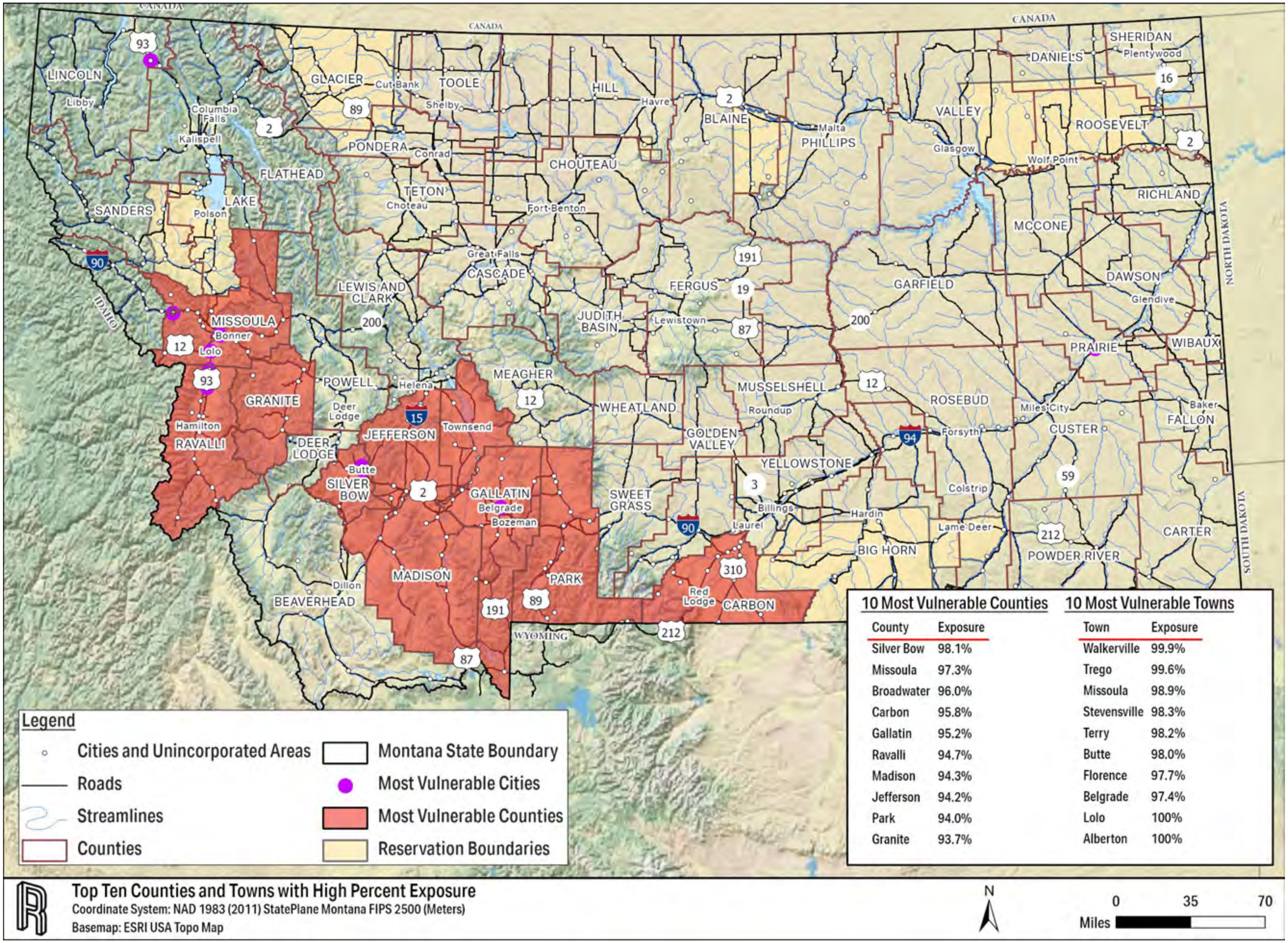

Figure 4.2-2. The top ten counties with the highest percent exposure to WUI hazard areas.

FUTURE DEVELOPMENT

The WUI is a popular place to live in Montana. Development in this hazard area has increased in recent years and has amplified the vulnerabilities in the unincorporated parts of the State. Regulating growth in these areas is a delicate balance between protecting private property rights and promoting public safety. Montana land use planning strategies to reduce wildfire risk include growth policies, subdivision regulations, zoning guidelines, and building codes.

The 2007 Montana Legislative session passed a bill specific to wildfire and the WUI that reduces the impact of wildfire and rangeland fire on future development. Senate Bill 51, which took effect on October 1, 2009, revised growth policy and subdivision law requiring the consideration of wildland fire. The law requires that growth policies include an evaluation of the potential for wildland fire, including whether or not there is need to delineate the WUI or adopt regulations that require defensible space around structures, adequate ingress, and egress to and from structures to facilitate fire suppression activities, and/or adequate water supply for fire protection. Growth policies provide the legal basis and rationale to create rules for the WUI but are not regulatory documents and don't have the weight of law. Growth policies provide an opportunity to discuss risks and improvement projects with federal and state officials, fire districts, and landowners.

Montana Code Annotated section 76-13-104(8) required that DNRC adopt administrative rules that address development within the WUI. This included best practices for development within the WUI and criteria for providing grant and loan assistance to local governments to encourage them to adopt those practices. It also directed DNRC to develop rules addressing a potential means of enforcement. (DNRC, 2009).

Building Codes and the WUI Code

The Montana Legislature passed *The Wildland-Urban Interface Code of Montana* in 2012. This code applies to the construction, alteration, movement, repair, addition, change-of-use or remodeling of any building, structure, or premises within the designated WUI within a jurisdiction. The WUI Code primarily addresses fire-resistant construction materials such as noncombustible roof coverings, walls, windows, vent coverings, and similar matters, but also includes a wide-ranging appendix covering vegetation management and certain land use practices.

The objective of the Montana WUI Code is to establish minimum regulations consistent with nationally recognized good practice for the safeguarding of life and property. Regulations in this code are intended to mitigate the risk to life and structures from intrusion of fire from wildland fire exposures and fire exposures from adjacent structures and to mitigate structure fires from spreading to wildland fuels. The extent of this regulation is intended to be tiered commensurate with the relative level of hazard present.

The WUI Code states that the governmental body or official state or local agency must declare the WUI areas within the jurisdiction based on mapping, boundary designations, or wildland fire plans. Cities, counties, and towns that have adopted the International Building Code or the International Residential Code in connection with their certification to enforce building codes will, if they elect to enforce the International WUI Code, record the official WUI areas on maps available for inspection by the public.

According to the Montana DLI website, only seven of Montana's 56 counties have adopted building codes and none has adopted the WUI code. General resistance to regulation and personnel capacity issues are likely reasons that only a few counties have adopted building codes or the WUI code.

Where local governments have not adopted building codes, DLI administers building codes (including the WUI code) for all commercial structures, plumbing and electrical permits for all structures, and also construction materials and techniques for residential structures consisting of five or more units. However, because much of the development in the WUI consists of single-family residential homes, DLI does not have authority to address fire-related construction issues in most instances [Headwaters Economics, 2017].

Subdivision Guidelines

Senate Bill 51 also amended subdivision regulations to require every county, city, and town to reasonably avoid subdivisions where there is danger of injury to health, safety, or welfare by reason of natural hazard, including but not limited to fire and wildland fire. The regulations prohibit subdivisions in these areas unless the hazards can be eliminated or overcome by approved construction techniques or mitigation measures such as requiring sprinklers in certain circumstances or prohibiting cedar shake roofs.

Subdivision guidelines provide a list of recommendations that can be incorporated into local subdivision regulations (development of lots in new subdivisions):

- Wildland fuel mitigation discussing defensible space and the preparation of vegetation management plans;
- Site development discussing steep slopes, fire chimneys, and improvements prior to construction;
- Fuel breaks and greenbelts;
- Means of access including ingress and egress roads, gates, and signage;
- Water supply requirements and guidelines;
- Alternative development; and
- A miscellaneous category which discusses mapping of fire protection features and maintenance of equipment and features.

When the Montana DLI defines what construction techniques or other mitigation measures are appropriate for use in mitigating hazards during the subdivision process, local government can choose to adopt them into their county subdivision regulations as well. The disadvantages of subdivision regulations are that there is no regulatory mechanism to ensure water supplies and vegetation are maintained over time; covenants, which may not be adhered to, are necessary to ensure the construction techniques are implemented; and, the requirements only apply to new subdivisions while WUI development issues also include existing lots and structures (Headwaters Economics, 2017).

Zoning Ordinances

Montana land use planning statutes authorize counties and municipalities to adopt zoning with the express purpose of providing for public health, safety, and general welfare. Zoning can be adopted by local governments, with great flexibility for how much detail to include. The zoning guidelines can be adopted as part of the regulations for a new zoning district, as an amendment to regulations for an existing zoning district or regulations for an overlay zoning district. Zoning is optional, meaning local governments are not required to adopt it.

Zoning can be designed to address specific areas of WUI. The state's zoning guidelines provide a list of recommendations that can be incorporated into city/county zoning regulations for issues such as maintenance of vegetation management on existing lots, construction of driveways on existing lots, and development of lots in subdivisions. If a local government adopts zoning to address development in the WUI, it is necessary to avoid items that are included in building codes such as roofing materials, windows, and vents. Instead, zoning can be used to designate minimum lot sizes or densities in the WUI, fuels reduction requirements, and other elements.

DATA LIMITATIONS

Risk assessment results for wildfire are only a general representation of potential vulnerabilities. The wildfire hazard impact area developed for this project may not be accurate for all jurisdictions; it was however, developed with the best available information as of the date of this Plan.

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4.3 FLOODING

CPRI SCORE =2.83

DESCRIPTION

Floods are the result of a multitude of naturally occurring and human-induced factors, but they all can be defined as the rapid rise and accumulation of water outside its expected confinements in response to an event. The types of floods Montana experiences include regional floods, flash floods, ice-jam floods, and post-fire debris flows. Flooding resulting from dam failure is discussed in *Section 4.4.10*.

Regional Flooding

Regional flooding occurs in river systems whose tributaries drain large geographic areas and include many independent river basins. Riverine flooding occurs when runoff flows exceed the natural drainage system's carry capacity. Significant flooding can cause damage to infrastructure within inundated areas. Factors that directly impact runoff volumes include form of precipitation, intensity and distribution of precipitation, existing soil moisture conditions, seasonal variation in vegetation, snow depth and variation of water-resistance of the surface due to urbanization. Duration of flooding also plays a major role in flooding impacts, often ranging from a few hours to many days.

Floodplains are river and stream adjacent land that are normally dry but become inundated with water during flood events. Obstructions within the floodplain such as buildings, roadways, or fill material may change the way floodwaters navigate the floodplain. These obstructions often increase flood-caused damage because they block the flow of water and increase the width, depth, or velocity of floodwaters.

Floodplain designations and delineations are shown on Flood Insurance Rate Maps (FIRMs), but many are outdated and not updated to digital versions. FEMA is currently working on their Map Modernization Program and updating to Digital Flood Insurance Rate Maps (DFIRMs). These updates include the digitization of paper FIRMs and new flood studies to update flood zones and boundaries. FIRMs and DFIRMs help property owners to determine whether their properties are within the floodplain and what steps are necessary to develop on their properties.

Many communities in Montana are protected from flood hazards by levees and dikes. With the production of updated DFIRMs through FEMA's Map Modernization Program, communities must demonstrate their levees are expected to provide 1-percent-annual-chance flood risk reduction, as certified by a registered professional engineer. Without a new certification, DFIRMs show that no levee exists, requiring homeowners to purchase flood insurance through the National Flood Insurance Program (NFIP), which may cause property values to drop. Figure 4.3-1 shows the location of many of the levees in Montana.

Figure 4.3-1. Location of most levees within Montana. Source: Montana State Library

Flash Floods

Flash floods are local floods of great volume and short duration. In contrast to riverine flooding, flash floods usually result from a torrential rain on a relatively small drainage area or within an inadequate urban drainage system that becomes overwhelmed during intense rain events. Dam failure also may result in flash floods. Often, flash floods occur within several minutes to several hours without warning. They can be deadly because they produce rapid rises in water levels and have devastating water velocities. Factors contributing to flash flooding include rainfall intensity and duration, surface conditions, and topography and slope of the receiving basin.

Urban areas are susceptible to flash floods because a high percentage of the surface area is composed of impervious streets, roofs, and parking lots where runoff occurs very rapidly. Mountainous areas also are susceptible to flash floods, as steep topography may funnel runoff into a narrow canyon. Flash floods and debris floods often occur in areas recently burned by wildfire because little vegetation exists, and the soil becomes relatively impervious. Rainfall that would normally be absorbed by soil may run off extremely quickly after a wildfire. A post-fire environment combined with wet weather can lead to flash flooding and mudflows for several seasons.

Source: NBC, 2013. Flash flood in Bannack State Park.

Ice Jams

An ice jam is an accumulation of ice in a river that restricts water flow and may cause backwater that floods low-lying areas upstream from the jam. Downstream areas also can be flooded if the jam releases suddenly, sending a flash flood downstream. Ice jam flooding is more likely to occur in break-up events as opposed to freeze-up events. Sudden seasonal changes are the greatest factor increasing the risk of ice jam flooding. Prolonged cold periods causing significant ice formation followed by unseasonably warm periods in the winter or spring are likely formulas for ice jams.

Damages resulting from ice jams may affect roads, bridges, buildings, and homes, and can cost the affected community thousands to millions of dollars, depending on volume and extents of floodwaters. Predicting ice jam locations can be difficult, but they often form in sharp bends or a narrowing of a stream channel. Prior ice jam locations can often be a good predictor of future locations. In most instances, ice jams result in highly localized, yet serious damages, which makes it difficult to obtain the type of disaster assistance available for large-scale flooding events.

Source: KBZK, 2022. Ice jam on the Gallatin River near Logan.

Post-Fire Debris Flows

Wildfires can drastically change a landscape and ground condition, leading to a higher risk of flooding. When a wildfire burns just a portion of a watershed, the resulting burn scar is at higher risk for flooding until vegetation is re-established within the scar. Normally, vegetation and unburnt soil absorb water during a rainfall event. In any burnt area the charred soils form a water-repellant layer and restrict water absorption, causing runoff water velocities increase and the amount of rainfall to result in flooding is greatly reduced, thus increasing the risk for flash flooding downstream. Because of these increased water velocities, runoff can create major erosion and pick up large amounts of rocks, boulders, burnt trees, and ash. This collection of material generates debris flows, which are fast-moving and can be highly destructive. These debris flows can threaten areas miles away from the burn scar, and often strip downstream vegetation, block drainages, damage structures, and may endanger human life since they can occur with little warning [Montana DNRC, 2022[1]].

GEOGRAPHIC AREAS AFFECTED

Regional flooding is a common occurrence in Montana and affects every county in the state. The other three flood types occur with less frequency and are often hard to predict. Since the entire state generally experiences cold winters and quick melting of the snowpack, and have impoundments or structures to act as obstructions, risk of ice jams exists throughout the state. Flash flooding and debris flows generally occur in steeper regions of the state, which means the Western region is more prone to flash floods and debris flows. Increasing fire activity in the Western region also creates a higher risk for flash floods and debris flows within the region.

PAST OCCURENCES

Flooding is a common occurrence in Montana. The following discussion summarizes historical flooding throughout Montana, as well as for flash floods, ice jam flooding, and post-fire debris flows.

Regional Flood History

The following sections summarize the regional flooding history for Montana, broken out into the major river basins. The major river basins were defined by the Water Management Bureau of the Montana Department of Natural Resources and Conservation (DNRC) and are concurrent with the state and regional water plan updates.

Clark Fork and Kootenai Basins

June 1908 - The June 1908 flood in Missoula County involved nearly every major stream and river. This event was the result of unseasonably warm temperatures and 33 consecutive days of rain (NWS, 2022[2]).

June 1964 - Approximately 15 inches of rain accumulated over a 30-hour period in the upper Flathead drainage. The resulting flood damaged more than 350 houses near Kalispell. The USACE estimated $25 million in damages in the Flathead Basin.

January 1974 - Lincoln, Sanders, Flathead, Glacier, Mineral, Missoula, and Deer Lodge counties were hit by flood waters which caused approximately $16 million worth of damage to Forest Service roads, bridges, and facilities, and private property.

June 1975 - Lincoln, Sanders, Flathead, Glacier, Mineral, Missoula, and Deer Lodge counties suffered flood related losses again in June 1975, totaling nearly $35 million.

May 2018 – Missoula County experienced the largest amount of flooding on the Clark Fork River since the 1908 event, with a flood stage reaching 13.82 feet on the Clark Fork River. This event was the result of late-season rapid melting of a record snowpack (MTPR, *Montana Flood News Roundup*, 2018).

Upper and Lower Missouri River Basins

April 1952 - Heavy snow, the associated snowmelt, and ice jams caused the greatest flood on record for this river in April 1952. Over $6 million in damages were recorded between Havre and the river's mouth below Nashua, causing significant economic impacts during this month-long flood. Over 1,000 homes flooded and almost 3,000 people evacuated. Levees offered limited protection to the communities of Havre, Chinook, Malta, Saco, Glasgow, and Nashua.

June 1964 - This event was initiated by 8 to 10 inches of rain over three days on a deeper-than-average snowpack. The principal rivers involved were the Dearborn, Sun, Teton, and Marias. All counties situated along the Continental Divide were affected to some degree; however, the greatest damage was received by the City of Great Falls. The flood included the failure of two dams; Swift Reservoir on Birch Creek and Two Medicine Dam on Two Medicine Creek in the Blackfeet Reservation. The disaster resulted in the loss of 30 lives and an estimated $62 million in damages, with the greatest damage in the city of Great Falls (NWS, 2022[2]). The USACE has since completed a $12 million flood control levee along the north bank of the Sun River near Great Falls, which protects over 500 homes and businesses.

May 1981 - The 1981 flood in Lewis and Clark County was the result of a combination of snowmelt and heavy rainfall. Records from the NWS indicate that 6 inches of precipitation fell in May 1981. Of that amount, 3.4 inches fell during the three days leading to the flood on May 21st. Peak flows reached 3,290 cubic feet per second and were estimated to equate to a 500-year event. Flooding resulting in over $4.3 million in damages to Lewis and Clark County and nine other counties.

1984 - The combination of snowmelt and spring rains with frequent ice jams caused flooding on the Beaverhead River near Dillon. Crews successfully prevented major damage by channeling floodwaters through town on streets lined with sandbags and straw. The Clark Canyon Dam above Dillon and emergency dikes built on the river near town reduced potential damages.

September 1986 - Significant flood caused by thunderstorms impacted those along the Milk River from Havre to Nashua causing over $3 million in FEMA reimbursed damages and one death, but some sources indicate over $36 million in total damages were incurred.

November 2006 - On November 5, 2006, unprecedented heavy rains caused catastrophic flooding in Glacier National Park. Going to the Sun Road was washed out in several areas with several bridges washed out. The Many Glacier Hotel was also flooded. The Associated Press reported $7 million in damages.

June 2011 - This flood was the result of snowmelt and heavy rainfall and affected numerous areas causing extensive damage in the Helena Valley due to the inadequate capacity of the main roadside ditches, culverts and catchments which led to overland sheet flow, and flooding of streets, yards, and structures. Lewis and Clark County and 30 other Montana counties and four reservations received over $62 million in flood-related damages. (See description of this event in the *Declared Disaster Section*, below).

May - June 2018 – A state of emergency was declared for Pondera, Hill, Blaine, Valley, Toole, Liberty, and Petroleum counties. Above normal snowfall, rainfall, rapid snowmelt caused flooding that impacted the Milk River and Marias River basins. The Milk River reached a stage of 13.93 feet near Havre, a flow that had not been recorded since 1952. Significant flooding also occurred along the Sun River and its tributaries occurred, with flood warnings issued for Lewis and Clark, Teton, and Cascade counties [Flood List, *USA – Snowmelt Flooding in Montana Prompts State of Emergency*, 2018].

Yellowstone River Basin

1899 – Large floods occurred on the Yellowstone River because of an ice jam, causing destruction of a new bridge and 12 fatalities in Glendive.

1936 – An ice jam isolated Glendive for 10 days. The USACE built a levee in 1959, which protects a portion of Glendive, but does not provide adequate protection at a 50-year ice jam flood event.

June 2008 – Floodwaters destabilized one of the pylons of the 9th Street Island Bridge in Livingston, causing the bridge to buckle at one end and sink several feet into the river. The 9th Street Island contains over 40 houses and businesses, so evacuation of the entire island was issued so residents would not be stranded, as the bridge is the only access to the island. Federal and state funding has been spent for replacement of the bridge by Park County; however, the 40+ residences on 9th Street Island are still a major concern for the State with regards to mitigation actions, particularly as they reside in an extremely obvious flood hazard area. A DFIRM for Livingston and this area of Park County clearly shows nearly the entire surface of the islands are in the floodway with only a small portion in the floodplain. The State still considers acquisition/demolition or relocation of these homes and structures a high priority mitigation action item.

June 2011 – After a record snowfall and rain-on-snow event, the Musselshell River crested at 14.75 feet, surpassing the 1975 record of 12.9 feet, according to the National Climate Data Center (NCDC, 2022). The river flooded low-lying neighborhoods in Roundup twice over the course of two weeks. Much of the town was inundated for almost a week. As a result of these flood events and the 2018 MHMP update, several FEMA grant projects have funded acquisitions of property in Roundup to remove houses from flood-prone areas.

The Yellowstone River crested at its third-highest level on Record in Billings, Forsyth, and Miles City, caused by nearly up to a foot of rain failing in locations across south central Montana. Miles City, located at the confluence of the Yellowstone and Tongue Rivers, experienced flooding after 2.22 inches of rain fell in just one day. Flood maps adopted in 2010 place well over 80 percent of the city limits inside the 100-year floodplain and do not recognize the protection offered by the levee system and as such, a total of 3,384 structures are in the 100-year floodplain with 324 in the floodway. The estimated value of structure and content values at risk is

$311 million (USACE, 2016). One of the flood mitigation techniques in the local MHMP and identified reconstruction of their levees as a high priority mitigation action. To reconstruct the levee to a 100-year standard would cost an estimated $37 million, while the 500-year standard would cost an estimated $39 million. In 2017, Miles City applied to FEMA for a Flood Mitigation Assistance Grant and was identified for further review.

Flooding of 2011 was also experienced along Pryor Creek, where significant infrastructure damage occurred near Huntley. The Crow Agency also experienced significant losses from the flooding of the Little Bighorn River along Interstate 90. In total, 31 of Montana's 56 counties were declared on a presidential disaster, and public infrastructure damage was estimated to be $8.6 million at the time.

June 2022 – Above-average late season snowpack, combined with warm temperatures and large amounts of rainfall caused record flooding in Stillwater, Carbon, and Park counties. The rivers most notably affected were the Yellowstone River, the Stillwater River, Rock Creek, Gardiner River, Clarks Fork of the Yellowstone, and Rosebud Creek. Many homes, businesses, and infrastructures were destroyed, most notably in Yellowstone National Park, Gardiner, Red Lodge, Laurel, and Livingston. Several bridges were damaged beyond repair and left hanging into the river. Entire houses, along with large debris were transported by the floodwaters. In Red Lodge, much of the community lost power, and a water main was compromised causing town water to be shut off (MTPR, *Montana Flood News Roundup*, 2022). Damage to transportation infrastructure was estimated to total $29 million, however, a complete record of flood damages has not become available for this event (Bozeman Daily Chronicle, *Montana Seeks Disaster Declaration for Flooding – Early Estimates Show at Least 29 Million in Damages,* 2022).

Entrances were closed in Yellowstone National Park because of the flooding after multiple roads were damaged between the north entrance near Gardiner, Mammoth Hot Springs, Lamar Valley, and Cooke City. The tourism industry for the park and the towns at each entrance was greatly impacted due to the road closures and repair work. In June 2022, the National Park Service designated $50 million to restore temporary access to Gardiner and Cooke City [NPS, *National Park Service announces $50 million in emergency funding,* 2022[2]]. Gardiner was isolated by the floodwaters and water levels overtopped the road at certain locations outside of Gardiner in the Yankee Jim Canyon.

Source: KPAX, 2022. Yellowstone River flooding.

Flash Flooding

Flash flooding is common in some areas of the state during the summer storm season. The best examples of this type of flooding have occurred in the Billings area . Flooding of the tributaries of the Yellowstone River has resulted from intense summer thunderstorms, typically short in duration, which produce high peak flows. Major flooding of this type occurred in 1923 and 1937 and continues to cause property damage in downtown Billings where there are inadequate storm drains to handle the runoff.

Flash flooding is also common along drainages in northwestern Montana during the summer storm season. Flash flooding can occur anywhere in Montana with slow moving thunderstorms and intense rain. Numerous people were killed in Terry at the turn of the century when a train was swept off its tracks by flash flooding. The most recent occurrence of flash flooding was in Helena in July of 2022, when a fast moving storm caused a flash flood down North Last Chance Gulch. The floodwaters deposited large amounts of mud, gravel, and dirt in and around the downtown Helena area.

Ice Jam Flooding

Montana has recorded more ice jam events than any other state in the United States, with over 4,500 ice jams reported since 1894 on 380 different streams. Ice jams occur most frequently in the months of February (20%) and March (43%) [USACE CRREL, 2022]. Recorded ice jams do not always indicate flooding occurred with the ice jam, just the presence of an ice jam and the increased risk of flooding. **Table 4.3-1** summarizes some of the damages caused by ice jams. The data is summarized from USACE Coldwater Regions Research and Engineering Laboratory's (CRREL) Ice Jam Database [USACE CRREL, 2022].

Table 4.3-1. Ice Jam Damages in Montana

Year	Degree of Damage
Loss of Life	
1894	Three men died while trying to escape ice jam flood waters in the Glendive area.
1899	12 people lost their lives to an ice-jam and flash flood in the Glendive area on the Yellowstone River. Three bridges were destroyed.
1996	A volunteer in Fort Benton collapsed and died from a heart attack as he was helping to load sandbags.
1996	Two died because of ice jam flooding on the Missouri River in Fort Benton.
Property Damage	
1881	Main Street in Miles City filled with water from an ice jam in March. Residents evacuated to higher ground for one week, which they spent in tents, waiting for the floodwaters to recede.
1899	$35,000 of estimate rural damage occurred in Sidney along the Yellowstone River.
1927	$27,400 of estimated rural damage occurred in Sidney along the Yellowstone River.
1939	Severe flooding and evacuations were reported in Glasgow along the Milk River.
1943	$484,800 of estimate rural damages occurred in Sidney and severe flooding in Savage, Glendive, and Fallon, all along the Yellowstone River.
1944	An ice jam on the Tongue and Yellowstone Rivers in Miles City caused 300 to 500 people to be evacuated from their homes. An estimated $85,600 of rural damages occurred in Sidney along the Yellowstone River.
1951	Severe flooding, evacuations, and damages on the scale of hundreds of thousands of dollars reported in Sidney along the Yellowstone River.
1959	Damages upwards of $55,000 from ice jam breakups reported in Sidney and West Glendive on the Yellowstone River.
1960	400 acres flooded and an estimated $15,000 of damage occurred in Bridger along the Clark Fork River.
1963	A truss bridge was destroyed in Logan on the Gallatin River as the result of an ice jam break-up.
1939	14,000 acres were flooded with an estimated $230,000 of damage in Sidney as the result of an ice jam break-up. A highway, sewage pump station, and oil well supply were flooded in Glendive along the Yellowstone River.
1971	A levee was almost lost to erosion in Miles City along the Yellowstone River as the result of an ice jam break-up.
1994	5 families were evacuated from ice jam flooding of the Milk River in Chinook. 60 cattle died because of ice jam flooding on the Yellowstone River in Glendive.
1996	Ice jams along the Blackfoot River caused bridge damage in Bonner, the loss of 2 houses and a bridge in Milltown, bridge destruction in Ovando, and estimated property damage of $510,000 in Ravalli County (mainly in Hamilton). Ice jam flooding of the Clark Fork River caused an estimated $200,000 of road damage in Thompson Falls. Flooding of Cottonwood Creek damaged 10 homes and a laundromat in Chester. A bridge was destroyed on the East Gallatin River in Belgrade. 4 homes were destroyed and 60 threatened along the Little Bighorn River within the Crow Agency.
2014	Power lost to 30 homes and residents were helicopter rescued in Glendive as a result of an ice jam break-up on the Yellowstone River.
Environmental Damage	
1996	Fish killed in the Blackfoot River by habitat destruction and disruption of spawning activity.
1996	Fish killed in Clark Fork River by ice jam scouring and releases of soils contaminated with toxic metals.

Figure 4.3-2 presents ice jam statistics for Montana communities and streams with data from the USACE CRREL. Most ice jams occur east of the Continental Divide with the most events occurring in Miles City (118), Bozeman (88), Culbertson (87), Wolf Point (82), and Browning (77). The most ice jams reported for one river have occurred on the Missouri River (412), followed by the Milk River (222), the Yellowstone River (211), and the Musselshell River (141), all east of the Continental Divide. West of the divide, ice jams occur most frequently on the Clark Fork River with 43 events. The CRREL data indicated many ice jams at the International Boundary with no specific location; as such, these events were not included in **Figure 4.3-2**. Ice jams attributed to the place referred to as "Locate" were also not charted as there is no location in Montana by that name.

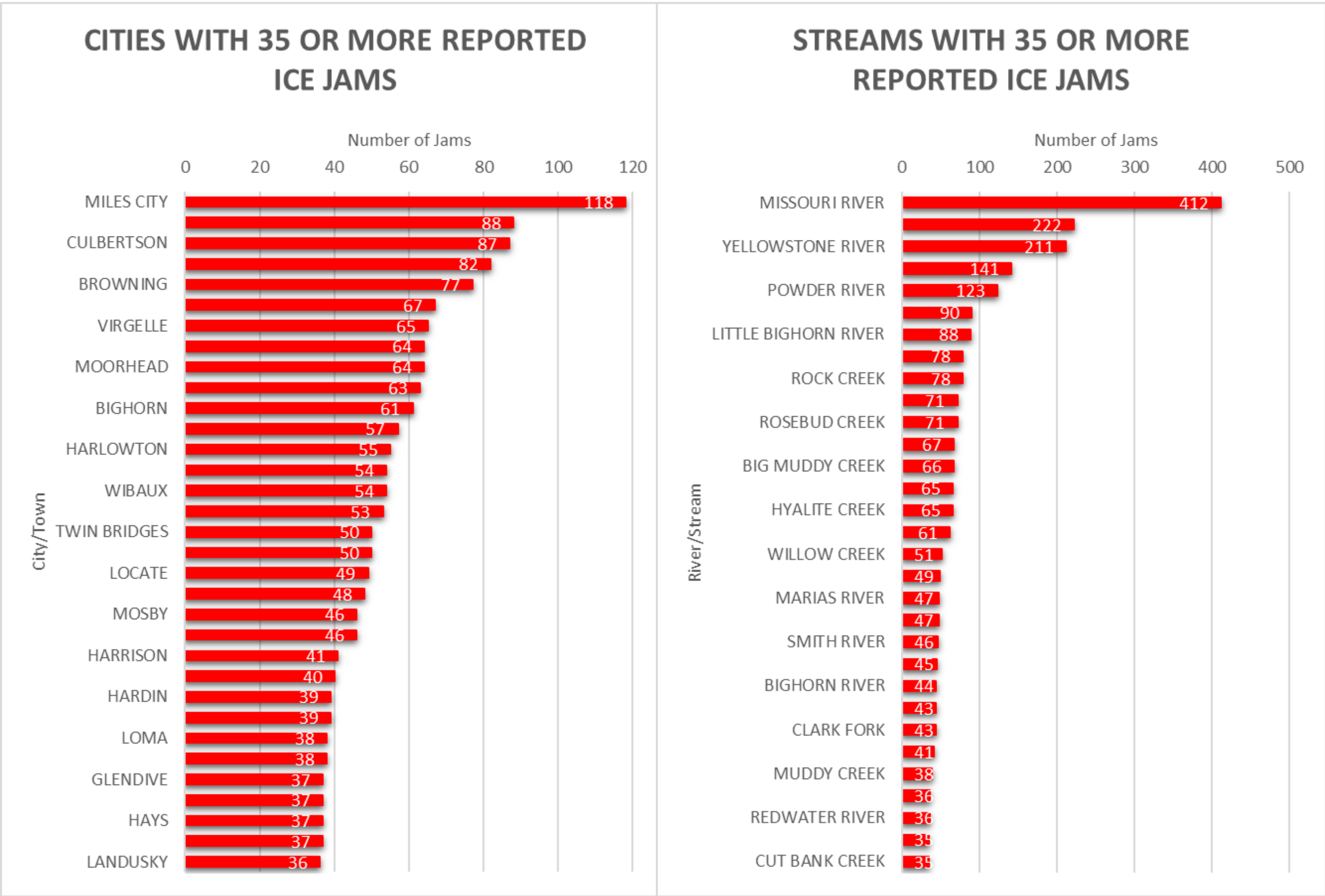


Figure 4.3-2. Montana cities (left) and streams (right) with the most reported ice jams.

Post-Fire Debris Flows

2000-2001 – Following the wildfires in the summer of 2000, Montana experienced debris flows in two post-fire burned areas: the Bitterroot area in southwestern Montana, the Canyon Ferry area near Helena, and the Ashland area in southeastern Montana. The spring and summer of 2000 were unusually warm and dry across Montana, with precipitation totals ranging from 47-58 percent of normal. By the end of July, large wildfires were burning in much of western Montana and in forested areas of eastern Montana [USGS, 2001].

Source: USGS, 2001. Debris flow channel at an unnamed tributary to Sleeping Child Creek.

The debris flows in the Bitterroot began in September 2000, when daily precipitation with a recurrence interval of approximately 10 years resulted in debris flows and peak flood discharges on Sleeping Child Creek with a recurrence interval of about 100 years. This same creek experienced debris flows again in July 2001, after thunderstorms caused debris flow activity on small, steep tributaries to Sleeping Child Creek. The flood recurrence intervals for the small tributaries ranged from 200–500-year intervals for the peak discharges.

The Canyon Ferry area experienced debris flows after a series of thunderstorms from May through July in Cave Gulch, Crittenden Gulch, Magpie Creek, and Hellgate Gulch. Crittenden Gulch had two major debris flood events, the first occurred on May 28 with an approximate flood recurrence interval of 50 years, and the second occurred on July 17 with a flood recurrence interval of 200 years.

The debris flows in the Ashland area occurred in response to severe thunderstorms in June and July of 2000. Several Otter Creek and Tongue River tributaries that drained previously burnt areas suffered severe flooding with heavily sediment laden waters. Most of the streams that flooding in June and July drained basins that were burnt in 2000. One tipping-bucket rain gage installed near the headwaters of Paget Creek recorded 0.56 inches of rain in 5 minutes, and a storm total of 0.95 inches in 30 minutes during the June thunderstorm events. Resulting recurrence intervals for the 16 gaged sites were calculated to be greater than 50 years for the peak discharges.

2013 – Heavy rain cased debris flows in Bear Trap Canyon in the Madison Valley onto the roadway and hiking trail. Access to the canyon was restricted until the storms subsided. These debris flows occurred in the burn scar caused by the 2012 Bear Trap Fire [Bozeman Daily Chronicle, *Mudslides a threat in Bear Trap Canyon*, 2013].

2019 – A debris flow and two landslides occurred in the headwaters of Dunham Creek, a tributary to the Blackfoot River. A large plume of debris was deposited into the Blackfoot River, and a road was damaged. These events resulted from the 2017 Rice Ridge Fire [Missoulian, *Debris flow damages road sends plume into Blackfoot River*, 2019].

2021 – Debris flows following an intense rainstorm occurred in the Monture area near Seeley Lake. The debris flows occurred as a result of 2017 Dry Cabin Fire post-burn conditions, the intense rain, and steep slopes. Debris flows occurred within the tributaries of Spread, Falls, Bill, and Yellowjacket Creeks. Debris was piled 15-20 feet high in some locations. No injuries or fatalities occurred; however, several businesses were impacted by the debris flows and several campers were stuck behind the debris until it was cleared [Montana Outdoor, *Damaging debris flows close Monture Creek Trail*, 2021].

Declared Disasters

Since 1974 there have been 18 federal disaster declarations in Montana with over $__ million in public assistance granted. Montana counties with federal disaster declarations for flood events are shown in **Table 4.3-2.** Federal public assistance funding amounts were obtained from FEMA [FEMA, 2022[8]]. In the same time period, 60 state disaster declarations have occurred, with over $_ million in public assistance granted. Montana counties with state disaster declarations are shown in **Table 4.3-3**. A description of recent flood disasters follows these tables. State and local public assistance funding totals were obtained from Montana Department of Emergency Services [].

Table 4.3-2. Federal Disaster Declarations for Flooding (1974-2022).

Year	Federal Declarations	Counties/Reservations	Public Assistance			
			Federal	State	Local	Total
1974	FDAA-417-DR-MT	Deer Lodge, Flathead, Glacier, Lincoln, Mineral, Missoula, Sanders	$603,144	-	-	$603,144
1975	FDAA-472-DR-MT	Broadwater, Cascade, Fergus, Flathead, Glacier, Jefferson, Judith Basin, Lewis & Clark, Meagher, Pondera, Powell, Teton, Toole, Wheatland	$2,070,551	-	-	$2,070,551
1978	FDAA-558-DR-MT	Big Horn, Carbon, Powder River, Rosebud, Stillwater, Sweet Grass, Treasure, Yellowstone	$3,838,126	-	-	$3,838,126
1981	FEMA-640-DR-MT	Broadwater, Cascade, Gallatin, Granite, Jefferson, Lewis & Clark, Meagher, Missoula, Powell, Silver Bow	$4,339,082	$762,796	$313,286	$5,415,164
1986	FEMA-761-DR-MT	Chouteau, Daniels, Dawson, Deer Lodge, Fergus, Glacier, Granite, Liberty, Petroleum, Phillips, Pondera, Powell, Sanders, Teton, Toole, Valley	$1,497,290	$177,421	$321,673	$1,996,384
1986	FEMA-777-DR-MT	Blaine, Garfield, McCone, Phillips, Rosebud, Valley	$893,564	$35,021	$262,829	$1,191,414
1996	FEMA-1105-DR-MT	Chouteau, Deer Lodge, Gallatin, Jefferson, Lewis & Clark, Lincoln, Meagher, Mineral, Missoula, Park, Powell, Ravalli, Sanders, Silver Bow	$1,820,739	$241,888	$365,006	$2,427,633
1996	FEMA-1113-DR-MT	Blaine, Flathead, Hill, Liberty, Phillips, Toole	$1,480,471	$179,892	$313,594	$1,973,957
1997	FEMA-1183-DR-MT	Broadwater, Carbon, Dawson, Deer Lodge, Flathead, Judith Basin, Lincoln, Madison, Meagher, Missoula, Musselshell, Park, Prairie, Ravalli, Richland, Roosevelt, Sanders, Sweet Grass, Treasure, Valley, Wheatland, Yellowstone, Flathead Reservation	$5,762,964	$544,458	$1,379,520	$7,686,942
2010	FEMA-1922-DR-MT	Hill, Chouteau	$517,982	$94,141	$77,185	$689,308
2010	FEMA-1922-DR-MT	Rocky Boy's Reservation	$6,196,753	-	$24,000,000	$30,196,753
2011	FEMA-1996-DR-MT	48 Counties, 5 Reservations	$33,593,227	$8,380,000	$2,784,000	$44,757,227
2013	FEMA-4127-DR-MT	Hill, Blaine, Chouteau, Custer, Dawson, Fergus, Garfield, McCone, Musselshell, Petroleum, Rosebud, Valley Counties, Rocky Boy's, Fort Belknap, Fort Peck Reservations.	$2,847,969	$643,852	$298,895	$3,790,716
2014	FEMA-4172-DR-MT	Broadwater, Dawson, Golden Valley, Jefferson, Lake, Musselshell, Park, Pondera, Prairie, Ravalli, Richland, Rosebud, Sanders, Stillwater, Wheatland	$2,774,453	$155,243	$482,702	$3,412,398
2018	FEMA-4388-DR-MT	Blaine, Hill, Liberty, Pondera, Toole, and Valley	$1,924,380	-	-	$1,924,380
2018	FEMA-4405-DR-MT	Carbon, Custer, Golden Valley, Lewis and Clark, Missoula, Musselshell, Park, Powell, Treasure	$1,648,425	-	-	$1,648,425

2019	FEMA-4437-DR-MT	Daniels, Lake, McCone, Park, Powder River, Stillwater, Treasure, Valley	$1,017,426	-	-	$1,017,426
2022	FEMA-4655-DR-MT	Carbon, Flathead, Park, Stillwater, Sweet Grass, Treasure, Yellowstone	$578,254	-	-	$578,254
TOTAL			$73,404,799	$11,214,712	$30,598,690	$115,218,201

Table 4.3-3. State Emergency Declarations for Flooding (1976-2022).

Year	State Declaration	County/City/Town	Public Assistance		
			State	Local	Total
1976	PA-ST-76-1	Froid (Roosevelt)	$31,268	$718	$31,986
1978	EO-13-78; PA-ST-78-11	Winnett (Petroleum)	$16,442	$238	$16,680
1978	EO-13-78; PA-ST-78-12	Petroleum County	$119,279	$25,638	$144,917
1979	PA-ST-79-10	Denton (Fergus)	$97,048	$885	$97,933
1979	PA-ST-79-11	Petroleum County	$85,544	-	$85,544
1980	EO-4-80; PA-ST-80-1	Lake County	$8,320	$47,102	$55,422
1984	PA ST-84-2	Beaverhead County	$388,784	$23,699	$412,483
1984	PA ST-84-1	Madison County	$191,245	$27,860	$219,105
1991	EO-12-91; MT-1-91	Teton County	$74,191	$25,622	$74,191
1991	EO-15-91; MT-2-91	Blaine County	$54,203	$23,130	$77,333
1991	EO-24-91; MT-3-91	Richland County	$442,065	$46,097	$488,162
1991	EO-33-91; MT-4-91	Blaine County	$49,882	-	$49,882
1993	EO-11-93; MT-1-93	Custer County	$105,630	$15,910	$121,540
1994	EO-04-94; MT-1-94	Petroleum County	$59,179	$4,099	$63,278
1994	EO-05-94; MT-2-94	Winnett (Petroleum)	$4,977	$240	$5,217
1995	EO-1-95; MT-1-95	Lima (Beaverhead)	$38,994	$385	$39,379
1996	EO-12-96; MT-1-96	Sweet Grass County	$29,899	$18,364	$48,263
1996	EO-12-96; MT-2-96	Park County	$107,445	$38,934	$146,379
1996	EO-12-96; MT-3-96	Livingston (Park)	$18,399	$17,888	$36,287
1996	EO-12-96; MT-4-96	Stillwater County	$27,876	$38,454	$66,330
1996	EO-12-96; MT-5-96	Miles City (Custer)	$11,024	$14,844	$25,868
1997	EO-4-97; MT-2-97	Miles City (Custer)	$41,788	$15,842	$57,630
1997	EO-14-97; MT-3-97	Libby (Lincoln)	$57,549	$6,434	$63,983
1997	EO-16-97; MT-4-97	Wolf Point (Roosevelt)	$13,833	$3,994	$17,827
1998	EO-10-98; MT-1-98	Custer County	$21,993	$17,982	$39,975
1998	EO-10-98; MT-2-98	Hill County	$134,124	$47,550	$181,674
1998	EO-10-98; MT-3-98	Jefferson County	$50,453	$45,260	$95,713
1998	EO-10-98; MT-4-98	Roosevelt County	$110,899	$46,552	$157,451
1998	EO-10-98; MT-5-98	Culbertson (Roosevelt)	$15,474	$1,184	$16,658
1999	EO-3-99; MT-1-99	Daniels County	$546,305	$10,062	$556,367
2001	EO-19-01; MT-1-01	Custer County	$56,322	$15,424	$71,746
2003	EO-5-03; MT-1-03	Roosevelt County	$14,260	$92,898	$107,158
2005	EO-09-05; MT-1-05	Sweet Grass County	$148,159	$27,782	$175,941
2005	EO-11-2005; MT-2-05	Chouteau County	$220,826	$3,218	$224,044
2005	EO-11-2005; MT-3-05	McCone County	$89,311	$35,496	$124,807

2005	EO-11-2005; MT-4-05	Ronan (Lake)	$303,517	$10,524	$314,041
2005	EO-15-2005; MT-5-05	Dawson County	$80,729	$21,200	$101,929
2006	EO-39-06; MT-2-06	Ravalli County	$184,576	$143,374	$327,950
2007	EO-13-07; MT-2-07	Nashua (Valley)	$4,364	$390	$4,754
2007	EO-13-07; MT-3-07	Glasgow (Valley)	$144,492	$5,082	$149,574
2007	EO-13-07; MT-4-07	Melstone (Musselshell)	$600	$400	$1,000
2008	EO-34-2008; MT-2-08	Livingston (Park)	$255,237	$48,356	$303,593
2009	EO-6-2009; MT-1-09	Brockton (Roosevelt)	$6,473	$160	$6,633
2009	EO-8-2009; MT-2-09	Custer County	$32,184	$17,067	$49,251
2010	EO-16-2010; MT-1-10	Custer County	$90,824	-	$90,824
2010	EO-20-2010; MT-2-10	Dawson County	$44,409	$23,738	$68,147
2010	EO- 21-2010; MT-3-10	Roosevelt County	$32,209	$36,732	$68,941
2010	EO- 21-2010; MT-4-10	Petroleum County	$72,940	$3,136	$76,076
2011	EO-3-2011; MT-1-11	Libby (Lincoln)	$68,165	$5,570	$73,735
2014	EO-3-2014; MT- 01-14	Manhattan, (Gallatin)	$59,479	$5,276	$64,755
2015	EO-07-2015; MT-01-15	Powder River County	$198,071	$17,914	$215,985
2017	EO-04-2017; MT-06-2017	Daniels County	$178,451	$11,898	$190,349
2018	EO-11-2018	Fort Belknap Indian Reservation, Town of Chester, Pondera, Hill, Blaine, Valley, Toole, Liberty, Petroleum			
2018	EO-11-2018	Chester (Liberty)			
2018	EO-20-2018	Cascade County, Lewis and Clark County, Great Falls (Lewis and Clark)			
2019	EO-5-2019	Crow Indian Reservation, Town of Broadus (Powder River), Counties: Daniels, Lake, McCone, Park, Powder River, Stillwater, Treasure, Valley			
2019	EO-13-2019	Teton County			
2022	EO-4-2022	Carbon County, Park County, Stillwater County			
TOTAL			$5,239,710	$1,090,602	$6,304,690

2010 Presidential Flood Disaster - Between June13-17, 2010, the Rocky Boy's Reservation in Hill and Choteau Counties received 4.8 inches of precipitation which caused major flooding. The floods left 300 homes without running water on the reservation and caused major disruption to daily life. Thirty (30) families were evacuated, and eight miles of water lines were destroyed. More than 200 homes were without drinking water and about 500 housing units had water damage. In addition, flood waters destroyed many bridges, culverts, and driveways.

The main concern was the road leading to the health clinic and tribal offices which was destroyed. Rushing waters moved the $12 million clinic several inches, damaging a weight-bearing wall and rendering the facility a total loss. A Presidential disaster declaration was received and $30.2 million in public assistance was granted.

2011 Presidential Flood Disaster - A Presidential disaster declaration was declared on June 17, 2011, for the State of Montana. Flooding resulting from heavy rains (4-10 inches in 24 hours) and run off from snow melt of record snows occurred throughout the state. Out of the 56 counties, 46 were affected along with 6 of the 7 Tribal Nations. Damages were over $60 million statewide.

Roundup was one of the hardest-hit towns as record flooding struck twice in two weeks forcing residents to flee homes as the Musselshell River gushed into low-lying neighborhoods. Cars and trucks left behind were nearly submerged, and the ground floors of some homes were swamped by the river before it began receding. Officials evacuated between 30 and 35 residences and businesses on the southern end of town. It was a repeat of a scene that occurred two weeks prior when the Musselshell flooded dozens of homes and businesses in Roundup. Much of the town was inundated for almost a week.


Source: **Bozeman Daily Chronicle, 2011.** Musselshell flooding in Roundup.

Flood warnings also covered much of the rest of the state, stretching from southwestern Missoula to northeastern Glasgow. The Lewis and Clark County Commission declared a flood emergency and officials issued an evacuation advisory for at least a half-dozen homes in East Helena. Upstream from Missoula, the Clark Fork River rose two feet above major flood stage, threatening East Missoula homes and roadways in the area.

2013 Presidential Flood Disaster - A disaster was declared on July 10, 2013, due to flooding which resulted from heavy rains. Near record amounts of rain caused infrastructure damage for 8 counties and 3 Tribal Nations. Damages were almost $3.8 million.

2014 Presidential Flood Disaster - A rain on snow event in March 2014 caused wide-spread flooding in 15 counties. A blizzard the week before dumped a massive amount of snow on the state and then warm temperatures and a half-inch of rain caused numerous flash floods. The Ravalli County town of Florence was particularly hit hard due to a high density of homes in the high-water zone.

2018 Presidential Flood Disasters - A presidential disaster was declared on August 30, 2018, as a result of flooding from rapid melting of an above average snowpack. The declaration applied to Blaine, Hill, Liberty, Pondera, Toole, and Valley Counties, with an estimated total damage of over $3.3 million. A second presidential disaster was declared on October 31, 2018, for Carbon, Custer, Golden Valley, Lewis and Clark, Missoula, Musselshell, Park, Powell, and Treasure Counties. This declaration came as the result of rapid flooding caused by rain on snow events. The estimated total damage was over $1.5 million [FEMA, 2022[3]].

2019 Presidential Flood Disaster: Ice jams on the Milk and Yellowstone Rivers cause wide-spread flooding in Daniels, Lake, McCone, Park, Powder River, Stillwater, Treasure, and Valley Counties from March through April. A presidential disaster was declared on May 24, 2019, with an estimated total damage of over $2.2 million.

2022 Presidential Flood Disaster: A major disaster declaration occurred on June 16, 2022, for Carbon, Flathead Park, Stillwater, Sweet Grass, Treasure, and Yellowstone Counties. The flooding was caused by a large late-season snowpack, warm temperatures, and above average rainfall events. 328 individual assistance applications have been approved as of October 2022.

NATIONAL FLOOD INSURANCE PROGRAM

The National Flood Insurance Program (NFIP) is the primary insurer for flood insurance in the United States. Currently, there are 136 Montana communities that participate in the NFIP. Of these, 11 have no special flood hazard and 31 are minimally flood prone [FEMA, 2022[2]]. According to the Montana Risk Rating 2.0, as of May 28, 2021, Montana had 4, 339 policies in-force. As of August 9, 2022, the NFIP has paid over $15.2 million associated with 3,521 policies of insured properties [FEMA 2022[1]]. Counties and cities with the highest flood insurance claims are shown below in **Table 4.3-4.** Note that although flood insurance claims are being used to show past losses, this data is not an entirely accurate representation of flood losses. Many homeowners without flood insurance may have sustained flood damages and those losses would not be reflected in these figures.

Table 4.3-4. Communities with highest Flood Insurance Claims (1978-2022).

County	Insurance Claim Amount	Cities	Insurance Claim Amount
Yellowstone County	$1,814,878	Roundup (Musselshell Co.)	$850,775
Valley County	$1,590,366	Miles City (Custer Co.)	$373,972
Musselshell County	$1,201,833	Billings (Yellowstone Co.)	$371,541
Carbon County	$1,089,354	Red Lodge (Carbon Co.)	$275,717
Missoula County	$976,035	Bozeman (Gallatin Co.)	$166,389

Eight (8) communities in Montana do not participate in the NFIP, shown in **Table 4.3-5**. According to FEMA, all eight have been identified in a flood hazard area [FEMA, 2022[2]].

Table 4.3-5. Counties & Communities Not Participating in NFIP (2022).

Counties	Cities/Towns
Garfield County	Grass Range, Town of (Fergus)
McCone County	Poplar, City of (Roosevelt)
Prairie County	Thompson Falls, Town of (Sanders)
Wibaux County	Sunburst, Town of (Toole)

The Biggert-Waters Flood Insurance Reform Act of 2012 was signed into law on July 6, 2012, calling for changes to the NFIP to make it more sustainable. Key provisions of the legislation will require the NFIP to raise rates to reflect true flood risk, make the program more financially stable, and change how Flood Insurance Rate Map (FIRM) updates impact policyholders. On March 21, 2014, President Obama signed the Homeowner Flood Insurance Affordability Act of 2014 into law. This law repeals and modifies certain provisions of the Biggert-Waters Flood Insurance Reform Act and makes additional program changes to other aspects of the program not covered by that Act [FEMA, 2022[7]].

Montana has 118 communities with repetitive losses, and 121 repetitive loss buildings, 23 of which are insured [FEMA, 2022[9]]. Most communities' repetitive losses are not in currently mapped flood zones. A repetitive loss property is any insurable building for which two or more claims of more than $1,000 were paid by the NFIP within any rolling ten-year period, since 1978. Valley County has had the majority of these (54) followed by Yellowstone County (36). There are no Severe Repetitive Loss (SRL) properties in the State. Severe repetitive loss properties have had at least four NFIP claim payments over $5,000 each and the cumulative amount exceeding $20,000; or, where at least two separate claim payments have been made with the cumulative amount exceeding the market value of the building. A summary of these communities with the highest number of NFIP repetitive losses are shown below in **Table 4.3-6**. The data below was provided by FEMA's NFIP [FEMA, 2022[9]].

Table 4.3-6. Communities with Highest Number of NFIP Repetitive Losses as of 08/2022.

Community	RL Buildings	RL Buildings Insured	RL Losses Total	RL Losses Insured	$ Losses Total	$ Losses Insured
Blaine County	1	0	3	0	$72,744	$9,947
Billings, City of	6	1	13	2	$70,222	$8,863
Bozeman, City of	2	0	4	0	$75,476	$0
Broadus, Town of	1	0	2	0	$8,075	$0
Carbon County	3	0	7	0	$76,357	$0
Cascade County	6	2	13	5	$151,182	$9,478
Dawson County	1	0	2	0	$137,967	$0
Fergus County	1	0	3	0	$129,158	$0
Flathead County	6	0	7	0	$89,603	$0
Gallatin County	1	1	2	2	$13,001	$13,001
Glasgow, City of	2	0	5	0	$104,066	$0
Great Falls, City of	3	0	6	0	$19,334	$0
Hill County	1	1	2	0	$23,227	$23,227
Lake County	1	0	2	2	$7,359	$0
Laurel, City of	1	0	2	0	$3,762	$0
Lewis and Clark County	7	2	15	4	$110,881	$17,585
Lewistown, City of	1	1	2	2	$6,620	$6,620
Lincoln County	3	1	6	2	$84,452	$25,664
Livingston, City of	1	0	2	0	$8,862	$0
Meagher County	1	0	2	0	$56,021	$0
Missoula County	11	2	25	4	$243,091	$13,769
Missoula, City of	1	0	2	0	$9,837	$0
Musselshell County	1	0	3	0	$79,199	$0
Park County	9	1	18	1	$519,032	$2,250
Phillips County	2	0	4	0	$15,605	$3,318
Ravalli County	3	2	4	2	$32,578	$0
Roundup, City of	7	2	16	5	$559,789	$249,744
Saco, Town of	1	0	1	0	$12,069	$0
Townsend, City of	1	0	2	0	$13,604	$0
Valley County	23	1	54	2	$906,283	$227,507
Yellowstone County	13	6	36	19	$665,533	$371,558
TOTAL	121	23	265	52	$4,304,989	$982,531

Montana's strategy to reduce NFIP repetitive losses involves identifying willing and voluntary homeowners wanting to mitigate their repetitive loss structures, utilizing previously implemented mitigation techniques, and developing projects for those homeowners. The State succeeded in the acquisition of seven substantially damaged homes and one business from the floods of 2011, 2013, and 2014 (DR-1996, DR-4127 and DR-4198) and considers this considerable progress since no acquisitions/elevations had been done in Montana in well over 15 years. Acquisitions were made within the City of Deer Lodge (Powell County), the City of Missoula (Missoula County), Musselshell County, and in Fergus County. In locations with higher housing values, acquisitions can be difficult because often the value of the properties exceeds the awarded grant money to buy out more than a few properties, which is what occurred in Missoula after the 2018 flood. In locations with low housing values, acquisitions can be difficult because the house values are not worth enough to make it feasible to move the residents, which occurred in Harlem (Blaine County).

Valley, Yellowstone, Missoula, and Park Counties together have had over 50 percent of the NFIP repetitive losses for the state and will remain as viable targets for Repetitive Loss Strategy actions in the foreseeable future. Floodplain mitigation planning work has already been completed in these communities. Section 6.0, *Capabilities Assessment*, discusses the State's intention to utilize the FEMA Flood Mitigation Assistance (FMA) grant as part of its Repetitive Loss Strategy.

The NFIP Community Rating System (CRS) is a voluntary incentive program that recognizes and encourages community floodplain management activities that exceed the minimum NFIP requirements. CRS discounts on flood insurance premiums range from 5 percent up to 45 percent. Those discounts provide an incentive for new flood protection activities that can help save lives and property in the event of a flood. To participate in the CRS, a community can choose to undertake some of the 18 public information and floodplain management activities. Based on the total number of points a community earns, the CRS assigns you to one of ten classes. The discount on flood insurance premiums is based on your class. **Table 4.3-7** presents the Montana communities that participate in the CRS [FEMA, 2022[1]].

Table 4.3-7. Community Rating System Eligible Communities as of 08/2022.

Community Name	Current Effective Date	Current Class (% Discount)	Community Name	Current Effective Date	Current Class (% Discount)
Belt, Town of	10/1/1992	8 - (10%)	Lewis and Clark	10/1/2002	8 - (10%)
Bozeman, City of	10/1/2009	8 - (10%)	Miles City, City of	1/4/2022	8 - (10%)
Cascade County	5/1/2013	8 - (10%)	Missoula, City of	10/1/2019	8 - (10%)
Circle, Town of	5/1/2015	10 - (0%)	Missoula County	10/1/2017	7 - (15%)
Flathead County	10/1/2007	8 - (10%)	Three Forks, Town	10/1/1998	8 - (10%)
Gallatin County	1/4/2022	8 - (10%)	Yellowstone	4/1/2022	8 - (10%)
Great Falls, City	10/1/2017	7 - (15%)			

FREQUENCY/LIKELIHOOD OF OCCURRENCE

Probability is based on hazard frequency over a 10-year period. The MHMP Planning Team rated flooding as "Likely". A likely rating indicates that flooding will not likely occur every year but will occur more than once every 10 years. The *Climate Change* section discusses the potential change in frequency of flooding associated with the changing climate.

CLIMATE CHANGE CONSIDERATIONS

Many scientists agree that climate change will increase heavy rainfall and storms across the U.S., which may increase water levels and lead to a higher frequency of flooding. Temperature change increases will also change how much precipitation falls as rain and the timing of snowpack melt. The Montana Climate Assessment (2017) provides a well-referenced discussion on the effects of climate change on flooding, as summarized below.

Across Montana, future precipitation is projected to increase during the winter, spring, and fall, with the largest increases to be experienced in the southern part of the state in the spring. Slight decreases in precipitation are expected during the summer months throughout the entire state. The climate assessment also projects a 30% larger potential for more days of extreme precipitation events.

Table 4.3-8 presents counties with the highest projected mean 1-inch rain days at mid- and end- of century according to the low- and high-emission scenarios from NOAA Climate Explorer data [NOAA, 2022[2]]. The data projects that by the end of the century, several counties in western Montana are expected to receive more 1-inch rain days which could mean increased flooding since increases in precipitation are projected to occur in the spring compared to other seasons.

Table 4-3-8. Counties with Projected Highest Number of Mean Days with 1-Inch Rain at Mid- and End-Century.

County	Observed Mean 1950-2006 (Days/Yr)	Low Emission Scenario (Days/Yr)	Change from Observed (Days/Yr)	High Emission Scenario (Days/Yr)	Change from Observed (Days/Yr)
Mid-Century (2050)					
Flathead	3.8	4.3	0.49	4.7	0.89
Missoula	2.8	2.9	0.13	3	0.23
Park	1.6	1.6	-0.03	1.6	-0.03
Carbon	1.5	1.6	0.13	1.8	0.33
Cascade	1.0	1.3	0.3	1.2	0.2
Stillwater	1.2	1.2	0	1.3	0.1
Custer	0.8	1.1	0.3	0.7	-0.1
Richland	0.8	1.1	0.3	0.8	0
Blaine	0.7	1	0.3	0.8	0.1
Treasure	0.6	0.8	0.2	0.5	-0.1
Roosevelt	0.7	0.8	0.1	0.8	0.1
Rosebud	0.6	0.8	0.2	0.6	0
Musselshell	0.6	0.7	0.1	0.7	0.1
Yellowstone	0.7	0.6	-0.1	0.5	-0.2
Valley	0.6	0.6	0	0.7	0.1
End of Century (2099)					
Flathead	3.81	4.5	0.69	5.9	2.09
Missoula	2.77	2.9	0.13	4	1.23
Park	1.63	2.2	0.57	2.3	0.67
Carbon	1.47	2	0.53	2.4	0.93
Stillwater	1.2	1.7	0.5	1.9	0.7
Cascade	1	1.3	0.3	1.4	0.4
Richland	0.8	1	0.2	1.2	0.4

Custer	0.8	0.9	0.1	0.9	0.1
Blaine	0.7	0.85	0.15	0.8	0.1
Musselshell	0.6	0.8	0.2	0.8	0.2
Roosevelt	0.7	0.7	0	1	0.3
Yellowstone	0.7	0.6	-0.1	0.9	0.2
Treasure	0.6	0.6	0	0.8	0.2
Rosebud	0.6	0.6	0	0.8	0.2
Valley	0.6	0.5	-0.1	0.6	0

Source: NOAA 2022[2]. Notes: The low-emissions scenario assumes that global emissions of the greenhouse gases than cause changes in climate conditions peak in the year 2040 and then decline. The high-emissions scenario assumes that global emissions of greenhouse gases remain largely unabated through the 21st century.

Both annual and seasonal temperature increases are projected across Montana. Larger average monthly temperature increases are expected for summer and winter months than those in the fall and spring. The average mid-century temperature increase for the state is projected to be 4.5 °F in the low emission scenario and 6.0 °F in the high emission scenario. The average end-of-century temperature increase is projected to be 5.6 °F in the low emission scenario and 9.8 °F for the high emission scenario [Whitlock C., et al, 2017].

The climate assessment results presented above provide a large range in how the severity of flood risk change could change in response to climate change. The first scenario that could result from these climate change predictions is that of low flood risk. Increased warming throughout the winter months could reduce the mountain snowpack and therefore decrease the amount of water stored as snow available for melt in rain-on-snow events. The second scenario that could result is a combination of warming increasing the temperature of the snowpack and higher spring precipitation falling as rain. This combination will accelerate snowmelt and increase the volume of water available for flooding when a rain-on-snow event occurs. The severity of both scenarios depends on antecedent snowpack snow water equivalent, soil moisture, aspect, slope, and other conditions. These potential rain-on-snow events will be difficult to predict because they will be location-and event-specific.

There is considerable uncertainty surrounding future flood risk in response to climate change, and some research suggests that extreme precipitation events can intensify more quickly than what is projected by general circulation models. Additionally, flood risk depends on specific storm characteristics that are difficult to capture in most models. Moreover, the effects of projected changes in temperature and precipitation on flood risk will depend on location, elevation, and antecedent weather conditions, and human practices [Whitlock C., et.al, 2017]. Runoff patterns may change, resulting in flooding of areas that historically have not flooded. Because of this, population, property, and critical facility flood exposure may increase.

The significance of increased flooding is great. In addition to the social and economic impacts to communities, destruction of housing and infrastructure, and fatalities; floods pose a risk to contamination of drinking water, chemical or hazardous material spills, and impacting critical municipalities such as wastewater treatment. Resultant effects of contamination often impact the surrounding environment, such as the pollution of aquatic and terrestrial vegetation and introduction of the spread of disease to animals. In summary, if flooding is to increase from climate change it may pose risks to individual and public health, environmental health, communities' social and economic well-being, and existing infrastructure.

POTENTIAL MAGNITUDE AND SEVERITY

The magnitude of a flood event can be measured in terms of severity; how much precipitation occurred and under what conditions, how many evacuations were required, and level of response necessary. Hydrologists often use terms like "100-year flood" or "500-year flood" to convey the flood's magnitude. These numbers are developed by extrapolating historical data to longer time periods. The term "100-year flood" means that, in any given year there is a one in 100 chance of a flood of that magnitude. In other words, the probability of a flood of that magnitude in any given year is 1/100 or 1 percent. The actual amount of water that causes a particular flood (e.g., a 100-year flood) varies from river to river.

NOAA's data on Montana's flood losses dated from 1996 to 2022 (adjusted for inflation) indicate there have been 6 fatalities (but all fatalities may not have been recorded) and $43 million in property damage across the state [NOAA, 2022[1]]. FEMA has paid a total amount of over $15 million in loss coverage for property owners in the NFIP as of August 9, 2022. This loss coverage is based on the period of record since each property was incorporated into the NFIP [FEMA, 2022[6]]. In addition to property damage, the USDA estimates over $22 million in crop damage from 1989 - June 2022 [USDA, 2022]. **Table 4.3-9** summarizes counties with the highest amount of property and crop damage on record for insured properties and crops. Insured crop values were obtained from USDA's Cause of Loss database [USDA, 2022], and insured property values were received from FEMA's NFIP [FEMA, 2022[6]]. Crop losses include the record from 1989-2022, and property losses include all recorded property losses since a property joined the NFIP.

Table 4.3-9. Top 30 Counties with Flood Losses (2022 Dollars).

County	Property Loss	Crop Loss	County	Property Loss	Crop Loss
Yellowstone	$1,814,878	$945,746	Blaine	$71,266	$438,716
Valley	$1,590,366	$821,659	Richland	$96,344	$412,251
Park	$2,227,355	$10,397	Big Horn	$245,117	$246,431
Cascade	$860,925	$371,877	Lewis and Clark	$432,257	$30,065
Musselshell	$1,201,833	$20,722	Lincoln	$446,923	$0
Carbon	$1,089,354	$43,021	Sweet Grass	$431,524	$1,273
Missoula	$976,035	$296	Fergus	$243,625	$130,102
Stillwater	$915,175	$13,891	Phillips	$173,304	$161,268
Treasure	$0	$800,484	Gallatin	$323,244	$5,253
Roosevelt	$59,145	$725,660	Sanders	$223,490	$0
Rosebud	$15,452	$745,388	Dawson	$144,610	$52,875
Flathead	$690,321	$22,802	Chouteau	$0	$172,569
Custer	$400,061	$209,773			

VULNERABILITY ASSESSMENT

Flooding becomes a hazard when people compete with nature for the use of floodplains. If floodplain areas were left in their natural state, flooding would not cause major damage. Urban, industrial, and other surface development in natural floodplain areas of Montana has increased the vulnerability to serious flooding. The extent of artificial surface area created by development prevents rainfall from soaking into the ground and increases the rate of runoff.

Vulnerability to flooding is also dependent on local weather conditions and site-specific flood water constraints. Some areas can be completely immune to flooding because the steeply incised riverbanks have physically impeded development near the river, limiting flood damage when floodwaters arrive. Other areas experience flooding annually where meandering rivers have created broad floodplains and development has encroached and impeded floodwaters. Because local conditions have a significant impact on the vulnerability to flooding, historic data on occurrence and loss is the best means to assess flooding vulnerability statewide.

There are increased risks of flash flooding and debris flows in Montana because of recent active fire seasons. In general, post-fire debris flow risk lasts for two to five years after the fire event. After that period, the vegetation regrowth and soil recovery increase water absorption and significantly lower the post-fire risks [Montana DNRC, 2022]. Locations downhill and downstream from burned areas are most susceptible, especially near steep terrain. Rainfall that would normally be absorbed will run off extremely quickly after a wildfire, as burned soil can be as water repellant as pavement. As a result, much less rainfall is required to produce a flash flood. As water runs downhill through burned areas it can create major erosion and pick up large amounts of ash, sand, silt, rocks and burned vegetation. The force of the rushing water and debris can damage or destroy culverts, bridges, roadways, and buildings even miles away from the burned area [NWS, 2013].

Some current burn scars/areas of concern in Montana are from the following fires [NWS, 2022]:

- Bobcat and Peterson fires in Musselshell County,
- Crooked Creek Fire in Big Horn County,
- Richard Spring Fire in Big Horn and Rosebud counties,
- American Fork Fire in Park and Sweet Grass counties,
- Bridger Canyon Fire in Gallatin County, and
- Robertson Draw Fire in Carbon County.

Statewide Vulnerability

The flood hazard does not pose a uniform risk across the State. As such, the MHMP analysis was completed using Digital Flood Insurance Rate Maps (DFIRMs) adopted by the communities. In addition, and to illustrate the potential for increased flooding due to climate change, channel migration maps were added to the impact area for flooding, as well as data from flood models completed by in 2017 and 2022 using Hazards of the U.S. (HAZUS) software.

Figures 4.3-3 A-C present the flood hazard impact area used in the MHMP analysis by DES District. These maps also show the perimeters of the wildfires from 2021 and 2022 and USGS modeled potential post-fire debris flow to indicate where flash flooding and debris flows may occur over the next several years.

To complete the vulnerability analysis for the flood hazard, GIS was used to intersect the flood hazard impact area, from both flood event and debris flows, with both the general building stock, critical facility, cultural resource datasets. Vulnerable population was calculated based on the DNRC Dam Failure vulnerable population estimates, which assign a population value to a structure based on its type and is based on 2020 US Census Data. Exposure values are presented in **Table 4.3-10**. **Appendix B-4** presents supporting documentation from the risk assessment including a list of critical facilities in the flood hazard area and loss estimates for counties and incorporated cities and towns.

Table 4.3-10. Flooding Exposure Summary by DES District

Item	West District	Central District	East District
Flood Hazard Area (Square Miles)	3220.8	2605.5	4691.5
Flood Hazard Area Percent of District	6.64%	6.98%	7.68%
Residential Building Exposure ($)	$2,703,682,811	$1,079,902,642	$848,317,627
Residential Building Exposure (# structures)	16,203	10,173	11,186
Commercial, Ag, and Industrial Building Exposure ($)	$250,040,022	$322,885,393	$74,367,400
Commercial, Ag, and Industrial Building Exposure (# structures)	1,115	1,121	926
Essential Facility Exposure ($)			
Essential Facility Exposure (# structures)			
Cultural Resources (# features)	60	36	39
Persons Affected in Hazard Area	69,818	56,093	52,925

Risk assessment results indicate that DES West District has the highest building stock exposure in terms of number of structures at risk from flooding. District _ has the highest number of critical facilities and cultural resources at risk from flooding, while the West District has the most population at risk.

Table 4.3-11 presents a vulnerability summary of the flooding hazard as it relates to percent exposure and growth rates in Montana's counties, cities, and towns. Percent exposure was derived by dividing the value of residential and commercial/agricultural/industrial building stock exposed to the hazard into the total value of the building stock. Percent exposure is a more accurate way of displaying vulnerability than presenting jurisdictions with the highest exposure because it reflects areas with the greatest risk opposed to those with high value real estate. Provided in the **Table 4.3-11** are vulnerable counties with populations greater than 1,000 and towns with populations greater than 500. A complete ranking of percent exposure for counties is presented in the *Flooding* section of Appendix B-4.

Table 4.3-11. Flooding Exposure Summary for Top Counties, Cities and Towns

County/Town	% Flood Exposure	% Growth (2016 to 2021)	$ Residential Exposure	# Residences at Risk	$ Commercial/ Ag/Industrial Exposure	# Commercial/ Ag/Industrial Buildings at Risk	$ Critical Facilities Exposure	# Critical Facilities at Risk
Counties with Highest Percent Exposure (Counties with Pop. > 1,000) ($ Residential + $ Commercial-Ag- Industrial Exposure in Hazard Area / Total Exposure)								
Phillips	50.9%	1.7%	$56,584,512	593	$10,415,708	81		
Custer	42.1%	0.6%	$275,279,691	2,315	$20,526,085	587		
Blaine	34.2%	3.9%	$70,376,926	647	$7,274,089	40		
Dawson	26.8%	-4.0%	$79,601,670	667	$13,766,171	70		
Chouteau	23.4%	2.4%	$74,467,503	615	$10,223,693	96		
Hill	18.5%	-1.6%	$78,228,354	735	$66,810,982	223		
Valley	18.1%	-0.2%	$96,244,300	867	$0	1		
Rosebud	13.5%	-12.3%	$19,530,856	214	$1,351,270	17		
Mineral	13.0%	17.7%	$39,549,323	231	$0	0		
Beaverhead	12.4%	0.7%	$60,543,908	309	$11,000,162	20		

Cities/Towns with Highest Percent Exposure (Towns with Pop. > 500) ($ Residential + $ Commercial- Ag- Industrial Exposure in Hazard Area / Total Exposure)								
Malta	55.0%	-4.3%	$45,919,682	413	$9,060,412	63		
Fort Benton	52.9%	3.3%	$67,415,234	560	$10,223,693	94		
Chinook	48.4%	-5.9%	$63,788,245	574	$6,826,279	38		
Miles City	46.6%	-2.0%	$263,533,925	2,315	$15,436,845	569		
Crow Agency	41.8%	-3.6%	$12,426,128	87	$872,679	7		
Hungry Horse	34.7%	-1.7%	$19,276,828	140	$142,850	244		
Ashland	32.1%	-18.8%	$3,296,352	53	$211,890	2		
Three Forks	30.9%	30.9%	$101,168,547	492	$23,902,688	80		
Glendive	29.0%	-8.4%	$78,394,180	656	$13,766,171	70``		
Lincoln	28.8%	28.8%	$43,144,678	352	$0	1		

Counties with the highest exposure from flooding include: Phillips, Custer, Blaine, Dawson, and Choteau; while the top cities/towns include: Malta (Phillips Co.), Fort Benton (Chouteau Co.), Chinook (Blaine Co.), Miles City (Custer Co.), and the Crow Agency (Big Horn Co.). **Figure 4.3-4** presents percent exposure for the top counties and cities/towns showing regional vulnerability.

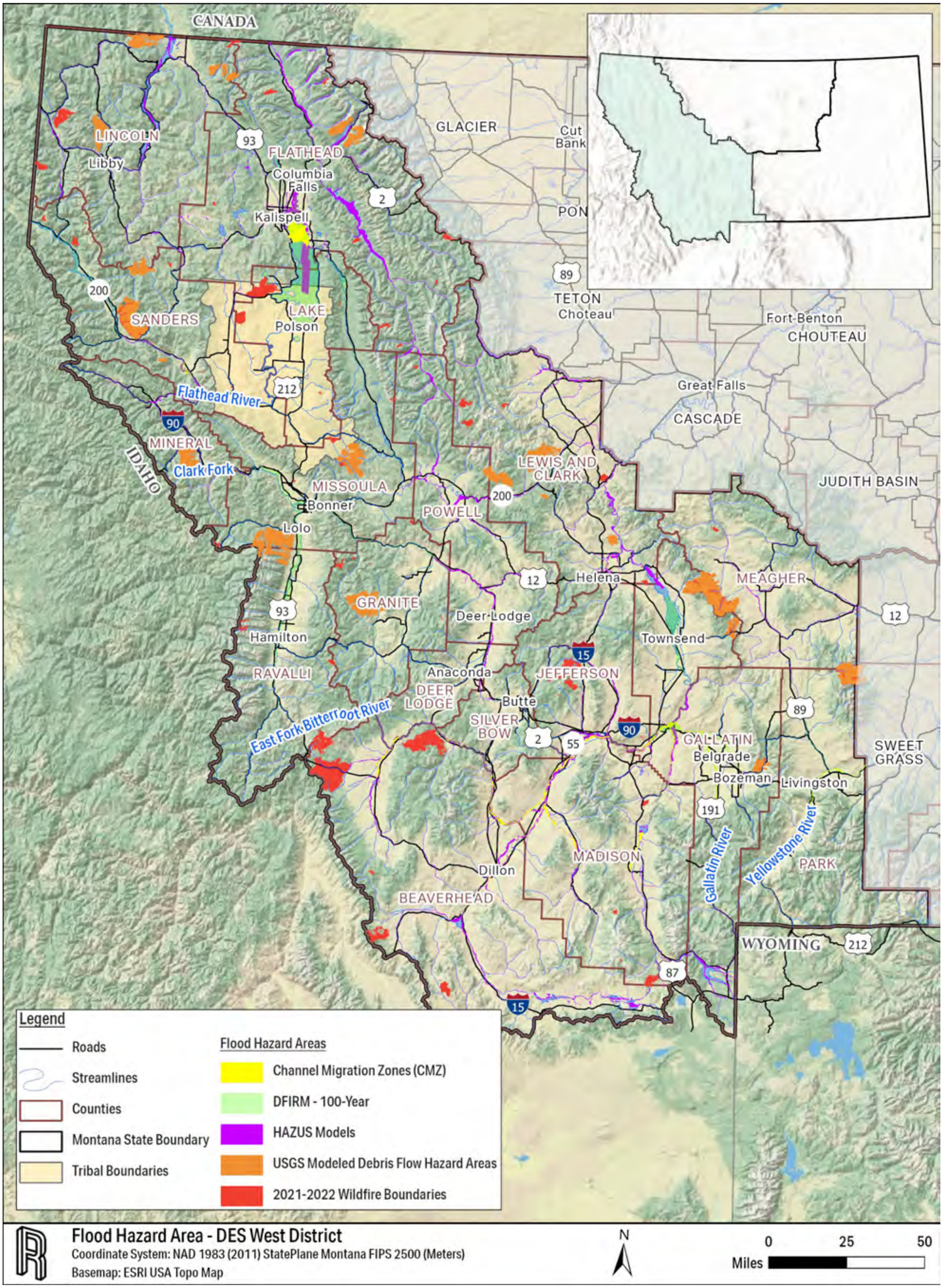


Figure 4.3-3A. Flood Hazard Areas for DES West District.

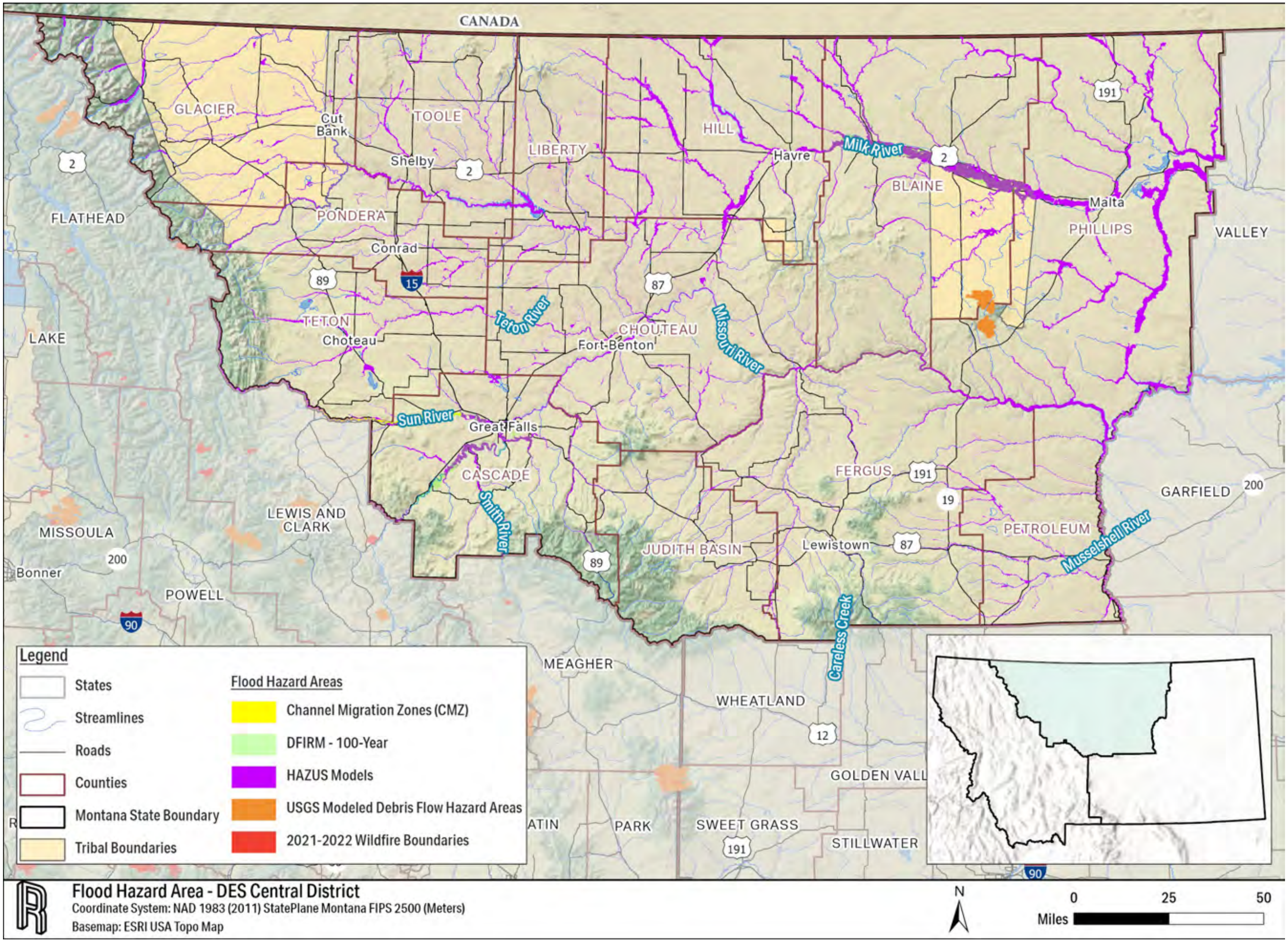


Figure 4.3-3B. Flood Hazard Areas for DES Central District.

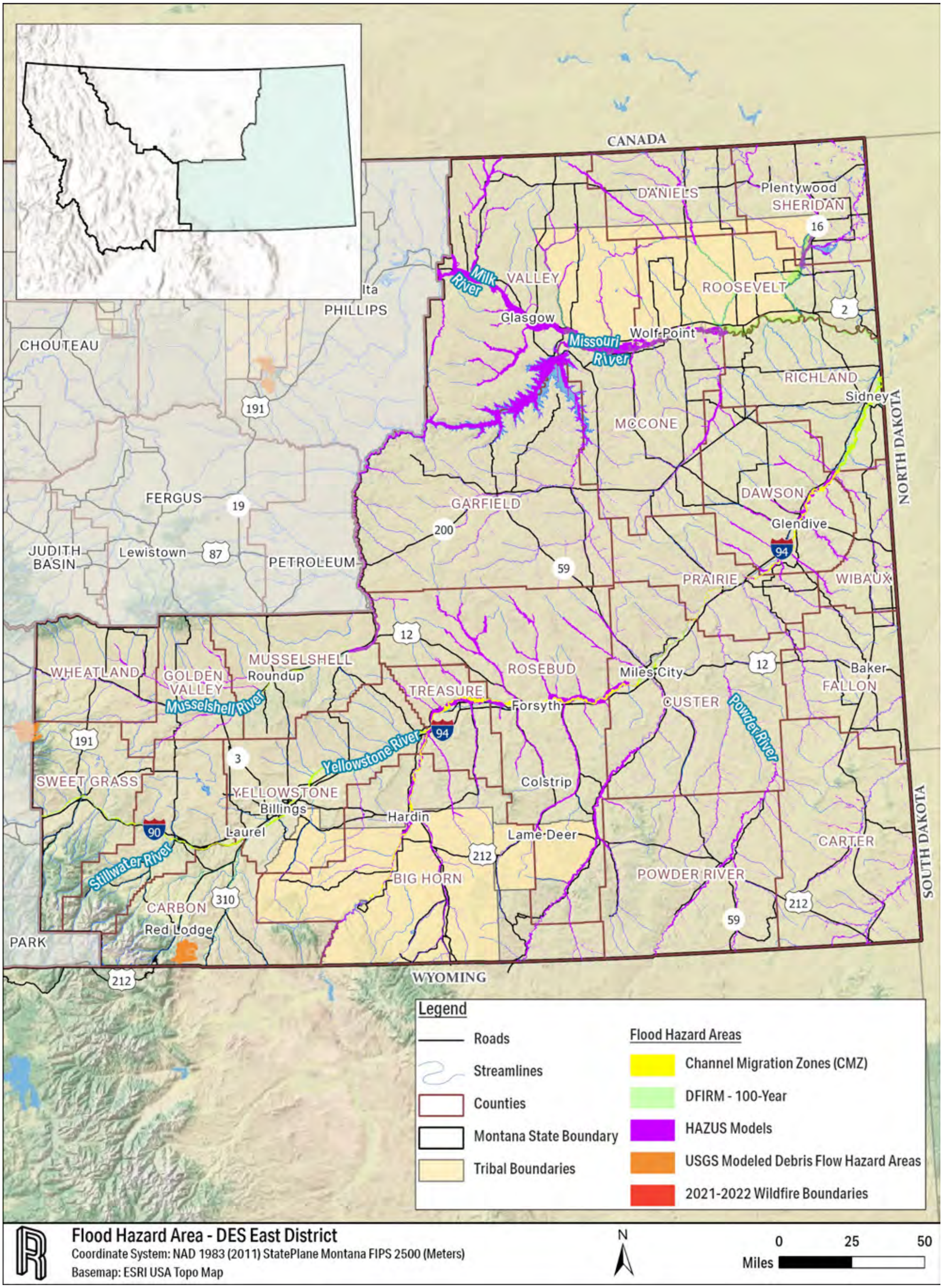
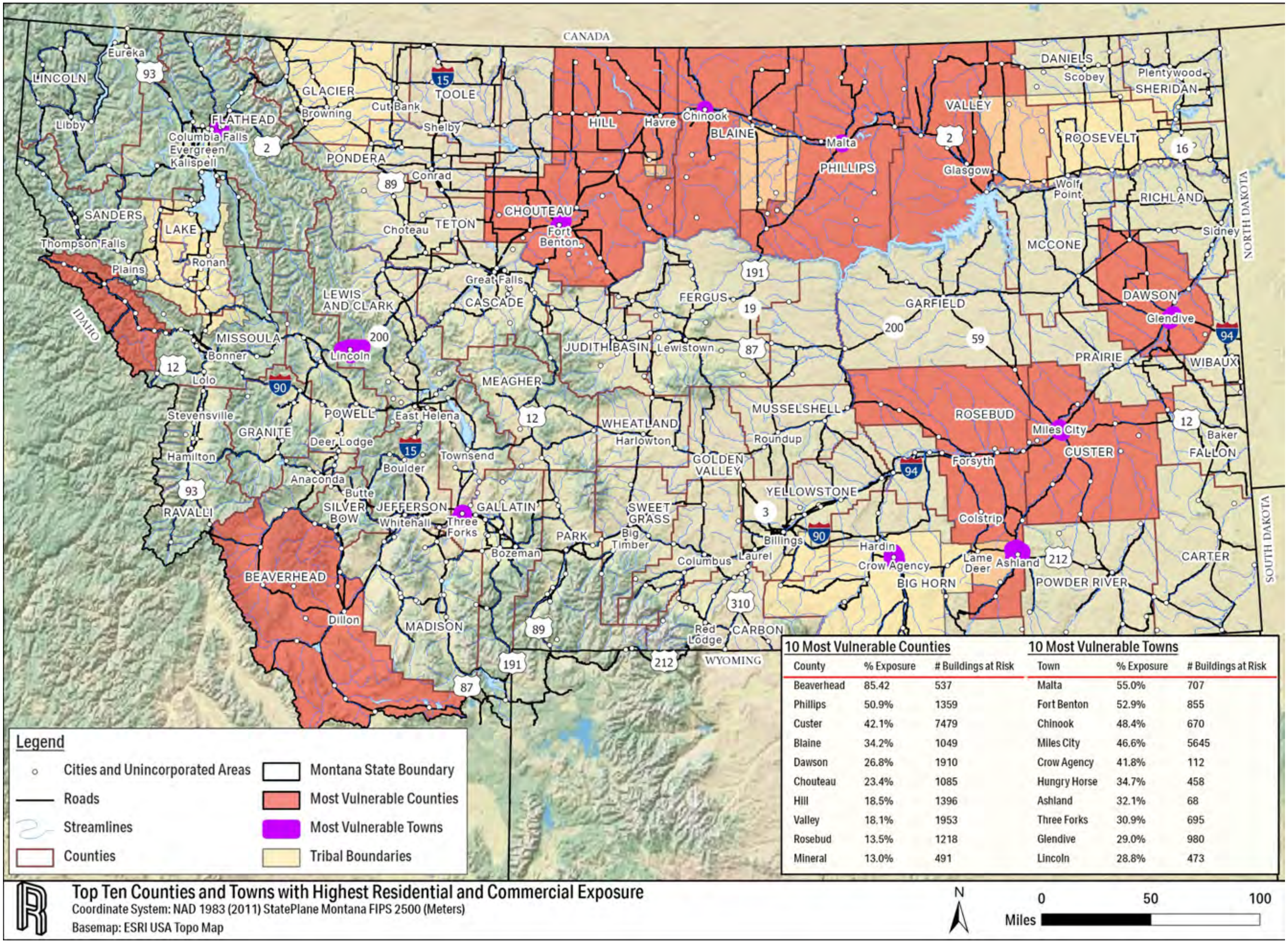


Figure 4.3-3C. Flood Hazard Areas for DES East District.



10 Most Vulnerable Counties

County	% Exposure	# Buildings at Risk
Beaverhead	85.42	537
Phillips	50.9%	1359
Custer	42.1%	7479
Blaine	34.2%	1049
Dawson	26.8%	1910
Chouteau	23.4%	1085
Hill	18.5%	1396
Valley	18.1%	1953
Rosebud	13.5%	1218
Mineral	13.0%	491

10 Most Vulnerable Towns

Town	% Exposure	# Buildings at Risk
Malta	55.0%	707
Fort Benton	52.9%	855
Chinook	48.4%	670
Miles City	46.6%	5645
Crow Agency	41.8%	112
Hungry Horse	34.7%	458
Ashland	32.1%	68
Three Forks	30.9%	695
Glendive	29.0%	980
Lincoln	28.8%	473

Figure 4.3-4. The top ten counties with the highest percent exposure to flood hazard areas.

Review of Potential Losses in Local Hazard Mitigation Plans

All the local MHMPs evaluated the flooding hazard in their risk assessment. Local jurisdictions that ranked flooding as one their top three hazards are presented below.

- #1 Hazard – Dawson, Golden Valley, Musselshell, Park, Richland, Sheridan, and Valley counties and the Blackfeet, Fort Peck and Rocky Boy reservations.
- #2 Hazard – Beaverhead, Big Horn, Fergus, Flathead, Garfield, Granite, Lewis and Clark, Madison, Powder River, Powell, Ravalli, Roosevelt, Sweet Grass, Teton and Yellowstone counties.
- #3 Hazard – Deer Lodge, Glacier, Hill, Judith Basin, Lincoln, McCone, Missoula, Phillips Pondera, and Wheatland counties and the Fort Belknap Reservation.

The Local Plan Exposure Summary table in the *Flooding* section of **Appendix B-4** presents a summary of potential flood losses from the Local Hazard Mitigation Plans.

Vulnerability of State Facilities

Table 4.3-12 presents loss claims associated with flooding of state-owned facilities. The results of the 2018 MHMP risk assessment identified several state critical facilities within the flood hazard area (**Appendix B-4**).

Table 4.3-12. Loss Claims for State Facilities Caused by Flooding

Agency	City/County	Date of Loss	Claim Description	Total
		Dept. Fish, Wildlife & Parks		
P-22230	Pryor	5/24/2011	Riverine flood damage	$41,811
P-22511	Denton	6/1/2011	Riverine flood damage	$15,000
P-22810	Townsend	1/24/2012	Ice jam flood damage	$4,015
Canyon Ferry	Lewis & Clark	1/24/2012	Ice dam flooded building	$17,718
Fisheries	-	6/6/2013	Runoff caused river to change channels and wash equipment away	$11,902
Bannack State Park	Beaverhead	7/17/2013	Hangman Gulch flood	$1,243,805
Les Mason	-	8/3/2013	Neighbor's dam broke and flooded park	$5,221
Smith River	Meagher	3/15/2014	Rapid ice out flood	$2,147
Fisheries	-	3/9/2017	Abrupt ice out flood	$66,828
Bannack State Park	Beaverhead	3/14/2017	Grasshopper creek flooding	$58,681
		Dept. of Justice		
Law Enforcement Ac.	Helena	6/8/2011	Flood damage	$13,023
		University System		
Ag Experiment Sta.	Bozeman	7/22/2008	Riverine flood damage	$250,000
P-20079	Dillon	7/24/2008	Flood damage due to heavy rains.	$11,636
TOTAL				**$1,741,787**

Montana FWP completed a flood mitigation project at Bannack State Park in 2017. Bannack is Montana's first territorial capital and has many structures that are unique and historically significant. In recent years, flooding has caused considerable damage to Bannack's historic structures and natural resources and raised concerns about public safety. The newly completed flood detention facility will protect the park by holding flash flood waters and safely redirecting flows away from the townsite and into a storm drainage channel and aqueduct.

Many of Montana's bridges have been compromised by scour associated with flooding. Scour is the hole left behind when sediment (sand and rocks) is washed away from the bottom of a river. Although scour may occur at any time, scour action is especially strong during floods. Swiftly flowing water has more energy than calm water to lift and carry sediment down river. The Montana Dept. of Transportation has identified 106 bridges in the state which have critical scour potential. **Table 4.3-13** identifies the 27 state-owned bridges with critical scour potential while the State critical facilities in the flood hazard area identified in Appendix B-4.

Table 4.3-13. State-Owned Bridges with Critical Scour Potential.

County	Water-Body Crossed	Location	Main Span Material	Structure Condition	Comments
Big Horn	Little Bighorn River	Sappy Creek Road	Concrete	Satisfactory	Not Deficient
Blaine	White Bear Creek	Highway 66 S	Wood	Satisfactory	Not Deficient
Blaine	Bean Creek	Cleveland Road	Wood	Satisfactory	Not Deficient
Daniels	Smoke Creek	Highway 251 S	Wood	Fair	Not Deficient
Gallatin	Jefferson River	Highway 2 S	Steel	Satisfactory	Not Deficient
Gallatin	Cougar Creek	US Highway 191FH 45	Concrete	Fair	Not Deficient
Gallatin	East Gallatin River	West Dry Creek Road	Concrete	Fair	Not Deficient
Golden Valley	Musselshell River	Highway 300 S	Steel	Satisfactory	Not Deficient
Granite	Rock Creek	Marshall Creek Road	Concrete	Fair	Structurally Deficient
Lewis and Clark	Elk Creek	MT Highway 21 S	Concrete	Fair	Not Deficient
Madison	Beaverhead River	MT Highway 41	Steel	Fair	Not Deficient
Madison	Jefferson River	Highway 359 S	Concrete	Good	Not Deficient
McCone	Timber Creek	Highway 24 S	Concrete	Good	Not Deficient
Park	Yellowstone River	I 90	Steel	Satisfactory	Not Deficient
Park	Yellowstone River	I 90	Steel	Satisfactory	Not Deficient
Pondera	Dry Fork Marias	Highway 91 N	Concrete	Satisfactory	Not Deficient
Ravalli	Skalkaho Creek	Skalkaho Highway	Wood	Serious	Structurally Deficient
Ravalli	Bitterroot River	Highway 93	Steel	Satisfactory	Not Deficient
Ravalli	Bitterroot River	Bell Crossing	Concrete	Good	Not Deficient
Ravalli	Bitterroot River	Woodside Cutoff Road	Steel	Good	Not Deficient
Richland	Yellowstone River	Highway 23 S	Steel	Poor	Structurally Deficient
Rosebud	Tongue River	Highway 447 S	Concrete	Fair	Not Deficient
Sheridan	Big Muddy Creek Overflow	West Reserve Highway	Wood	Fair	Not Deficient
Wibaux	Beaver Creek	Highway 7 S	Wood	Fair	Not Deficient
Wibaux	Beaver Creek	Highway 7 S	Steel	Satisfactory	Not Deficient
Wibaux	Beaver Creek	2nd Ave NE	Steel	Satisfactory	Not Deficient
Yellowstone	Yellowstone River	Old Highway 312	Steel	Fair	Structurally Deficient

FUTURE DEVELOPMENT

Montana law prevents development of structures in the floodway; however, structures may be developed in the 100-year floodplain with an approved floodplain development permit. Counties may have more stringent floodplain regulations than those the state enforces. Floodplain regulations are in place to promote public health, safety, general welfare, protect the floodplain, and to minimize flood losses in flood-prone areas. To develop in a mapped flood zone, the state requires a minimum freeboard of two feet to reduce the vulnerability of the new development. Because the program relies on effective floodplain mapping, and many counties in the state do not have up to date mapping, occurrences of development within flood prone areas occurs. Because of these outdated maps, the DNRC has a plan in place, which was last updated in 2021, to begin updating most counties who do not have up to date maps by the 2026 grant cycle. **Figure 4.3-5** shows the status of the Montana Map Modernization Project as of the most recent update in November of 2021. Section 6.1.2 presents additional information on this map modernization project. The development of new Model Floodplain Hazard Management Regulations was also completed in 2014 and were last revised in 2021. The resultant model regulations are available for use by communities to utilize and update or establish local regulations.

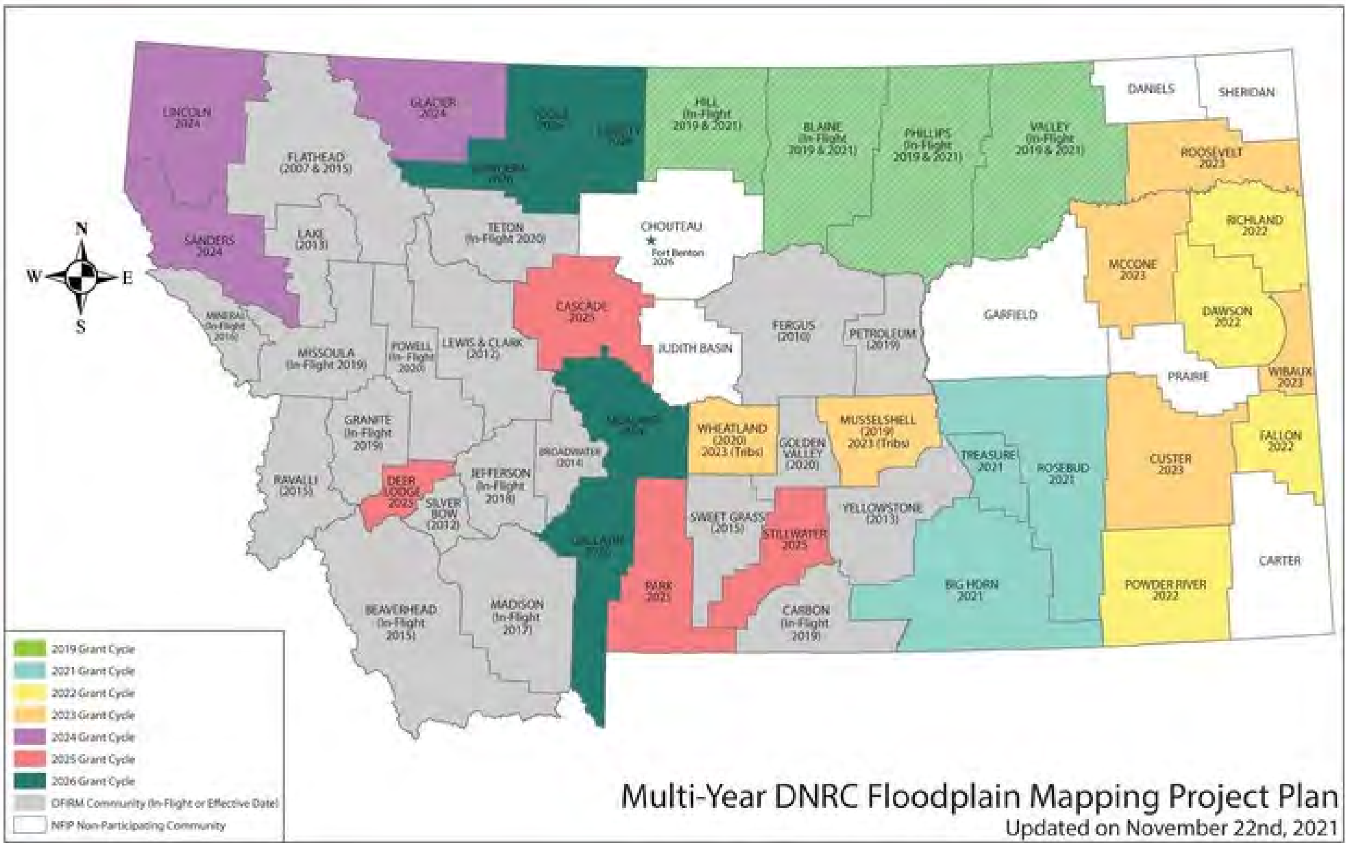


Figure 4.3-5 Montana Map Modernization DFIRM Production Status and Plan Source: Montana DNRC, 2022.

Because much of the growth in Montana is occurring near rivers and streams., the Montana Floodplain Association is advocating adoption of the No Adverse Impact approach for floodplain management. No Adverse Impact requires communities developing in the floodplain to mitigate potential resultant impacts from development before flood damages occur. No Adverse Impact standards can be incorporated into a community's zoning ordinances, subdivision regulations, building and health codes, and/or special purpose ordinances recognizing that future development can cause impacts elsewhere in the watershed.

Progress has been made on the incorporation of flood-resistant construction standards in both the International Building and Residential Codes. Incorporation of standards for flood-resistant construction in these codes will help ensure that building officials become involved in that part of the floodplain management process that deals with how buildings are constructed.

DATA LIMITATIONS

The MHMP analysis utilized a flood hazard layer that was derived from a combination of a HAZUS flood models, DFIRMs, and channel migration zones. DFIRMs are not available for the entire State, but as they become available in the future, the flood hazard layer for the State will be appended with this data. Some areas shown at risk from flooding by the HAZUS model may be misleading. One example is Last Chance Gulch in Helena, which is channeled below ground and does not pose a flood risk but is shown by HAZUS as having flood risk. As such, the MHMP analysis incorrectly identified several buildings in this area as being in the flood hazard area. There may be other examples where buildings are mistakenly identified to have flood risk in unmapped areas due to the HAZUS model.

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4.4 EARTHQUAKES CPRI SCORE = 2.93

DESCRIPTION AND HISTORY

An earthquake is ground shaking and radiated seismic energy caused by a sudden slip on a fault in the earth's crust, volcanic or magmatic activity, or other sudden stress changes in the earth. Magnitude and intensity are used to describe the size and effects of earthquakes. Magnitude is a measure of the total energy released. Each earthquake assigned a magnitude, usually measured on the Richter Scale or the similar but more modern Moment Magnitude Scale. Intensity is used to describe the effects of the earthquake at a particular place. Intensity is typically greatest near the epicenter and decreases with greater distance from the epicenter. Intensities are reported using the Modified Mercalli Intensity Scale (using Roman numerals) that range from I (barely felt) to XII (total destruction).

An earthquake of magnitude 8 or larger on the Richter Scale is termed a great earthquake. Montana has not experienced a great earthquake in recorded history. A great earthquake is not likely in Montana, but a major earthquake (magnitude 7.0-7.9) occurred near Hebgen Lake in 1959 and dozens of active faults have generated magnitude 6.5-7.5 earthquakes during recent geologic time.

Thousands of faults have been mapped in Montana, but scientists think only about 95 of these have been active in the past 1.6 million years (the Quaternary Period). Although it has been over sixty years since the last destructive earthquake in Montana, small earthquakes are common occurring at an average rate of 4-5 earthquakes per day. Scientists, including those at the Earthquake Studies Office of the Montana Bureau of Mines and Geology, continue to study faults in Montana to determine future earthquake potential.

A belt of seismicity known as the Intermountain Seismic Belt extends through western Montana, from the Flathead Lake region in the northwest corner of the state to the Yellowstone National Park region (**Figure 4.4-1**). Seismic events may lead to landslides, uneven ground settling, flooding, and damage to homes, dams, levees, buildings, power and telephone lines, roads, tunnels, and railways. Broken natural gas lines may cause fires.

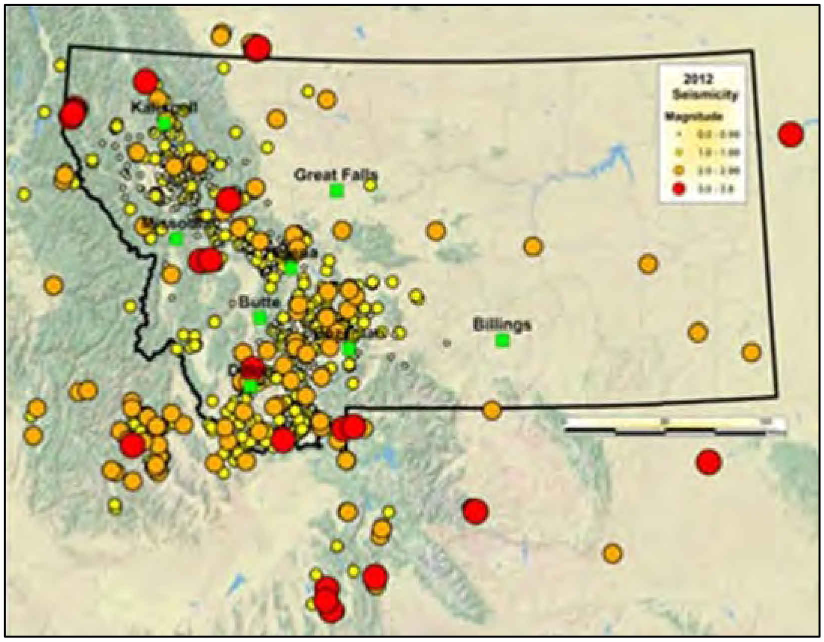

Figure 4.4-1 Intermountain Seismic Belt (Source: MBMG, 2022).

PAST OCCURENCES

Montana is one of the most seismically- active states in the United States. Since 1925, the state has experienced five shocks that reached intensity VIII or greater (Modified Mercalli Scale). During the same interval, hundreds of less severe tremors were felt within the state. Montana's earthquake activity is concentrated mostly in the mountainous western third of the state, which lies within the Intermountain Seismic Belt (**Figure 4.4-1**).

Table 4.4-1 shows the historic earthquakes of Montana and surrounding regions with magnitude of 5.5 or greater since 1900. Although one significant earthquake occurred in eastern Montana in 1909, the majority have occurred along the Intermountain Seismic Belt and Centennial Tectonic Belt in western Montana.

Table 4.4-1. Historic Earthquakes of Montana and Surrounding Regions with Magnitudes of 5.5 or Greater Since 1900

Date	Magnitude	Approximate Location	Date	Magnitude	Approximate Location
3424	5.5	Northeast Montana	21780	6	Hebgen Lake, MT
9311	6.6	Clarkston Valley, MT	21780	5.6	Hebgen Lake, MT
10640	5.6	Clarkston Valley, MT	21780	6.3	Hebgen Lake, MT
13069	5.9	Helena, MT	21781	6	Hebgen Lake, MT
13076	6.3	Helena, MT	23671	5.6	Hebgen Lake, MT
13088	6	Helena, MT	27575	5.9	Yellowstone Park
16265	6.1	Central Idaho	28102	5.5	Yellowstone Park
16482	6	Central Idaho	30617	7.3	Challis, ID
16703	5.5	Flathead Valley	30618	5.5	Challis, ID
17494	6.1	Virginia City, MT	30618	5.5	Challis, ID
19085	5.7	Swan Range, MT	30916	5.6	Challis, ID
21780	7.5	Hebgen Lake, MT	38559	5.6	Beaverhead Co., MT
21780	6.5	Hebgen Lake, MT	42922	5.8	Lincoln MT

1959 Hebgen Lake Earthquake - The Hebgen Lake magnitude 7.5 earthquake, which occurred on August 18, 1959, was the largest earthquake in Montana and the 14th largest earthquake in the contiguous U.S. in historic times (Stover and Coffman, 1993). This earthquake caused 29 fatalities and about $11 million in damage to highways and timber. It created extensive fault scarps, subsidence and uplift, a massive landslide, and a seiche (large wave) in Hebgen Lake. A maximum Intensity X or greater (Modified Mercalli Scale) was assigned to the epicentral area.

Source: **USGS, 2004**. The Madison Canyon slide with Earthquake Lake behind. Hebgen Lake fault crosses at the dark forested spur near the head of the lake.

The most spectacular and disastrous effect of the earthquake was the huge landslide of rock, soil and trees that cascaded from the steep south wall of the Madison River Canyon. This slide formed a barrier that blocked the Canyon and blocked the flow of the Madison River and, within a few weeks, created a lake almost 174 feet deep. The volume of material that blocked the Madison River below Hebgen Dam was estimated at 989 to 1,165 cubic feet. All but 3 of the 29 deaths were caused by rockslides that covered the Rock Creek public campground on the Madison River, about 5.9 miles below Hebgen Dam. Two people were killed by rock fall near Cliff Lake 6.5 miles west of the Madison Canyon landslide and a lone climber was killed by rock fall on north face of Granite Peak 83 miles to the northeast.

Source: USGS, 2004. The Red Canyon Fault Scarp from the Hebgen Canyon Earthquake in 1959 where it cut through Blarneystone Ranch. The fault scarp is 10 to 12 feet high.

New fault scarps as high as 20 feet formed near Hebgen Lake during this earthquake. The major fault scarps formed along pre-existing normal faults northeast of Hebgen Lake. The earth-fill Hebgen Dam sustained significant cracks in its concrete core and spillway and a seiche (water wave) overtopped the dam several times in the hour following the earthquake, but it continued to be an effective structure.

Many summer homes in the Hebgen Lake area were damaged; houses and cabins shifted off their foundations, chimneys fell, and pipelines broke. Most small masonry structures and wooden buildings along the major fault scarps survived with little damage when subjected only to vibratory forces.

Roadways were cracked and shifted extensively, and much timber was destroyed. Highway damage near Hebgen Lake was due to landslides slumping vertically and flowing laterally beneath pavements and bridges, which caused severe cracks and destruction. Rocks fell from road cuts and steep slopes partly or completely blocking roads in many places. Three of the five reinforced bridges in the epicentral area also sustained significant damage. High intensity earth movements were observed in the northwest section of Yellowstone National Park where new geysers erupted, and massive slumping caused large cracks in the ground from which steam emitted. Many hot springs became muddy.

1935 Helena Earthquakes – Starting with a small tremor on October 3, 1935, the City of Helena suffered through a devastating series of several hundred earthquakes, including three damaging earthquakes with magnitudes of 5.8, 6.3, and 6.0 on October 12th, 18th, and the 31st, respectively. Although no surface ruptures occurred during this earthquake sequence, shaking from the earthquakes damaged more than half of Helena's buildings. The epicenters of the 1935 earthquake series are not precisely known but were probably located about 3.7 to 14 miles north of the city, possibly along the Prickly Pear fault zone (Qamar and Stickney, 1983) and the Helena Valley fault [Doser, 1989].

The following description of the earthquake is from the National Information Service for Earthquake Engineering [NISEE, 1998]. Before the cluster of Helena earthquake tremors there had been little recorded seismic activity in the Helena area. The earthquakes disproved a then-popular misconception that all seismic activity within the U.S. occurred solely in California and Alaska. Before October 1935, the sense of immunity from natural disaster contributed to an atmosphere of uncontrolled construction in Helena. Earthquake-resistant design methods were disregarded. Older, antiquated construction in Helena behaved predictably during the tremors.

Damage in Helena included collapsed chimneys, fallen parapets, gables, and end walls, shattered walls parallel to interior framing, with partial or total collapse of structures as the ultimate end. Most buildings with unreinforced masonry-bearing walls were severely damaged within the month-long barrage of seismic activity. Likewise, industrial smokestacks built almost entirely of brick fell.

The October 18th earthquake brought serious damage to City Hall, as well as the area to the east of the mercantile district along Main Street. There, many chimneys fell, brick dwellings were seriously damaged or partly collapsed, brick veneer was thrown off, and many commercial, school, and public buildings were greatly affected, some destroyed. The worst wreckage occurred in structures on the softer alluvial soil toward the valley, notably the new High School and the Bryant School.

The last large shock of October 31st caused the collapse of parts of buildings which previously had been seriously affected, but which remained standing, including the new High School and the Kessler Brewery.

Source: NEHRP, 2022. Earthquake damage to the Bryant Elementary School in Helen from the series of 1935 earthquakes. 276 students attended school in a basement of Central School until reconstruction was completed. Photo by L.H. Jorud, courtesy of MT Historical Society and MBMG.

2005 Dillon Earthquake - On the evening of July 25, 2005, at 10:08 p.m. a magnitude 5.6 earthquake occurred in southwestern Montana 10 miles north of Dillon. The Intensity VI shaking at Dillon caused damage to some masonry structures, particularly older chimneys. A large chimney on Old Main Hall on The University of Montana-Western campus in Dillon sustained severe damage and was subsequently removed to prevent total collapse. Beaverhead County DES personnel estimated that that up to 60 percent of the older masonry chimneys in Dillon were damaged. An overpass above Interstate-15 located 4 miles southwest of the epicenter experienced sheared anchor bolts and spalled concrete but remained in good service. Ground cracks formed in weakly consolidated deposits approximately 2 miles southwest of the epicenter, apparently a result of strong ground shaking in weak soils but were unrelated to primary faulting. The Dillon earthquake occurred on a previously unknown subsurface fault[(Stickney, 2007].

2017 Lincoln Earthquake – One of more than 1,700 seismic events detected near Helena in 2017, a 5.8 magnitude earthquake centered six miles south of Lincoln on July 6 was the biggest ever recorded west of the Continental Divide in Montana and the strongest to hit the state in more than 40 years. The U.S. Geological Survey (USGS) recorded at least nine tremors within an hour of the initial 12:30 am quake, and they ranged in magnitude from 4.9 to 3.1. The earthquakes were strong enough to knock items off walls and shelves as far away as Helena and Missoula, cause a temporary power outage in Lincoln, and cause a gas leak in Helena. Though some businesses suffered a financial loss, no serious damages or injuries were reported. The earthquake occurred near a fault line that was not previously mapped by seismologists [Independent Record, 2017].

Declared Disasters

No federal or state disasters have been declared due to earthquakes as all of Montana's significant earthquakes occurred prior to the disaster declaration process.

CLIMATE CHANGE CONSIDERATIONS

The impacts of global climate change on earthquake probability are unknown. Some scientists say that melting glaciers could induce tectonic activity. As ice melts and water runs off, tremendous amounts of weight are shifted on the earth's crust. As newly freed crust returns to its original, pre- glacier shape, it could cause seismic plates to slip and stimulate volcanic activity, according to research into prehistoric earthquakes and volcanic activity. NASA and USGS scientists found that retreating glaciers in southern Alaska may be opening the way for future earthquakes [NASA, 2004].

Because impacts on the earthquake hazard are not well understood, increases in exposure and vulnerability of the local resources are not able to be determined.

FREQUENCY/LIKELIHOOD OF OCCURENCE

Hazard probability for the MHMP was assessed based on hazard frequency over a 10-year period. Since the earthquake hazard does not occur with an intensity to cause significant property damage or loss of life more than once every 10 years it was given an "Possible" probability rating.

POTENTIAL MAGNITUDE AND SEVERITY

The largest earthquake in Montana, the 1959 Hebgen Lake event, caused more than $11 million in damage ($93.7 million in 2018 dollars). The second most-damaging earthquakes were the October 1935 Helena earthquakes, which caused more than $4 million in damage ($72.4 million in 2018 dollars).

Qamar and Stickney (1983) developed earthquake recurrence intervals for high-incidence seismic zones in the state based on historic earthquake information. Wong and others (2005) compiled a more complete historic earthquake catalog and used it to develop improved recurrence relations for five regional seismic source zones in Montana. The five regional source zones are: Northern Intermountain Seismic Belt, Centennial Tectonic Belt, Northern Rocky Mountains, Middle Rocky Mountains, and Northern Great Plains. These results suggest that a magnitude 6 or larger earthquake may strike the Northern Intermountain Seismic Belt once in a 23-year period (**Table 4.4-2**). This seismic source zone includes the cities of Kalispell, Missoula, Helena, Bozeman, and Livingston, as well as the rapidly growing rural population and infrastructure surrounding those cities.

Table 4.4-2. Earthquake Recurrence Rates by Seismic Source Zone

Seismic Source Zone	M*5	M*6	M*7	# Quakes M >=6
Northern Intermountain Seismic Belt	3.84	22.6	133	2
Centennial Tectonic Belt	8.69	75.7	659	2
Northern Rocky Mountains	36.6	420	4821	0
Middle Rocky Mountains	237	1754	13000	0
Northern Great Plains	26.8	184	1281	0

* Predicted return time (in years) of earthquakes with magnitude M or greater.
Note: These values reflect recurrence times in the entire source zone.
Source: Wong and others, 2005

The probabilistic peak ground acceleration for western Montana (**Figure 4.4-2**) suggests that the magnitude of future earthquakes in Montana could cause significant damage. According to Qamar (2008), at 9.2%g an earthquake is felt by all with many frightened. Some heavy furniture is moved with a few instances of fallen plaster. Damage is considered slight. At 18%g, damage is negligible in buildings of good design and construction, slight to moderate in well-built ordinary structures, and considerable in poorly built or badly designed structures. Some chimneys may be broken, and the shaking is noticed by people driving cars. At 34%g, damage is slight in specially designed structures, considerable in ordinary substantial buildings with partial collapse, and great in poorly built structures. Chimneys and walls may fall, and heavy furniture is overturned. Areas of western Montana have a 2 percent probability in a 50-year period that ground shaking due to earthquakes will reach the 40%g range.

VULNERABILITY ASSESSMENT

Earthquakes will continue to occur in Montana; however, the precise time, location, and magnitude of future events cannot be predicted. As discussed above, earthquake hazard areas in Montana are concentrated in the western portion of the state, which is part of the Intermountain Seismic Belt (**Figure 4.4-1**). Many factors contribute to determining areas of vulnerability: historical earthquake occurrence, proximity to faults, soil characteristics, building construction, and population density, to mention a few.

During, the summer of 2017, a previously unmapped fault scarp was discovered in the Bitterroot Valley in Ravalli County. The Montana Bureau of Mines and Geology (MBMG) was used Light Detection and Ranging (LIDAR) equipment as part of a floodplain study. LIDAR uses laser to map the ground, showing what the land is like devoid of structures and vegetation. The scarp appears to travel along the lower east face of the Bitterroot Range, quite possibly through the Lake Como Dam and at least up to Victor, according to the LIDAR images. It is difficult to know if the fault goes through the dam due to glacial deposits that cover part of the scarp. It is not possible to predict when the fault might produce another earthquake. [Missoulian, 2017].

Another vulnerability associated with the earthquake hazard is liquefaction. Soil liquefaction describes a phenomenon whereby a saturated soil substantially loses strength and stiffness in response to an applied stress, usually earthquake shaking or other sudden change in stress condition, causing it to behave like a liquid. Consequently, the fluid pressure of the liquefied region may cause tilting or breaking of walls, failure of basement floors, and if the foundations are weak, severe damage to the structures may occur. Western Montana valleys within the Intermountain Seismic Belt may be susceptible to liquefaction in locations where thousands of people live. Conditions needed to create a liquefaction hazard include unconsolidated sediments (alluvial deposits that contain sand and silt) that are saturated with groundwater. Soil liquefaction hazard areas with moderate or high risk of liquefaction are shown in **Figures 4.4-2A-C**.

Vigilant Guard is a National Guard Bureau exercise that was conducted in four states each year, however, has not been conducted since 2018. It was held in and around Great Falls in February 2018. The exercise gives the local agencies opportunities to practice activating emergency operations plans. The exercise included a mock earthquake near Hebgen Dam, causing dam failures leading to impacts at Great Falls.

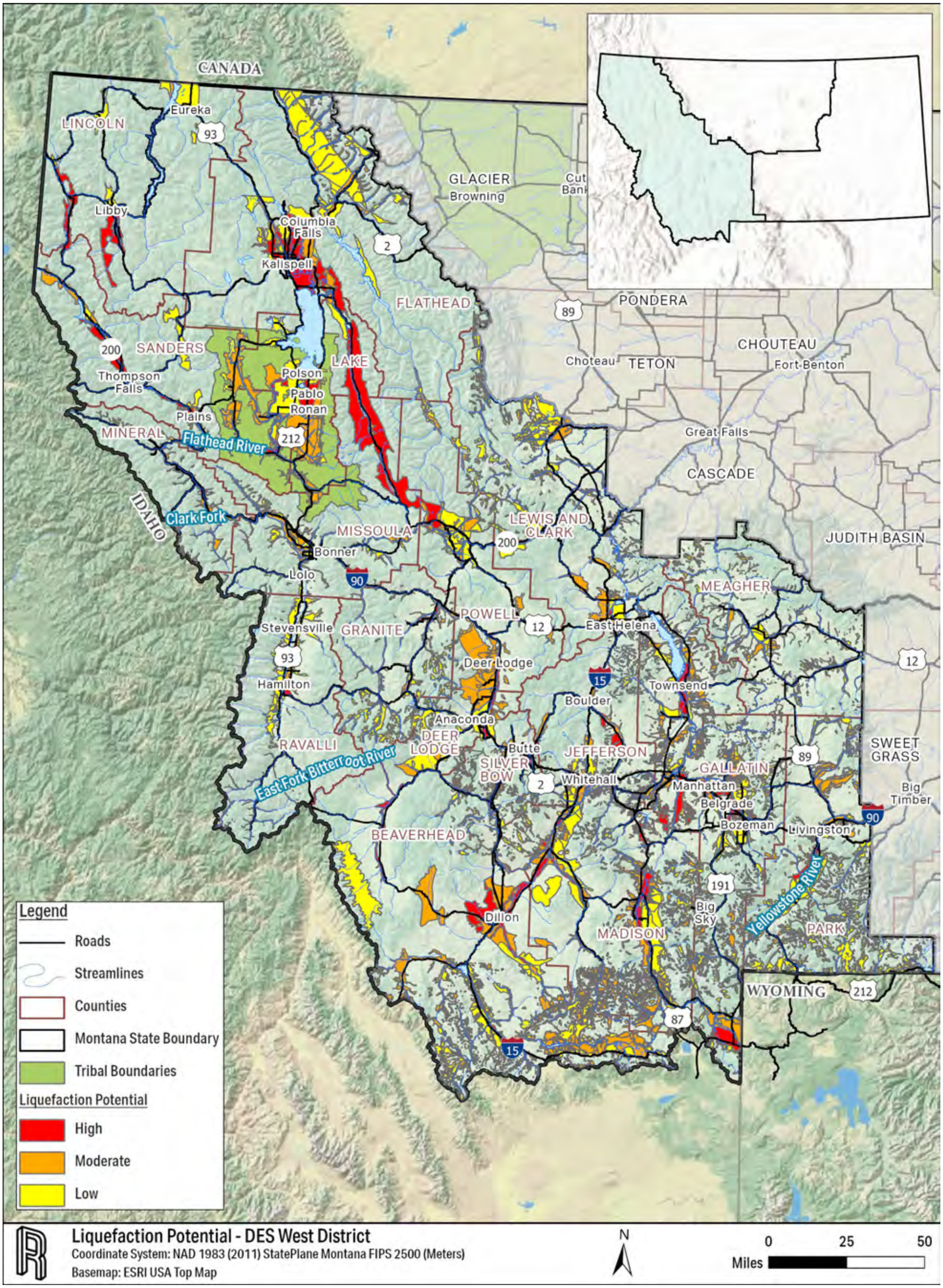

Figure 4.4-2A. Liquefaction Hazard Area DES West District, MHMP 2023 Update.

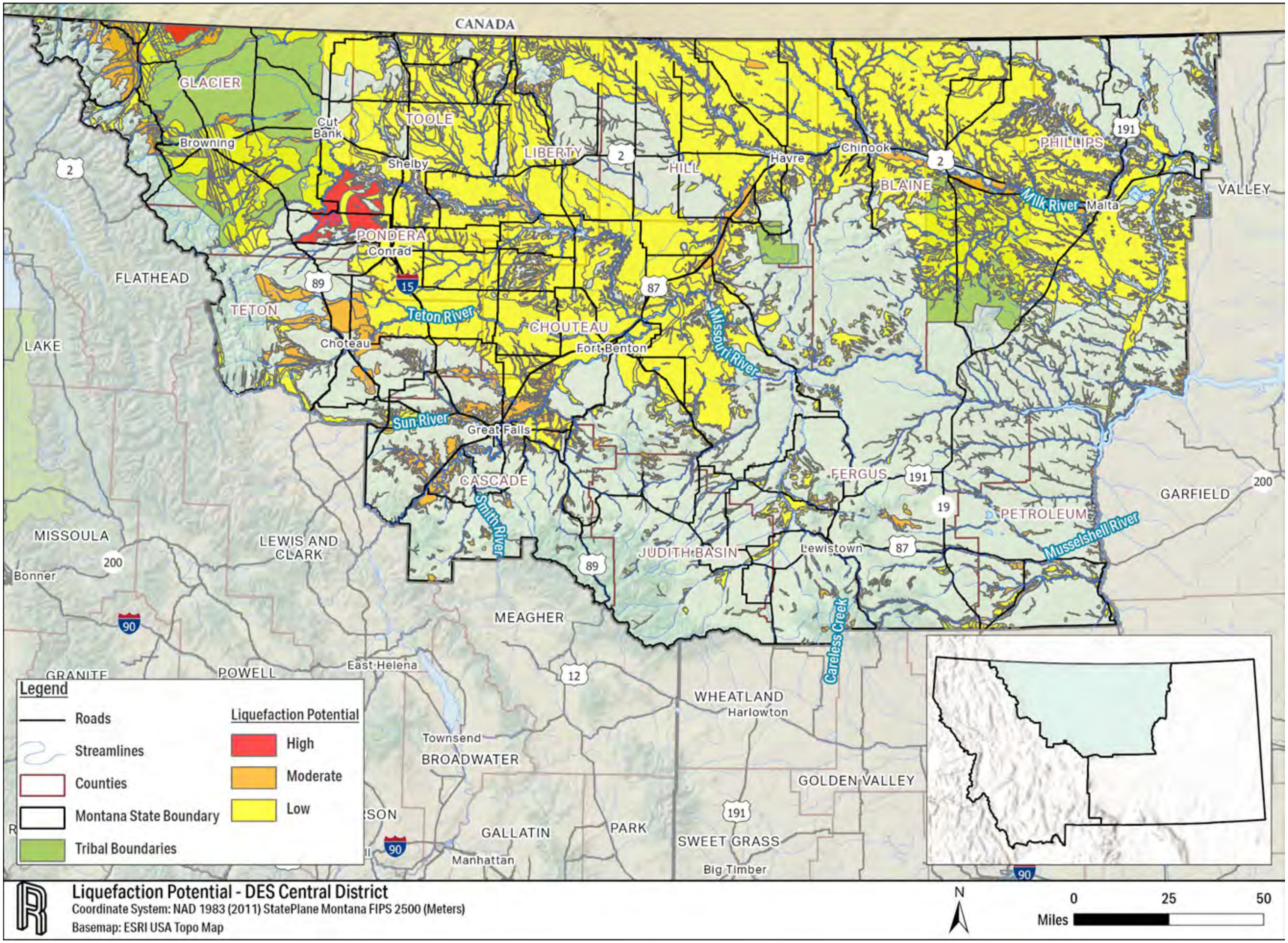

Figure 4.4-2B. Liquefaction Hazard Area DES Central District, MHMP 2023 Update.

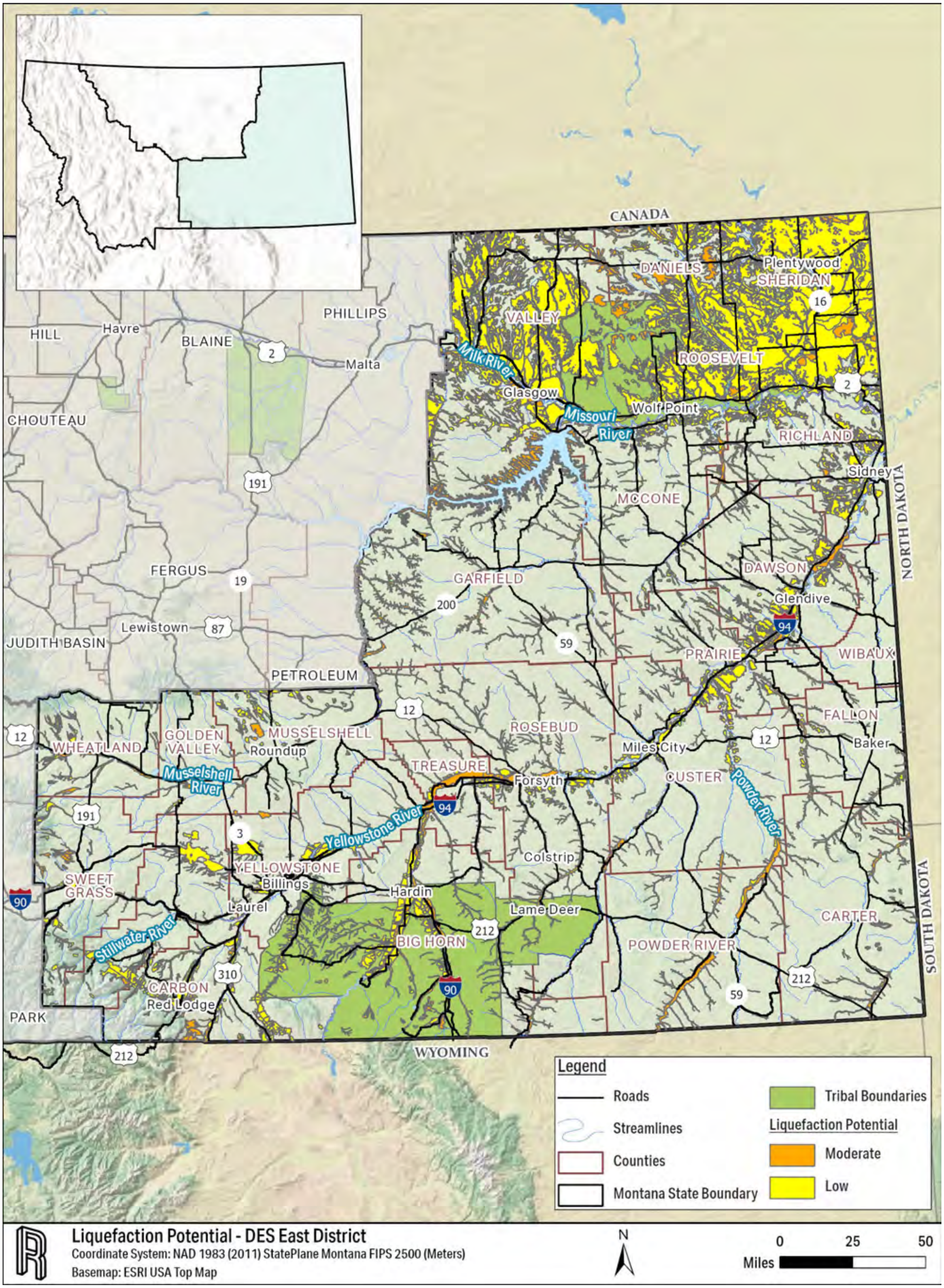

Figure 4.4-2C. Liquefaction Hazard Area DES East District, MHMP 2023 Update.

Statewide Vulnerability

The USGS has developed earthquake hazard maps showing ground acceleration for the United States, most recently updated in 2014. The peak ground acceleration values applicable to Montana are shown in **Figures 4.4-3A-C.** The zone values show the earthquake ground motions (with acceleration expressed as a percentage of the acceleration of gravity) with a two percent probability of being exceeded in 50 years. The figures show that peak ground acceleration is most intense along the Intermountain Seismic Belt with centers around Flathead Lake in Lake County and adjacent to the northwest corner of Yellowstone National Park in Madison County.

To complete the vulnerability analysis for the earthquake hazard, GIS was used to intersect the USGS peak ground acceleration zones with 18%g and greater with the general building stock, critical facility, and cultural resource datasets. Estimates of vulnerable population were calculated by applying a population value based on structure type, a technique DNRC used for calculating vulnerable populations downstream of dams if failure occurred. Exposure values are presented in **Table 4.4-3**. **Appendix B-5** presents supporting documentation from the risk assessment including a list of critical facilities in the 18%g seismic zone and exposure estimated by county and city/town.

Table 4.4-3. Earthquake Exposure Summary by DES District

Item	East District	Central District	West District
Landslide Area (Square Miles)	957.59	4,941.08	33,923.95
Percent Hazard Area	1.57%	13.25%	69.92%
Residential Building Exposure ($)	$51,292,958	$440,579,798	$49,270,071,843
Residential Building Exposure (# structures)	482	5,507	229,029
Commercial, Ag, Industrial Building Exposure ($)	$3,337,130	$52,209,071	$6,291,544,689
Commercial, Ag, Industrial Building Exposure (# structures)	15	354	14,616
Critical Facility Exposure ($)			
Critical Facility Exposure (# structures)			
Cultural Resource Exposure (# features)	1	22	393
Population Living in Hazard Area	513	16,358	607,213

Risk assessment results shows that DES West District has the highest residential and commercial/agricultural/industrial building exposure from the earthquake hazard as well as population at risk.

Table 4.4-4 presents a vulnerability summary of the earthquake hazard as it relates to percent exposure in Montana's counties and cities. Percent exposure was calculated by dividing the value of residential and commercial/agricultural/industrial building stock exposed to the hazard into the total value of the building stock. Percent exposure is a more accurate way of displaying vulnerability than presenting jurisdictions with the highest exposure because it reflects areas with the greatest risk, as opposed to those with high value real estate. A complete ranking of percent exposure is presented in **Appendix B-5**.

Table 4.4-4. Earthquake Exposure Summary for Top Counties, Cities and Towns

County/Town	% Flood Exposure	% Growth (2016 to 2021)	$ Residential Exposure	# Residences at Risk	$ Commercial/ Ag/Industrial Exposure	# Commercial/ Ag/Industrial Buildings at Risk	$ Critical Facilities Exposure	# Critical Facilities at Risk
Counties with Highest Percent Exposure (Counties with Pop. > 1,000) ($ Residential + $ Commercial-Ag- Industrial Exposure in Hazard Area / Total Exposure)								
Madison	96.57%	10.4%	$4,473,845,808	5,199	$138,304,998	409		
Gallatin	94.55%	16.9%	$13,360,260,831	32,968	$2,073,294,089	5,626		
Jefferson	91.06%	5.9%	$865,597,672	3,488	$31,759,664	109		
Broadwater	90.76%	25.9%	$154,129,730	835	$9,826,280	138		
Lake	90.32%	7.8%	$1,337,246,872	10,776	$105,351,573	793		
Flathead	87.78%	10.8%	$11,639,522,135	38,014	$1,492,611,630	3,454		
Beaverhead	85.42%	0.7%	$423,899,617	2,867	$69,880,173	225		
Park	82.28%	8.3%	$2,031,107,144	6,128	$244,196,220	646		
Glacier	80.74%	0.6%	$184,544,175	1,721	$32,044,161	337		
Lewis and Clark	77.75%	7.8%	$4,850,973,291	23,444	$191,479,164	61		
Cities/Towns with Highest Percent Exposure (Towns with Pop. > 500) ($ Residential + $ Commercial- Ag- Industrial Exposure in Hazard Area / Total Exposure)								
Big Sky	97.93%	10.4%	$4,218,606,833	1,578	$171,965,713	359		
Belgrade	97.49%	39.9%	$2,098,919,429	6,960	$267,566,186	1323		
West Yellowstone	97.10%	-6.6%	$315,458,534	944	$188,424,692	416		
Manhattan	96.65%	24.6%	$551,563,438	1,730	$57,778,304	124		
Lincoln	95.22%	28.8%	$142,501,987	1,079	$452,180	5		
Three Forks	94.25%	30.9%	$333,275,726	1,529	$48,566,902	178		
Sheridan	93.79%	4.3%	$161,662,676	769	$7,536,423	56		
Clancy	93.65%	21.7%	$498,592,344	1,655	$16,195,559	45		
Townsend	93.62%	-4.0%	$86,658,709	538	$7,307,290	117		
Bozeman	93.15%	20.4%	$8,463,256,224	20,130	$1,359,698,338	3137		

Counties with the highest earthquake exposure experiencing the fastest growth include Madison, Gallatin, Jefferson, Broadwater, and Lake Counties; while the top cities/towns (with population over 500) are Big Sky (Gallatin Co. and Madison Co.), Belgrade (Gallatin Co.), West Yellowstone (Gallatin Co.), Manhattan (Gallatin Co.), and Lincoln (Lewis and Clark Co).

Bozeman, Belgrade, and Manhattan (Gallatin Co.), Kalispell, Columbia Falls and Whitefish (Flathead Co.) and Helena (Lewis and Clark County). **Figure 4.4-4** presents percent exposure for the top counties and cities showing the most vulnerable areas.

Seasonal tourism increases exposure to seismic hazards in all areas, but the greatest exposure is in the Yellowstone National Park-Hebgen Lake region, where several million people visit annually.

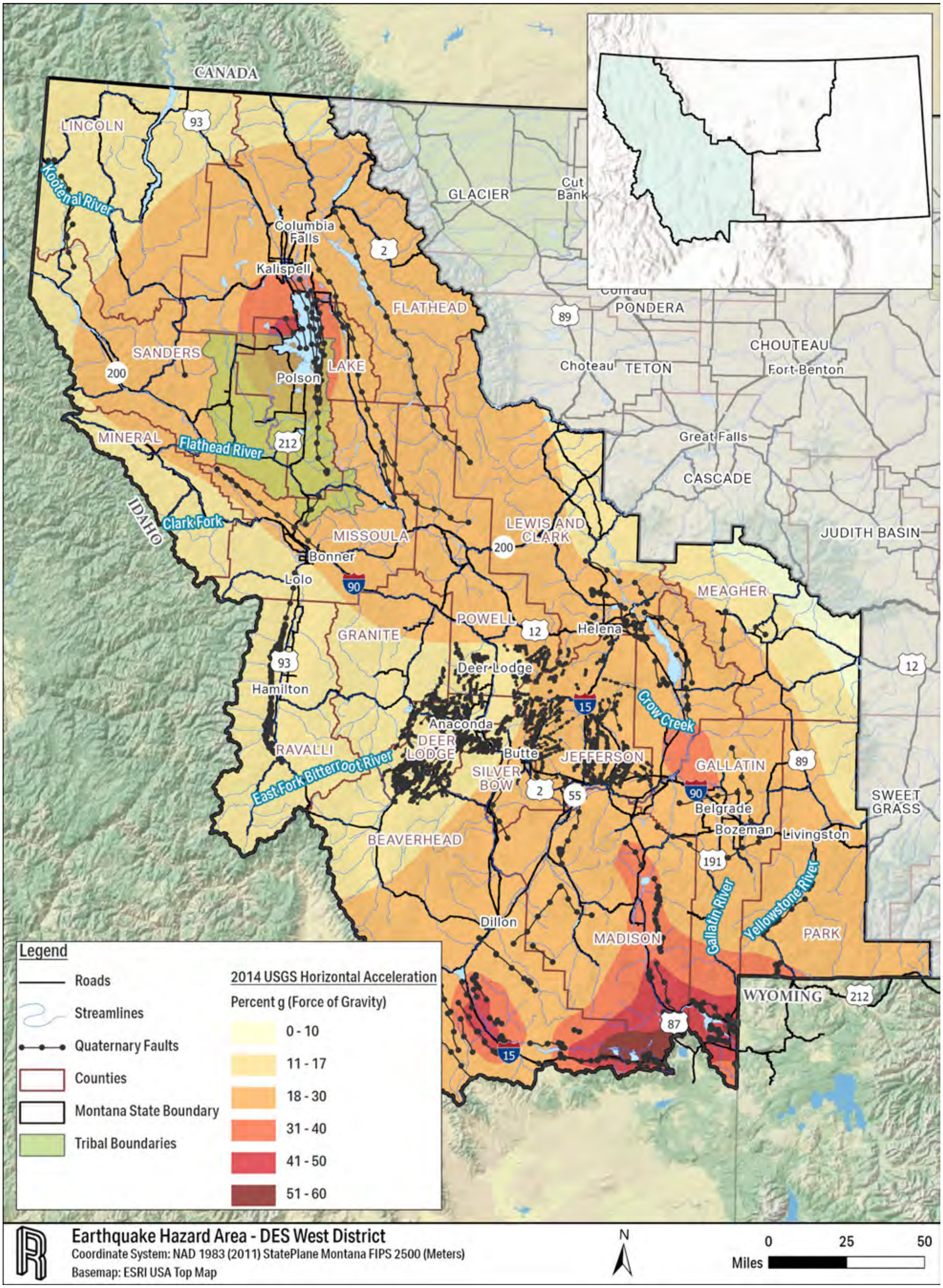

Figure 4.4-3A. Earthquake Hazard Area DES West District, MHMP 2023 Update.

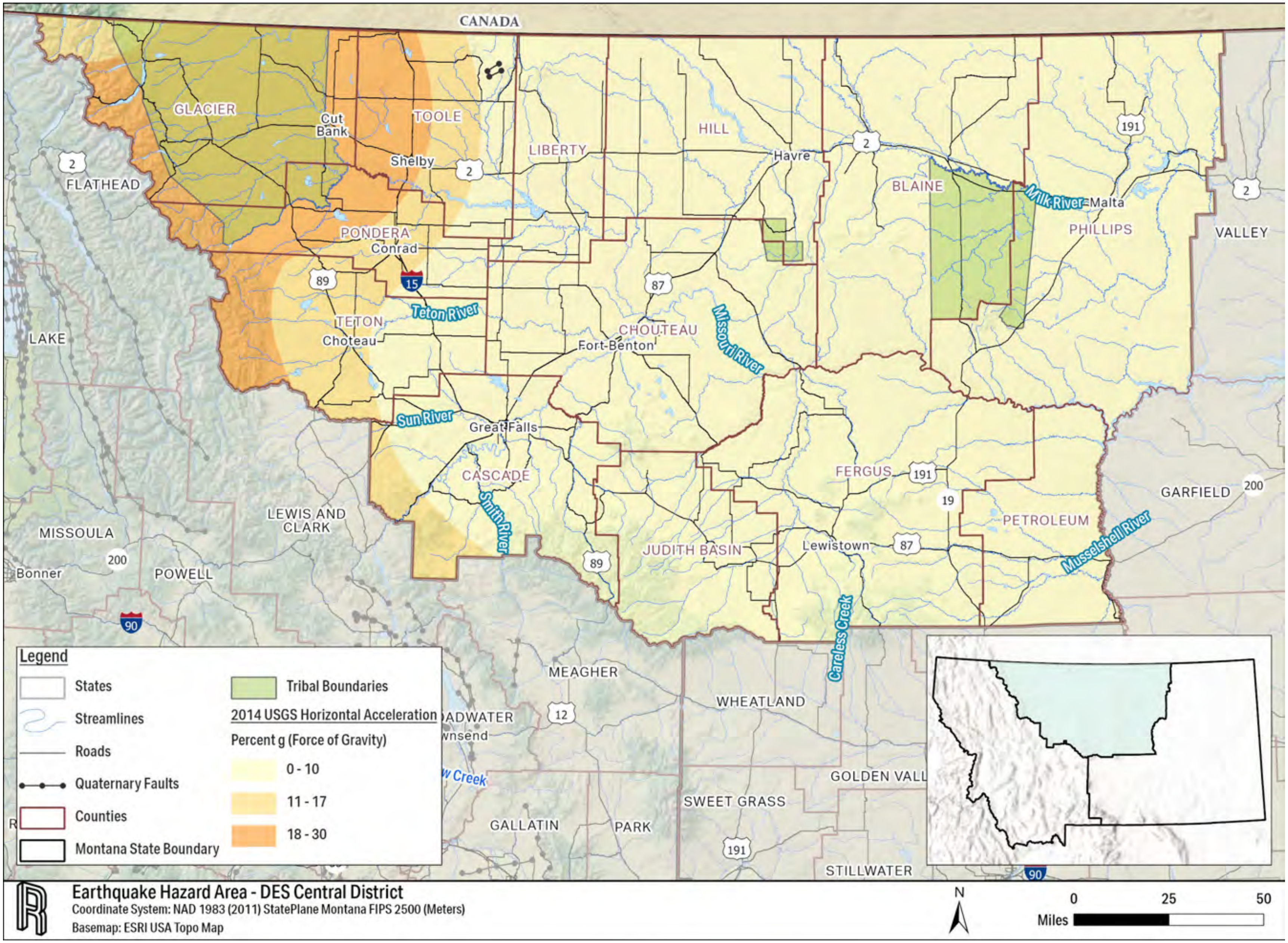

Figure 4.4-3B. Earthquake Hazard Area DES Central District, MHMP 2023 Update.

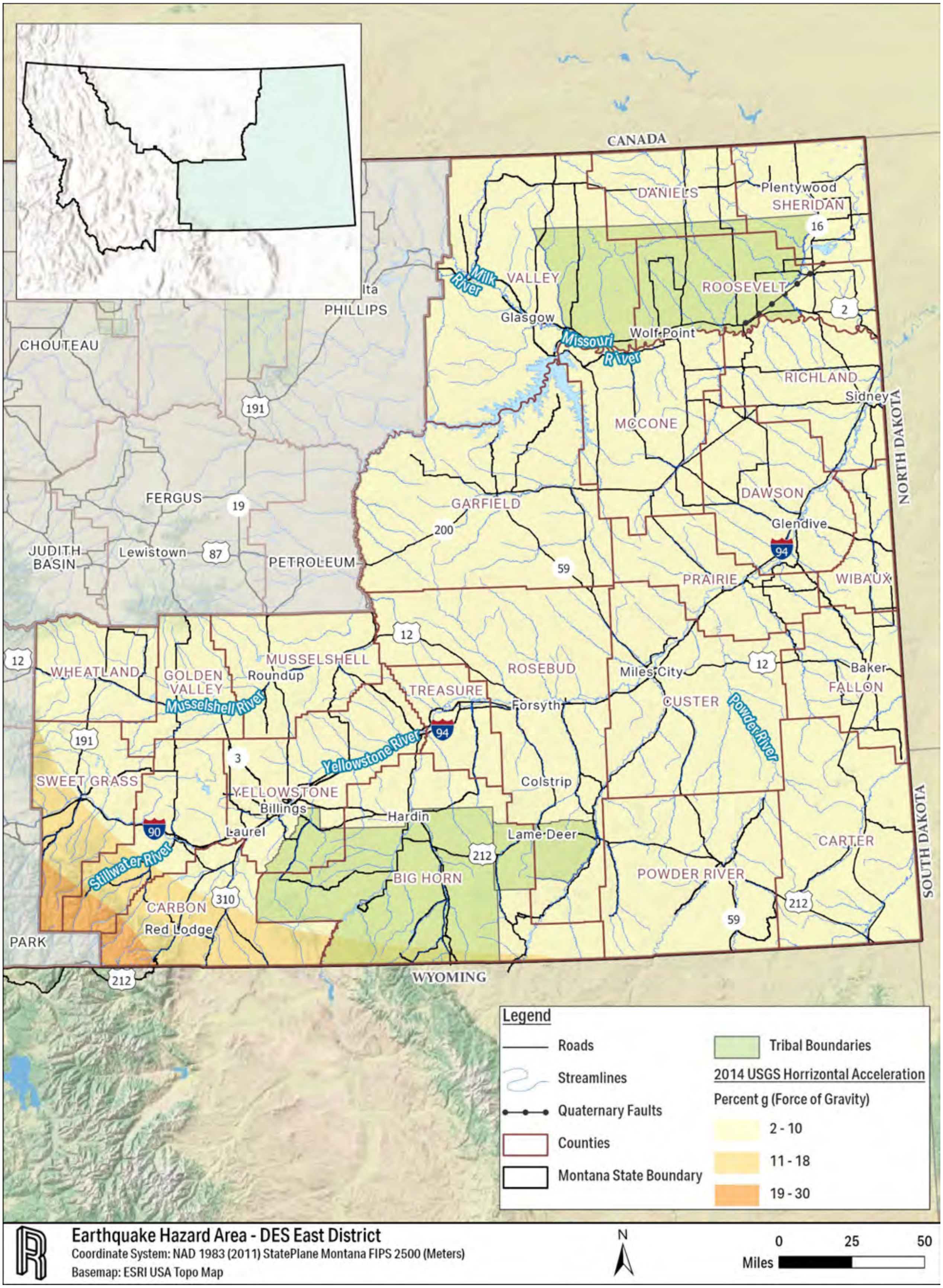

Figure 4.4-3C. Earthquake Hazard Area DES East District, MHMP 2023 Update.

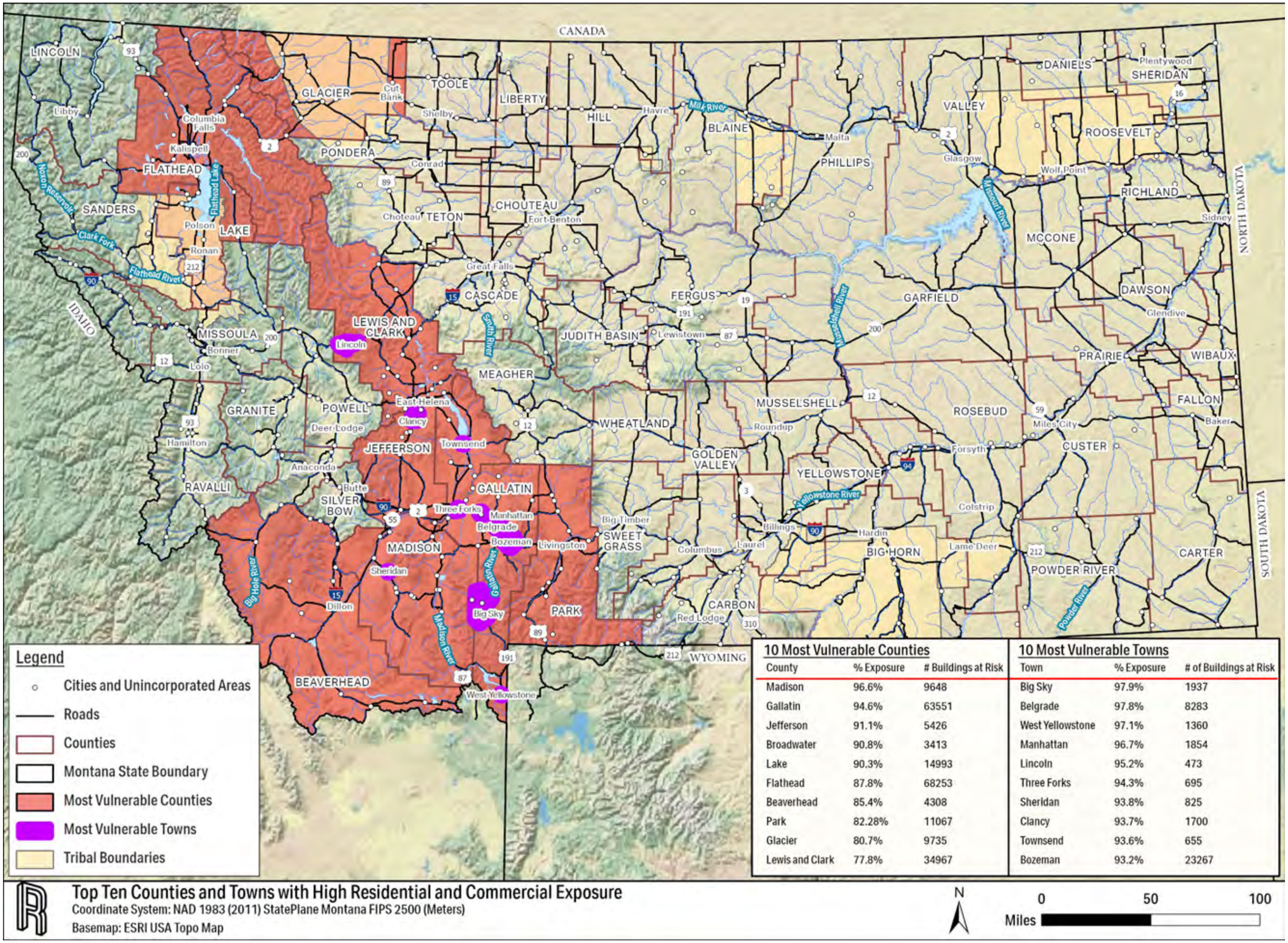

Figure 4.4-4. Top ranked counties and towns/cities with high residential and commercial exposure , MHMP 2023 Update.

Review of Potential Losses in Local Hazard Mitigation Plans

Approximately 40 percent of the local Hazard Mitigation Plans evaluated the earthquake hazard in their risk assessment. Local jurisdictions that ranked earthquake as their #1 hazard included: Beaverhead and Madison counties. Gallatin and Deer Lodge County ranked earthquake as their #2 hazard. Granite, Lewis and Clark, Park, Powell, Silver Bow and Teton counties ranked it #3. **Appendix B-5** present a summary of potential earthquake losses from the Local Hazard Mitigation Plans.

Vulnerability of State Facilities

Counties located in the Intermountain Seismic Belt are shown in **Table 4.4-5** with the total value of state buildings and contents, numbers of state employees. It is assumed that these state assets are most vulnerable to the earthquake hazard.

Table 4.4-5. State-Owned Buildings in Counties Highly Vulnerable to Earthquake Loss

County	Building Value	Contents Value	Total Value	State Employee Count
Gallatin	$963,969,286	$402,009,820	$1,371,912,423	9,013
Missoula	$893,521,957	$340,880,832	$1,239,620,652	3,192
Lewis and Clark	$514,462,216	$226,162,513	$743,967,737	9,055
Silver Bow	$177,626,970	$78,004,103	$256,746,224	583
Powell	$119,646,082	$29,749,518	$150,271,584	472
Beaverhead	$123,091,872	$25,460,187	$148,552,060	764
Deer Lodge	$69,575,244	$15,627,686	$85,635,043	471
Flathead	$57,229,726	$20,677,633	$78,511,996	521
Madison	$31,888,918	$2,569,449	$34,705,516	25
Jefferson	$25,565,364	$5,806,733	$31,372,097	237
Broadwater	$15,531,155	$14,763,225	$30,331,359	7
Lake	$14,463,375	$5,679,327	$20,290,673	3,035
Park	$4,236,197	$1,529,477	$5,825,498	46
Sanders	$2,198,903	$1,553,619	$3,796,310	30
TOTALS				

The MHMP analysis indicates that 600 critical facilities are located in the earthquake hazard area, as shown in **Appendix B-5**. From 2009 to 2012, the Montana Dept. of Administration received a FEMA grant to complete Tier 1 seismic evaluations of state buildings located in the Intermountain Seismic Belt. This project evaluated State-owned facilities including: the State Capitol Complex and Law Enforcement Academy in Helena; State Hospital in Warm Springs; Montana Veterans Home in Columbia Falls; Montana Developmental Center in Boulder; State Prison in Deer Lodge; Montana University System campuses in Butte, Dillon, Helena, Missoula, and Bozeman; Montana Department of Transportation facilities in West Yellowstone, and Montana National Guard facilities in Anaconda, Livingston, and Helena. Eighty- seven (87) Tier 1 evaluations were completed by a structural engineering firm. The earthquake appendix of the 2013 State of Montana MHMP contains the individual Tier 1 reports with a summary of structural and non-structural deficiencies.

Table 4.4-6 presents the facilities where critical structural issues were identified, and additional evaluation was recommended along with building and content values. A Level II HAZUS analysis was conducted to analyze the vulnerability (percent loss) of the individual facilities. Earthquake scenarios used in the analysis were selected based on past events. Tier 2 seismic evaluations were recommended for these facilities to: evaluate lateral systems and connections, investigate evidence of structural distress and deterioration, and investigate non-compliant issues. Since FEMA has not yet updated the HAZUS software to include 2020 Census Data, the data presented remains the same as that in the 2018 update.

Table 4.4-6. Summary of State Buildings with Structural Issues and Their Value

Campus/Building	Building & Contents Value (2017)	% Loss (HAZUS)	Estimated Loss
Montana Tech, Butte			
Engineering Hall	$3,892,937	36.45%	$1,418,976
Health Sciences (aka Petroleum Building)	$7,799,478	29.42%	$2,294,606
Museum Building	$9,416,756	45.56%	$4,290,274
Student Union Building	$9,604,045	12.33%	$1,184,179
Montana State Prison, Deer Lodge			
Infirmary	$1,782,952	0.04%	$713
UM-Western, Dillon			
Heating Plant and Garage	$2,001,967	48.03%	$961,545
IT Metals (Art Annex)	$440,821	7.62%	$33,591
IT Woods (Business & Technology Building)	$5,817,260	58.82%	$3,421,712
Library Administration	$15,267,576	29.72%	$4,537,524
Montana Law Enforcement Academy, Helena			
Administration/School	$2,183,940	33.51%	$731,838
Aspen Cottage	$588,381	38.22%	$224,879
Gymnasium	$655,664	27.54%	$180,570
Maple Cottage	$2,190,662	38.38%	$840,776
Spruce Cottage	$1,781,371	26.71%	$475,804
State Capitol Complex, Helena			
Aeronautics Operations Building	$1,520,713	27.74%	$421,846
Airport Hangar Building	$379,020	27.95%	$105,936
Aviation & Support Facility Shop	$3,381,386	30.41%	$1,028,279
Capitol Building	$145,098,564	36.51%	$52,975,486
Cogswell Building	$23,751,374	29.73%	$7,061,283
Dept of Public Health and Human Services	$10,694,849	23.18%	$2,479,066
Margaret Condon Building	$11,895,004	16.55%	$1,968,623
Mitchell Building	$32,876,695	16.85%	$5,539,723
Scott Hart Building	$16,805,048	33.57%	$5,641,455
Veterans & Pioneer Memorial Building	$19,073,783	20.77%	$3,961,625
Walt Sullivan Building	$11,538,734	22.72%	$2,621,600
UM-Helena			
College of Technology Airport Campus	$25,162,367	8.35%	$2,101,058

Most of the State-owned buildings evaluated had non-compliant non-structural issues, including:

- Lack of seismic supports and diagonal bracing suspended lights, ceilings, gas lines, steam lines, ductwork and mechanical piping and equipment.
- Interior non-bearing walls not connected at top and require top restraint for seismic stability.
- Shelving and IT equipment not anchored.
- Masonry chimneys with limited connection to structures.

The Montana Dept. of Administration and Montana University System submitted grant applications to FEMA to fund seismic retrofits. Three projects were funded including: seismic retrofit of the Creative Arts Center at Montana State University (MSU)-Bozeman ($2,240,750 federal share); seismic retrofit of Mathews Hall at UM-Western in Dillon ($857,904 federal share) and non-structural retrofits at the Montana Law Enforcement Academy in Helena ($94,209 federal share). These projects are now complete and offer their occupants enhanced safety from seismic hazards.

FUTURE DEVELOPMENT

New construction in the Intermountain Seismic Belt is taking place in areas vulnerable to earthquake damage. The State of Montana has adopted the International Building Code (IBC), 2012 edition. Seismic provisions or requirements found in the IBC are what the state requires for commercial buildings built in Montana.

Seismic requirements are found throughout the code and are not condensed into a table or chart of requirements. Different building types, different occupancies and different uses all have varying degrees of seismic requirements and even different materials used in those different buildings and occupancies carry additional or different requirements i.e. wood construction of a police station would have different seismic requirements than a masonry built police station. A building with an occupant load of over 300 people would require additional seismic considerations than if the building held less than 300 (same use, same materials). The staff of architects and engineers at the Montana Dept. of Labor and Industry, Bureau of Building and Measurement Standards perform plan reviews to ensure designers have included the seismic provisions and requirements found in the building code.

The IBC recognizes the differences in seismic activity by evaluating three main parameters:

- Amount of motion – this is a site-specific value derived from software using a location's zip code,
- Site class or soil type for a specific building site, and
- The seismic use group which is the type of building use.

These three parameters are analyzed to arrive at a "seismic design category" which the code then provides for specific requirements based on a project's seismic design category label. For example, a project located in an area where the ground motion has been determined to be high, the soil type at the site is determined to be such that not much dampening of that motion is likely to occur (not hard rock – silt or loose soil present) and the building is considered an "essential facility" such as a police station or hospital then the seismic design category will calculate out to be such that higher seismic requirements will be placed on that structure. The same motion and same soil type for a building that is not essential (could be right across the street from the police station) would require a lower seismic design.

The IBC does not cover single family residences. The State of Montana has adopted the International Residential Code (IRC), 2012 edition for one and two-family residences and townhouses. The Dept. of Labor does not have jurisdiction over single family residences (they are exempt from the requirements of a building permit by law). Local jurisdictions can elect to become certified to take on enforcement of single-family residences. Currently there are 46 certified jurisdictions including seven counties (Table

4.4-7) that are certified to enforce building codes; however, they must adopt the same codes and operate under the same process as the State of Montana.

Table 4.4-7. Jurisdictions Certified to Enforce Building Codes within Intermountain Seismic Belt

County Jurisdiction	Enforcing Building Codes	Area of Enforcement
Broadwater	Townsend	Within city limits
Deer Lodge	Anaconda/Deer Lodge	Entire county
Flathead	Columbia Falls, Kalispell, Whitefish	Within city limits
Gallatin	Belgrade, Bozeman, Manhattan, West Yellowstone*	Within city limits
Glacier	Cut Bank	Within city limits
Lake	Polson, Ronan	Within city limits
Lewis and Clark	East Helena, Helena	Within city limits
Lincoln	Libby, Troy	Within city limits
Missoula	Missoula	Within city limits
Missoula	Missoula	County
Park	Livingston	Within city limits
Ravalli	Darby, Hamilton, Stevensville	Within city limits
Silver Bow	Butte/Silver Bow	Entire county
Teton	Choteau	Within city limits

Provided future development complies with State building codes, earthquake damage of new structures should be minimized. However, damage to new buildings and infrastructure will occur if earthquakes stronger than the "seismic design categories" in the building codes take place.

DATA LIMITATIONS

Fault mapping and specific local-level hazard mapping (such as liquefaction) is incomplete across the State. Many faults within the State are believed to be unmapped or not studied. Continuing research in the areas of geology and earthquakes could significantly improve the vulnerability analysis.

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4.5 DROUGHT

CPRI SCORE = 2.95

DESCRIPTION AND PAST OCCURENCES

Drought is an extended period of below-normal precipitation that causes damage to vegetation, diminishes natural streamflow, and depletes soil and subsoil moisture. These effects cause social, environmental, and economic impacts in Montana.

Drought conditions are defined relative to long-term average relationships between precipitation and evapotranspiration perceived as "normal." Drought is related to the timing (i.e., the principal season of occurrence, delays in the start of the rainy season, the occurrence of rains in relation to principal crop growth stages) and the effectiveness (i.e., rainfall intensity, number of rainfall events) of precipitation.

Drought is the second costliest weather disaster in the U.S.. Unlike hazards that create immediate and visible damage, drought develops slowly, without apparent impacts until water shortages become severe. In Montana, economic losses from drought account for roughly 72 percent of all losses from major weather events since 1980 [NCEI, 2022[1]]. Vulnerability to drought will increase in the future with a warming climate [NOAA, 2017].

Drought does not typically result in loss of life. However, drought can have a widespread impact on the environment and the economy. In agriculture, non-irrigated croplands are the most susceptible to moisture shortages. Although rangeland and irrigated agricultural lands do not feel the effects of drought as quickly as non-irrigated croplands, their yields are typically reduced. Drought can also affect the quality and quantity of livestock food supplies.

Reductions in yields may be further aggravated by wind-induced soil erosion. An additional hazard resulting from drought conditions is insect infestation. In the Northern Great Plains, rangeland grasshopper outbreaks have caused considerable damage to the agricultural economy. Grasshopper populations increase with livestock grazing rates and dry conditions. During a severe grasshopper outbreak, grasshoppers often remove more vegetation than cattle in the same pasture [NDMC, 2004; Branson, 2002].

Principally, drought results in lower plant growth rates, higher plant stress, and greater susceptibility to disease. Extended drought may lead to loss of plant cover, shifts in plant composition, and increases in invasive species abundance. Prolonged dry conditions produce more severe fires due to very low moisture content in forest vegetation. Under extreme drought conditions, lakes, reservoirs, and rivers can be subject to severe water shortages which impact irrigation, drinking water, and riverine ecosystem health. Drought causes streamflow to decrease and water temperatures to increase, leading to negative consequences for aquatic species, especially cold water-dependent species like bull trout.

Drought also threatens the supply of hydropower produced in the state. Further, drought affects groundwater resources which can lead to reduced pumping capacity, dry wells, and degraded groundwater quality. In general, drought decreases water quality and quantity for other human uses [USDA, 2017].

The U.S. Drought Monitor (USDM) uses analysis and weather data to create drought designations. The designations to describe drought conditions range from abnormal dryness to exceptional drought. The USDM consolidates information from drought indicators, climate and hydrological data, soil measurements, models, and local observations.

The Palmer Drought Severity Index (PDSI) and Surface Water Supply Index (SWSI) are other indicators of drought. The PDSI is a soil moisture index based on measured precipitation, estimated evaporation and evapotranspiration, as well as climatic characteristics. PDSI figures are available for over 140 stations statewide. The SWSI projects streamflow for runoff and snowmelt- driven hydrologic regimes. The SWSI is based on snowpack, mountain precipitation, soil moisture, and reservoir storage. The Natural Resources Conservation Service (NRCS) calculates SWSIs for over 50 individual Montana river basins.

History of Drought in Montana

The first observed drought impacts in Montana occurred shortly after homesteaders flooded the state. The homestead boom of 1906 through 1918 "busted" when severe drought swept the state from 1917 through 1923. The drought was compounded by plummeting market prices and banks demanding repayments [Montana Historical Society, 2004].

The Dust Bowl years further impacted agricultural production and local economies. The period from 1928 through 1939 was the driest in the historic record and was further exacerbated by poor farming practices, low market prices, and a depressed economy. A variety of adjustments ensued: improved farmland management, the establishment of insurance programs, liberalization of credit, and diversification of the regional economy. As a result, impacts caused by the drought of the 1950s were much less severe than those of the 1930s, despite similar conditions to those of the dust bowl era of the 1930s [Montana Drought Response Plan, 1995].

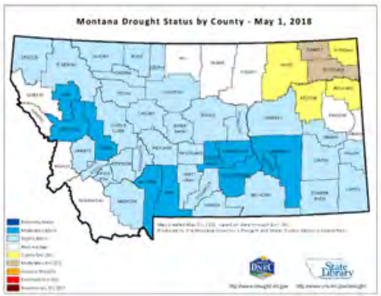
From 1976 through the present, Montana has endured a period characterized by years of below average precipitation, punctuated by the extremely dry years of 1977, 1987-88, 1992, 1994, 2004, 2017, and 2021. In fact, the drought from 2000-2007 suggests a level of dryness and hydrologic deficits that mimic the Dust Bowl years. According to the Palmer Drought Index, Montana has been in severe and extreme drought 10 to 20 percent of the time in the last one hundred years.

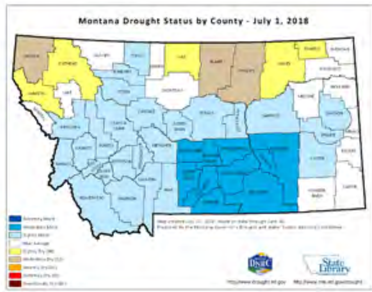
Montana's drought status (now known as its water supply and moisture conditions) for May, July and September for the period 2018 through 2022 are shown in **Figure 4.5-1** [Montana State Library, 2022].

Figure 4.5-1. Montana Drought Status 2018 - 2022

2018 Montana Drought Status by County

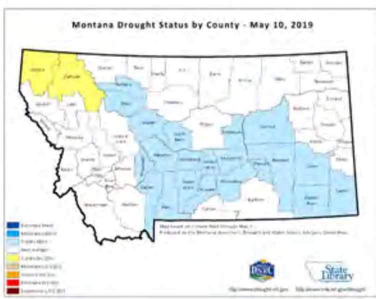
May	July	September

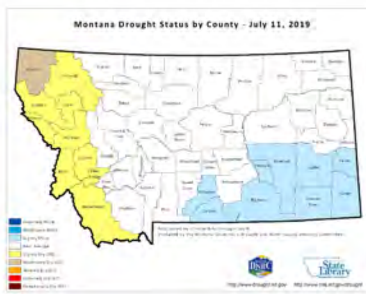


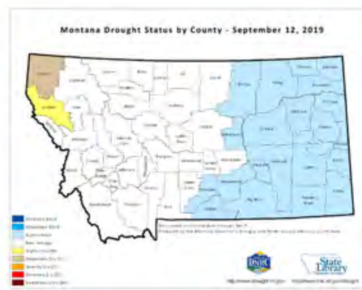


2019 Montana Drought Status by County

May	July	September

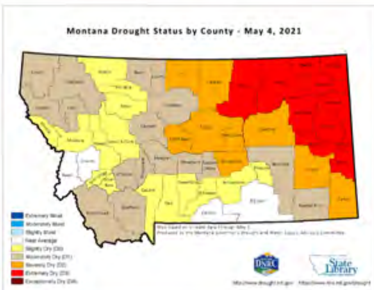
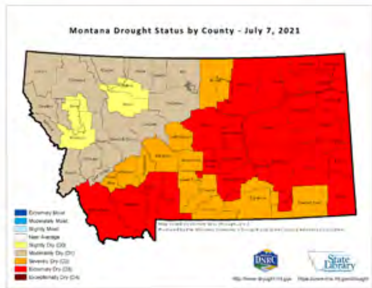
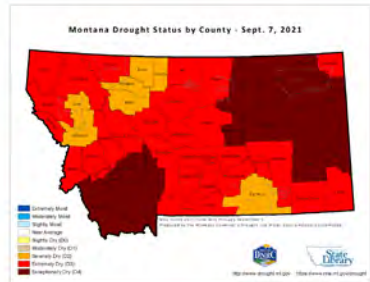
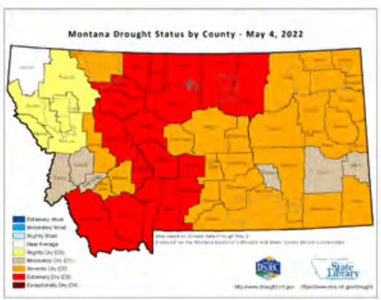
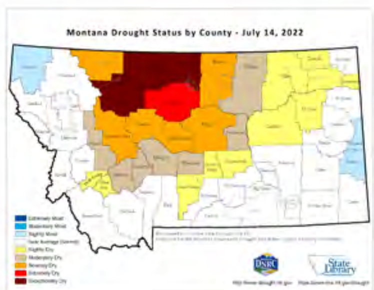






2020 Montana Water Supply and Moisture Conditions by County

May	July	September

2021 Montana Water Supply and Moisture Conditions by County		
May	July	September
		
2022 Montana Water Supply and Moisture Conditions by County		
May	July	September
		

The drought of 2021 surpassed the magnitude of the 2017 drought-- a year previously used as the benchmark for 20th century drought magnitude in Montana. In 2021, the entire state experienced drought conditions simultaneously, ranging from severely to exceptionally dry. It was the first year since 2017 that more than 10 percent of the state was in extreme drought. Notably, 46 percent of the state was under extreme drought and 69 percent of the state was under severe drought according to the National Integrated Drought Information System [NIDIS, 2022]. The summer of 2021 was the third warmest on record since 1895 at 4 degrees above average [NCEI, 2022[2]]. Only four years that have been drier than 2021 were 1931, 1919, and 1952. On average, the entire state was 4.7 inches behind annual precipitation [Great Falls Tribune, *Montana in Grip of 4th Driest Year on Record*, 2021].

Declared Disasters

Droughts typically do not require evacuations or constitute an imminent threat to life or property. As a result, disaster declarations and assistance are provided by agencies such as the USDA Farm Service Agency (FSA) and Small Business Administration (SBA). There have been no Presidential disaster declarations for drought. Declarations at the federal level have been from the Secretary of Agriculture, referred to as Natural Disaster Determinations (NDD). NDDs allow various assistance programs, such as the low-interest FSA Emergency Loans to Eligible Producers, and assistance through the Crop Disaster Program, Livestock Compensation Program, and Livestock Indemnity Program, among others. State disaster declarations and assistance were provided for grasshopper infestations in Valley County in 1975; Judith Basin, Pondera, Prairie, Sheridan, and Wibaux Counties in 1985; and

Carter, Daniels, Golden Valley, Petroleum, Richland, Roosevelt, Sheridan, Treasure, and Wibaux Counties in 1986. Since the last update to the MHMP in 2018, one statewide drought emergency was declared in July of 2021. Drought and agricultural disaster declarations in Montana are summarized in **Table 4.5-1**, as updated from the previous MHMP based on data from the Governor's office [Executive Orders, 2022].

Table 4.5-1. Montana Drought and other Agricultural Disasters

Date	Event	Damages
1985	All 56 counties received disaster declarations for drought during this year. From 1982 to 1985, cattle herds reduced by one-third. Smallest wheat crop in 45 years. Extended effects of drought: loss of off-farm jobs, closing of implement dealerships and Production Credit Associations.	Est. economic loss: $3 million
June, 1986	Grasshopper Infestation. Carter, Daniels, Golden Valley, Petroleum, Richland, Roosevelt, Sheridan, Treasure & Wibaux counties.	State: $350,000 Local: $350,000
June, 1992	Drought Emergency (EO 13-92). All areas of the state suspend certain regulatory authorities relating to the issuance of beneficial water use permits by DNRC because of drought.	N/A
June, 1993	Drought Disaster (EO 14-92). All areas of the state continue the suspension of certain regulatory authorities relating to the issuance of beneficial water use permits by DNRC because of drought.	N/A
August, 1994	Drought emergencies were declared in a number of Montana counties with 83% of the State reporting drought conditions at mid-month. Stress to stream fisheries (low water levels, high temp.); crop yields, wildfires.	N/A
2000	Severe drought and persistent heat causing significant losses to agriculture and related industries.	$4.2 billion in damage/costs and 140 deaths nationwide
2000- 2002	USDA issued NDD for drought for entire state of Montana for 2000, 2001, and 2002. This designation entitled counties to low interest loans for producers, SBA loans, and an Internal Revenue Service provision deferring capital gains.	N/A
2003	USDA issued NDD for drought for 35 Montana counties on 12/3/2003. This designation made farmers and ranchers eligible for FSA emergency farm loans.	$154,012,122 paid by FSA in Montana
2004	USDA issued NDD for drought for 20 Montana counties on 4/23/2004. This designation made farmers and ranchers eligible for FSA emergency farm loans.	N/A
2017	Unprecedented drought; "As dry as it's been in recorded history" according to the NWS in Glasgow. By late August, the U.S. Drought Monitor classified all of Montana in some stage of drought, with 65% of the state in extreme or exceptional drought. More than half of spring planted dryland crops rated in poor to very poor condition with production off by 29 million bushels. Per acre, spring wheat yields at 21.5 bushels, the worst yield since 1943. (Billings Gazette, *Nearly all of Montana is in* Drought, August 19, 2017).	Crop losses in hundreds of millions of dollars
July, 2021	Executive order proclaiming statewide drought emergency in Montana due to conditions that continue to cause significant and widespread damage to agricultural crops including livestock forage, forcing Montana's ranchers to suffer economic hardships (State of Montana Executive Order No.11-2021)	Ongoing drought conditions have resulted in great economic hardship for Montana livestock producers (State of Montana Executive Order No.11-2021)

FREQUENCY/LIKELIHOOD OF OCCURENCE

Probability for the MHMP is based on hazard frequency over a 10-year period. According to the National Drought Mitigation Center, drought losses are sustained every year in Montana. Although some years are more severe than others, the probability that drought will continue to occur somewhere in Montana on an annual basis resulted in the drought hazard being assigned a "Highly Likely" probability rating.

CLIMATE CHANGE CONSIDERATIONS

Changes in climate are likely to increase the incidence of drought. Montana has been on a steady warming trend for decades, amounting to over 3 degrees Fahrenheit since 1950. Montana can expect additional warming with less precipitation in the summer months. Over the next century, extreme heat days (above 90 degrees Fahrenheit) are projected to increase across the state. Projected warming in winter and spring will lead to a higher proportion of the annual flow earlier in the year, resulting in lower flows during the summer months [Whitlock et.al., 2017].

Table 4.5-4 presents the median 95-degree days projected for the low- and high-emission scenarios at mid-century and end-of-century. The data is presented in relation to the top crop- and livestock-producing counties based on 2019 cash sales from the *Annual Montana Agricultural Statistics* Report for 2021 [NASS, 2021]. Data shows that Fergus County, the top livestock- producing county, is projected to experience between 8 and 12 more 95-degree days at mid- century. Chouteau County, the top crop producing county, is projected to experience between 9 and 15 more 95-degree days at mid-century. These predictions are even more extreme at the end-of-the century. Extreme heat will likely exacerbate future drought conditions. Refer to *Severe Weather* Hazard Profile (section 4.6) for climate change data.

Table 4.5-4. Top Agricultural Counties with Projected Median Days per Year Over 95 Degrees at Mid- and End-Century

Type of Cash Crop Receipt	County	Cash Receipts ($1,000s of Dollars)	Observed Mean 1950-2013 Days/Year >95°	Low Emission Scenario Weighted Mean Days/Year >95°	Low Emission Change from Observed Mean Days/Year >95°	High Emission Scenario Weighted Mean Days/Year >95°	High Emission Change from Observed Mean Days/Year >95°
Mid-Century (2050)							
Livestock	Fergus	91,974	4.2	16.5	12.3	19.8	7.5
	Yellowstone	87,559	8.3	28.7	20.4	32.9	12.5
	Beaverhead	76,291	0.1	1.2	1.1	2.1	1.0
	Rosebud	64,450	12.0	32.7	20.7	36.5	15.8
	Carbon	62,004	2.3	12.7	10.4	15.8	5.4
Crop	Chouteau	165,418	6.3	21.5	15.2	24.3	9.1
	Hill	122,756	5.3	18.7	13.4	20.7	7.3
	Gallatin	116,500	1.0	8.3	7.3	10.5	3.2
	Pondera	93,126	7.6	21.6	14.0	23.9	9.9
	Teton	84,105	0.8	7.5	6.7	10.0	3.3
End of Century (2099)							
Livestock	Fergus	91,974	4.2	25.0	20.8	52.1	31.3
	Yellowstone	87,559	8.3	39.0	30.7	70.6	39.9
	Beaverhead	76,291	0.1	2.4	2.3	20.4	18.1
	Rosebud	64,450	12.0	43.4	31.4	72.4	41.0
	Carbon	62,004	2.3	18.5	16.2	46.4	30.2
Crop	Chouteau	165,418	6.3	31.0	24.7	59.4	34.7
	Hill	122,756	5.3	27.2	21.9	54.9	33.0
	Gallatin	116,500	1.0	14.0	13.0	41.2	28.2
	Pondera	93,126	7.6	30.7	23.1	60.4	37.3
	Teton	84,105	0.8	12.6	11.8	38.9	27.1

The changes in temperature and precipitation brought on by climate change will make it harder to grow crops. Evaporation and the higher rate at which plants lose moisture through their leaves increases with temperature. Unless higher evapotranspiration rates are matched by increased precipitation, soil and vegetation will dry. Intense rains can increase runoff and deprive plants of nutrient-rich topsoil. Changes in temperatures may cause crops to mature earlier, which can expose them to harsh weather. Warmer temperatures can introduce new agricultural pests to the region or make conditions better for pests already present, including weeds and invasive plants that compete with crops. Maintaining agricultural activities on marginal lands may no longer be sustainable [FEMA, 2016].

According to a 2016 report prepared for the Montana Farmers Union, by the middle of the century, climate change is projected to reduce cattle and grain production in Montana by 20 and 25 percent, respectively, resulting in a loss of 25,000 jobs and $736 million in earnings [Bozeman Daily Chronical, The Worst Drought We've Ever Had: Farmers, Ranchers Across the State Struggle with Historic Dry Spell, September 3, 2017]. Documentation shows that farmers and ranchers have also been psychologically impacted by these changes [The Guardian, The Unprecedented Drought That's Crippling Montana and North Dakota, September 7, 2017].

Changes in stream temperature due to lower flows and rising air temperature are likely to have negative impact on aquatic species, with ripple effect on Montana's important river- based recreation industry. Recent studies show that distributions of brown trout and bull trout have shifted upstream as fish seek cooler habitats. In larger rivers at lower elevations, warming trends may result in more frequent fishing season closures and disease outbreaks. Sections of rivers that currently support trout fisheries may transition gradually into bass fisheries [Whitlock, et.al, 2017].

Maintaining stream flows during warm season months will necessitate reconsideration of water storage practices and reservoir management. Changing seasonality of water availability will put additional stress on the water rights system, making it difficult to access water at crucial times [Whitlock, et.al, 2017].

Population exposure to drought is also likely to increase because of climate change. People without access to backup water supplies may suffer water shortages and a greater number of people may need to engage in behavioral changes to conserve water. The societal impact from extreme heat is discussed in the Severe Weather (section 4.6).

Property exposure and vulnerability may increase because of increased drought resulting from climate change. Indirect impacts of drought, such as wildfire, may increase the threat to structures.

Critical facility exposure to drought is not expected to increase because of climate change; however, facility operators may need to alter standard management practices and actively manage resources, particularly in the water-related service sector.

POTENTIAL MAGNITUDE AND SEVERITY

The effects of drought can be quantified by damage to the agricultural industry, including reduced rangeland productivity, foundation stock, and grazing availability on public lands. Other effects include rising costs of acquiring supplemental feed or finding new pasture, disruption of reproduction cycles, high cost/unavailability of water for livestock, greater wildfire threat to rangeland, increased fuel and labor costs, and reduced revenues to businesses in agricultural communities. Ranchers may also be forced to sell off calves early due to lack of grass pasture. A dry year could mean that cattle end up weighing 50 pounds less than average, cutting roughly $100 off their individual sale price [Billings Gazette, *nearly all of Montana is in Drought*, August 19, 2017; Billings Gazette, *Montana Drought Drives Cattle to Market Early*, October 14, 2017].

For example, annual total wheat yields per acre in 2021 were 22.2 bushels, compared to 42.4 bushels in 2019 in which no drought emergency was declared. 2021 saw the lowest harvest price of wheat since 2017. Table 4.5-2 shows how drought has impacted total state economic value of wheat yield since 2017, adjusted for 2022 inflation. Yield data was obtained from the USDA National

Agricultural Statistics Service (NASS) [NASS, 2022]. The analysis shows that drought years, such as 2017 and 2021, directly correlate to decreased economic yield to farmers, and higher crop indemnity pay-outs.

Table 4.5-2. Total State Economic Wheat Loss from Drought; 2017-2021

Year	Total State Economic Value (Inflated to 2022)
2021	$973,773,233
2020	$1,375,727,942
2019	$1,185,487,725
2018	$1,225,228,724
2017	$787,291,599

The USDA Risk management Agency (RMA) tracks up-to-date indemnity payments for losses suffered due to drought on a county basis. **Table 4.5-3** presents drought damages for 2015 to 2022, listing the top four counties for each year as reported by the USDA [RMA, 2022]. Crop indemnity data from 1989 to 2014 is reported in the 2018 MHMP. Data shows that 2021 had the greatest indemnity payments from drought for the state, with $ 437 million, followed by 2017, with $231 million. From the table, it is observed that 2020 saw the lowest indemnity payments for the state, at $15 million. Over this 7-year period, the top four counties with the most indemnity pay-outs were Valley County at $151 million, followed by Roosevelt County with $102 million, Sheridan County with $90 million, and Powder River County at $47 million. As such, it may be determined that the Central and Eastern DES Districts suffer the most economic hardship in the event of drought.

Table 4.5-3. Drought Insurance Claims; 2015-2022

Year	State Total	Top 4 Counties	
2015	$46,492,929	Hill	$7,226,968.66
		Liberty	$5,804,460.00
		Toole	$5,574,994.62
		Pondera	$3,758,154.36
2016	$16,506,663	Carter	$2,696,822.01
		Wheatland	$1,871,964.06
		Fallon	$1,515,795.60
		Powder River	$1,086,123.80
2017	$230,941,289	Roosevelt	$45,383,502.27
		Sheridan	$45,040,275.26
		Valley	$38,203,598.99
		McCone	$17,879,053.85
2018	$42,247,383	Phillips	$8,512,149.13
		Roosevelt	$7,334,166.48
		Valley	$6,869,066.37
		Hill	$4,205,138.24
2019	$21,089,377	Toole	$6,899,005.10
		Hill	$4,875,185.04
		Liberty	$3,736,205.68
		Blaine	$1,244,163.89
2020	$15,532,459	Powder River	$1,657,504.86
		Roosevelt	$1,326,001.85

		Sheridan	$1,325,189.67
		Valley	$1,308,723.72
2021	$437,139,697	Valley	$60,843,995.42
		Roosevelt	$47,973,123.02
		Sheridan	$36,183,302.19
		Hill	$34,317,816.93
2022	$17,422,999	Hill	$2,763,157.10
		Liberty	$2,085,451.55
		Chouteau	$1,774,734.15
		Fergus	$1,613,337.20

VULNERABILITY ASSESMENT

State actions to mitigate drought impacts vary due to Montana's diverse topography and precipitation regimes. Annual precipitation ranges from 6 inches in the southcentral prairies to 120 inches in the northwest mountains. The mountainous regions of the state receive 55 to 80 percent of annual precipitation between October and April. Most of this precipitation is snow that is stored as snowpack until spring runoff. Records indicate that in years when snowpacks are below normal by March 1st, and soil moisture levels are low, stream flows most likely will be low in coming months [MT Drought Response Plan, 1995].

In contrast, the eastern two-thirds of the state, characterized by prairie topography, receive 55 to 65 percent of its annual precipitation between April and August. The prairie dryland farming regions must receive spring and summer rains to avert the impacts of drought. Drought mitigation management for this region consists primarily of conservation farming practices, use of drought-resistant grain varieties, and participation in programs that remove land from production such as the Conservation Reserve Program [MT Drought Response Plan, 1995].

Statewide Vulnerability

Anywhere in Montana is vulnerable to drought. Weather cycles dictate the availability of water and temperatures that cause drought. The ability to have adequate water storage, adopt drought resistant crops, and implement conservation measures all help reduce negative drought impacts. Agriculture, and those who directly depend on the agricultural economy are most vulnerable to drought. Compared to other hazards, drought has the most profound impact on growing crops and providing enough feed for livestock.

Since Montana's population and water usage is continuing to grow, demand for water is rising at a steady rate. Available water supplies have also increased through a variety of structural (dams) and non-structural (conservation) means, but the State's ability to create new levels of supply is marginal. In recent years, water demand has been increasing faster than the creation of supplies. As such, tolerance to deal with water shortages is diminishing. In the future, water shortages are likely to be more frequent and costly. Water shortages can reduce recreation opportunities and increase the threat of wildland and rangeland fire.

Drought impacts related to surface water shortages can be mitigated by changes in water management practices. This is especially true in mountainous regions of the state that are dependent on mountain snowpack runoff for irrigation, and anywhere that irrigation water from rivers and reservoirs is fed by snowmelt. Improved planning to facilitate a reliable water supply for irrigation should occur early for runoff-dependent regions of the state that rely on dams to irrigate crops. In contrast, dryland farming regions depend on timely precipitation to provide soil moisture for crop growth. [MT Drought Response Plan, 1995]

The Governor's Drought Advisory Committee was established by an act of the Montana State Legislature in 1991 following the drought years of the late 1980s, including the highly publicized Yellowstone National Park wildfire year of 1988. The rationale behind the initiative to create a state drought advisory committee was that if state, local, and federal officials who monitor water supply and moisture conditions can be brought together on a regular basis, measures could be taken to lessen drought impacts. House Bill 59 signed by the Governor changed the name to Drought and Water Supply Advisory Committee. The committee discusses water supply and moisture conditions on a monthly basis among state and local agency officials. The drought statute provides guidance on the membership of the committee and its responsibilities. This includes development of a state drought plan that specifies actions that correspond expected conditions. In its monthly assessment of forecast precipitation, mountain snowpack, streamflow, soil moisture, reservoir contents, and agricultural and livestock production. The committee also provides planning support and information sharing to watershed groups and county drought committees.

State voting member agencies include the Governor's Office, DNRC, DEQ, FWP, Agriculture, Livestock, Commerce, and DES. Federal reporting partners include the Bureau of Reclamation, U.S. Geological Survey, Natural Resource Conservation Service, Agricultural Statistics Service, and the National Weather Service. Other reporters include the multi-agency Northern Rockies Coordination Center for fire conditions, Montana Tech's Groundwater Information Center, Montana Climate Office, USDA Farm Service Agency, U.S. Congressional delegation representatives, U.S. Small Business Administration, Rural Development, and Montana State University Extension Service. The committee chair is held by a Governor's representative and is traditionally the Lieutenant Governor. The committee is required to meet every month between April and October at a minimum.

Other State agencies have plans and policies to mitigate the impact of drought. FWP maintains a Fisheries Division Drought Contingency Plan that supports popular fisheries. While natural events cannot be controlled, the additive impact of angling pressure during the stressful drought conditions can be reduced to help aquatic ecosystems. FWP's drought strategy is an attempt to balance recreational opportunity with resource protections. During periods of drought, the FWP Wildlife Division monitors wildlife populations, documents drought impacts, informs the public of impacts, and takes appropriate management actions in accordance with a Wildlife Drought Contingency Plan.

Federal agencies have mobilized to provide improved information, emergency planning assistance, land management improvements, and investments in new technologies to aid water resource management. Continued drought conditions in the West and projections of more extreme droughts underscore the urgency to pursue long term solutions. In partnership with the Montana DNRC and others, the Missouri Headwaters Basin was selected as a national drought resilience pilot project. Partners are engaging communities in drought planning to implement projects that build resiliency. Both the Big Hole and Jefferson River Water Councils have developed Drought Management Plans. The purpose of these plans is to reduce resource damage and to provide equitable water resources during water critical periods.

Review of Potential Losses in Local Hazard Mitigation Plans

Approximately 60 percent of the local Hazard Mitigation Plans evaluated the drought hazard in their risk assessment. Local jurisdictions that ranked drought as their #1 hazard included Big Horn, Judith Basin, Teton, and Toole counties and the Fort Belknap Reservation. Those who ranked drought as their #3 hazard included Carter, Cascade, Custer, Jefferson, and Ravalli counties.

Drought loss is described in terms of its effect on the economy, either as a dollar value or high- moderate-low rating referring to the potential impact to the economy from the hazard. **Appendix B- 6** presents a summary of potential drought losses from the Local PDM Plans.

Vulnerability of State Property

In the event of drought, state land is more prone to wildland fire. Lands leased for agricultural purposes could generate lower lease payments if the availability of livestock grazing forage and/or water availability for irrigation is reduced. State-owned facilities are not generally considered vulnerable to drought; however, there is a greater threat of structure damage in a drought-affected area due to increased risk of wildfire.

FUTURE DEVELOPMENT

The impact of future development will increase the likelihood of drought hazard. New developments require water for outdoor and indoor use, further exacerbating surface water and groundwater resources. New water resources will have to be identified on a local basis to support future development. The Montana DEQ carefully monitors and regulates public water systems, meaning future developments could often face water-usage stipulations in times of drought.

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4.6 SEVERE WEATHER CPRI SCORE = 2.75

DESCRIPTION AND PAST OCCURENCES

Severe summer and winter weather have been combined into one hazard profile for the 2022 MHMP. Drought is profiled separately in *Section 4.5*. Thunderstorms, hailstorms, high winds, extreme heat, heavy snow, freezing rain and sleet occur multiple times each year. Wind gusts of more than 70 mph are not uncommon.

Severe Winter Weather

Severe winter weather presents one of the greatest threats to life of any hazard in Montana. Nationally there are an average of 100 lives, directly and indirectly, lost to winter weather each year. This is more than lightning, hurricanes, or tornadoes. Winter storms are deceptive because most deaths are indirectly related to the storm. People die in traffic accidents on snow- or ice-covered roads, from hypothermia due to prolonged exposure to cold, and from heart attacks due to overexertion. About 70 percent of winter deaths in the U.S. occur in automobiles and nearly 25 percent are from people caught out in the storm [NOAA, 2001].

Winter storms may be categorized as ice storms, heavy snowfall, or blizzards. These storms vary in size and intensity. They may affect a small part of the state or several states at once. Blizzards are common in Montana. A blizzard is a storm that has sustained winds or gusts of at least 35 miles per hour coupled with snow and blowing snow that reduces visibility. Blowing and rapid snowfall can overwhelm snow-plowing resources, making roadways impassable. Particularly heavy snows and ice events can damage infrastructure such as power lines, block roads, or damage structures with downed trees. Cold temperatures, below 0 degrees Fahrenheit, are also common throughout the winter months in Montana. The coldest places in Montana are in Valley, Sheridan and Roosevelt Counties where average daily low temperatures have ranged from -5.8°F to -2.0°F. The coldest temperature ever recorded in Montana was -70°F at Rogers Pass north of Helena, on January 20, 1954. Extended cold periods, coupled with strong winds, can create dangerous situations for people outdoors or without heat, such as in the case of a utility disruption.

Major problems typically only occur during record snowfalls and extended periods of below zero temperatures. Initial consequences include threats to vulnerable populations from utility interruption, freezing pipes, and snow removal costs. Examples of economic losses include commercial aviation delays/cancellations and loss in revenue to hotels and restaurants when roads become closed and businesses are not accessible. Residual effects from high snowpack winters include potential spring flooding from rapid snow melt.

Source: KPAX, 2019. February car accident on I-90.

Most Montana residents are prepared for winter weather each year. Every community receives snow on an annual basis and residents expect measurable snow several times each winter. Winter storms generally develop slowly, taking one to three days to mature. As such, the National Weather Service is often able to provide advance notice of winter storms, sometimes up to two days in advance. Winter weather typically affects the state from November to April, but late storms can extend into June, causing extreme impacts to the agricultural industry.

Blowing and drifting snow, extreme cold, hazardous driving conditions, and utility interruption are also common. From 2018 until November 2022 there were a total of 186 severe winter weather events. Of these, 10 events lead to loss of life or injury, summing to 11 deaths in this time frame according to the National Centers for Environmental Information [NCEI, 2022]. However, a 2022 report from the Montana Department of Transportation (MDT) attributed 46 fatal car crashes to winter weather in 2020 alone. Further, the report states that the average number of fatal crashes due to winter weather between 2011 and 2020 was 43 per year [MDT, 2022]. Since the 2018 MHMP, several emergencies and one disaster have been declared due to winter weather, described below [Executive Orders, 2020].

February 2018 – A winter storm emergency was declared due to an unrelenting series of snowstorms, gale-force winds and subzero temperatures that drained emergency resources on the Blackfeet Reservation. Many families living in more remote locations were blocked in their homes for weeks without access to food, medicine, and heat. Emergency coordinators finally caught a break and managed to clear out some of the snow accumulation, which totaled six feet in some areas, carving a narrow two-lane path through highway arteries that had been intermittently closed for weeks, cutting off supplies to the reservation and making travel virtually impossible. The brutal weather prompted the Blackfeet Nation to declare a state of emergency in early January, while Governor Steve Bullock followed up with a declaration on February 27th, sending a semi-load of food and two shipments of firewood to the beleaguered communities of Browning, Hearth Butte, East Glacier, Babb, and St. Mary. [Flathead Beacon, Clobbered by Snow, Beleaguered Blackfeet Communities Begin to Gain Ground, March 3, 2018].

February 2019 - Beginning on February 24th, 2019, extreme cold and blizzard conditions impacted southwest Montana, leading to the declaration of a winter storm emergency. The extreme cold and almost record snowfall created extraordinary conditions for roads and travel, leading to public safety concerns that spurred the emergency declaration. These conditions quickly exhausted resources in Deer Lodge County. The county was forced to appropriate city funds for clearing roads in order to ensure the safe travel of emergency personnel. County officials stated that it would take more than a week to clear all the roads. The county was forced to enlist the help of MDT to clear roads. According to county officials, the cost to the county for clearing the snow was $3,000 per hour [Daily Dispatch, Anaconda-Deer Lodge County Declares State of Emergency, 2019]. The declaration of the emergency allowed the county to be reimbursed for some of these costs. [ABC Fox Montana, Anaconda-Deer Lodge County Declares State of Emergency, 2019].

Source: ABC FOX, 2019. Snow accumulation in Anaconda.

September 2019 - National Weather Service predictions prompted the governor to declare a state of emergency on September 27th, as record-low temperatures and extreme snowfall accumulation were predicted. Consequently, the early-season blizzard culminated in up to 4 feet of snow over a three-day period. Additionally, strong winds and wet, heavy snow caused power outages and road closures in north-central and southwest Montana. During the event, Great Falls broke a single-day record for September snowfall while the City of Choteau urged residents to stay indoors due to downed trees and power lines. Gusty winds toppled up to 30 trees around Flathead Lake. Building and vehicle damage was reported extensively due to fallen or damaged trees. In the following days, temperatures in the 20s exacerbated the snowy conditions and recovery efforts. Throughout many of the affected areas, only emergency travel was recommended. [CBS News, *Powerful September Snowstorm Dumps More than a Foot of Snow in Northwestern Montana,* 2019].

January 2022 - On January 18th, prolonged harsh winter conditions lead to an increased short-term demand for propane and heating oil. Concurrently, a national shortage of commercial drivers led to delays in fuel deliveries. Due to the combination of low heating fuels and extremely cold temperatures, it was determined that these shortages and delays were a threat to public health, property, and welfare of Montana residents. To rectify this issue, expanded hours of trucking operation were permitted to expedite fuel deliveries to the state. [Executive Orders, 2022].

Severe Summer Weather

Severe summer weather includes thunderstorms, high winds, hail, lightning, tornadoes, extreme heat, and microbursts that typically occur between May and October. A brief description of these weather phenomena is presented below.

A thunderstorm is formed from a combination of moisture, rapidly rising warm air, and a force capable of lifting air (such as a warm/cold front or topography). A severe thunderstorm is a thunderstorm that produces tornadoes, hail 1 inch or more in diameter, or winds in excess of 50 knots (58 mph). All thunderstorms contain lightning. Thunderstorms may occur singly, in clusters, or in lines. Thus, it is possible for several thunderstorms to affect one location over a few hours. Straight-line winds are responsible for most thunderstorm damage.

Source: NWS, 2022. Destructive winds fester near Hardin.

High winds can occur with strong pressure gradients or gusty frontal passages. The entire state is capable of being affected by winds that may reach speeds of 75-100 mph. A Chinook is a warm wind that develops down the east slopes of the Rocky Mountains. At times, these winds can reach several hundreds of miles into the high plains.

Lightning is an electrical discharge that results from the buildup of charges within the clouds. When the buildup becomes strong enough, it is released in the form of lightning. Lightning only causes severe damage when the discharge connects to the earth's surface. Lightning's electrical charge and intense heat can split trees, ignite fires, and cause electrical failures.

Extreme Heat often results in the highest number of annual deaths among all weather-related hazards. In most of the United States, extreme heat is defined as a long period (2 to 3 days) of high humidity and temperatures above 90 degrees. In extreme heat, the human body must work extra hard to maintain a normal temperature, leading to abnormal stress and health issues.

A microburst is a localized column of sinking air that produces damaging winds that are similar to, but distinguishable from, tornadoes. The scale and suddenness of microbursts makes them a great danger to aircraft, with several fatal crashes having been attributed to the phenomenon over the past several decades. Microbursts in forested regions have been known to flatten acres of standing timber.

A tornado is a violently rotating column of air in contact with the ground, extending from the base of a thunderstorm. Until 2006, tornadoes were categorized by the Fujita scale based on wind speed. Then, the Enhanced Fujita (EF) Scale was implemented and began operational use on February 1, 2007. A comparison of the Fujita and EF scales and wind speeds are summarized in **Table 4.6-1.** The EF scale has categories from zero to five representing increasing degrees of damage. It was revised to reflect better align wind speeds more closely with associated storm damage. It also adds more types of structures as well as vegetation, expands degrees of damage, and better accounts for variables such as differences in construction quality. The EF-scale is a set of wind estimates based on damage. It uses three-second estimated gusts at the point of damage. These estimates vary with height and exposure. Forensic meteorologists use 28 damage indicators and up to 9 degrees of damage to assign estimated speeds to the wind gusts.

Table 4.6-1. Comparison of Fujita and Enhanced Fujita Tornado Scale

Fujita Scale				Enhanced Fujita (EF) Scale		
Scale	Wind Speed (mph)	3-Second Gust Speed (mph)	Typical Damage	Scale	3-Second Gust Speed (mph)	Typical Damage
F0	40-72	45-78	Light Damage - Some damage to chimneys; branches broken off trees; shallow-rooted trees pushed over; sign boards damaged.	EF0	65-85	Light Damage – Causes some damage to siding and shingles.
F1	73-112	79-117	Moderate Damage - Peels surface off roofs; mobile homes pushed off foundations or overturned; moving autos blown off roads.	EF1	86-110	Moderate Damage – Considerable roof damage. Winds uproot tees and overturn mobile homes. Flagpoles bend.
F2	113-157	118-161	Considerable Damage - Roofs torn off frame houses; mobile homes demolished; boxcars overturned; large trees snapped or uprooted; light object missiles generated; cars lifted off ground.	EF2	111-135	Considerable Damage – Most single-wide mobile homes destroyed. Permanent homes can shift off foundations. Flagpoles collapse. Softwood trees debarked.
F3	158-206	162-209	Severe Damage - Roofs and some walls torn off well-constructed houses; trains overturned; most trees in forest uprooted; heavy cars lifted off ground and thrown.	EF3	136-165	Severe Damage – Hardwood trees debarked. All but small portions of houses destroyed.
F4	207-260	210-261	Devastating Damage - Well-built houses leveled; structures with weak foundations blown away some distance; cars thrown and large missiles generated.	EF4	166-200	Devastating damage – Complete destruction of well-built residences, and large sections of school buildings.
F5	261-318	262-317	Incredible Damage - Strong frame houses lifted off foundations and swept away; automobile sized missiles fly through the air in excess of 100 meters.	EF5	>200	Incredible Damage – Significant structural deformation of mid- and High-rise buildings.

In Montana, most tornadoes occur in June, followed closely by July. From 1952 to 2022, Montana had an annual average of six tornadoes. The 2018 MHMP provides details on historic tornado data going back as far as 1880. With an increased focus on recent tornadoes, **Table 4.6-2** provides a list of Montanan tornados that have occurred since the MHMP was last updated [NCEI, 2022]. No tornados in this timeframe have led to death, injury, or property damage. The most severe class of tornado experienced during this time was an EF2 in Carter County.

Table 4.6-2. Montana Tornados: 2018-2022

Date	County	EF Scale
8/26/2022	Blaine	EF0
7/18/2022	Valley	EF2
7/6/2022	Judith Basin	EF0
7/6/2021	Blaine	EFU
7/7/2020	Petroleum	EF0
7/7/2020	Petroleum	EF0
5/20/2020	Valley	EF0
7/18/2019	Carter	EF1
6/27/2019	Judith Basin	EF0
6/27/2019	Wheatland	EF0
6/27/2019	Phillips	EF0
8/20/2018	Beaverhead	EF0
7/9/2018	Sheridan	EF1
6/28/2018	Carter	EF0
6/28/2018	Carter	EF0
6/28/2018	Carter	EF0
6/28/2018	Carter	EF2
6/23/2018	Chouteau	EF0
6/7/2018	Big Horn	EF1
5/23/2018	Dawson	EF0
5/9/2018	Judith Basin	EF0

Besides tornados, **Table 4.6-3** shows counties with the highest frequency of other severe summer weather events [NCEI, 2022]. Valley County has had the greatest number of tornadoes, large hail, and high thunderstorm wind events. The highest number of events occur in the eastern region of the state, which may be characterized by flat prairie land. Concentrations of these recorded events identify patterns of where they are likely to occur in the future. Only one severe summer weather disaster/emergency event has occurred since 2018, presented below. Severe summer weather events prior to 2018 are discussed in the previous MHMP.

Table 4.6-3. Counties with High Frequency of Severe Weather Events: 19252-2022

Tornadoes (≥ EF0)		Hail (≥2-inch diameter)		Thunderstorm Wind (≥ 80 mph)	
County	No. of Events	County	No. of Events	County	No. of Events
Valley	39	Valley	47	Valley	46
Fergus	27	Powder River	34	Yellowstone	35
Yellowstone	21	Yellowstone	34	Custer	30
Carter	18	Carter	28	Roosevelt	29
Powder River	18	Rosebud	27	Richland	26
Roosevelt	16	Custer	26	Dawson	24
Chouteau	15	Garfield	25	Rosebud	23
Dawson	15	McCone	23	Big Horn	21
Judith Basin	15	Phillips	18	McCone	20
Fallon	14	Fergus	17	Carter	14
Phillips	13	Fallon	16	Phillips	14
Richland	13	Big Horn	15	Cascade	11
Beaverhead	12	Dawson	15	Garfield	11
Cascade	12	Daniels	14	Hill	10
Garfield	12	Chouteau	13	Sheridan	10
Big Horn	10	Musselshell	13	Lincoln	9
Sheridan	10	Prairie	12	Powder River	9
Daniels	9	Roosevelt	12	Prairie	9
McCone	9	Sheridan	11	Treasure	9
Rosebud	9	Cascade	10	Blaine	7
Custer	8	Richland	10	Fallon	7
Petroleum	8	Treasure	10	Fergus	7
Wibaux	8	Golden Valley	9	Musselshell	7
Wheatland	7	Judith Basin	9	Teton	7
Blaine	6	Lewis And Clark	9	Chouteau	6
Hill	6	Stillwater	9	Gallatin	6
Toole	6	Wibaux	9	Beaverhead	5
Musselshell	5	Petroleum	8	Park	5
Flathead	4	Blaine	7	Broadwater	4
Gallatin	4	Missoula	7	Carbon	4
Lewis And Clark	4	Pondera	6	Daniels	4
Liberty	4	Teton	6	Flathead	4
Teton	4	Wheatland	5	Lewis And Clark	4
Carbon	3	Beaverhead	4	Missoula	4
Glacier	3	Carbon	4	Toole	4
Lake	3	Sweet Grass	4	Wibaux	4
Meagher	3	Gallatin	3	Madison	3
Prairie	3	Hill	3	Stillwater	3
Ravalli	3	Liberty	3	Judith Basin	2
Treasure	3	Toole	3	Lake	2

Granite	2	Flathead	2	Liberty	2
Madison	2	Granite	2	Petroleum	2
Missoula	2	Jefferson	2	Sweet Grass	2
Park	2	Meagher	2	Deer Lodge	1
Powell	2	Ravalli	2	Jefferson	1
Sweet Grass	2	Silver Bow	2	Mineral	1
Broadwater	1	Broadwater	1	Pondera	1
Deer Lodge	1	Lake	1	Powell	1
Sanders	1	Lincoln	1	Sanders	1
Stillwater	1	Mineral	1	Wheatland	1
Golden Valley	0	Powell	1	Glacier	0
Jefferson	0	Deer Lodge	0	Golden Valley	0
Lincoln	0	Glacier	0	Granite	0
Mineral	0	Madison	0	Meagher	0
Pondera	0	Park	0	Ravalli	0
Silver Bow	0	Sanders	0	Silver Bow	0

June 2021 - Several severe thunderstorms impacted five east-central Montana counties: Dawson, Garfield, McCone, Richland, and Roosevelt. As described in the Governor's executive order "severe thunderstorms with hail as large as three inches in diameter and recorded wind speeds of 70-90 mph with winds up to 115 mph, caused damages to over 800 power poles and lines" [Executive Orders, 2022]. Extensive power outages left too many residents without power to not declare a disaster. On July 29th, the governor requested a major disaster declaration due to the straight-line winds that were experienced. After federal damage assessments were conducted, President Biden declared that a major disaster existed on August 13th, making the state eligible for federal reimbursement to repair damages [FEMA, 2021].

Source: **Great Falls Tribune**, 2020. Example of straight-line wind damage.

Declared Disasters

Numerous disasters and emergencies have been declared in Montana due to severe weather. **Table 4.6-4** summarizes federal disaster declarations and state-declared emergencies from 2018 to 2022, leaving off where this data was last updated in the 2018 MHMP.

Table 4.6-4. Federal Disaster and State of Emergency Declarations due to Severe Weather: 2018-2022

Year	Declaration No./ Type	Counties / Reservations	Public Assistance ($)
Feb, 2018	Executive Order No. 5-2018; Extreme Cold and Blizzard Conditions	Blackfeet Reservation, Fort Belknap Reservation, Northern Cheyenne Reservation, Glacier, Golden Valley,	Not disclosed
Feb, 2019	Executive Order No. 2-2019; Extreme Cold and Blizzard Conditions	Anaconda (Deer Lodge Co.)	Not disclosed
Sep, 2019	Executive Order No. 15-2019; Severe Winter Weather	Statewide	Not disclosed
Jun, 2021	FEMA-4608-DR-MT; Straight-Line Winds	Dawson, Garfield, McCone, Richland, Roosevelt	Not disclosed
Jan, 2022	Executive Order No. 1-2022; Harsh Winter Conditions	Statewide	Not disclosed

FREQUENCY/LIKELIHOOD OF OCCURENCE

Probability of the severe weather hazard for this MHMP was assessed based on a 10-year period. Severe weather occurs several times per year and as such, has been assigned a "Highly Likely" probability rating. Higher temperatures associated with climate change are expected to increase the frequency and probability of future severe weather events.

CLIMATE CHANGE CONSIDERATIONS

The frequency of severe weather events has increased steadily over the last century. The number of weather-related disasters during the 1990s was four times that of the 1950s, and cost 14 times as much in economic losses. Historical data shows that the probability for severe weather events increases in a warmer climate. There has been a sizable upward trend in the number of storms causing large financial and other losses. Climate change presents a challenge for risk management associated with severe weather.

Montana has seen an uptick in average temperature of about 2 degrees F in the last 50 years, while precipitation has stayed largely the same. At the same time, temperatures extremes – the absolute coldest and absolute warmest temperatures of the year have shifted upwards by about 10 degrees for the absolute low, with more days falling into the hotter extreme as well (Independent Record, *Temps Getting Warmer, Nobel-Winning Scientist Says*, March 6, 2018).

According to the National Climate Change Assessment (2014), climate change can and has altered the risk of certain types of extreme weather events. The number of heat waves has been increasing in recent years with the number being almost triple the long-term average. These increases in extreme heat will have many negative consequences, including increases in surface water losses, heat stress, and demand for air conditioning. Rising temperatures are leading to increased demand for water and energy. In parts of the region, this will constrain development, stress natural resources, and increase competition for water among communities, agriculture, energy production, and ecological needs.

The average daily maximum temperature averaged over the course of the year is an effective overall indicator of the effect of changing climate conditions on local temperatures. **Figure 4.6-4** illustrates the projected median days per year above 95 degrees F for mid-century (2050) and end-of-century (2099) for the low and high emissions scenarios for each Montana county using data from the National Environmental Modeling and Analysis Center [NEMAC, 2022].

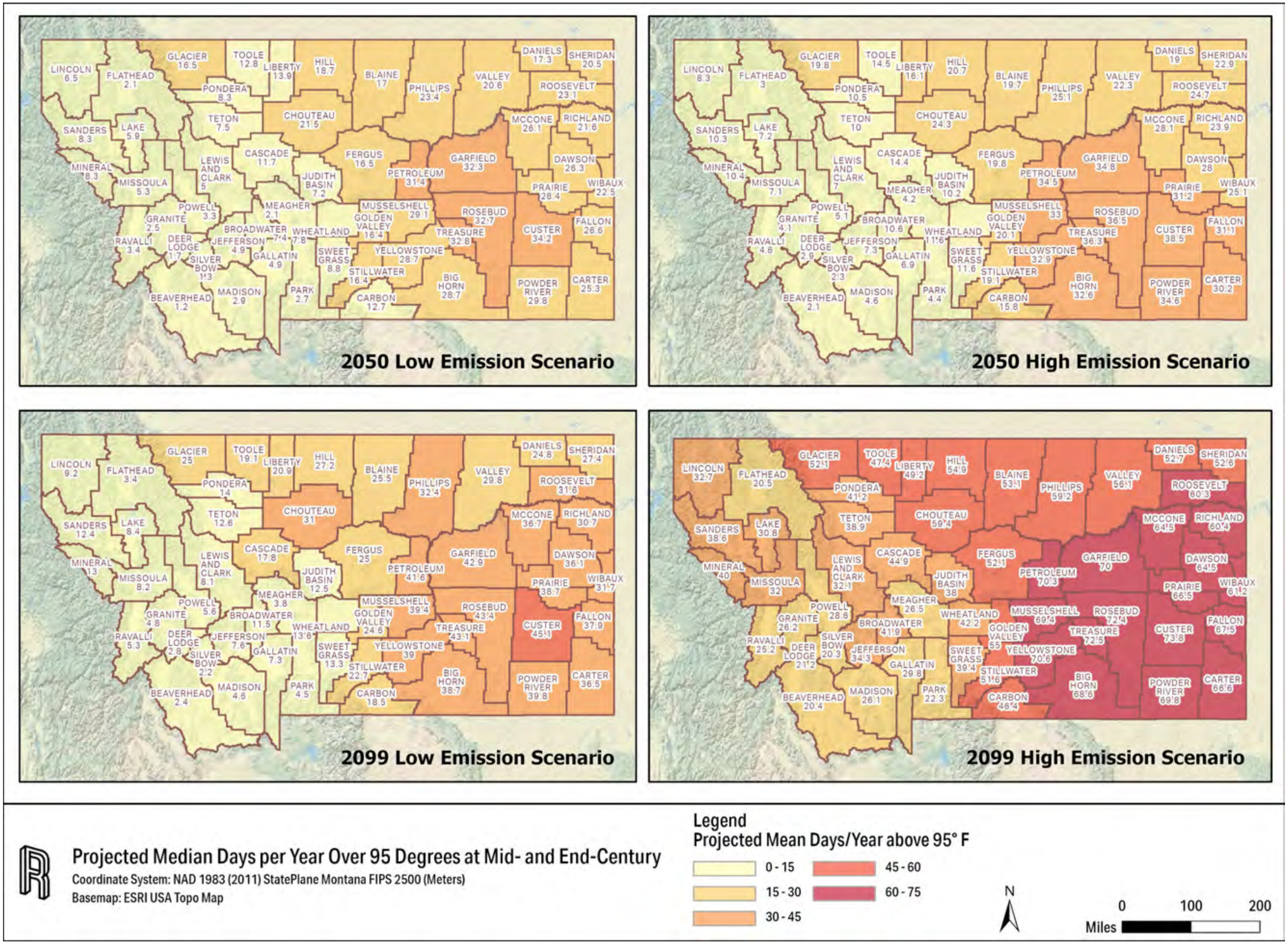

Figure 4.6-3. Projected climate change data for all counties.

The temperature projection figure shows that Yellowstone County, the county with the greatest population, will experience 28.7 more 95-degree days at mid-century according to the low-emissions scenario and 32.9 more according to the high-emissions scenario at mid-century. Projections for the end of the century are even higher. Cooling centers will likely be needed to manage extreme heat for vulnerable populations.

Changes in average temperatures can impact vegetation growth and the location and extent of pests. Higher temperatures may also lead to increases in wildfire occurrences. Extreme heat will have a profound effect on vulnerable populations, as most Montana homes do not have air conditioning.

Changing extremes in precipitation are projected across all seasons, including higher likelihoods of both increasing heavy rain and snow events. Winter and spring precipitation is projected to increase in the northern states of the Great Plains, relative to the 1971-2000 average. Winter storms have increased in frequency and intensity since the 1950s, and their tracks have shifted northward over the U.S. Projected changes in summer and fall precipitation are small; however, the number of days with heavy precipitation is expected to increase by mid-century. **Table 4.3-15** in the *Flooding* section presents the counties with the projected highest median 1-inch rain days for both emission scenarios at mid- and end-of-century.

For other types of extreme weather events, such as tornadoes and severe thunderstorms, more research is needed to understand how climate change will affect them. These events occur over much smaller scales, which makes observations and modeling more challenging. Projecting the future influence of climate change on these events can also be complicated by the fact that some of the risk factors for these events may increase with climate change, while others may decrease.

Population exposure and vulnerability to severe weather are likely to increase as a result of climate change. Severe weather events may occur more frequently which would lead to increased exposure and vulnerability. Although all people may be affected by the health-related impacts of climate change, the elderly, young children, and people with weakened immune systems are often the most susceptible.

Property exposure and vulnerability may increase because of increased severe weather resulting from climate change. Increased structure damage from high winds, hail and snow load could result as well as damage to crops and landscaping. Secondary impacts, such as wildfire, may increase and threaten structures.

Changes to the frequency, severity, and affected area of climate-related hazards may have economic consequences. Potential decreases in agricultural outputs due to severe weather may affect the economy in farming and ranching areas. Communities that rely on tourism may see a decrease in visitors due to severe weather. If these economic effects become widespread, the impacts could be felt at a statewide or regional level [FEMA, 2016].

Critical facility exposure and vulnerability are unlikely to increase because of climate change impacts associated with severe weather; however, critical facility owners and operators may experience more frequent disruption to the services they provide. For example, extreme heat can decrease the effectiveness of electrical equipment, including power lines, which can lead to blackouts during very hot conditions. An increase in requests for medical assistance during a heat wave may challenge emergency response capabilities. The need for community cooling centers could cause an increase in number of critical facilities.

POTENTIAL MAGNITUDE AND SEVERITY

The magnitude of severe weather is measured by the severity of the event and the resulting damage. Winter storms are generally slow in developing and advance notice can lessens their impacts. Severe winter weather that results in loss of life, extended road closures, long-term power outages, or significant isolation problems represent high magnitude weather events for Montana. Routine damages to property are largely due to frozen pipes. Collapsed roofs from snow load are not common due to the low percent moisture in typical snow loads. Severe summer weather can cause damage to buildings, homes, and other property but rarely cause death, serious injury, or long-lasting health effects. Straight-line winds are responsible for most thunderstorm damage.

Severe weather leads to millions of dollars in property and crop damage as well as life lost. **Table 4.6-5** presents rankings of the top twenty counties based on inflated total crop loss to date [USDA, 2022], as well as property damage, fatalities, and injuries [NCEI, 2022] attributed to severe summer and winter weather. Inflated crop loss data ranges from 1992 to 2022, while property damage, fatality, and injury data range from 1952 to 2022.

Table 4.6-5. Severe Weather Loss Summary for Crop Damage (1991-2022), Property Damage, Injuries, and Fatalities (1952-2022)

Ranking	County	Crop Damage	County	Property Damage	County	Injuries	County	Fatalities
1	Valley	$191,351,933	Valley	$21,355,000	Missoula	20	Missoula	10
2	Roosevelt	$179,157,655	Flathead	$11,480,000	Lake	16	Sanders	7
3	Sheridan	$144,401,069	Lake	$10,854,000	Granite	12	Lake	5
4	Chouteau	$124,954,613	Pondera	$7,145,000	Powell	12	Flathead	4
5	Hill	$113,272,805	Roosevelt	$6,750,000	Lewis and Clark	11	Ravalli	4
6	Toole	$109,556,799	Sanders	$6,010,000	Ravalli	8	Rosebud	4
7	Pondera	$95,359,266	Dawson	$5,270,000	Sanders	8	Wibaux	4
8	Teton	$84,002,007	Carter	$4,503,000	Valley	8	Granite	3
9	Glacier	$70,945,618	Fergus	$4,188,000	Fallon	7	Mineral	3
10	Liberty	$61,244,998	McCone	$4,178,000	Flathead	6	Roosevelt	3
11	McCone	$57,345,803	Sheridan	$2,850,000	Judith Basin	6	Sheridan	3
12	Blaine	$55,173,525	Fallon	$2,800,000	Richland	6	Big Horn	2
13	Big Horn	$55,063,107	Glacier	$2,675,000	Deer Lodge	5	Custer	2
14	Yellowstone	$48,827,936	Lincoln	$2,031,000	Glacier	5	Dawson	2
15	Fergus	$47,238,162	Big Horn	$1,825,000	Rosebud	5	Gallatin	2
16	Richland	$46,371,964	Teton	$1,766,000	Yellowstone	5	Powell	2
17	Cascade	$37,980,567	Lewis and Clark	$1,747,000	Dawson	3	Yellowstone	2
18	Phillips	$36,466,749	Richland	$1,478,000	Fergus	3	Beaverhead	1
19	Dawson	$30,332,734	Ravalli	$1,437,000	Park	3	Broadwater	1
20	Judith Basin	$26,995,047	Phillips	$1,237,000	Phillips	3	Carbon	1

Valley County has experienced the most crop loss and property damage to date, most likely due to the county's high number of farms. Conversely, Missoula County has seen the most injuries and fatalities.

VULNERABILITY ASSESMENT

Electric utilities in Montana are usually the first entities to experience loss from severe weather. Losses to local electric utilities can be expensive to replace and put a major burden on other emergency services during these critical times by not having electricity available.

Statewide Vulnerability

The entire State is considered equally vulnerable to severe winter weather. Arctic cold fronts typically enter the state from the northeast and may cross the Continental Divide, affecting the western portion of the State. Arctic fronts meeting wet maritime fronts often combine to cause heavy snowfall, which can occur in all parts of the State. The lowest temperatures are typically experienced in the northeast, whereas the heaviest snowfall most often occurs in the mountain regions.

Regional variation is apparent when observing summer weather hazards in Montana. To create an impact area map for the MHMP analysis, spatial data from the National Centers for Environmental Information from 1952 to 2022 was used to map occurrences of tornadoes, hail, and severe thunderstorm wind, as reflected in **Figures 4.6-1A-F** for each DES District. **Table 4.1- 5** in *Section 4.1.3* describes the methods used to create this hazard map.

To complete the vulnerability analysis, GIS was used to intersect the hazard area with the general building stock, critical facility, and cultural resource datasets. Because the severe winter weather hazard is considered uniform across the state, the severe summer weather area was created by connecting areas that experience a high density of severe weather events within a 20-mile radius. Estimates of vulnerable population were calculated by assigning a population to a structure type, a technique DNRC used when estimating vulnerable populations downstream of dams and is based on US Census Data. Exposure values by district are presented in **Table 4.6-6**. Appendix B-7 presents supporting documentation including loss estimates for counties and incorporated cities and towns.

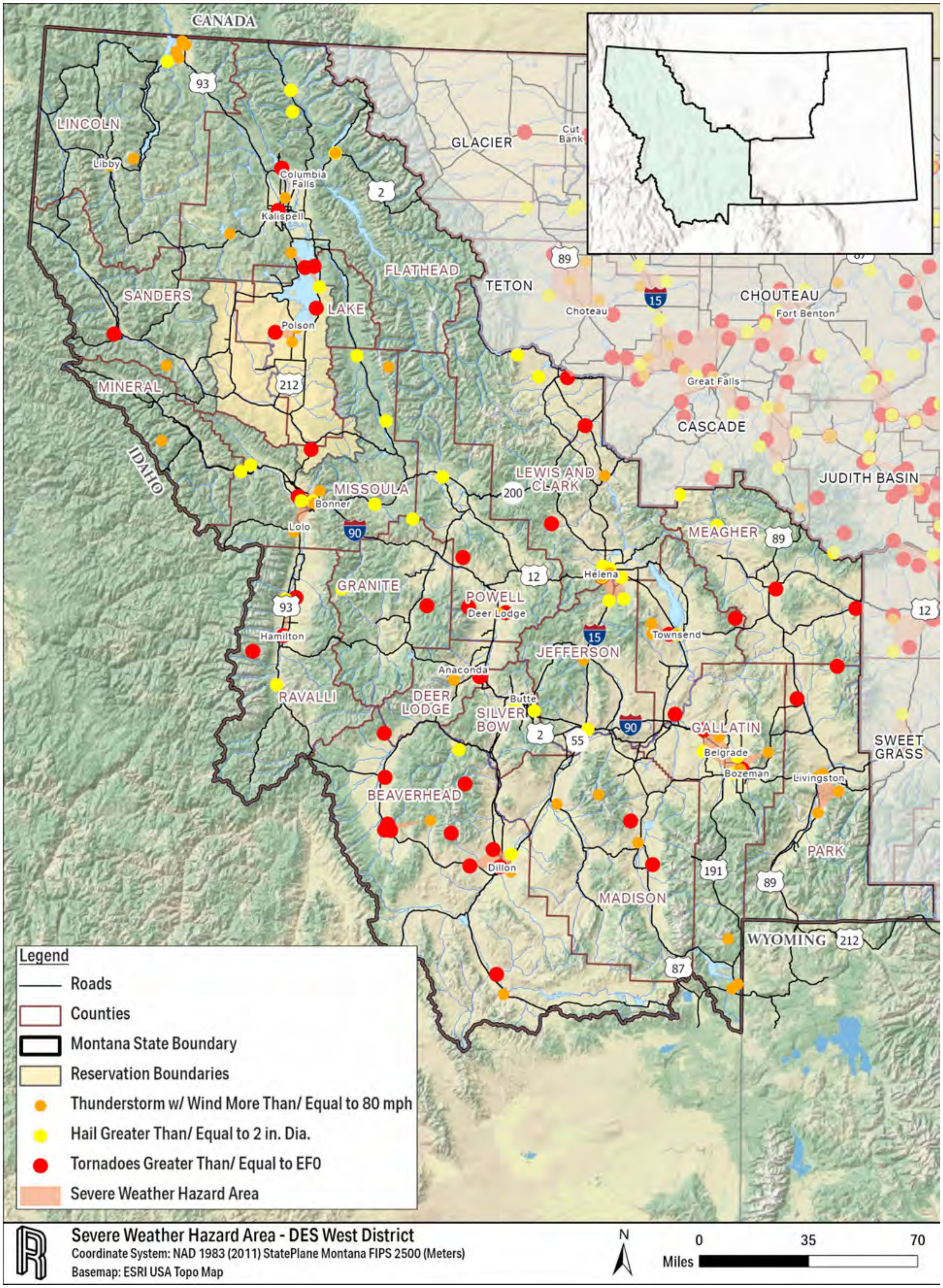

Figure 4.6-1A. Severe Weather Hazard Areas for DES West District.

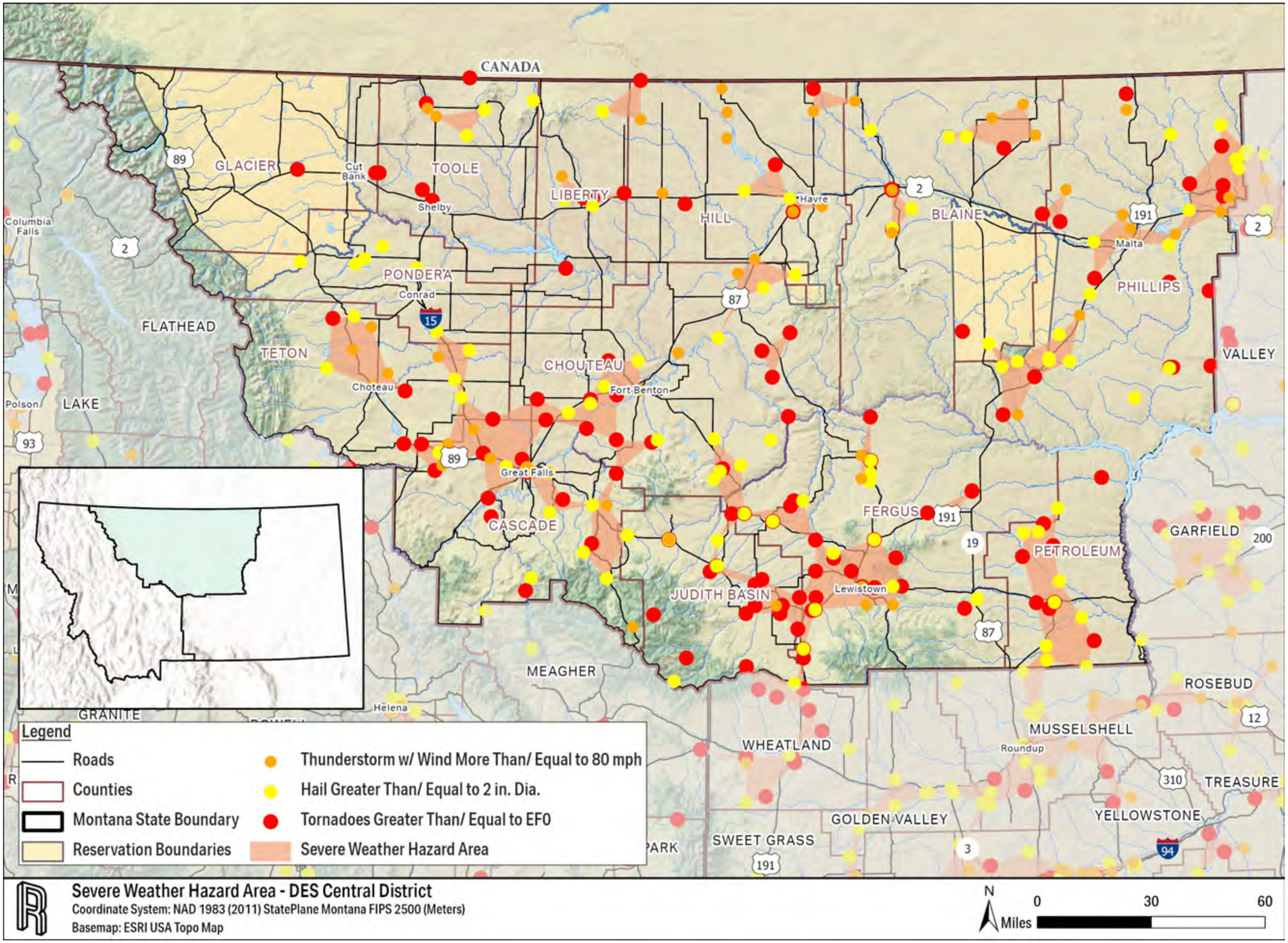

Figure 4.6-1B. Severe Weather Hazard Areas for DES Central District.

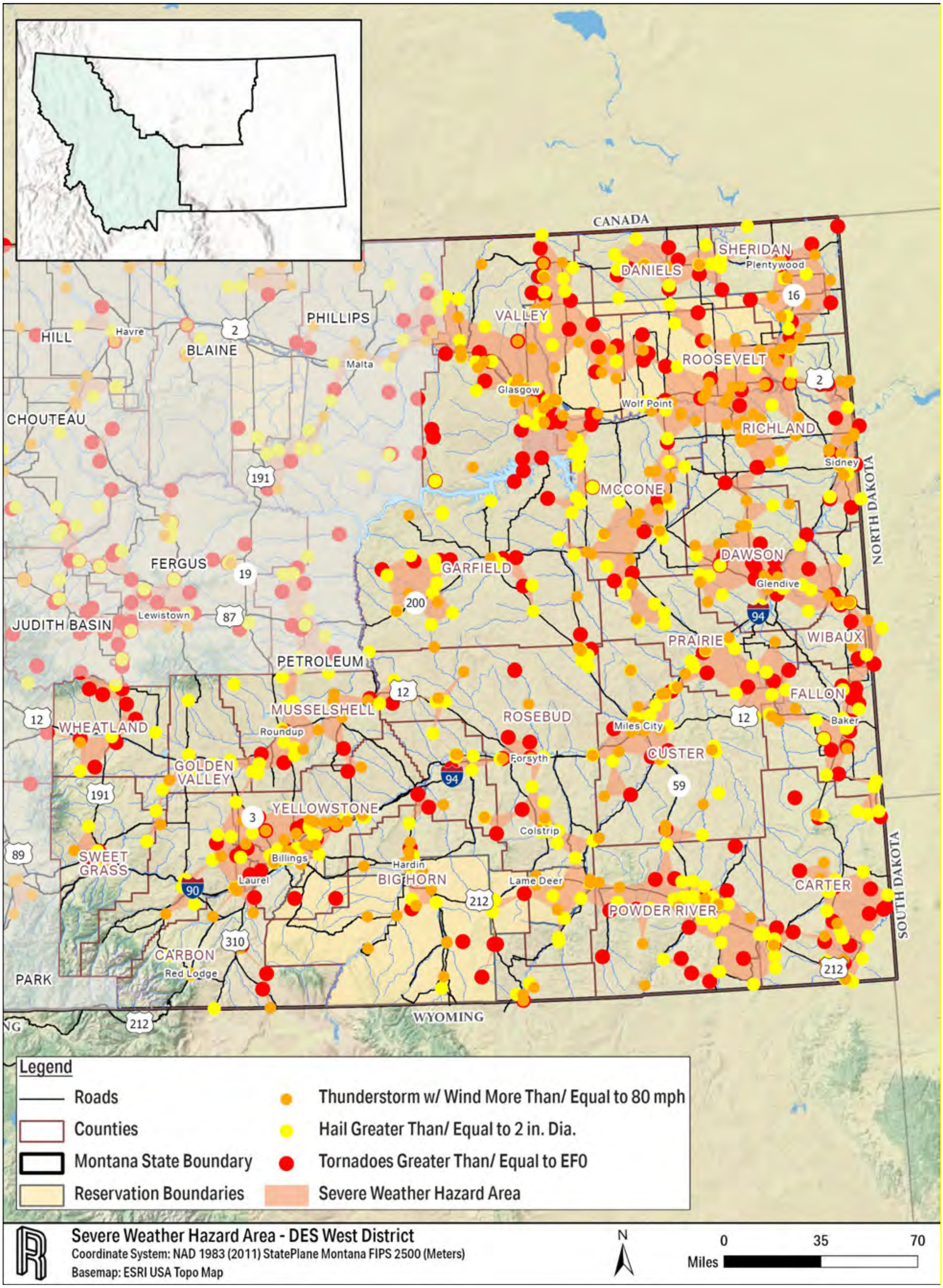

Figure 4.6-1C. Severe Weather Hazard Areas for DES East District.

Table 4.6-6. Severe Weather Exposure Summary by DES District

Item	West District	Central District	East District
Severe Weather Hazard Area (Square Miles)	403	3415	13627
Severe Weather Hazard Area Percent of District	0.83%	9.15%	22.30%
Residential Building Exposure ($)	$9,831,055,154	$4,226,555,492	$12,573,324,874
Residential Building Exposure (# structures)	36,708	24,893	64,760
Commercial, Ag, Industrial Building Exposure ($)	$2,111,749,423	$1,242,725,703	$525,819,186
Commercial, Ag, Industrial Building Exposure (# structures)	2,012	1,120	1,421
Essential Facility Exposure ($)			
Essential Facility Exposure (# structures)			
Cultural Resources (# features)	81	48	91
Persons Affected in Hazard Area	202,663	97,888	194,793

Risk assessment results indicate that DES East District has the highest building stock exposure in terms of number of residential structures at risk from severe summer weather. District _ has the highest number of critical facilities and cultural resources at risk from flooding, while the West District has the most population at risk.

Table 4.6-7 presents a vulnerability summary of the severe weather hazard as it relates to percent exposure in Montana's counties, cities, and towns. Percent exposure was derived by dividing the value of residential and commercial/agricultural/industrial building stock exposed to the hazard into the total value of the building stock. Percent exposure is a more accurate way of displaying vulnerability than presenting jurisdictions with the highest exposure because it reflects areas with the greatest risk opposed to those with high value real estate. A complete ranking of percent exposure is presented in the *Severe Weather Section of* **Appendix B-4**.

Table 4.3-7. Severe Weather Exposure Summary for Top Counties, Cities and Towns

County	% Flood Exposure	$ Residential Exposure	# Residences at Risk	$ Commercial/ Ag/Industrial Exposure	# Commercial/ Ag/Industrial Buildings at Risk	$ Critical Facilities Exposure	# Critical Facilities at Risk
Counties with Highest Percent Exposure ($ Residential + $ Commercial-Ag- Industrial Exposure in Hazard Area / Total Exposure)							
Custer	87.20%	$531,091,162	4,019	$80,995,701	269		
Dawson	82.50%	$239,967,848	1,810	$47,656,293	87		
Fallon	75.42%	$114,162,859	974	$36,186,302	91		
Richland	74.99%	$434,814,053	2,545	$107,247,970	197		
Valley	74.39%	$396,020,055	2,633	$0	0		
Daniels	72.92%	$68,465,393	760	$20,859,982	104		
Sheridan	72.59%	$100,516,821	960	$20,850,841	68		
Cities/Towns with Highest Percent Exposure (Towns with Pop. > 500) ($ Residential + $ Commercial- Ag- Industrial Exposure in Hazard Area / Total Exposure)							
Molt	93.89%	$71,294,457	224	$611,810	3		
Miles City	91.28%	$475,639,231	2,988	$67,878,457	200		
Scobey	89.21%	$58,229,302	541	$19,905,122	82		
Glendive	87.90%	$230,537,814	774	$47,497,773	45		
Huntley	86.00%	$150,503,208	696	$0	0		
Sidney	85.22%	$383,459,370	1,710	$103,284,873	144		
Baker	83.98%	$110,558,749	724	$36,186,302	56		

Counties with the highest exposure from severe weather include: Custer, Dawson, Fallon, Richland, Valley, Daniels, and Sheridan counties. Cities and towns (over 500 in population) with the highest exposure include Molt (Stillwater Co.), Miles City (Custer Co.), Scobey (Sheridan Co.), Glendive (Dawson Co.), Huntley (Yellowstone Co.), Sidney (Richland Co.), and Baker (Fallon Co.). **Figure 4.6-2** presents percent exposure for the top counties and cities/towns showing regional vulnerability.

Counties with the highest exposure from severe weather that are experiencing the fastest population growth include: Richland, Gallatin, Roosevelt, Garfield, Fallon, Sheridan, and Yellowstone counties. Top cities and towns (with population over 500) with the highest exposure that are experiencing the fastest population growth include: Fairfield (Teton Co.), Sidney (Richland Co.), Bozeman and Belgrade (Gallatin Co.), Baker (Fallon Co.), Kalispell (Flathead Co.), and Culbertson (Roosevelt Co). **Figure 4.6-2** presents percent exposure and population change for the top counties and cities/towns showing the most vulnerable areas experiencing the fastest population growth.

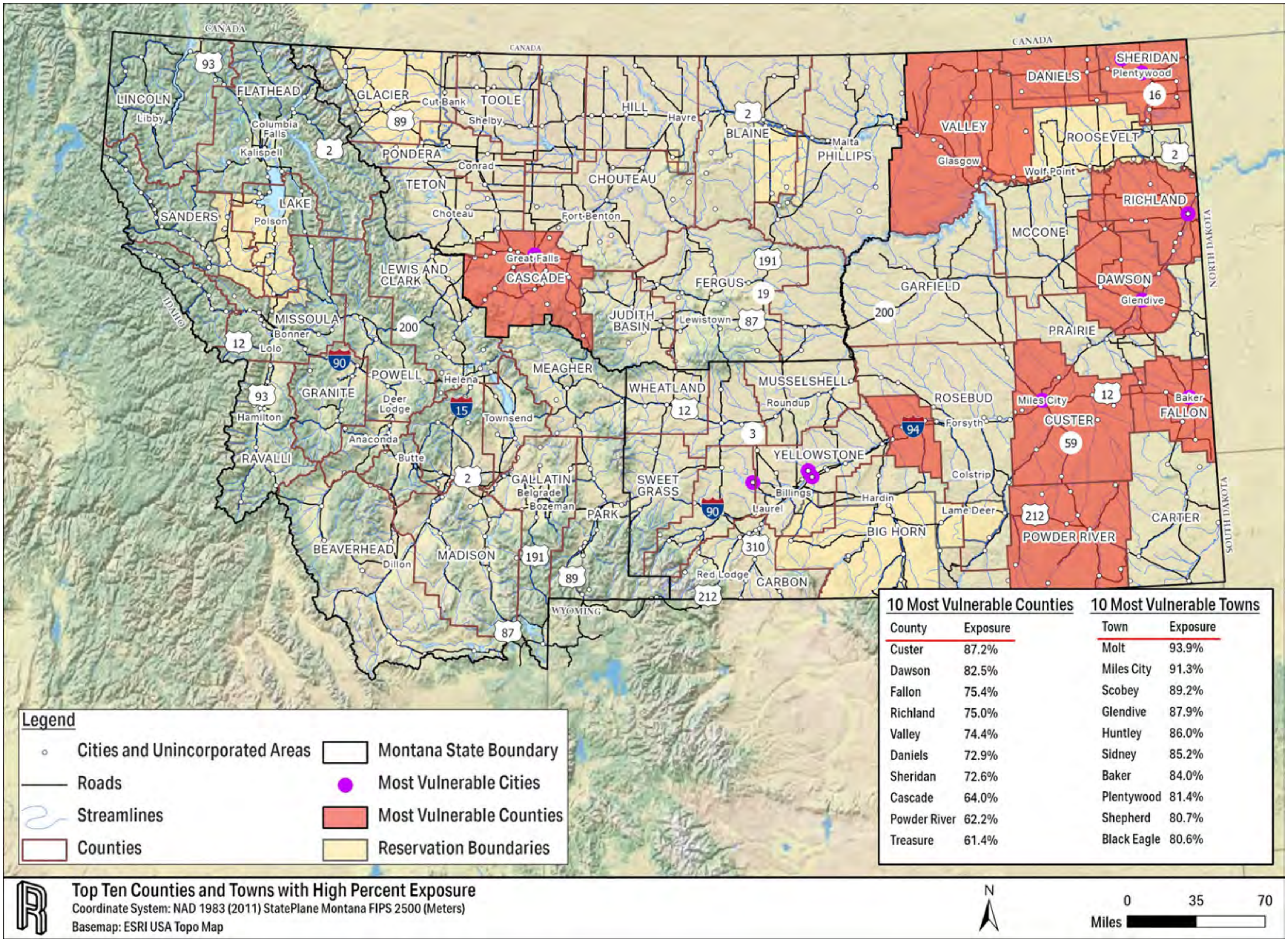

Figure 4.6-2. The top ten counties with the highest percent exposure of residential and commercial buildings to severe weather hazard areas.

Review of Potential Losses in Local Hazard Mitigation Plans

All of the local plans evaluated the severe weather hazard in their risk assessment. Local jurisdiction ranking of the severe weather hazard is summarized below.

- #1 Hazard: Carter, Daniels, Glacier, Liberty, McCone, Petroleum, Prairie, Wheatland, Yellowstone counties and the Northern Cheyenne Reservation.
- #2 Hazard: Chouteau, Custer, Fallon, Hill, Mineral, Phillips, Pondera, Rosebud, Sheridan, Treasure, Wibaux counties and the Crow Reservation.
- #3 Hazard: Big Horn, Cascade, Dawson, Golden Valley, Jefferson, Powder River, Ravalli, Richland, Roosevelt, Stillwater, Sweet Grass counties and the Blackfeet, Fort Peck and Rocky Boy reservations.

Most of the local plans treated severe weather as a uniform hazard across their jurisdiction; as such, all building stock was at risk. Jurisdictions with higher population had more individuals at risk.

The Local Plan Exposure Summary table in **Appendix B-7** presents a summary of potential severe weather losses from the Local Hazard Mitigation Plans.

Vulnerability of State Property

All state property is vulnerable to severe weather; however, most property damage is from frozen water pipes, severe wind, and hail. **Table 4.6-11** shows totals by state agency and university for insurance claims related to severe weather. The highest total claims are from the university campuses in Bozeman and Missoula. Many of these losses are related to flooding from frozen pipes.

Table 4.6-11. Loss Claims for State Facilities Caused by Severe Weather (2012-2017)

Agency	City	Date of Loss	Claim Description	Total
Dept. of Administration				
Scott Hart Building	Helena	6/13/2017	Rain water entered basement	$12,611
Capitol	Helena	1/8/2017	Waterline ruptured offices, basement flooded	$7,347
General Services Div.	Helena	8/14/2015	Storm caused several quick power outages	$5,716
Capitol	Helena	12/5/2013	Pipe in south entrance froze and broke	$6,318
Capitol Complex	Helena	12/9/2015	Storm blew trees down shut power down	$4,287
Walt Sullivan Bldg.	Helena	2/8/2014	Extreme cold weather	$44,370
General Services Div.	Helena	8/15/2014	Capitol roof hail damage	$2,978
Public Defenders	Helena	6/13/2016	Storm caused power surge	$615
Dept. of Commerce				
Board of Housing	Laurel	4/17/2015	Wind blew shingles off	$580
Dept. of Corrections				
Women's Prison	Billings	2/17/2017	Roof leak during heavy snow build-up	$12,950
Prison	Deer Lodge	7/8/2013	Major hail storm	$2,161
Dept. Fish, Wildlife & Parks				
FWP	Great Falls	6/11/2016	Vehicle hail damage	$10,214
Bannack State Park	Beaverhead	3/14/2017	Grasshopper creek flooding	$58,681
Bannack State Park	Beaverhead	6/24/2017	Tree fell on building	$6,525
First People's B Jump	Cascade	5/24/2017	Wind damaged shop roof	$500
Fisheries	-	12/19/2016	Wind damaged vehicle	$268

Giant Springs SP	Great Falls	7/8/2013	Wind damaged landscape trees	$1,280
Makoshika	Dawson	7/21/2016	Hail damage to roof and fence	$840
Placid Lake	Seeley	3/13/2017	Tree fess on day use boat dock	$11,555
Wall Creek WMA	Madison	1/25/2014	Roof shingles missing from wind	$3,291
West Shore SP	Lake	5/21/2013	Wind damaged floating dock	$998
Yellowstone Hatcher	-	6/3/2016	Hail damage	$20,127
Department of Justice				
Crime Lab		1/6/2015	Roof leak from snow and rain	$1,083
Crime Lab		3/4/2014	Drains on roof froze, pipes burst	$16,587
Crime Lab		1/14/2016	Roof drains froze, ice melting flooded building	$5,606
Crime Lab		6/3/2013	Weather related outage damaged equip.	$10,146
Highway Patrol	Anaconda	6/3/2017	Lightning struck tower	$9,702
Law Enforce. Academy	Helena	6/2/2017	Lightning damaged equipment	$3,256
Law Enforce. Academy	Helena	4/22/2015	Lightning damaged phone, alarm system	$11,168
Dept. of Labor & Industry				
Butte Job Service	Butte	1/17/2017	Frozen supply line	$2,315
Job Service	-	7/8/2013	Large hail caused roof, siding damage	$436
Dept. of Natural Resources				
SWLO	-	11/10/2014	Tree fell on building, roof damage	$7,495
Trust Lands	-	1/10/2015	Ice dammed in gabled roof, water damage	$991
NWLO	Kalispell	2/6/2017	Ice dam on roof	$3,321
Oil & Gas	Billings	5/21/2016	Major hail storm	$45,626
Dept. of Transportation				
Airport	Bozeman	12/3/2012	Wind blew off airport roof	$8,521
Maintenance Shop	Glendive	7/8/2013	Major hail storm	$5,584
Maintenance Shop	Glendive	7/10/2016	Major hail storm	$31,856
Winnett/Roy Section	Lewistown	7/10/2016	Major hail storm	$8,531
Bonner Shop	Missoula	2/22/2012	Wind blew over loader shed	$13,109
Historical Society				
Moss Mansion	Helena	3/20/2014	Roof leak, water damage	$10,560
Multiple Agencies				
Billings Hail	Billings	5/18/2014	Hail storm	$729,489
Billings Storm	Billings	9/7/2013	Storm with wind/rain, multiple locations	$547,248
Women's Prison	Billings	5/18/2014	Major hailstorm, greenhouse roof	$3,539
Corrections	Glendive	7/27/2015	120 mph wind tore down fence	$25,354
Missoula Wind	Missoula	8/10/2015	Hail winds blew roofs and downed trees	$120,076
MSU, NARC		7/4/2015	Tornado damaged buildings	$322,441
MSU-Northern	Havre	11/17/2015	Wind damage to gym	$59,323
Dept. Public Health & Human Services				
Developmental Center	Boulder	5/26/2015	Lightning storm damaged fire panel	$14,538
Veteran's Home	Glendive	3/14/2012	High winds blew down light pole	$3,350
Veteran's Home	Glendive	7/24/2012	Lightning strike damaged equipment	$5,886
Veteran's Home	Glendive	7/8/2013	Major hail storm	$631
University System				
MSU-Billings	Billings	12/9/2013	Frozen fire sprinkler	$9,756

MSU-Bozeman	Bozeman	6/8/2017	Microburst, wind damage to barn	$8,178
MSU-Bozeman	Bozeman	11/22/2013	Pipe frozen, water damage	$22,867
MSU-CARC	Bozeman	7/23/2016	Wind damaged metal and shingles, seed barn	$1,805
MSU-CARC	Bozeman	6/5/2012	Hail damage to 5 buildings	$1,789
MSU-EARC	Bozeman	6/19/2015	Hail and wind damage to various buildings	$90,462
MSU, EARC	Bozeman	8/10/2013	Hail damage to multiple buildings	$64,628
MSU-WTARC	Bozeman	8/13/2013	Lightning strike damaged computers, phones	$2,077
MSU-EARC	Bozeman	7/15/2012	Hail damage to buildings	$433
MSU-Post Farm	Bozeman	1/17/2012	Wind blew/bent metal roofing	$6,774
MSU-Bozeman	Bozeman	3/31/2012	Wind damage to tennis fence	$2,037
MSU-Bozeman	Bozeman	7/27/2015	Heavy rain with small hail	$3,546
MSU Hannon Hall	Bozeman	6/21/2015	Lightning strike	$122,486
MSU Microbiology	Bozeman	3/1/2016	Wind blew shingles and soffit off	$435
MSU Plan Biosciences	Bozeman	11/16/2014	Frozen water pipes	$7,276
MSU Renne/Plew	Bozeman	6/29/2013	Backup of rainwater	$39,511
MT Tech-Highlands	Butte	11/12/2014	HVAC coils froze	$16,682
MT Tech	Butte	12/10/2013	Pipes froze, water damage to Residence Life	$3,371
MT Tech	Butte	8/18/2016	Computer damage due to power outage	$590
MT Tech-Highlands	Butte	10/7/2015	Hail damage on HVAC coils	$25,401
MSU-Northern	Havre	3/28/2015	Power outage, surge due to high winds	$6,872
MSU-Northern	Havre	6/6/2012	Tree fell on roof of Morgan Hall	$5,544
MSU-Northern	Havre	1/5/2016	Frozen heater pipe in housing	$701
MSU-Northern	Havre	2/6/2016	Wind damage to roof	$1,335
UM-Missoula	Missoula	3/20/2017	Water leak damaged Daly Mansion	$2,239
UM-Missoula -Kiln An	Missoula	3/2/2014	Large amount of snow caused roof to collapse	$12,993
UM-Msla Banch Rch	Missoula	1/21/2012	Heavy snow, high wind, hayshed roof collapse	$39,950
UM-Msla Adams Cent	Missoula	3/10/2014	Snow drift on roof caused drain damage	$1,903
UM-Msla Forestry	Missoula	12/28/2016	Weight of snow caused roof collapse	$852
UM-Western	Dillon	10/21/2014	Water entered building	$13,902
TOTAL				$2,758,375

FUTURE DEVELOPMENT

The State of Montana has adopted the 2012 International Building Code (IBC). The IBC includes a provision that buildings must be constructed to withstand a wind load of 75 mph constant velocity and three second gusts of 90 mph. Buildings must be designed to withstand a snow load of 30 pounds per square foot minimum.

Local building codes could be developed in highly vulnerable areas to require shatter-proof glass on critical facilities and/or facilities housing vulnerable populations, higher standards for tying down roofs, and/or other methods to mitigate impacts from severe summer storms. Montana snow is generally dry and snow loads do not threaten roof collapse in most areas. However, the northwestern portion of the State where snow contains greater moisture content should consider building regulations that require a stricter design standard for flat roofs to ensure they can support maximum snow loads.

DATA LIMITATIONS

The recording of weather events is highly dependent upon the public's observations and reporting to the National Weather Service. While weather stations are used to document wind speeds and precipitation, the spotting of tornadoes and assessment of hail stone size is often recorded based on a person's observations. These observations may be more accurate in populated areas where weather stations and other observations can verify extreme events. Rural areas may go under reported because of the fewer people that observe or witness the events. As a result, records of storm events may indicate more frequent storms in recent history than in the past, a greater number of reports in populated areas versus rural areas, and more recent recording and documentation of losses related to severe thunderstorms.

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4.7 HAZARDOUS MATERIAL INCIDENTS AND TRANSPORTATION ACCIDENTS CPRI=2.62

DESCRIPTION AND HISTORY

The hazardous material and transportation accident hazards have been combined into one profile because they often occur together. Transportation accidents can occur on highways, railroads, or in the air and often result in fatalities and injuries. Hazardous material incidents can occur during transportation accident, but also occur at fixed facilities which include bulk propane facilities, gas stations and agricultural supply dealers. In addition to these hazards, petroleum releases have the potential to occur from pipelines.

Hazardous materials are chemical substances, which if released or misused can pose a threat to the environment; personal health, causing death, injury, long- lasting health effects; and damage to buildings, homes, and other property. Hazardous materials come in the form of explosives, flammable and combustible substances, poisons, and radioactive materials.

Varying quantities of hazardous materials are manufactured, used, or stored at an estimated 4.5 million facilities in the U.S. from major industrial plants to local dry-cleaning establishments and gardening supply stores. As many as 500,000 products pose physical or health hazards and can be defined as "hazardous chemicals" [FEMA, 2013]. The Montana Dept. of Transportation regulates transportation routes and speed limits used by carriers and monitors the types of hazardous materials crossing state lines.

The volume and type of hazardous materials that flow into, are stored, and flow through communities determine exposure to a potential release of hazardous materials. The Emergency Planning and Community Right-to-Know Act (EPCRA) was enacted in 1986 to inform communities and citizens of chemical hazards in their areas. EPCRA requires businesses to report the locations and quantities of chemicals stored on-site to State and local governments in order to help communities prepare to respond to chemical spills and similar emergencies. EPCRA also requires the U.S. Environmental Protection Agency (EPA) and States to annually collect data on releases and transfers of certain toxic chemicals from industrial facilities and make the data available to the public in the Toxics Release Inventory (TRI). In 1990 Congress passed the Pollution Prevention Act which required that additional data on waste management and source reduction activities be reported under TRI. The goal of TRI is to empower citizens, through information, to hold companies and local governments accountable in terms of how toxic chemicals are managed. Table 4.7-1 presents TRI data for the total amount of waste managed by County from 2017-2021.

Table 4.7-1. Toxic Release Inventory for Montana (2022)

County	Reporting Year	Releases (lb)	Air Releases (lb)	Water Releases (lb)	Land Releases (lb)	Off-Site Releases (lb)	Waste Managed (lb)	RSEI Score (Most Recent)
Big Horn, MT	2017 - 2021	348,135	66,055	1	11	282,069	429,156	124
Broadwater, MT	2017 - 2021	269,994	46	0	269,948	0	269,994	0
Cascade, MT	2017 - 2021	577,301	549,577	0	17,019	10,705	36,582,049	5,658
Dawson, MT	2019 - 2021	2,281	2,281	0	0	0	2,281	0
Deer Lodge, MT	2017 - 2021	93,327	93,187	0	0	140	93,469	1
Fallon, MT	2019 - 2021	1,788	1,788	0	0	0	10,206	0
Flathead, MT	2017 - 2021	949,189	948,637	0	552	0	11,340,309	13,018
Gallatin, MT	2017 - 2021	224,661	139,921	0	66,107	18,633	598,014	5
Jefferson, MT	2017 - 2021	785,323	54,879	0	730,444	1	1,312,880	29
Lewis And Clark, MT	2017 - 2021	176,523	136,568	0	39,955	0	231,768	145
Lincoln, MT	2017 - 2021	2,237	2	0	2,235	0	2,237	0
Mineral, MT	2018 - 2021	38	12	0	25	0	38	0
Missoula, MT	2017 - 2021	656,275	655,575	1	560	139	2,540,418	79,497
Ravalli, MT	2017 - 2021	121,068	119,451	0	0	1,617	996,241	560
Richland, MT	2017 - 2021	1,653,385	1,026,106	1,563	45,802	579,914	1,656,932	13
Rosebud, MT	2017 - 2021	44,987,955	1,722,105	0	43,070,560	195,290	50,529,483	2,386
Sanders, MT	2017 - 2021	20,680	20,608	0	71	0	3,564,560	4
Sheridan, MT	2017 - 2021	156	0	0	134	22	1,418	0
Silver Bow, MT	2017 - 2021	202,335,106	204,313	110	202,130,225	457	203,336,002	4,235
Stillwater, MT	2017 - 2021	3,836,540	33,364	0	1,881,104	1,922,072	10,700,108	2,426
Sweet Grass, MT	2017 - 2021	1,946,713	832	0	1,945,881	0	2,078,830	6
Toole, MT	2017 - 2021	448	52	0	0	396	1,294	No RSEI Score
Yellowstone, MT	2017 - 2021	3,988,592	3,425,642	298,443	75,560	188,947	72,929,829	
Total		**262,977,713**	**9,201,003**	**300,117**	**250,276,192**	**3,200,402**	**399,207,514**	---

Table 4.7-2 shows a summary of the hazardous material incidents in Montana from 2008 to 2021 reported to the National Response Center (NRC) by type of release. During this time, 738 releases were reported. Of these, 322 were from fixed facilities, 158 from Mobile facilities, 84 from pipelines, 68 from Railroads, 68 from Storage Tanks and 38 from miscellaneous spills.

Table 4.7-2. Hazardous Material Incidents in Montana (2008-2017)

Year	Fixed	Mobile	Pipeline	Railroad	Storage Tank	Other	Counties and # Incidents
2008	16	14	3	6	4	2	Big Horn (2), Carbon (2), Cascade (1), Dawson (1), Fallon (1), Fergus (2), Flathead (3), Gallatin (1), Glacier (2), Lake (3),Lincoln (1), Missoula (3), Musselshell (1), Pondera (1), Powder River (1), Richland (1), Rosebud (2), Sanders (2), Toole (1), Yellowstone (13)
2009	28	14	8	7	6	5	Big Horn (4), Carbon (2), Cascade (3), Dawson (1), Fallon (2),Fergus (1), Flathead (3), Gallatin (2), Glacier (4), Hill (1), Lake (2), Lewis and Clark (1), Lincoln (4), Mineral (1), Missoula (4), Petroleum (1), Pondera (2), Powder River (1), Richland (2), Roosevelt (4), Sanders (4), Valley (2), Yellowstone (16)
2010	15	12	3	5	5	3	Big Horn (3), Cascade (3), Custer (1), Dawson (1), Fallon (2), Flathead (1), Glacier (3), Jefferson (1), Lake (2), Lewis and Clark (1), Lincoln (1), Madison (1), Meagher (1), Missoula (2), Powder River (1), Powell (1), Ravalli (1), Richland (1), Sanders (1), Teton (1), Valley (1), Wheatland (1), Yellowstone (10)
2011	23	11	20	6	3	6	Big Horn (7), Blaine (2), Cascade (2), Dawson (3), Fallon (4), Flathead (3), Gallatin (1), Glacier (6), Golden Valley (1), Hill (2), Lake (1), Lewis and Clark (4), Lincoln (3), McCone (1), Mineral (1), Missoula (2), Musselshell (1), Phillips (1), Ravalli (1), Richland (3), Roosevelt (1), Sanders (1), Sweet Grass (1),Valley (2), Yellowstone (15)
2012	22	12	4	7	6	3	Big Horn (5), Blaine (2), Cascade (2), Fallon (1), Flathead (4),Gallatin (1), Glacier (3), Hill (2), Lake (2), Lewis and Clark (4), Liberty (1), McCone (1), Mineral (1), Missoula (2), Phillips (1), Pondera (1), Ravalli (1), Richland (4), Roosevelt (2), Rosebud (2), Sanders (2), Silver Bow (2), Teton (1), Valley (1), Yellowstone (10)
2013	20	14	3	2	8	4	Big Horn (3), Cascade (1), Chouteau (1), Custer (1), Dawson (1), Deer Lodge (1), Fergus (1), Glacier (5), Lewis and Clark (4), Lincoln (2), Park (2) Petroleum (1), Richland (5), Roosevelt (8), Rosebud (1), Sheridan (3), Sweet Grass (1), Toole (1), Wibaux (1), Yellowstone (9)
2014	21	13	5	6	6	2	Beaverhead (1), Big Horn (2), Blaine (1), Broadwater (1), Cascade (6), Dawson (1), Fallon (1), Fergus (1), Flathead (1), Gallatin (3), Glacier (4), Hill (1), Judith Basin (1), Lake (2), Lewis and Clark (1), Lincoln (1), Mineral (1), Missoula (3), Musselshell (1), Park (1) Richland (1), Roosevelt (2), Rosebud (1), Sanders (2), Valley (1), Wibaux (1), Yellowstone (11)
2015	12	6	4	4	3	2	Big Horn (2), Broadwater (1), Cascade (3), Dawson (3), Deer Lodge (1), Fergus (1), Flathead (2), Gallatin (3), Glacier (1), Lake (1), Lewis and Clark (1), Roosevelt (3), Silver Bow (2), Wheatland (1), Wibaux (1), Yellowstone (6)
2016	20	9	5	3	4	1	Blaine (1), Broadwater (1), Cascade (4), Dawson (2), Fallon (1), Flathead (2), Gallatin (2), Glacier (2), Hill (2), Lake (2), Lewis and Clark (1), Missoula (2), Phillips (1), Ravalli (2), Richland (2), Roosevelt (1), Sanders (2), Silver Bow (3), Teton (1), Valley (1), Yellowstone (7)
2017	23	10	0	3	5	4	Big Horn (4), Blaine (1), Carbon (2), Cascade (9), Custer (1), Flathead (2), Gallatin (1), Glacier (1), Granite (1), Hill (1), Lewis and Clark (2), Liberty (1), Lincoln (1), Madison (1), Mineral (1), Missoula (2), Petroleum (1), Pondera (1), Ravalli (1), Roosevelt (2), Sanders (1), Silver Bow (1), Sweet Grass (1), Teton (1), Valley (1), Yellowstone (5)
2018	25	12	10	6	6	1	Beaverhead (2), Bighorn (2), Blaine (3), Cascade (6) Chouteau (1), Dawson (2), Fergus (1), Flathead (7) Gallatin (2), Glacier (6), Hill (2), Lewis and Clark (1) Lincoln (1), Mineral (1), Missoula (3), Pondera (1) Ravalli (2), Richland (1), Roosevelt (3) Sanders (1), Silver Bow (4), Stillwater (3), Sweet Grass (1) Toole (2), Valley (4), Yellowstone (16)
2019	39	13	11	8	4	2	Big Horn (4), Blaine (1), Carbon (1), Carter (1), Cascade (12), Custer (1), Dawson (4), Fallon (2), Flathead (3), Gallatin (3), Judith Basin (1), Lewis And Clark (4), Mineral (5), Missoula (3), Phillips (2), Powell (2), Ravalli (1), Richland (3), Roosevelt (3), Sanders (1), Sheridan (1), Stillwater (1), Yellowstone (18)
2020	38	8	3	1	4	2	Beaverhead (2), Big Horn (2), Carbon (2), Cascade (9), Chouteau (1), Custer (1), Flathead (4), Gallatin (1), Granite (1), Jefferson (1), Lewis and Clark (3), Liberty (1),

							Lincoln (3), Madison (2), Missoula (2), Musselshell (2), Petroleum (1), Pondera (1), Ravalli (1), Richland (2), Silver Bow (1), Wibaux (1), Yellowstone (11)
2021	20	10	5	4	4	1	Beaverhead (1), Big Horn (3), Cascade (5), Flathead (3), Gallatin (4), Hill (1), Jefferson (1), Lake (2), Lewis and Clark (1), Missoula (1), Park (1), Powder River (1), Prairie (2), Richland (4), Roosevelt (1), Rosebud (1), Silver Bow (3), Valley (2), Yellowstone (7)
TOTAL	322	158	84	68	68	38	

The most likely locations for transportation-related hazardous material releases are along Montana's highways, railroads, and pipelines. The source and location of transportation accidents vary but the response is typically the same. Response is focused on assisting the injured, then determining the presence of hazardous materials. Montana has six regional hazardous-material response teams including those located in Billings, Bozeman, Great Falls, Helena, Kalispell, and Missoula.

Car crashes occur across the nation and can be devastating to families, friends, and communities. It is estimated that vehicle crashes cost the State over $35 million each year on emergency department encounters and inpatient hospital admissions for injuries caused by motor vehicle crashes. Vehicular accidents occur for a number of reasons including distracted drivers, driver fatigue, drunk driving, speeding, aggressive driving, weather, and collisions with wildlife. Statistics on various types of highway accidents are presented in **Table 4.7-3** for 2011-2020, including the top counties with fatalities and serious injuries.

Table 4.7-3. Vehicular Crash Data; 2011-2020

	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	TOTAL
All Crashes											
Fatal Crash	211	205	229	192	224	190	186	182	184	212	**2,015**
Serious Injury	967	1,129	1,101	964	999	834	730	769	709	730	**8,932**
Total # Crashes	45,150	42,406	43,488	46,387	47,074	46,482	49,726	47,638	46,846	40,134	**455,331**
Top Counties with Fatal & Serious Injury Crashes	Missoula 11.8%, Yellowstone 9.5%, Flathead 8.9%, Gallatin 5.7%, Lewis & Clark 4.8%										
Nighttime Crashes											
Fatal Crash	92	88	110	72	85	84	71	78	70	90	**840**
Serious Injury	265	364	345	275	273	249	218	223	208	250	**2,670**
Total # Crashes	11,162	11,059	10,814	11,608	12,276	12,011	12,939	12,111	11,731	11,355	**117,066**
Top Counties with Fatal & Serious Injury Crashes	Yellowstone 11.3%, Flathead 9.3%, Missoula 8.2%, Gallatin 5.5%, Cascade 5.0%										
Rural Roadway Crashes											
Fatal Crash	175	189	209	174	199	176	164	151	160	198	**1,795**
Serious Injury	785	921	906	763	781	653	546	559	552	585	**7,051**
Total # Crashes	18,437	18,064	18,986	20,194	20,929	21,361	23,908	23,180	23,998	22,483	**211,540**
Top Counties with Fatal & Serious Injury Crashes	Flathead 9.5%, Yellowstone 6.6%, Missoula 6.5%, Gallatin 5.5%, Ravalli 4.6%										
Winter Crashes (Nov, Dec, Jan & Feb)											
Fatal Crash	56	43	54	41	41	47	43	57	37	54	**473**
Serious Injury	233	315	278	260	265	206	159	170	179	198	**2,263**
Total # Crashes	17,621	15,477	15,974	19,131	17,455	16,737	20,007	17,883	17,694	14,132	**172,111**
Top Counties with Fatal & Serious Injury Crashes	Missoula 11.7%, Yellowstone 10.5%, Flathead 8.9%, Gallatin 5.8%, Lewis & Clark 5.7%										
Wild Animal Involved Crashes											
Fatal Crash	4	3	8	1	2	6	2	2	7	5	**40**
Serious Injury	26	39	36	30	30	28	23	26	23	29	**290**
Total # Crashes	3,086	3,325	3,356	3,502	4,795	5,121	5,411	5,279	4,666	5,166	**43,707**
Top Counties with Fatal & Serious Injury Crashes	Lincoln 9.5%, Flathead 8.5%, Ravalli 8.2%, Sanders 7.8%, Missoula 7.5%										

According to the National Transportation Safety Board (NTSB), 60 percent of all railroad accidents occur at unprotected or passive crossings. **Table 4.7-4** summarizes railroad accidents at crossings in Montana over the past 10 years with details on which counties sustained the most incidents.

Table 4.7-4. Accidents at Railroad Crossings; 2011-2021

Year	# of Vehicle/Train Collisions	Counties and # Incidents	Fatalities	Injuries
2011	13	Flathead (1), Judith Basin (1), Missoula (1), Phillips (2), Richland (2), Roosevelt (4), Wheatland (1), Wibaux (1)	2	4
2012	10	Big Horn (1), Glacier (1), Liberty (1), Missoula (1), Richland (1), Roosevelt (2), Treasure (1), Yellowstone (2)	2	5
2013	13	Big Horn (2), Cascade (1), Judith Basin (2), Missoula (2), Park (1), Roosevelt (2), Treasure (1), Yellowstone (2)	1	6
2014	14	Gallatin (2), Hill (2), Lincoln (2), Missoula (1), Park (1), Roosevelt (1), Silver Bow (1), Toole (1), Treasure (1), Yellowstone (2)	2	2
2015	15	Big Horn (3), Carbon (1), Cascade (1), Gallatin (3), Glacier (1), Hill (1), Missoula (1), Roosevelt (1), Sweet Grass (1), Yellowstone (2)	5	2
2016	11	Big Horn (3), Flathead (2), Gallatin (1), Lewis and Clark (1), Missoula (2), Park (1), Powell (1)	1	3
2017	22	Big Horn (1), Broadwater (2), Glacier (1), Granite (1), Hill (2), Judith Basin (1), Lewis and Clark (1), Liberty (1), Gallatin (3), Missoula (1), Powell (1), Prairie (1), Roosevelt (1), Sweet Grass (1), Wibaux (2), Yellowstone (2)	0	6
2018	10	Flathead (2), Roosevelt (1), Sanders (1), Big Horn (2), Missoula (1), Treasure (1), Blaine (1), Gallatin (1)	2	3
2019	11	Gallatin (1), Yellowstone (3), Stillwater (1), Mineral (1), Glacier (2), Roosevelt (3)	6	1
2020	10	Missoula (1), Yellowstone (2), Roosevelt (2), Sanders (1), Valley (2), Deer Lodge (1), Sweet Grass (1)	3	8
2021	17	Yellowstone (2), Missoula (4), Broadwater (2), Big Horn (1), Gallatin (1), Blaine (1), Phillips (1), Park (1), Flathead (1), Valley (2), Lewis & Clark (1)	6	7
TOTAL	146		30	47

Federal Railroad Administration data indicates that between 2011 and 2021, 286 railroad accidents occurred in Montana, including 199 derailments involving trains carrying hazardous materials. During this 10-year period, 18 railcars released hazardous materials to the environment in Montana. **Table 4.7-5** presents this data.

Since the early 2000's, oil trains are a constant concern because of the catastrophic impacts that could result from a derailment that ruptures tanker cars in town or into waterways. Numerous oil trains pass through Montana communities each week with up to 1 million gallons of crude oil per train. The railroad has redesigned its tanker cars to make them less apt to rupture if derailed. Coal trains do not pose as great a public safety concern since rail sidings have been expanded to accommodate the train length to ensure that evacuations routes are not blocked. Derailment of coal trains into Montana's waterways could have water quality implications.

Table 4.7-5. Railroad Accidents; 2011-2021

Year	# Accidents	Haz-Mat Cars Derailed	Haz-Mat Cars w/ Release	Fatalities	Injuries
2011	48	2	0	0	5
2012	31	40	13	1	4
2013	29	11	0	1	2
2014	36	45	0	0	3
2015	24	22	5	0	0
2016	18	8	0	1	0
2017	25	19	0	0	3
2018	27	9	0	0	1
2019	18	11	0	3	0
2020	16	26	0	2	5
2021	14	6	0	5	74
TOTAL	286	199	18	13	97

Declared Disasters

Two separate incidents that occurred within one week of each other are the only two State emergency declarations for hazardous material release: the Alberton Chlorine Spill (EO-8-96) and another derailment involving a chlorine tanker car near Dodson (EO-9-96). The Dodson derailment did not cause a chlorine release. There have been no federal disaster declarations associated with hazardous material incidents in Montana.

FREQUENCY/LIKELIHOOD OF OCCURRENCE

Probability for the MHMP is based on the frequency of the hazard over a 10-year period. Since hazardous material incidents occur more than once per year, the probability rating is "Highly Likely" for this hazard. The MHMP Planning Team rated the hazardous material/transportation accident hazard as "Possible".

CLIMATE CHANGE CONSIDERATIONS

Hazardous material incidents and transportation accidents are not expected to increase as a result of climate change. No increase in exposure or vulnerability to the population, property, or critical facilities are expected to occur. Climate change is not anticipated to directly impact the transportation accident hazard. However, secondary impacts to public health may result due to increased smoke from wildfire activity which may increase highway accidents.

POTENTIAL MAGNITUDE AND SEVERITY

Hazardous materials incidents can cause death, serious injury, long-lasting health effects, and damage to buildings, homes, and the environment. The magnitude of the hazard is often expressed as a percentage of property damage caused by the incident. **Table 4.7-6** presents the most damaging transportation-related hazardous material incidents in Montana since 1993 from the U.S. Department of Transportation, Office of Hazardous Materials Safety. The complete dataset reveals that over $50 million in damages have resulted from hazardous material incidents during this period; $10 million from highway accidents and $40 million from railroad accidents.

Table 4.7-6. Top Highway and Railroad Hazardous Material Incidents (1993-2021)

Incident Date	Mode of Transport	Carrier/Reporter Name	City	Quantity Released (GAL)	Commodity	Damages
8/19/1993	Highway	Keller Transport Inc.	Bozeman	3,857	Gasoline	$235,168
6/23/1995	Rail	Montana Rail Link Inc.	Helena	16,700	Aviation fuel	$173,517
10/18/1995	Highway	Styer Transportation C.	Grass Range	8	Flammable gas	$147
10/30/1995	Highway	Red Mountain Truck Lines	Townsend	95	Gasoline	$130,119
11/20/1996	Highway	Gold Leaf Physical Therapy LLC	Bozeman	1	Liquefied petroleum gas	$125,001
1/16/1996	Highway	Koch Industries Inc.	Sidney	4,200	Petroleum crude oil	$302,300
4/11/1996	Rail	Montana Rail Link Inc.	Alberton	16,250 17,000 680	Chlorine Potassium hydroxide Sodium chlorate	$10,000,000
7/11/1999	Rail	Montana Rail Link	Paradise	55,000	Corrosive liquid	$641,995
9/30/1999	Rail	Montana Rail Link Inc.	Drummond	26,000	Denatured alcohol	$126,556
6/22/2004	Highway	Sanjel (USA) Inc.	Chinook	5,660	Liquid Nitrogen	$266,944
1/10/2005	Highway	CHS Inc.	Montana City	3,048	Gasoline	$269,215
5/6/2005	Highway	CHS Inc.	Belfry	3,066	Petroleum crude oil	$163,650
6/18/2006	Rail	Montana Rail Link Inc.	Missoula	13,063	Alcohol	$414,858
3/4/2007	Highway	Schneider National Inc.	Lewistown	485	Combustible liquid	$140,000
1/1/2008	Highway	IBI Secured Transport	Billings	1,520	Corrosive acid	$209,259
4/2/2008	Highway	Keller Transport Inc.	Polson	6,403	Gasoline	$1,019,000
9/10/2008	Highway	Curt Laingen Trucking Inc.	Lewistown	12,500	Gasoline	$240,000
7/26/2009	Highway	Farstad Oil Inc.	Belfry	5,402	Gasoline	$310,500
9/1/2010	Highway	Ryan Brothers Trucking	Billings	1,500	Elevated temp. liquid	$130,836
10/14/2010	Highway	J & H Oilfield Services LLC	Fairview	2,859	Petroleum crude oil	$387,241
8/5/2012	Railroad	BNSF Railway Company	Plevna	0	Combustible liquid	$197,200
1/11/2013	Highway	Savannah Transport Inc.	Columbus	20	Hazardous waste	$118,000
3/4/2013	Highway	Simons Petroleum LLC	Sidney	3,000	Diesel	$720,000
5/18/2013	Highway	Keller Transport Inc.	Wibaux	6,000	Fuel Oil	$424,000
8/14/2013	Highway	Dixon Gros. Inc.	Big Sandy	2,940	Diesel	$341,956
11/26/2013	Highway	Dixon Bros. Inc.	Winnett	3,000	Flammable liquid	$179,705
1/5/2014	Highway	Heetco Inc. Kansas	Shelbina	0	Liquified petrol. gas	$182,620
12/22/2014	Highway	Story Distributing Company	Belgrade	200	Gasoline	$182,000
7/16/2015	Rail	BNSF Railway Company	Culbertson	26,449	Petroleum crude oil	$640,110
2/29/2016	Highway	CHS Inc.	Townsend	1,687	Denatured alcohol	$153,500
4/20/2016	Highway	Tece Trucking Inc.	Alberton	2,100	Gasoline	$276,745
3/9/2017	Highway	City Service Valcon LLC	Billings	8,000	Gasoline	$342,231
3/8/2017	Highway	Propane Services Inc.	Butte	600	Petroleum gas	$112,800
3/15/2018	Highway	CHS Inc.	Cut Bank	214	Diesel Fuel	$171,516
4/25/2018	Highway	Keller Transport, Inc.	Lindsay	301	Fuel Oil (NO. 1, 2, 4, 5, OR 6)	$821
9/8/2018	Highway	Oaks Disposal Trucking Inc.	Keene	2,250	Hydrochloric Acid	$65,000
12/8/2018	Rail	BNSF Railway Company	Browning	48,000 (SLB)	Solid N.O.S.	$140,000
8/29/2019	Highway	Story Distributing Company	Livingston	264	Gasoline	$132,671

VULNERABILITY ASSESSMENT

The volume and type of hazardous materials that flow into, are stored, and flow through communities will determine exposure to a potential release of hazardous materials. An accidental or intentional release of materials could produce a health hazard to those in the immediate area, downwind, and/or downstream.

Transportation of hazardous materials on highways, pipelines, and by the railroads could result in an accident that would have the potential to impact Montana residents. Large quantities of propane, anhydrous ammonia, agricultural chemicals, and petroleum products are stored in various locations and transported by rail and truck through the state.

The U.S. Department of Transportation issued an emergency restriction order on May 7, 2014, that requires railroad carriers to identify to the State Emergency Response Commission through which counties Bakken crude oil is being transported. The notification provides information regarding the estimated volumes and frequencies of train traffic per week and describes the petroleum crude oil expected to be transported and applicable emergency response information [USDOT, 2014]. MT DES forwards copies of the notifications to county emergency managers for their information and dissemination.

Trucks and trailers carry interstate and intrastate cargo. Highway accidents caused by severe weather and high speeds occur frequently. Railroad related hazards such as derailments, toxic spill contamination, and vehicle collisions are a constant concern. According to the NTSB, more than 80 percent of public railroad crossings do not have lights and gates, and 60 percent of all railroad accidents occur at these unprotected crossings.

Statewide Vulnerability

To model hazardous material incident risk a GIS data layer of transportation arteries was developed which included highways, major roadways, railroads, and TRI facilities. Pipeline data was not available for analysis as these locations were deemed confidential. TRI facilities, highways, and railroad were buffered by 0.25 miles to represent the hazardous material hazard area, as shown by DES District in **Figures 4.7-1A-C**

Exposure was calculated by intersecting the hazardous material buffer with the general building stock, critical facility, and cultural resources datasets. Estimates of vulnerable population were calculated by assigning a population to a structure type, a technique DNRC used when estimating vulnerable populations downstream of dams and is based on US Census Data. Exposure values are presented in **Table 4.7-7**.

Table 4.7-7. Hazardous Material Incident Exposure Summary by DES District

Item	East District	Central District	West District
Haz-Mat Hazard Area (Square Miles)	1,836	848	2,117
Percent Haz-Mat Hazard Area	3.75%	3.50%	8.90%
Residential Building Exposure ($)	$18,761,880,000	$4,223,991,000	$9,184,162,000
Residential Building Exposure (# structures)	84,600	23,800	45,700
Commercial, Ag & Industrial Building Exposure ($)	$10,238,101,000	$3,323,211,000	$5,525,349,000
Commercial, Ag & Industrial Building Exposure (#)	18,800	6,000	11,300
Critical Facility Exposure ($)	$1,102,216,000	$42,799,000	$370,547,000
Critical Facility Exposure (# structures)	228	21	51
Cultural Resources (# features)	45	14	21
Population Living in Hazard Area	221,910	44,680	76,500

Table 4.7-8 presents a vulnerability summary of the hazardous material incident hazard as it relates to percent exposure and growth rates in Montana's counties, cities, and towns. Percent exposure was derived by dividing the value of residential and commercial/agricultural/industrial building stock exposed to the hazard into the total value of the building stock. Percent exposure is a more accurate way of displaying vulnerability than presenting jurisdictions with the highest exposure because it reflects areas with the greatest risk opposed to those with high value real estate.

Table 4.7-8. Hazardous Material Incident Exposure Summary for Top Counties

County	% HAZMAT Exposure	% Growth (2018 to 2021)	$ Residential Exposure	# Residences at Risk	$ Commercial/ Ag/Industrial Exposure	# Commercial/ Ag/Industrial Buildings at Risk	$ Critical Facilities Exposure	# Critical Facilities at Risk
Counties with Highest Percent Exposure ($ Residential + $ Commercial-Ag-Industrial Exposure in Hazard Area / Total Exposure)								
Mineral	65.20%	12.66%	$307,305,699	1,598	$56,860,679	220	$0	0
Deer Lodge	63.80%	3.62%	$383,040,376	2,948	$79,402,480	366	$83,008,324	27
Glacier	59.90%	-9.00%	$127,660,927	1,165	$383,905,907	560	$50,214	2
Richland	59.50%	2.99%	$437,582,747	1,845	$308,981,180	771	$1,675,096	3
Dawson	59.40%	2.55%	$355,193,881	2,061	$118,125,487	403	$4,038,159	3
Toole	56.50%	3.75%	$173,231,295	1,385	$105,364,153	312	$128,622	2
Cascade	55.20%	3.37%	$2,976,849,354	15,084	$2,130,814,905	2,538	$37,816,569	13

Review of Potential Losses in Local Hazard Mitigation Plans

All the local Hazard Mitigation Plans evaluated the hazardous material incident hazard in their risk assessment and many of them included the transportation accident hazard. Five (5) counties ranked haz-mat as their #1 hazard including: Cascade, Fallon, Pondera, Butte-Silver Bow, and Wibaux. Eleven (10) counties ranked haz-mat as their #2 hazard including: Blaine, Broadwater, Dawson, Jefferson, Lake, Liberty, Missoula, Richland, Stillwater, and Toole. Six (6) counties ranked haz-mat as their #3 hazard including: Flathead, Gallatin, Musselshell, Sanders, Treasure and Valley.

Appendix B-8 presents an exposure summary for hazardous material incidents as reported in the local Hazard Mitigation Plans.

Vulnerability of State Facilities

Current data and history do not suggest that State property is highly vulnerable to hazardous material releases; however, depending on the proximity of State facilities to hazardous material transportation routes and fixed facilities, some locations may be more vulnerable than others. Critical facilities and bridges located in the hazard area are listed in the *Haz-Mat & Transportation Accident* section of **Appendix B-8**.

Figure 4.7-1A Hazardous Material/Transportation Accident – West District

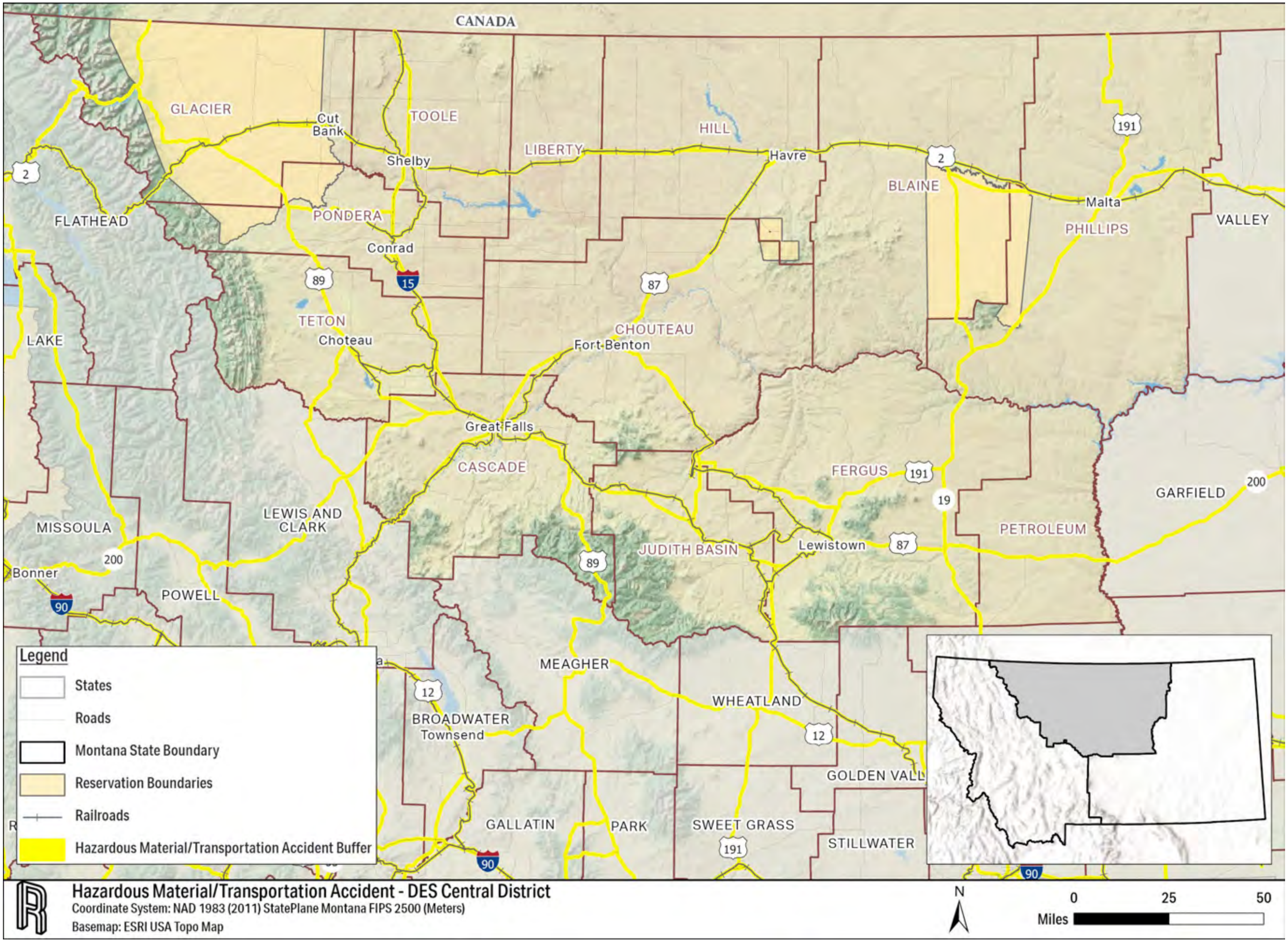

Figure 4.7-1B Hazardous Material/Transportation Accident – Central District

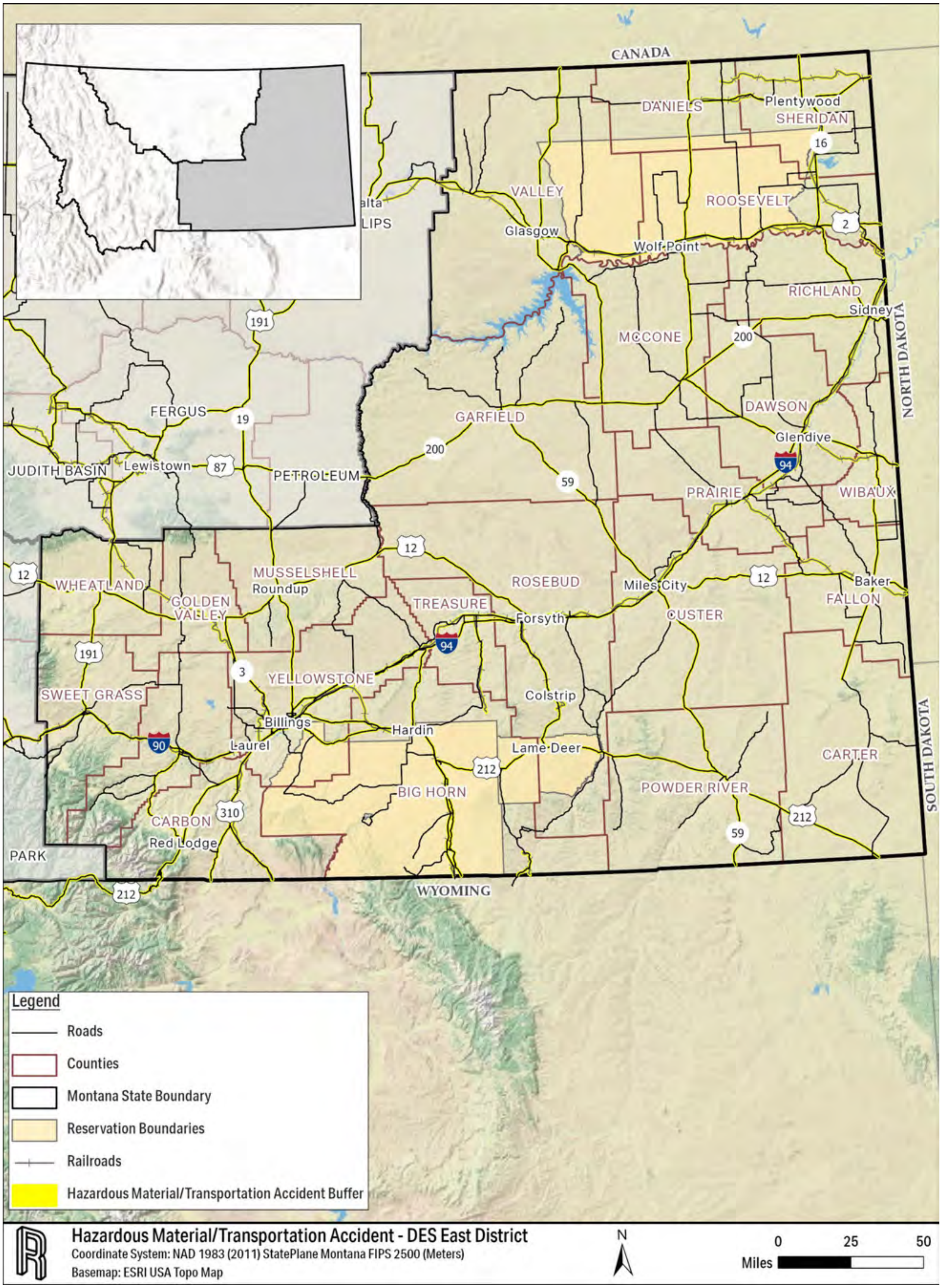

Figure 4.7-1C Hazardous Material/Transportation Accident – East District

FUTURE DEVELOPMENT

Much of the future development currently occurring in the State is off major roads and rail networks. The potential exists for development of agricultural lands bordering the highways and railroads, particularly in unincorporated parts of the State. Few restrictions are in place to prevent development in these areas.

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4.8 DISEASE

CPRI SCORES
PUBLIC HEALTH = 2.40
LIVESTOCK AND WILDLIFE = 2.41

DESCRIPTION AND PAST OCCURENCES

Infectious diseases are illnesses caused by organisms such as bacteria, viruses, fungi, and parasites. Sometimes the illness is not due to the organism itself, but rather a toxin that the organism produces after it has been introduced into a host. Disease may be transmitted (spread) either by one infected person to another, from an animal to a human, from an animal to an animal, or from some inanimate object (doorknobs, tabletops, etc.) to an individual. Public health emergencies that have affected Montana include vector-borne disease, such as West Nile Virus, food-borne illness like *E. coli*, and vaccine-resistant illness such as virulent strains of influenza and the ongoing COVID-19 pandemic.

The Montana Department of Public Health and Human Services (DPHHS) manages a database of reportable communicable disease occurrences. The communicable disease summary between 2012 and 2021 is presented in **Table 4.8-1**. Case counts include all probable or confirmed cases in Montana between 2012 and 2021.

Table 4.8-1. Communicable Disease Summary; 2012-2021

Conditions with at Least 50 Reported Cases	# of Cases	Counties with Highest Number of Cases				
2019 Novel Coronavirus (COVID-19)	300,496	Yellowstone [46,342]	Gallatin [38,476]	Flathead [31,977]	Missoula [30,790]	Cascade [27,435]
Chlamydia	24,951	Yellowstone [4,440]	Gallatin [3,153]	Missoula [2,881]	Cascade [2,401]	Flathead [1,561]
Hepatitis C, chronic	13,894	Yellowstone [2,424]	Missoula [1,257]	Cascade [1,183]	Flathead [909]	Roosevelt [863]
Gonorrhea	7,435	Yellowstone [2,177]	Cascade [762]	Roosevelt [586]	Big Horn [556]	Missoula [552]
Influenza, hospitalization, or death	4,743	Yellowstone [1,077]	Cascade [553]	Flathead [434]	Missoula [416]	Lewis and Clark [404]
Campylobacteriosis	3,342	Yellowstone [416]	Gallatin [390]	Missoula [292]	Flathead [258]	Cascade [211]
Pertussis	2742	Flathead [668]	Lewis and Clark [300]	Missoula [239]	Gallatin [215]	Yellowstone [186]
Giardiasis	918	Gallatin [176]	Flathead [144]	Missoula [140]	Yellowstone [74]	Cascade [64]
Shiga toxin-producing Escherichia coli (STEC)	894	Gallatin [121]	Yellowstone [98]	Flathead [87]	Missoula [82]	Cascade [74]
Streptococcus pneumoniae, invasive	855	Yellowstone [153]	Flathead [92]	Silver Bow [77]	Cascade [75]	Lewis and Clark [59]
Salmonellosis - prior to 2018	854	Yellowstone [144]	Lewis and Clark [94]	Gallatin [93]	Missoula [70]	Flathead [61]
Rabies, post-exposure prophylaxis (PEP)	784	Flathead [229]	Missoula [149]	Yellowstone [50]	Cascade [43]	Lewis and Clark, Ravalli [43]
Varicella (Chickenpox)	727	Flathead [160]	Lewis and Clark [67]	Gallatin [64]	Missoula [50]	Yellowstone [39]
Cryptosporidiosis	720	Gallatin [130]	Flathead [87]	Missoula [73]	Yellowstone [63]	Cascade [61]
Lead poisoning	720	Yellowstone [95]	Flathead [79]	Sliver Bow [73]	Cascade 62]	Lewis and Clark [49]
Salmonellosis (excluding paratyphoid and typhoid)	512	Yellowstone [65]	Gallatin [60]	Cascade [50]	Lewis and Clark [49]	Missoula [40]
Latent TB Infection (LTBI)	445	Missoula [79]	Yellowstone [73]	Cascade [52]	Gallatin [24]	Flathead [20]

Syphilis, unknown duration or late	305	Roosevelt [72]	Yellowstone [43]	Cascade [41]	Missoula [37]	Big Horn [22]
Hepatitis B, chronic	292	Yellowstone [63]	Missoula [56]	Flathead [30]	Gallatin [26]	Cascade [25]
Syphilis, primary	281	Cascade [58]	Yellowstone [52]	Roosevelt [44]	Gallatin [19	Big Horn [19]
Shigellosis	210	Cascade [39]	Big Horn [26]	Gallatin [25]	Yellowstone [21]	Rosebud [15]
Hepatitis C, acute	197	Yellowstone [69]	Missoula [16]	Flathead [12]	Powell [12]	Toole [12]
Rabies, animal	194	Missoula [21]	Flathead [17]	Lewis and Clark [17]	Big Horn [14]	Lincoln [14]
Syphilis, secondary	188	Yellowstone [49]	Cascade [23]	Gallatin [17]	Missoula [16]	Roosevelt [16]
Coccidioidomycosis	165	Cascade [24]	Flathead [19]	Gallatin [18]	Lewis and Clark [16]	Yellowstone [12]
Haemophilus influenzae, invasive	160	Yellowstone [31]	Flathead [18]	Gallatin [11]	Cascade [10]	Big Horn, Lake, Lewis and Clark, Missoula, Roosevelt [7]
Syphilis, early non-primary, non-secondary	142	Missoula [29]	Yellowstone [28]	Cascade [16]	Gallatin [16]	Roosevelt [12]
Salmonellosis - excl. paratyphi/typhi 2018 only	135	Gallatin [19]	Missoula [15]	Yellowstone [15]	Cascade [12]	Lewis and Clark, Silver-Bow [10]
HIV/AIDS	122	Yellowstone [29]	Cascade [20]	Missoula [20]	Gallatin [12]	Lewis and Clark [9]
Legionellosis	105	Cascade [15]	Lewis and Clark [15]	Missoula [15]	Flathead [11]	Yellowstone [9]
Lyme disease	98	Gallatin [19]	Flathead [17]	Missoula [11]	Ravalli [8]	Yellowstone [6]
West Nile virus, non-neuroinvasive	74	Yellowstone [13]	Custer [8]	Cascade [6]	Hill [5]	McCone [5]
Meningitis, Viral	59	Yellowstone [17]	Flathead [6]	Gallatin [5]	Lewis and Clark [5]	Big Horn [4]
Mumps	59	Gallatin [40]	McCone [6]	Deer Lodge [4]	Flathead [2]	Ravalli [2]
Hepatitis A, acute	55	Yellowstone [13]	Gallatin [8]	Lewis and Clark [7]	Ravalli [5]	Flathead [4]
Spotted Fever Rickettsiosis	55	Lewis and Clark [10]	Missoula [7]	Cascade [6]	Custer [4]	Gallatin [4]
Colorado tick fever	53	Missoula [21]	Ravalli [12]	Beaverhead [4]	Big Horn [4]	Gallatin [3]

Human Disease

Outlined below are frequently occurring human diseases that have either historically caused public health emergencies in Montana or are emerging diseases of concern that pose a risk to Montana's public and economic health. The selected diseases are based on diseases identified as common or recent threats to the state of Montana by the DPHHS and through the Montana Public Health and Safety Division's 2019 Communicable Disease in Montana Annual Report [DPHHS, 2019]. It should be noted that not all diseases are included in the following section, but instead, included are the most prevalent diseases.

Influenza

One of the most common infectious diseases affecting humans is influenza (flu). Influenza is a contagious, upper-respiratory disease caused by many different strains of influenza viruses. Symptoms can range from mild to severe illness. Serious outcomes of flu infection can result in hospitalization or death. Some demographics, such as the elderly, young children, and those with pre-existing health conditions are at high risk of serious flu complications.

There have been four major global flu pandemics, which are global disease outbreaks, since 1900. The Spanish flu pandemic (1918- 1919) killed between 50-100 million people worldwide. The Asian flu pandemic (1957-1958) originated in China and is estimated to have killed between one and four million people. The Hong Kong flu (1968-1969) killed approximately one million people. The 2009 swine flu pandemic killed over 18,000 people. The 2019-2020 flu outbreak in Montana claimed 41 lives. During the 2020-2021 influenza season, no lab-confirmed influenza cases, hospitalizations, or deaths were reported in Montana. The prevention measures taken to reduce the transmission of the COVID-19 Pandemic likely helped mitigate the spread of influenza during the 2020-2021 season. The best recommended way to prevent contraction of the flu virus is by annual vaccination.

The single deadliest flu pandemic in history was the Spanish flu pandemic during 1918-1919. Occurring in the three waves of increasing lethality, the Spanish flu killed more people in 24 weeks than AIDS did in 24 years. It also killed more people in one year than smallpox or the Black Plague did in 50 years [Iezzoni, 1999]. The Spanish influenza outbreak caused 9.9 deaths per 1,000 people in the State of Montana [Brainerd and Siegler, 2002]. Historical records from newspapers show that the influenza outbreak was so bad in 1918 that Montana residents were quarantined from November 30 to December 17 after 18 people died and 53 new cases were discovered. Native Americans died at a rate four times the national average from the Spanish flu [Iezzoni, 1999].

Annual flu viruses (not including flu pandemics) infect up to 20 percent of Americans, put 200,000 in the hospital with flu-related complications, and kill about 36,000 people per year [Friedlander, 2009]. As many as 200,000 Americans are hospitalized because of it each year, and as many as 36,000 die of the disease or complications associated with it. Children under age 1, people 65 or older and people suffering from underlying medical conditions are at a higher risk of serious complications. The cost of treating annual flu epidemics, including lost wages and productivity of workers, is billions of dollars each year in just the United States alone [Goldsmith, 2007].

Influenza cases, including hospitalizations and deaths, are reportable to local public health in Montana. In 2019, flu activity increased in mid-December and remained elevated for a total of 15 weeks. Season totals include 11,255 cases, 514 hospitalizations and 41 deaths attributed to influenza. Eighteen (18) outbreaks of influenza were reported during the season. Influenza activity was reported from all counties. **Figure 4.8-1** displays 2019–2020 seasonal influenza activity as case counts by county. In addition, each county is shaded by the incidence rate of disease (per 10,000 population).

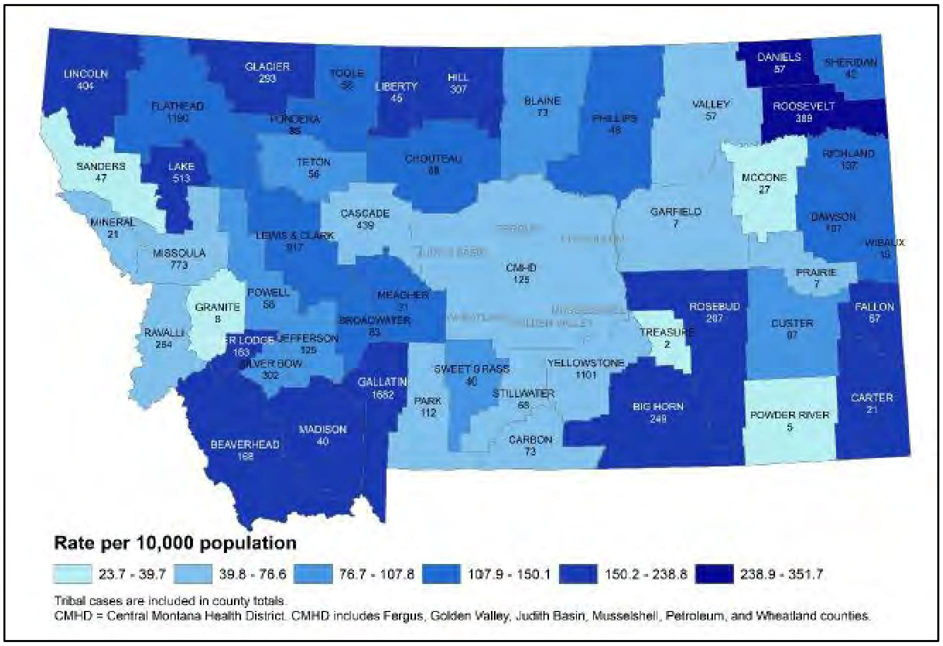

Figure 4.8-1. Number and Incidence Rate of Reported Influenza Cases by County; 2019-2020 Season [Montana DPHHS, 2020]

According to DPHHS, there were zero reported cases of flu for the 2020-2021 season. This is correlated to use of masks and lockdowns that occurred in attempt to reduce the spread of COVID-19. The 2019-2020 flu season was chosen as a comparison to a more "typical" year.

Coronaviruses

Prior to 2020, a lesser-known family of viruses called coronaviruses resulted in two outbreaks of respiratory disease. From 2002-2004 a coronavirus caused the Sudden Acute Respiratory Syndrome endemic (SARS), resulting in 774 deaths from 8,092 reported cases. In 2012 a second coronavirus outbreak led to Middle East Respiratory Syndrome (MERS), causing 850 deaths in 2,400 reported cases [Feehan, 2021]. A third outbreak of coronavirus occurred in the Wuhan Province of China in December of 2019. This third outbreak was caused by the SARS-CoV-2 virus, leading to the COVID-19 pandemic. Like SARS and MERS, COVID-19 spreads mainly from person to person through respiratory droplets when an infected person coughs, sneezes, or talks. Some people have little to no symptoms while others may experience severe symptoms or death. Cases have also been found in many species of animals, including, cats, dogs, deer, and mice [CDC, 2022[2]].

Since 2019 there have been over 634 million reported cases of COVID-19 resulting in over 6.6 million deaths [WHO, 2022]. The first case of COVID-19 recorded in the US occurred in January of 2020. Since then, the U.S. has reported 87 million cases leading to over 1 million deaths [CDC COVID Data Tracker, 2022]. As of December of 2022, Montana has recorded over 319,000 cases of COVID-19 resulting in 3,617 deaths and 13,666 hospitalizations [MT DPHHS, 2022[1]].

Monkeypox

Monkeypox is a rare viral infection transmitted through close, personal contact. Most infections last 2-4 weeks and resolve without a specific treatment. Monkeypox presents as rashes, bumps, or blisters near the hands, feet, chest, genitals, face, or mouth. Those symptoms are often accompanied by other symptoms such as fever, headaches, muscle aches, exhaustion, and respiratory symptoms. The first recorded human case of monkeypox was in 1970, however it was first discovered in 1958 when two outbreaks occurred in colonies of monkeys being kept for research. Since 1970, cases have been increasingly reported in several central and western African countries, occasionally spreading to the United States through travel [DPHHS, 2022[4]].

In 2003, the first monkeypox outbreak outside of Africa was in the United States and was linked to contact with infected pet prairie dogs. This outbreak let to over 70 cases of monkeypox in the U.S. Monkeypox has also been found in travelers from Nigeria in 2018, 2019, 2021, and 2022. The most recent outbreak in 2022 has cause 79,231 global cases, 28,881 U.S. cases, and 11 U.S. fatalities, as of November [CDC, 2022[5]]. Seven cases of monkeypox in 2022 have been recorded in Montana in Cascade, Flathead, Gallatin, Hill, Lake, and Missoula counties [DPHHS, 2022[4]].

Hepatitis

Hepatitis is an inflammation of the liver often caused by a virus. There are several strains of the hepatitis virus, but the most common types found in the U.S. are hepatitis A, hepatitis B, and hepatitis C. While hepatitis is a preventable disease, there are vaccines available for hepatitis A and hepatitis B. There is no known vaccine for hepatitis C. Symptoms of chronic viral hepatitis can take decades to develop, and many people with hepatitis are asymptomatic. One of the largest outbreaks of hepatitis in the United States was of hepatitis A, starting in 2016. As of October of 2022, 37 states have reported a total of 44,660 cases, 27,282 hospitalizations, and 417 deaths. No publicly reported cases have occurred in Montana yet.

Viral hepatitis cases were the second most reported communicable disease in Montana in 2019 comprising 14.4% of all reported disease [DPHHS, 2019]. While most cases were chronic hepatitis C, there was a noticeable increase in hepatitis A cases compared to previous years. In 2019 there were 17 reported cases of hepatitis A after several years of declining cases, including zero recorded cases in 2018. Montana DPHHS has linked the recent increase to person-to-person outbreaks due to injection drug use and homelessness.

Sexually Transmitted Diseases/Infections

Sexually transmitted diseases/infections (STIs) refer to more than 35 infectious organisms that are transmitted primarily through sexual activity. STIs are very common in Montana, as more than 75 new infections are recorded in Montana every week [DPHHS, 2022[1]]. Many individuals with an STI do not know because they often have no symptoms. The three most common reported STIs are chlamydia, gonorrhea, and syphilis. Chlamydia and gonorrhea often have little or no symptoms but can eventually cause serious reproductive damage and permanent health problems. In 2021, more than 4,000 cases of chlamydia and almost 1,700 cases of gonorrhea were reported in Montana.

Syphilis generally presents through sores that worsen as the infection progresses through its four stages but can be cured through medication. It is harmful to the growing fetuses of pregnant women and late stages are associated with problems affecting the heart, brain, and other organs. In 2021, 40 cases of syphilis were reported in Montana, two of which were passed to a baby before birth, causing damage to the fetus.

Even though STIs are largely preventable, the Centers for Disease Control and Prevention (CDC) estimates that 20% of the U.S. population had an STI on any given day in 2018, and that STIs cost the U.S. healthcare system nearly $16 billion in direct medical costs each year [CDC, 2022[3]]. Of that $16 billion, $13.7 billion is from HIV costs and $1.1 billion accounts for direct medical costs from chlamydia, gonorrhea, and syphilis. Because many cases of STIs go undiagnosed, the reported cases represent only a fraction of the true case count of STIs in the United States. Untreated STIs can lead to serious long-term health consequences, especially for adolescent girls and young women. The CDC estimates that undiagnosed and untreated STIs cause at least 24,000 women in the United States each year to become infertile.

Montana continues to see significant increases in STIs each year. In 2021, cases of chlamydia were reported to be up 10% from 2020, while gonorrhea was reported to be up 8% and syphilis was up 42% [Daily Montanan, STDs on the rise in Montana, 2021]. Chlamydia, gonorrhea, and syphilis continue to be the most reportable communicable diseases in Montana. The 2019 Montana Communicable Disease Annual Report noted that 66.6 % of all communicable diseases reported that year were STD's with nearly half associated with Chlamydia [DPHHS, 2019].

HIV/AIDS

Human Immunodeficiency Virus (HIV) affects the immune system and is spread by certain bodily fluids through sexual contact or sharing of injection drug equipment such as needles or syringes. Currently, there is no cure for HIV, however infected individuals can be treated with antiretroviral therapy (ART), helping to reduce the viral load and prevent transmission to others through sexual contact. If HIV is left untreated, infections or cancers may take advantage of the individual's weak immune system and indicate that the individual has Acquired Immune Deficiency Syndrome (AIDS). In 2019, 26 HIV cases were reported in Montana, and 6 of these cases were also diagnosed with AIDS at the same time [DPHHS, 2019].

From 2013-2020, 172 new cases have been diagnosed in Montana. According to the DPHHS, it is very likely that the COVID-19 pandemic decreased the number of individuals testing for HIV in Montana [DPHHS, 2021]. Since 2001, 14 to 32 new cases have been reported in Montana each year. More than 70% of new cases were reported from the most populated counties of Yellowstone, Missoula, Cascade, Gallatin, and Flathead [DPHHS, 2019].

Foodborne and Diarrheal Diseases

Campylobacteriosis – Campylobacteriosis is a bacterial diarrheal disease mostly caused by exposure to cattle and live poultry, which is often associated with farming and ranching in Montana. Common transmission methods are consumption of raw milk, untreated water, and under cooked meats like chicken. In 2019, Montana had an incident rate of 35 cases per 100,000 individuals, which is 79% higher than the national average of 19.5 cases per 100,000 individuals. 30% of the 374 cases reported in Montana in 2019 were of known result to exposure to cattle or live poultry.

Campylobacteriosis is on the rise in Montana. From 2014-2019, the number of cases per 100,000 rose from 20 cases to 41 [DPHHS, 2019].

Salmonellosis – Salmonellosis is a bacterial enteric disease characterized by the sudden onset of diarrhea, abdominal pain, fever, and nausea. Common risk factors for exposure to salmonellosis include exposure to live poultry and ingestion of contaminated food. In 2019, 136 cases were reported in Montana, 3.7% (5 cases) of which were linked to one outbreak that hospitalized two individuals [DPHHS, 2019].

In 2020, 24 Montanans were linked to a multi-state outbreak of 1,722 cases caused by contact with live poultry. This was the largest multi-state outbreak in over 10 years, causing 333 hospitalizations across the country [DPHHS, 2021[1]]. Also in 2020, a multi-state outbreak linked to recalled onions at restaurants affecting 16 Montana counties occurred, with an approximate 52 cases reported in Montana [DPHHS, 2020].

In 2019, the average case rate was 12.7 per 100,000 individuals, which was an increase from 2018 but lower than the five year (2014-2019) case rate of 15.2 cases.

Giardiasis and Cryptosporidiosis – Giardia and Cryptosporidium are parasites causing giardiasis and cryptosporidiosis infections. Both infections are often associated with waterborne exposures in recreational waters or untreated drinking waters. In 2019, 79 cases of giardiasis and 72 cases of cryptosporidiosis were reported in Montana, 15% of those involving consumption of untreated water and 26% resulting from recreational water exposure [DPHHS, 2019].

On average there are approximately 150 cases of giardiasis and cryptosporidiosis reported in Montana each year. 46% of those cases result from recreational water exposure or consumption of untreated water. From 2014 to 2019, the five year average is about 7.4 cases per 100,000 individuals for giardiasis and 6.7 cases per 100,000 individuals for cryptosporidiosis [DPHHS, 2019].

Shiga-Toxin Producing E. Coli - Shiga-toxin producing E. coli (STEC) is an enteric disease-causing abdominal pain and bloody diarrhea and is often linked to consumption of undercooked beef. In 2019, 69 reported cases of STEC occurred in Montana, 14% of which confirmed exposure to cattle before illness onset. 22% (15 cases) resulted in hospitalization [DPHHS, 2019].

STEC case counts have fluctuated over the 2014 to 2019 time period, with the low of 3.8 cases per 100,000 individuals occurring in 2013, and a high of 12.8 cases per 100,000 individuals occurring in 2016. The average 5-year case count was 8.7 cases per 100,000 individuals.

Vaccine Preventable Diseases

Pertussis – Pertussis, commonly known as the whooping cough, is a highly contagious respiratory illness characterized by long periods of uncontrollable coughing followed by a characteristic 'whoop' sound. In Montana, recorded case peaks occurred in 2005 and 2013, with reported case numbers of 586 and 663, respectively. In 2019, 494 cases in Montana were reported, an increase of 2.5 percent from 2018. Of these cases, three individuals were hospitalized, and one case was fatal. Immunization rates of individuals less than 18 years of age were 83% [DPHHS, 2019].

Varicella – Varicella-zoster virus is the cause of chickenpox. Since 2007, the reported cases in Montana have declined from a peak of 437 cases to 52 cases in 2019. The decline is largely attributed to the varicella vaccine. 8% of the cases reported in 2019 were in children less than one year of age, which is too young to receive the vaccine. The median age of infection is approximately 9 years old [DPHHS, 2019].

Mumps – Mumps is an infection characterized by fever and swelling and tenderness of the salivary glands. An increase of mumps cases occurred in Montana in 2016, with 26 reported cases resulting from a college campus outbreak. In the following years of 2017 and 2018, six cases of mumps were reported in both years. Another increase was seen in 2019, when 17 cases were reported, 71% of which were in Gallatin County. 65% of the reported cases in 2019 were unvaccinated individuals. Factors increasing risk of exposure to mumps include international travel, being unvaccinated, and being of school-age [DPHHS, 2019].

Tuberculosis

Tuberculosis (TB) is a bacterial infection most notably known to attack the lungs, however, can also attack the kidney, spine, and brain. The disease is transmitted from person to person, and infected individuals can develop an active form of the disease at any point in their lifetime after infection. Without treatment, approximately 10% of infected individuals will develop the TB disease. During the 1990's, an average of 20 cases were reported annually in Montana. From 2010-2019, this average decrease to 5.4 reported cases annually [DPHHS, 2019].

Incident rates in Montana and the United States have been decreasing. In 2021, Montana had a rate of 0.3 cases per 100,000 individuals. During the past 10 years, there was an average of 4.7 cases in Montana per year, which further declines in the most recent five year period (2017-2021), with an average of 3.4 cases per year. **Figure 4.8-2** was obtained from DPHHS's Annual Tuberculosis Screening Update and shows the declining trend of TB in Montana from 1990-2021 (DPHHS, 2021[2]).

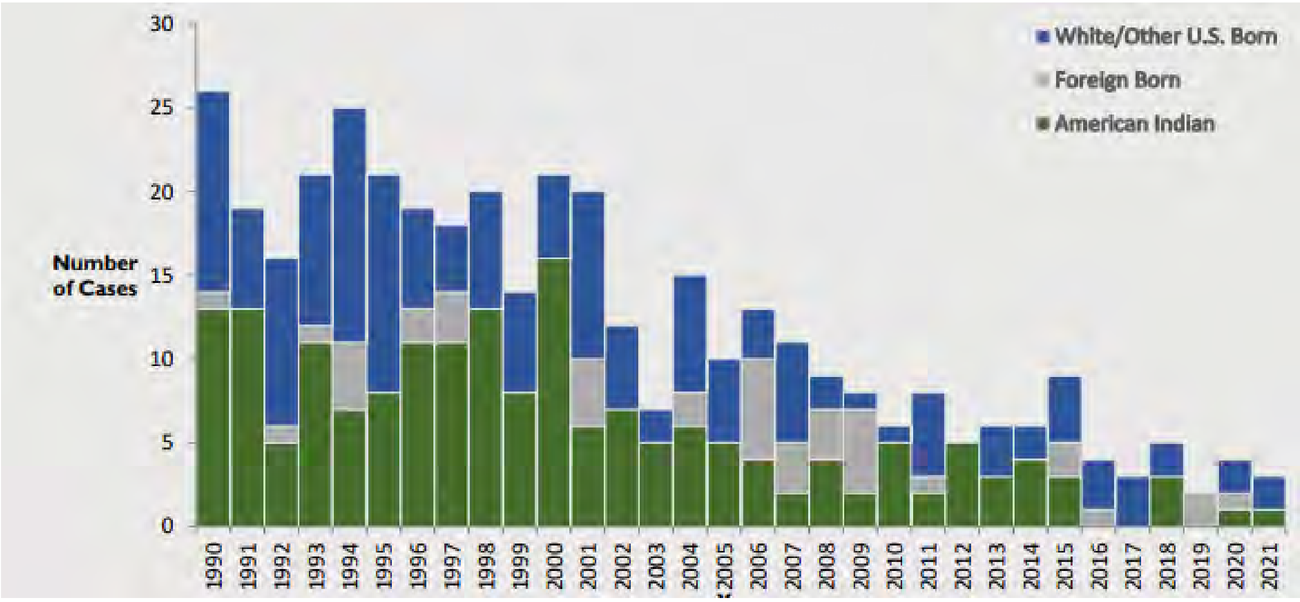

Figure 4.8-2. Decline of TB cases in Montana from 1990-2021.

Livestock and Wildlife Diseases

Agriculture dominates Montana's economy, contributing $3.5 billion per year with $1.9 billion coming from crops and $1.6 billion coming from livestock [USDA Census of Agriculture, 2017]. Montana's most important livestock commodities are cattle and calves, followed by hogs and pigs, and sheep and goats. The security of the state's livestock industry is of paramount importance to

Montana's economy. Some of the livestock diseases with the potential to threaten the state's agricultural industry include: anthrax, brucellosis, foot and mouth disease and mad cow disease. Biosecurity, the practice of protecting ranch and farm animals from disease, has become a major concern world-wide. Effective biosecurity requires several components including isolation, traffic control, and sanitation that aim to reduce exposure to bacteria, viruses and other organisms that may infect animals with disease.

There have been few cases of livestock disease in Montana that have caused significant economic impact. An anthrax outbreak occurred in 2003 causing the death of 37 cows in Roosevelt County. One case of a foot-and-mouth type disease was detected in Yellowstone County in 2005 and treated before it was spread further.

In addition to livestock diseases, several wildlife diseases have emerged in Montana in recent years; some of which may be related to the changing climate. These diseases may both impact livestock production and health of the state's wildlife. Summarized below are significant historic and recently emerging livestock diseases with reported cases in Montana or in closely surrounding areas.

Brucellosis

Brucellosis is a zoonotic disease, and in many places around the world still causes severe infections in humans. Brucellosis causes decreased milk production, weight loss, abortion, and infertility in cattle [Montana FWP,2022[2]]. It is thought that brucellosis arrived in North America with infected European cattle sometime between the 16th and 18th centuries. Beginning in the mid-1950s, great efforts were made to eliminate the disease from all livestock within the United States. Brucellosis arrived within the Greater Yellowstone Ecosystem sometime prior to 1917 when it was first detected in Yellowstone National Park, and subsequently spread to bison and elk throughout the region, including portions of Idaho, Montana, and Wyoming.

Montana has averaged one case of brucellosis per year since 2010. In 2022 there have 2 cases reported (Gallatin and Madison Counties), but the Montana Department of Livestock does not believe this represents an increased risk of outbreak. Recent research and surveillance efforts have indicated that the prevalence and geographical distribution of the disease in elk is likely increasing. Brucellosis now exists in elk populations outside of the Greater Yellowstone Area [Montana Department of Livestock, 2022].

Chronic Wasting Disease

Chronic Wasting Disease (CWD) is a progressive, fatal, neurological disease found in a small percentage of cervids (deer and elk) for which there is no known cure. CWD belongs to the family of diseases known as transmissible spongiform encephalopathies. CWD was first described clinically as a wasting syndrome in captive deer held in a Colorado wildlife research facility in 1967.

CWD was detected in free-ranging deer and elk in northern Colorado and adjacent sections of southeast Wyoming in the mid-1980s. Since then, CWD has also been found in captive herds across the United States and Canada. Montana Fish, Wildlife, and Parks Service (FWP) surveillance efforts of the 2020 hunting season confirmed the presence of CWD in free range deer populations in the north-central, north-eastern, south-central, and south-eastern borders of Montana. CWD was declared a "State of Emergency" by the U.S. Secretary of Agriculture in 2001. Since that declaration, every factor of CWD (growth, spread, persistence, adaptation, and exposure) has only increased, thus threatening the wildlife populations across the U.S. [Montana FWP, 2021].

Since 2017, the Montana FWP has been conducting samples on wild animals for CWD, mostly from hunter-harvested animals. From 2017-2022, 862 out of 29,391 samples on mule deer, white-tailed deer, elk, and moose have been positive. As of November of 2022, 57 of 1,663 samples have resulted in a positive test. These tests show that CWD is most prevalent in in northern and northeastern Montana in white-tailed deer [Montana FWP, 2022[3]].

Avian Influenza

Avian influenza (AI) is a naturally occurring virus of birds and is caused by a Type A influenza virus. Avian influenza viruses are classified as "low pathogenic" or "highly pathogenic" based on their genetic features and severity of the disease they cause in poultry. Highly pathogenic AI viruses are extremely infectious and fatal to poultry and some species of birds. Most influenza A viruses are of low pathogenicity and cause little to no signs of infection. Infected birds often show signs such as swollen eyes, discolored comb and legs, significant drops in egg production, and decrease fluid and food consumption.

Highly Pathogenic Avian Influenza (HPAI) was first detected in Southeast Asia in 1996 and since has spread across Asia into Europe and Africa. The first case in the United States occurred in 2004 in Texas in a commercial chicken flock, and the first known case in Montana was detected in a captive Gyrfalcon in 2015. Shortly after that detection, that same AI virus was detected in a backyard poultry flock in Judith Basin County [Montana FWP, 2022[1]].

The most recent outbreak of HPAI started in August of 2022. This was the United States' first major outbreak of HPAI since 2014-2015, and the new strain, H5N1, is more transmissible and deadly than in recent history. As of November of 2022, 613 confirmed flocks have tested positive for the virus in 46 different states. In Montana, there have been a total of 82,467 birds and 14 backyard flocks affected by this outbreak. No known commercial flocks have yet been affected [USDA, 2022[1]]. Also because of the same outbreak, 76 wild bird samples have resulted positive in Montana. Some species with HPAI detection are Canadian geese, wild turkeys, turkey vultures, American white pelicans, great horned owls, multiple types of hawks, and multiple types of ducks.

There are four subtypes of low pathogenic avian influenza (LPAI) confirmed to have infected people. Reported outbreaks occurred in 1996, 1998, 2002, 2004, 2010, 2013-2017, 2021, and 2022. Of those outbreaks, the most severe subtype caused more than 1,500 reported infections in China, during the epidemics from 2013-2017. These infections mostly caused mild upper respiratory tract symptoms, however some cases resulted in lower respiratory tract disease, severe pneumonia with respiratory failure, and multi-organ failure. Approximately all 40% of hospitalized patients resulted in fatalities [CDC, 2022[4]].

Two subtypes of highly pathogenic avian influenza (HPAI) have been confirmed to have infected people. Reported outbreaks occurred in 1959, 1997-2003, 2004, 2011, 2016, 2020, 2021, and 2022. Of those outbreaks, the most severe infection was that of the H5N1 virus strain. Since 1997, the strain has resulted in 880 infected people with approximately 50% case fatality.

Proliferative Kidney Disease

Proliferative Kidney Disease (PKD) is a fish disease caused by a microscopic parasite known to occur in Canada, the U.S. and Europe that can cause large fish kills. Other factors including high water temperatures, low stream flows and recreational stressors – in concert with this infection increase mortality. This disease can have devastating effects on whitefish and trout. The parasite associated with PKD has not been shown to cause health problems in humans, birds, domestic animals, and other mammals. However, bacteria and other harmful materials associated with decomposing fish could sicken pets. The disease has been documented previously in two isolated locations in central Montana during the past 20 years. Recent outbreaks have occurred in Washington, Oregon, and Idaho [Inside Climate News, 2016].

In August 2016, FWP confirmed a fish kill on nearly 100 river miles of the Yellowstone River as far upstream as near the border of Yellowstone National Park to Grey Bear Fishing Access (west of Big Timber). During the surveys, over 6,000 mortalities were recorded [Opitz and Rhoten 2017], resulting in estimates of total fish mortalities in the tens of thousands for the event. Mountain whitefish accounted for >99% of observed mortalities, but population estimates were not available prior to the outbreak so the proportion of the mountain whitefish population that died is unknown [Hutchins et al, 2021]. Environmental conditions overall on the Yellowstone River had been poor in terms of flows and temperature. For more than a month starting in mid-July, daytime high Yellowstone River water temperatures (at Livingston) hovered around 70 °F. Ideal temperatures for whitefish and trout are mid-50s.

The magnitude of the kill was unlike anything seen. FWP was concerned that any additional stress on the fish could cause similar levels of mortality in trout populations and therefore, closed the Yellowstone River to recreational use for several weeks at an estimated economic loss of $500,000. FWP was also concerned that the parasite could be spread from the Yellowstone River Basin to other Montana waters. The loss of income to fishing guides and floating companies, and secondary impact to Montana communities from canceled trips, caused a significant loss to Montana's economy.

PKD is considered a rare occurrence in Montana. Besides 2016, the only recorded PKD cases were a remote Montana reservoir during August and September of 1990 and 1991 [Macconnell, 1992].

Vector-Borne Diseases

Vectors—primarily arthropods such as ticks, mosquitoes, and fleas—are organisms that transmit diseases from one host to another. Vector-borne diseases include Lyme disease, West Nile virus, Rocky Mounted spotted fever, tularemia, and Colorado tick fever. These diseases are transmitted through the bite of an infected vector. Risk of infection is decreased using insect repellent and wearing protective clothing that covers exposed skin. Most vector-borne illnesses are rare occurrences in Montana [DPHHS, 2022[1]].

Rabies

Rabies is a viral disease transmitted to humans most often through the bite of a rabid animal. Majority of rabies cases reported each year in Montana occur in bats, skunks, raccoons, and foxes. Once known exposure occurs, rabies can be cured through vaccination. The last known cases of rabies in Montana occurred in 1996 and 1997, both of which were associated with bat exposures [DPHHS, 2022[5]]. In 2019, the Montana Veterinary Diagnostic Laboratory test 501 animals for rabies. Of the tested animals 17 bats and one skunk tested positive [DPHHS, 2019].

Hantavirus

Hantavirus, first identified in 1993, is most often caused by the Sin Nombre virus in deer mice in Montana. It is transmitted to humans through the droppings, urine, and saliva of infected mice that is inhaled when aerosolized or spread to the eyes, nose, or mouth after touching infected droppings or nesting materials. Hantavirus causes Hantavirus Pulmonary Syndrome (HPS) in humans and is a serious illness affecting the lungs. Most cases of hantavirus are reported during the spring and summer months. 47 reported cases in Montana have occurred from 1993-2021, 11 of which were fatal [DPHHS, 2022[2]].

Declared Disasters

On April 1st, 2020, President Donald Trump approved Montana's COVID-19 disaster declaration to provide federal aid to support local response efforts. This was the first time in Montana's history a federal disaster declaration had been issued as the result of a disease outbreak. Public health emergencies are issued when an infectious disease outbreak has occurred or is anticipated. State and federal partners coordinate rapid response teams for disease emergencies.

FREQUENCY/LIKELIHOOD OF OCCURENCE

Probability of contracting a human disease varies depending on the disease in question. Diseases such as influenza and sexually transmitted diseases are highly common and present themselves more than once a year. Others, such as vaccine preventable diseases, are generally decreasing due to the implementation of vaccines. The probability of contracting those diseases does depend on vaccination status of each individual and effectiveness of the vaccines. Diseases such as pertussis, varicella, and mumps are considered controlled through the use of vaccines to reduce infection and death to low levels locally, however they do have the potential to cause and outbreak or pandemic, often rare occurrences [CDC, 2022[6]].

Probability is based on hazard frequency over a 10-year period. Overall, the MHMP Planning Team rated human disease as "Highly Likely". A highly likely rating indicates that disease will likely occur every year. The *Climate Change* section discusses the potential change in frequency of disease associated with the changing climate.

Livestock and wildlife diseases were raked as "Likely" for probability of occurrence. A likely rating indicates that disease will not necessarily occur every year but will occur more than once every ten years.

CLIMATE CHANGE CONSIDERATIONS

It is relatively well accepted that climate change may increase the spread of human pathogenic diseases, however the degree is not well quantified. Overall, it is expected that gradual warming, changes in rainfall, and extreme events will affect contamination of water and food by bacteria, increase the number and activity of disease vectors, and expand areas of infection. Particularly in Montana, extreme heat and heatwaves are expected to increase exposure to heat stress and heat stroke, as well as increase wildfire activity and air pollution, which may lead to higher cases of respiratory and cardiovascular diseases. Extreme precipitation events may lead to water contamination and water-borne illnesses, resulting in rising gastrointestinal illnesses, and may cause adverse birth outcomes. Water-borne illnesses will flourish in the wake of heavy rainfalls and floods, as runoff from land enters water supply. Warmer water temperatures also allow for quicker reproduction of diarrheal disease-causing pathogens. Populations more vulnerable to these effects are children, elderly, pregnant women, racial minorities, and individuals with chronic medical conditions, outdoor professions, or low socioeconomic status [Montana Climate Assessment, 2021].

Due to warmer temperatures and milder winters, an increase in vector range, primarily that of ticks and mosquitoes, is anticipated in the United States. This will result in increased human exposure to diseases transmitted by these vectors. Climate change effects are also predicted to improve climate variables that favor West Nile virus and the mosquito vector, raising concerns for increasing infections in Montana.

Warmer water temperatures and lower water levels will accelerate the spread of disease-causing parasites, which are often released through fish urine and spread within the water. These lower water levels, mostly driven by drought, may also cause shifts in fish habitat and increase concentrations of fish in certain areas, which will allow for higher spread of disease [Montana Outdoor, 2022].

POTENTIAL MAGNITUDE AND SEVERITY

Human Disease

Diseases when on a pandemic or epidemic scale can lead to high infection rates in the population, causing isolation, quarantines, and large numbers of fatalities, all of which have been observed in the COVID-19 pandemic. It is impossible to predict when the next pandemic will occur, however history has shown that disease outbreaks are frequent enough to pose a risk to Montana socially, politically, and economically. Until recently, the influenza pandemic of 1918 was used as the major historical reference of potential magnitude and severity of outbreaks developing further. Although it has been extremely costly to both human health and the economy of Montana, the COVID-19 pandemic has served as a reminder of the potential magnitude and severity of disease outbreaks that not just the state, but the whole world, may encounter.

Over two years later, Montana is still working to recover from the unprecedented economic situation caused by this pandemic. In 2020, the Montana economy suffered an average employment decline of more than 50,000 jobs, representing a 7.3 percent decline. Most job losses occurred in the industries for accommodations, food service, retail, arts and entertainment, and personal services businesses. The Montana tourism industry reported 70 percent fewer bookings for June of 2020 compared to a year prior

[MTPR, *Montana Tourism Businesses Hurting Amid Pandemic*, 2020]. Visitor spending in Montana in 2020 decreased by 12% annually compared to 2019 [University of Montana, 2021]. The state made emergency financial relief available from the federal government to those who have been hardest hit economically. This financial assistance totaled approximately $1.25 billion in relief funding. As of August 29, 2021, 18,437 grants totaling over $575 million were awarded to businesses, including those in the health, agriculture, tourism, construction, and many other industries [Montana Department of Commerce, 2022].

Air travel has also significantly increased the speed with which diseases can spread. Most of the world's great cities are now within a few hours of each other. A virus that is in Hong Kong one day can be carried to any point in Southeast Asia within three or four hours, to Europe in 12 hours, and to North America in 18 hours. 4.5 billion passengers traveled by air in 2019 according to the International Civil Aviation Organization's 2019 Annual Report. Over 1.0 billion of those passengers flew into or out of the United States [USDOT, 2022].

Diseases that have been eliminated from the U.S. population, such as smallpox, are of concern to be used as weapons of bioterrorism. The CDC has identified three categories of biological agents or diseases that could be naturally occurring or used by terrorists [CDC, 2022[1]]. These diseases/bioterrorism agents can infect populations rapidly, particularly through groups of people in close proximity such as schools, assisted living facilities, and workplaces. The CDC defines these categories as bioterrorism agents or diseases that the U.S. public health system and primary healthcare providers must be prepared to address. The categories are as described below:

- **Category A** biological agents or diseases are high-priority agents that pose a risk to national security because they are easily disseminated or transmitted from person to person, result in high mortality rates and have potential for major public health impact, may cause public panic and social disruption, and require special action for public health preparedness. The agents or diseases within this category are Anthrax, Botulism, Plague, Smallpox, Tularemia, Viral hemorrhagic fevers (e.g. Ebola), and arenaviruses.
- **Category B** biological agents or diseases are the second-highest priority and include those that are moderately easy to disseminate, result in moderate morbidity rates and low mortality rates, and require specific enhancements of the CDC's diagnostic capacity and enhanced disease surveillance. The agents or diseases within this category include Brucellosis, Epsilon toxin, food safety threats (Salmonella, E coli, Shigella), Glanders, Melioidosis, Psittacosis, Q Fever, Ricin toxin, Staphylococcal enterotoxin B, Typhus fever, Viral encephalitis, and water safety threats (Vibrio cholerae, cryptosporidium parvum).
- **Category C** is the third highest priority agents that could be engineered for mass dissemination in the future because of availability, ease of production and dissemination, potential for high morbidity and mortality rates, and will have major health impact. Agents within this category include emerging infectious diseases such as Nipah virus and hantavirus.

The population of Montana has increased from 1.06 million in 2018 to 1.1 million in 2020 [U.S. Census, 2020]. Most of the population growth has occurred within the Western Mountain region around the larger cities, such as Bozeman, Kalispell, and Missoula. The increasing population will increase the human-to-human exposure of disease, thus quickening the spread of disease and potentially increasing the magnitude of disease outbreak Montana will incur. Alongside the potential effects of new disease outbreak, current outbreaks such as the current STI epidemic and yearly flu outbreaks may continue to increase in magnitude.

Livestock and Wildlife Disease

Brucellosis

Brucellosis can result in serious financial burdens to cattle producers, potentially resulting in quarantine of a herd, increased testing and vaccination costs, and possible difficulty in trade with other states and countries. The USDA describes brucellosis classifications as Class Free, Class A, Class B and Class C. Restrictions on the interstate movement of livestock become less stringent as a state approaches or achieves Class Free status. Montana is currently recognized as a brucellosis Class Free state. State animal health officials monitor brucellosis to maintain the marketability of livestock. A State Class status downgrade would cost Montana producers millions of dollars each year for testing as well as revenue from lost sales due to negative publicity (Montana Dept. of Livestock, 2022).

Chronic Wasting Disease

CWD has broad implications. Without action, CWD may cause severe population impacts, extinctions, negative impacts to economies such as the hunting industry, and unlikely, but potential transfer of the disease to humans. It is clear to scientists that a transfer of CWD to people could cause catastrophic implications to public health, economic stability, and in domestic and international trade. Because a long history exists in animal to human transmission of disease, it is not inconceivable that transfer to humans could occur through contact with infected urine, feces, and saliva.

Avian Influenza

There have been no reports of human infections with the Highly Pathogenic Avian Influenza (HPAI) strains recently detected in the United States. However, that is not to say HPAI viruses have not been transferred from avian species to humans. HPAI viruses have infected people in other countries and caused serious illness, and death in some cases. Human infections of HPAI generally occur after close and prolonged contact with infected birds, or from secretions of infected birds.

Avian influenza outbreaks can have large consequences for the poultry industry, the health of wild birds, farmer's livelihoods, and international trade. When outbreaks occur, healthy birds are often killed to contain outbreaks, which results in higher bird loss from flocks, meat wastage, and economic impacts for the farmers. Farmers may experience high levels of mortality within their flocks, with rates often around 50% [WOAH, 2022]. The poultry production industry in Montana saw more than $48 million in 2020, which is doubled in revenue from 2015 [Daily Montanan, 2022]. Since economic impact is not yet available, it is unclear how the 2022 outbreak will affect Montana's poultry production industry.

Proliferative Kidney Disease

Sections of the Yellowstone River were closed during August 2016 by Montana FWP because of a parasite outbreak that killed thousands of Whitefish. Closure of segments of the drainage to all water-based activities directly impacted spending behavior by visitors to counties affected by the closure, thus reducing revenue to river-dependent business such as outfitters and guides, fly shops, rafting companies, river shuttle companies and myriad spin-off businesses in lodging, food and beverage services, and area attractions. The river closure resulted in an economic loss to businesses in Park County of $360,000 to nearly $524,000. The estimated economic losses are the equivalent of five to eight full-time jobs [UM, 2016].

Vector-borne Diseases

While Lyme disease is still uncommon in Montana, approximately 98 cases have been reported from 2002-2021 [DPHHS, 2022[1]]. Other reported diseases in that period were Rocky Mountain spotted fever, tularemia, Colorado tick fever, and tickborne relapsing fever.

West Nile virus is increasing in the West and Montana had its first case of West Nile Virus in 2002. Cases have increased since then, with 51 cases reported by 2018. In 2021, Montana had two reported human cases of neuroinvasive West Nile in Rosebud and Lewis and Clark counties. Also in 2021, two horses tested positive for West Nile Virus in Rosebud and Phillips counties, along with mosquito pools from seven different counties. As of November of 2022, there have been no reported human infections, however a horse was infected in Lewis and Clark County and positive samples were received from mosquito pools in Dawson and Lewis and Clark counties [DPHHS, 2022[6]].

The severity of vector-borne disease seasons depends on several factors, originating from weather patterns, ecological factors in tick habitat, and human behavior. With climate change effects, the possibility for warmer winters and earlier springs is high, which will result in higher human-vector encounters, thus increasing the vulnerability of humans to vector-borne illnesses.

Rabies

In general, the probability of rabies or hantavirus exposure is relatively rare in Montana. For both diseases, viral exposure depends on infected animal populations and the number of infected animals in close proximity to human populations. Hantavirus also depends on human-controlled exposure precautionary measures, such as wearing masks and gloves, spraying areas with a disinfectant prior to cleaning, and thoroughly washing hands after cleaning in potentially infected structures like cabins, campers, and outhouses.

VULNERABILITY ASSESSMENT

Infectious disease or biological agents could be devastating to the population or economy of Montana. It is presumed that disease affects the State's population equally, such that a specific area of impact cannot be mapped. As such, the MHMP does not include a risk assessment for the disease hazard. Structures are not impacted.

Statewide Vulnerability

The entire population of the State is at risk for contracting disease. Urban population centers are more vulnerable to rapidly spreading highly contagious diseases than more rural parts of the state. The ability to control the spread of disease would be dependent on the contagiousness of the disease, movement of the population, and the warning time involved. The number of fatalities depends on the mortality rate and the percentage of the population affected. As with COVID-19, the mortality rates greatly affected the older population in Montana. 85% of COVID-19 deaths occurred in people aged 60 and older. Availability of vaccines can help control the spread of disease.

Effective disease control efforts rely on an effective surveillance and response system that promotes collaboration, coordination and communication among public health and clinical professionals, and/or agriculture and wildlife health specialists. A number of federal and state agencies are involved in disease surveillance and have developed response protocol. The DPHHS, as well as local counties and tribes, have been involved in pandemic influenza preparedness efforts and have a *State and Local Human Disease and Public Health (Pandemic Influenza) Emergency Plan*. States and local communities are responsible under their own authorities for responding to an outbreak within their jurisdictions and having comprehensive pandemic preparedness plans and measures in place to protect their citizens. The focus of these planning efforts is on practical, community-based procedures that could prevent or delay the spread of pandemic influenza and help to reduce the burden of illness communities would contend with during an outbreak.

Securing agriculture and wildlife health requires rapid detection of outbreaks, accurate diagnose of problems, and early response to minimize impact. The USDA Animal and Plant Health Inspection Service (APHIS) Plant Protection and Quarantine Program coordinates pest detection activities nationwide. Plant pest detection coordination is handled locally by the Montana Dept. of

Agriculture and Montana State University Extension Service. Animal and wildlife issues are managed by the Montana Dept. of Livestock and FWP.

Montana Dept. of Livestock, Agriculture, FWP, and DPHHS are charged with protecting public health, the safety of the food supply, the integrity of animal and plant agriculture industries and wildlife security in Montana. These agencies have developed guidelines for local and tribal governments to heighten biosecurity awareness and give direction to address public health, agricultural, and wildlife security issues.

The Montana Dept. of Livestock encourages producers to maintain a high sense of awareness for unusual occurrences of animal diseases in their communities. Producers need to initiate an appropriate level of biosecurity on their ranches and farms. A good biosecurity program helps to lower the risk of pathogens being transferred from ranch to ranch. Informed veterinarians and livestock producers are the first line of defense against foreign and other animal diseases. The agency maintains the Foreign Animal Disease Response Plan.

Review of Potential Losses in Local Hazard Mitigation Plans

Approximately half of local hazard mitigation plans evaluated the disease hazard in their risk assessment. Five counties (Cascade, Daniels, Deer Lodge, Glacier, and Roosevelt) ranked it as their #4 hazard while seven local jurisdictions (Beaverhead, Flathead, Gallatin, Ravalli, Stillwater, and Sweetgrass Counties and the Fort Belknap Reservation) ranked it as #5. Chouteau and Judith Basin counties ranked Agro-Security as their #3 and #6 hazards, respectively. All jurisdictions ranked the public health aspect of the disease hazard as having a high societal exposure. Most local plans recognized the potential for economic impacts from the disease hazard. **Appendix B-9** presents an exposure summary from the local Hazard Mitigation Plans.

Vulnerability of State Facilities

In general, critical facilities are not structurally threatened by disease; however, their accessibility and function can be lost. Contamination of a critical facility could render the facility non-functional until decontamination or the threat has passed. During the early stages of the COVID-19 pandemic, facilities lost large numbers of staff due to the quarantine and isolation protocols. For this reason, all critical facilities are assumed to be at risk from infectious disease. As with any human biological event, the hospitals and health service providers would most likely discover a threat and possibly become the first contaminated. COVID-19 caused hospitals and other healthcare facilities to become overwhelmed with patients limiting resources such as nursing staff, equipment, and PPE. This essentially shutdown medical facilities for all non-emergency healthcare as those facilities transitioned to "crisis standard of care" operations. Public water systems are also potentially at risk to communicable diseases.

DATA LIMITATIONS

Disease is a difficult hazard for which to predict and provide specific vulnerabilities. For a disease to have a major impact, it first has to enter the population and spread. That starting point, how the disease progresses, and preventive actions taken will determine the eventual outcome. The data and analysis are limited by these outside factors.

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4.9 LANDSLIDE AND AVALANCHE

CPRI SCORES

AVALANCHE = 2.39

LANDSLIDE = 2.41

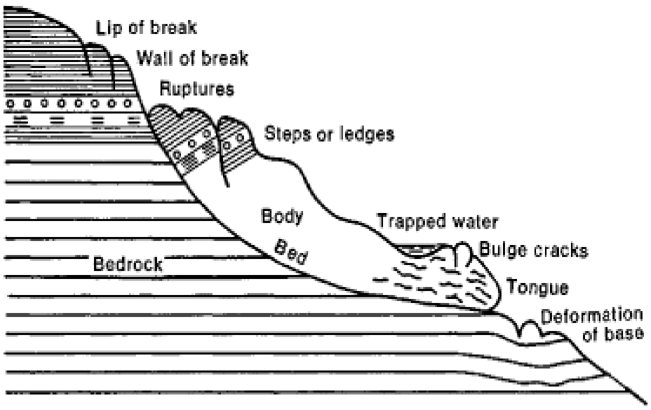
The landslide and avalanche hazards are profiled together because they are cause by similar geologic forces.

DESCRIPTION AND HISTORY

Landslides

A landslide is the mass movement of rock, soil, and debris down a slope due to gravity. It occurs when the driving force is greater than the resisting force. It is a natural process that occurs in steep slopes. The movement may range from very slow to rapid. It can affect areas both near and far from the source.

The surface of the earth is a collection of slopes that are inherently unstable. Earth movement may occur suddenly as catastrophic landslides or rockfalls, but more commonly, occurs as the slow creep of soil down gentle slopes. Precipitation, topography, geology, and human activities can all be factors in landslide occurrence. In landslide-prone areas, anything affecting slope condition, such as construction, seismic activity, or increased soil moisture, may cause movement or may reactivate prior movement. Recent landslide movements often are the reactivation of smaller sections of older, unstable landslide masses.



Source: **The Great Soviet Encyclopedia, 1979.** Cross section of a landslide.

Landslides are among the most common geologic hazards in Montana, causing damage in rural and urban areas of the state. Sudden movements are often spectacular and destructive. The Hebgen Lake earthquake of August 18, 1959, triggered the largest landslide in Montana history, where nearly 1.25 miles of the Madison River and Montana Highway 287 were buried to depths as great as 394 feet (see the Earthquake hazard profile in *Section 4.4*). Slower movement can also cause severe problems in developing areas. The effects of the very slow movements can be seen along many roadways in the form of leaning trees, misaligned fences and walls, and damaged road surfaces, foundations, and structures.

Source: Great Falls Tribune, 2017. Landslide from the Hebgen Lake earthquake in August of 1959.

When landslides occur in proximity to human-made structures, repairs and remediation can be costly. For example, a small lobe of a much larger ancient slide south of Dillon was reactivated by removing the toe of the slope. The slide is proving very costly to the railroad and could impact Interstate 15 if a larger segment of the slide area should move [MBMG, 2002].

Avalanches

Avalanches are often the result of severe winter weather in Montana. An avalanche is a mass of loosened snow, ice, and/or earth suddenly and swiftly sliding down a mountain. Avalanches occur throughout the mountains of Montana and, to a limited extent, elsewhere in the state. Avalanche hazards most-directly threaten winter recreationists and communication and transportation networks in mountainous regions. Two of Montana's ski areas, Bridger Bowl, and Big Sky are respectively the second and fourth most avalanche-prone ski resorts in the United States. Where developments have encroached into steep mountainous terrain, the vulnerability for avalanches increases. The complex interaction of weather and terrain factors contributes to the location, size, and timing of avalanches. In the absence of detailed scientific observation, any accumulation of snow on a slope steeper than 20 degrees should be considered a potential avalanche hazard.

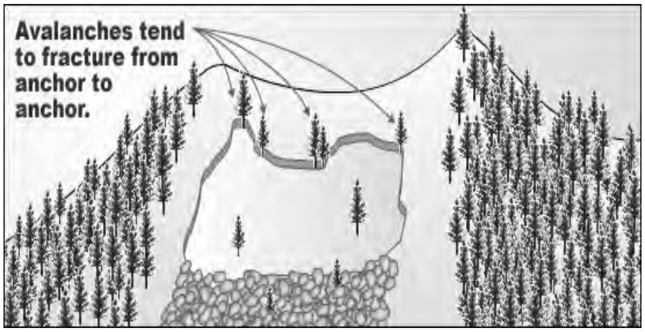
Avalanches come in many shapes and sizes and even small ones can be dangerous. According to the U.S. Forest Service National Avalanche Center, there are three types of avalanches:

1. Slab avalanches: Most people that die in avalanches, die in slab avalanches. Slab avalanches occur when a more cohesive or harder layer of snow sits on top of a less cohesive or softer and weaker layer of snow. Sometimes the weak layer can barely support the layers above it and when additional weight like a skier or snow boarder is added to the upper layers, the weak layer collapses and the snowpack fractures and a slab avalanche occurs. Slab avalanches often involve large volumes of fast-moving snow. Victims, like the skiers, typically trigger slabs at mid-slope below the fracture line which often makes escape very difficult.
2. Sluffs or loose snow avalanches: Sluffs are cold snow powdery surface slides that typically are the least dangerous type of slide; however, sluffs can and often do injure skiers and boarders by pushing them over cliffs and rock bands in steep terrain.
3. Wet avalanches: Wet slides occur when warm temperatures melt the surface snow layers and saturate them with water. The water weakens the bonds between layers and avalanches often occur. Wet avalanches move more slowly than dry avalanches, but they can still be very dangerous.

The West Central Montana Avalanche Center provides pre-season avalanche information updates beginning in November, then scheduled avalanche advisories three times a week from December through March. They also provide extra avalanche updates/bulletins/special advisories during this period, as needed [U.S. Forest Service, 2022].

Ninety percent of all avalanches occur on moderate slopes with an angle of 30 to 45 degrees (snow tends not to accumulate on steeper slopes). Avalanches occur when the gravity pushing the collection of snow at the top of the slope is greater than the strength of the snow itself. A change in temperature, a loud noise, or vibrations are all that are necessary to trigger one of these snowfalls that begin at a "starting zone." Artificial triggers of avalanches include skiers, snowmobiles, and controlled explosive work. The avalanche continues downslope along the "track" and ultimately the avalanche fans out and settles in the "runout zone."

Avalanche initiation can start at a point with only a small amount of snow moving initially; this is typical of wet snow avalanches or avalanches in dry unconsolidated snow. However, if the snow has sintered into a stiff slab overlying a weak layer, then fractures can propagate very rapidly, so that a large volume of snow, that may be thousands of cubic meters, can start moving almost simultaneously. Avalanche fracture lines tend to run from anchor to anchor because they are stress concentration points.



Source: U.S. Forest Service, 2018. Avalanche fracture example.

PAST OCCURENCES

Landslides


Source: Landslide Technology, 2002. Goat Lick Landslide on US Highway 2, Glacier National Park.

1993 - State Highway 2 was built on a landslide in Glacier Park and the roadway has had constant subsidence problems. The Goat Lick slide shut down a 16-mile section of the Going to the Sun Road between Avalanche Creek and Logan Pass. The slide aftermath forced the Montana Dept. of Transportation to re-construct the roadway with a cantilevered outside driving lane to prevent further subsidence. In 1993, the roadway construction totaled approximately $1.5 million.


Source, MDT, 2005. Beartooth Highway landslide. March 2005.

March 2005 - A rain-on-snow event caused a mudslide that severely damaged more than 12 miles of U.S. Highway 212 outside of Red Lodge. The road is a crucial link to the western route to Yellowstone Park and is only open to traffic from late-May until mid-October. An Executive Order was issued declaring an emergency in Carbon County and requested assistance from the Federal Highway Administration for the repairs. The $15.2 million repair involved excavating rock and slide debris, reconstructing the drainage, roadway, and new alignment, and constructing tie-back walls. Rock fall fences were also constructed at several locations and overall drainage capacity was increased by creating water diversions along stable locations on the mountain and constructing special inlets to allow rock over 3-inch diameter to pass.

June 2010 - The majority of the damage associated with the June 2010 flood on the Rocky Boy's Indian Reservation was due to mass movement. Slippage of land under the newly constructed Chippewa Cree Health Center caused significant structural damage and the building was no longer fit for occupancy. Several roads also failed due to the over-saturation from the heavy rainfall that resulted in mass movement. Reports of sinkholes were also associated with this flood event.


Source: Carol Arkell, 2015. Stillwater River Road is blocked by landslide, June 2015.

June 2015 - A rockslide occurred on the Stillwater River Road in Nye, closing the road for two years due to safety concerns. One home was evacuated, and officials recommended the evacuation of two others. Engineers evaluated the slide and concluded that moisture from heavy rainstorms seeped behind wedges that were holding large sections of rock together, causing the slide. The rockslide came down with enough force to push water and debris from the Stillwater River into the yard of a home on the opposite bank [Stillwater County News, 2015]. The County received a FEMA grant to stabilize the area.

Avalanches

January 2004 - Two separate avalanches hit an eastbound train near Essex (near Glacier National Park), throwing 15 cars off the rails and closing tracks used by Amtrak's Empire Builder. The slides occurred due to extremely heavy snowfall. The slide hit near the middle of the train, knocking seven cars off the tracks. While the train was stopped another slide hit near the rear of the train about 15 minutes later, knocking eight more cars off the track. [Independent Record, 2004].

Avalanches are also responsible for fatalities to recreationists such as skiers, snowboarders, snowmobilers, and climbers. From 2006 through 2022, there were 48 avalanche fatalities in Montana, representing about 11 percent of the nationwide avalanche-related deaths [Colorado Avalanche Information Center, 2022]. **Table 4.9-1** summarizes the avalanche-related fatalities in Montana since 2006.

Table 4.9-1. Summary of Avalanches in Montana: 2006-2022

Date	Location	Activity	Fatalities
12/16/2006	Scotch Bonnet Mountain near Cooke City	Snowmobiling	1
12/28/2006	Lionhead area near West Yellowstone	Snowmobiling	1
1/1/2007	Mt. Jefferson, Centennial Range	Snowmobiling	1
2/17/2007	Big Belt Mountains, northeast of Townsend	Snowmobiling	2
3/3/2007	Yellow Mountain near Big Sky	Skiing	1
1/13/2008	Canyon Creek, near Whitefish Mountain	Skiing	2
1/20/2008	Beehive Basin, near Big Sky	Skiing	1
1/17/2009	Gravelly Range	Snowmobiling	1
1/17/2009	Crown Butte	Snowmobiling	1
1/17/2009	Mount Jefferson	Snowmobiling	1
12/10/2009	Hyalite Drainage, northern Gallatin's, Bozeman	Climbing	1
1/3/2010	Scotch Bonnet Mountain, near Lulu Pass	Snowmobiling	1
3/27/2010	Near Missoula Lake	Snowmobiling	1
3/31/2010	Peak 6966 near Marias Pass, Glacier National Park	Snowboarding	1
4/14/2010	McAtee Basin, Southern Madison Range	Snowmobiling	1
6/14/2010	Lolo Peak	Skiing	1
2/14/2011	Truman Gulch, Bridger Ranger	Snowboarding	1
1/1/2012	Phillipsburg, Flint Range, Red Lion	Snowmobiling	1
2/1/2012	Twin Lakes, Swan Range	Skiing	1
2/20/2012	Lost Johnny drainage, east of Kalispell	Snowmobiling	1
2/22/2012	Daisy Pass Road, north of Cooke City	Snowmobiling	1
2/25/2012	Skyline Creek, near Marias Pass	Snowbiking	1
1/1/2013	Onion Basin, Northern Gallatin Range	Snowmobiling	1
2/22/2013	Troy, West Cabinet Mountain Range	Snowmobiling	1
2/28/2013	Mount Jumbo, Missoula	Snowboarding	1
3/7/2014	Altoona, 10 miles NE of Phillipsburg	Ski Touring	1
3/11/2014	Cooke City	Snowmobiling	1
5/3/2014	Olson Gulch, west of Anaconda	Ski Touring	1
11/26/2014	Near Henderson Peak, Cooke City	Snowmobiling	1
4/11/2015	Beehive Peak, northern Madison Range	Ski Touring	1
12/19/2015	Sheep Mountain, north of Cooke City	Snowmobiling	1
1/19/2016	Cedar Basin, west of Big Sky	Ski Touring	1
1/23/2016	Swede Creek area, Whitefish Range	Snowmobiling	1
1/5/2017	Mt. Stanton, north of West Glacier	Ski Touring	1
10/7/2017	Imp Peak, southern Madison Range	Ski Touring	1
1/2/2018	Cabin Creek, southern Madison Range	Snowmobiling	1
2/17/2018	Canyon Creek, Whitefish Range	Snowmobiling	1

4/14/2018	Saddle Peak, Bridger Range	Snowmobiling	1
1/5/2019	South Waldron Creek, north of Teton Peak	Snowmobiling	1
1/25/2019	Bell Lake, Tobacco Root Mountains	Ski Touring	1
2/26/2019	Truman Gulch, Bridger Ranger	Ski Touring	1
1/1/2020	Lake Dinah, west of Seely Lake	Snowmobiling	2
2/6/2021	Wounded Buck Creek, NW of Wildcat Lake	Snowmobiling	1
2/14/2021	Beehive Basin, near Big Sky	Snowboarding	1
12/27/2021	Lionhead area near West Yellowstone	Snowmobiling	1
2/19/2022	Miller Mtn, north of Cook City	Snowmobiling	1

In 2014, a devastating avalanche, triggered by winter recreationists, impacted a Missoula neighborhood, causing one fatality, destroying one home, and damaging three others. This incident is described below.

February 28, 2014 - At approximately 4:15 pm, a snowboarder triggered a hard slab avalanche on a west facing, 35 degree slope of Mount Jumbo, located within the Missoula City limits on Missoula Conservation District land. The snowboarder was caught by the avalanche but was able to self-arrest by digging in with the edge of his board and using his arms and fingers to grab the bed surface as the snow passed by. The avalanche entrained most of the available snow in the fetch zone and accelerated as it advanced over a terrain convexity halfway down the track.

At the base of the ravine, the avalanche caught two children, ages 8 and 10, who were playing in their backyard as it slammed into and destroyed a two story wood frame home. The two residents of the home were inside the house when the avalanche hit.

The two children saw and heard the avalanche coming down the ravine and ran downslope toward their home. Both were caught and carried several feet before coming to rest next to their home. One was partially buried and was able to dig herself out quickly. The other was completely buried next to the house about 3 feet deep and was later rescued. The house residents were together in their home and were also completely buried under several feet of snow and debris from their destroyed home, resulting in one fatality.

Source: Missoula Avalanche Center, 2014. Looking downslope from the foundation of the destroyed home.

At 4:18 pm, Missoula City Fire, Police, Missoula County Sheriff, MT Highway Patrol units and local EMS teams were dispatched. A large contingent of well- equipped neighbors with avalanche rescue gear soon began arriving on scene.

Rescue coordination was complicated by live power lines, broken natural gas lines and the very real possibility of another avalanche. Spot probing began and a probe line formed near the home just below the buried child's last seen point. He was located 3-4 feet deep by a probe strike after approximately 55 minutes. When extricated from the snow, he was unresponsive. Rescue breaths were given, and he was immediately transported by ground ambulance to St. Patrick Hospital's Emergency Department.

Rescue efforts then concentrated on spot probing and digging in areas directly below the last known location of the house residents. A neighbor showed rescue teams the probable location on the remaining foundation of where the couple may have been. Probe teams were directed to concentrate on possible catchment features on the fall line below this area of the house. A probe strike was confirmed, and the male was located in a cavity under a brick chimney and a wall or roof partition approximately 4 feet deep. He was responsive and able to inform rescuers that his wife was 3 feet from him when the house was hit. He was extricated and transported by ground ambulance to St. Patrick Hospital's Emergency Department.

An hour later, the woman was located by a responding neighbor with a probe. She was approximately 25 feet below her husband's location 2-3 feet deep. She was breathing but unresponsive and was transported to St. Patrick Hospital's Emergency Department in critical condition. She died on March 3 from traumatic injuries. Three other homes, several vehicles and an apartment building were also damaged by the avalanche.

Events Leading Up To The Avalanche - Four friends, ages 13-27, wanting to take advantage of a rare day when schools were closed, decided to snowboard or ski the untracked west face of Mount Jumbo. Earlier storms had deposited enough snow on the low elevation terrain in the mountains surrounding Missoula to allow for unique skiing and riding opportunities within walking distance of many residents. Mount Sentinel, above the University of Montana and south of Mount Jumbo, had been skied and ridden earlier in the week and was heavily tracked.

Source: Missoula Avalanche Center, 2014. Looking upslope at the avalanche path.

The snowboarder reached a point above the slide path and opted not to push toward the summit as the wind was making travel difficult at best. He strapped on his board, entered the slide path at the highest point where there was adequate snow, and immediately fell. He got back up and noticed movement in his peripheral vision and realized he was being carried downslope by an avalanche. He was at the top of the slab and able to self-arrest by digging in with the edge of his board and using his arms and fingers to grab the bed surface as the snow passed by. The sledders were near the base of the mountain to the north of the slide path. At least one of them saw a powder cloud and heard the avalanche slam into the home. They immediately went to the site and began digging for the buried child. Shortly after this the snowboarder walked down the slide path and also assisted with the initial rescue effort.

Declared Disasters

A federal disaster declaration was received for the Beartooth Highway landslide. Executive Order No. 08-05, proclaiming an emergency to exist in Carbon County was signed by the governor on May 27, 2005. The Federal Highway Administration reimbursed Montana $15 million for expenses associated with the highway repair as part of an emergency supplemental appropriations package passed by Congress and signed by President Bush. The SBA made a declaration to provide assistance to small, non-farm businesses in Big Horn, Carbon, Gallatin, Golden Valley, Meagher, Park, Stillwater, Sweet Grass, and Yellowstone Counties that suffered financial losses as a result of the highway closure due to the landslide disaster (SBA Declaration #10130) [SBA, 2007].

There have been no declared disasters due to the avalanche hazard.

CLIMATE CHANGE CONSIDERATIONS

Landslides represent a major threat to human life, constructed facilities and infrastructure in most mountainous regions of the world. Considering future climate scenarios and modified precipitation patterns, the landslide activity will most probably change too. More precipitation now falls as rain rather than snow in northern regions and, therefore, more landslides are expected to occur. It is expected that shallow slips and debris flows will take place more frequently because of more extreme weather events [Global Warming is Real .com, 2008].

While it is hard to tell the exact results that climate change will have on avalanches, one possibility includes an increase in the number of avalanches from current levels and the duration of high avalanche danger, followed by an eventual drop-off if snowpack continues to decline over time.

Average winter temperatures in Montana have increased by more than 3 degrees over the past century, which has led to more rain-on-snow events and long-term declines in snowpack. These warming trends have the potential for creating the "right" conditions for avalanches. A warming climate in Montana has already meant more winter days above the freezing point, which can lead to a significantly wetter snowpack - possibly resulting in wet, as opposed to dry, avalanches [Climate ChangeMT, 2022].

FREQUENCY/LIKELIHOOD OF OCCURRENCE

Probability for this MHMP is based on the frequency of the hazard over a 10-year period. Since damaging landslides do not occur more than once per decade, the probability rating is "Possible" for this hazard. The MHMP Planning Team rated the probability of the avalanche hazard as "Likely" due to the annual loss of life. Climate change may increase snowfall in mountainous regions of the state and therefore, the frequency of avalanche-caused fatalities may increase.

POTENTIAL MAGNITUDE AND SEVERITY

Landslides can damage and destroy homes, roads, railroads, pipelines, electrical and telephone lines, mines, commercial buildings, sewers, bridges, dams, and airports. According to the USGS, landslides cause several billion dollars in damages annually and kill between 25 to 50 people each year. The Beartooth Highway landslide cost $15.2 million to repair. **Table 4.9-2** presents Montana's landslide historic losses associated with the landslide hazard from the SHELDUS database.

Table 4.9-2. Landslide Losses (Adjusted to 2016 Dollars); 1993-2021

DES District	Date	County	Injuries	Fatalities	Property Damage (Adjusted to 2016 $)
1	Jan-95	Flathead	0	0	$100
1	Jan-95	Lake	0	0	$100
1	Jan-95	Lincoln	0	0	$100
1	Jan-95	Sanders	0	0	$100
1	Sep-04	Flathead	2	0	$0
3	Jul-04	Gallatin	0	0	$0
3	Jul-04	Park	0	0	$0
5	May-05	Carbon	0	0	$16,954,722
1	Jun-01	Lake	0	0	$108
3	Jul-12	Lewis and Clark	0	0	$10,644
1	Aug-13	Flathead	0	0	$104
3	Sep-13	Madison	0	0	$104
1	Aug-14	Missoula	0	0	$4,182
TOTALS			2	0	$16,970,264

Every year at least one winter recreationist dies from an avalanche in Montana's backcountry. Damage to infrastructure (railroad) has occurred near Glacier National Park in Flathead County. Costs associated with the 2014 Mount Jumbo avalanche in Missoula are not available; but, one home was damaged. Three other homes, several vehicles and an apartment building were also damaged by the avalanche. Costs incurred by local law enforcement and search and rescue outweigh the structural damage.

VULNERABILITY ASSESSMENT

Landslides appear to have a stronger association with faulting than with any specific geologic unit (MBMG, 2002); however, some geologic formations or lithologies can be identified as being particularly prone to movement:

- Volcanic rocks, or sediments derived from them, are often the originating lithology for landslides. These sediments often contain ash and clay materials that facilitate movement.
- Poorly-consolidated sediments, particularly those of Cretaceous, Tertiary and Quaternary age, appear to have a tendency toward landslide.
- In the Butte and Dillon 1:250,000-scale areas, Proterozoic-age (Precambrian Belt Supergroup) rocks appear to be prone to landslide.

The types of material identified for each slide or flow appears to generally correspond to well-defined topographic settings:

- Earth slides and flows occur most often on more gentle slopes with less vegetation—the foothills and river courses.
- Debris slides and flows generally occur in the steeper, mountainous areas and in areas covered with vegetation.
- Rockslides and flows occur in previously glaciated high valleys with steep slopes that generally lack vegetative cover, and along other very steep slopes (generally > 50 degrees).

Debris flows associated with flash flooding which can occur after wildfire are described in the *Flooding* profile in *Section 4.3*.

Activation of landslides depends upon environmental factors, such as amount of rainfall and snowmelt, and human activities, such as road and housing construction. Many landslides cannot be predicted and can be activated by multiple factors including earthquakes, high precipitation, overgrazing, and deforestation. Many, if not most, areas at high-risk from landslides can be identified based on past activity. Many recent landslides are small, relatively minor events within the boundaries of older, much larger ones. The Montana Dept. of Transportation indicated that traffic is often diverted along Interstate-90 in the Lookout Pass area of Mineral County due to landslides. Slope stabilization occurred in the Prickly Pear Creek Canyon along Interstate-15 (between Helena and Great Falls) to mitigate the rockfall hazard. The shale formations in many parts of Big Sky (Gallatin Co.) are susceptible to landslides, and many houses have been built in areas that could start moving if there's a period of exceptionally wet weather.

Avalanches are dangerous natural phenomena to the winter sport industry that threaten the safety of recreationists, primarily in back country locations. But, as was seen in Missoula's Rattlesnake Canyon neighborhood in 2014, avalanches also have the potential to impact residences and critical facilities located beneath steep slopes, and the occupants of these structures. Both Mount Jumbo and Mount Sentinel are steep slopes above highly populated areas of Missoula.

Of the major avalanche hazards, the interruption of communications lines probably occurs most frequently. Places of highest hazard include ski areas, mountain passes, and other areas where transmission lines cross avalanche paths. In regions where important highways or railroads cross areas subject to frequent snow slides, losses resulting from blocked roads, buried railroad tracks, and destroyed bridges can result in the millions of dollars of losses.

Statewide Vulnerability to Landslides

As part of the 2023 MHMP, a GIS layer was developed to evaluate landslide risk (**Figure 4.9-1A-C**). The landslide hazard area consisted of slopes greater than or equal to 30 percent and data from the MBMG digital geologic map of historic landslide units, as described in **Table 4.1-5** in *Section 4.1.3*.

To complete the vulnerability analysis for landslide, the hazard layer was intersected with the general building stock, critical facility, cultural resource datasets. Estimates of vulnerable population were calculated using the DNRC Dam Failure Risk Population estimates based on structure type. Exposure values are presented in **Table 4.9-3**. **Appendix B-10** presents supporting documentation including a list of critical facilities in landslide hazard areas.

Table 4.9-3. Landslide Exposure Summary by DES District

Item	East District	Central District	West District
Landslide Area (Square Miles)	0.44	0.32	4.80
Percent Hazard Area	0.00%	0.00%	0.01%
Residential Building Exposure ($)	$50,271,163	$10,207,324	$670,275,144
Residential Building Exposure (# structures)	281	95	2,245
Commercial, Ag, Industrial Building Exposure ($)	$285,300	$0	$11,704,500
Commercial, Ag, Industrial Building Exposure (# structures)	1	0	25
Critical Facility Exposure ($)			
Critical Facility Exposure (# structures)			
Cultural Resource Exposure (# features)	0	3	11
Population Living in Hazard Area	768	280	7,870

The vulnerability analysis shows that DES West District has the highest residential and commercial/ agricultural/industrial exposure to the landslide hazard in terms of value and the most residences at risk.

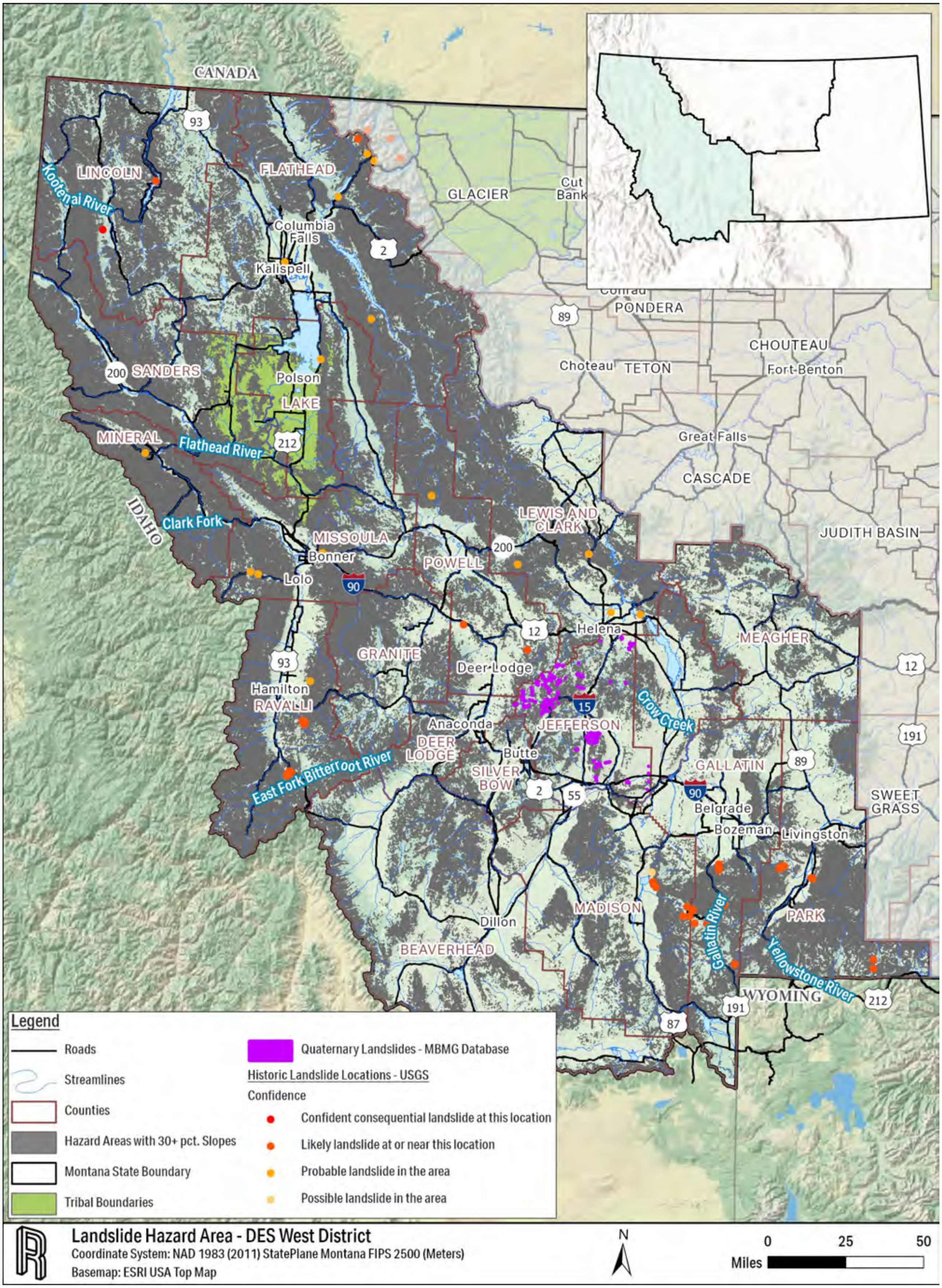


Figure 4.9-1A. Landslide Hazard Area DES West District, MHMP 2023 Update.

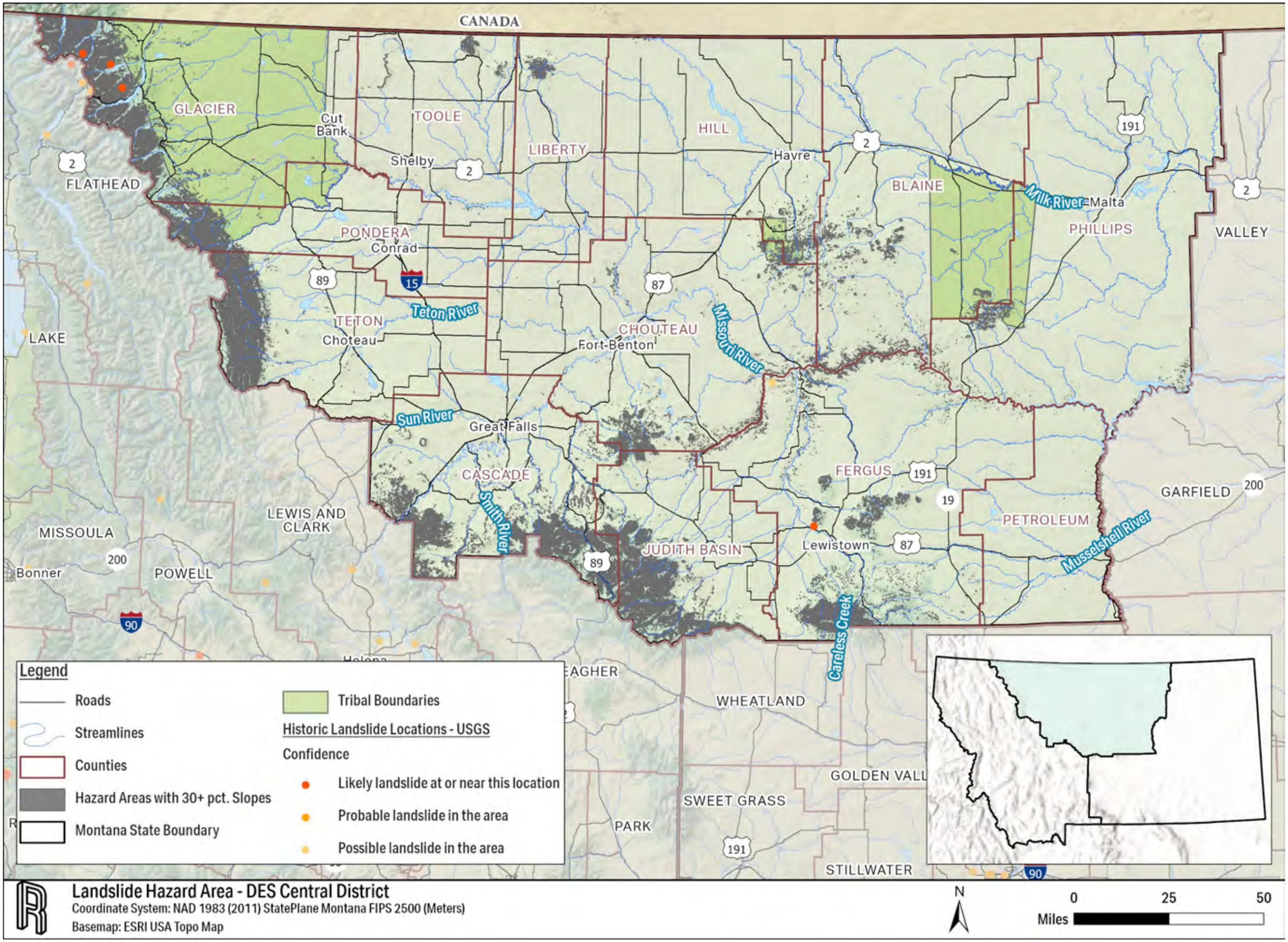


Figure 4.9-1B. Landslide Hazard Area DES Central District, MHMP 2023 Update.

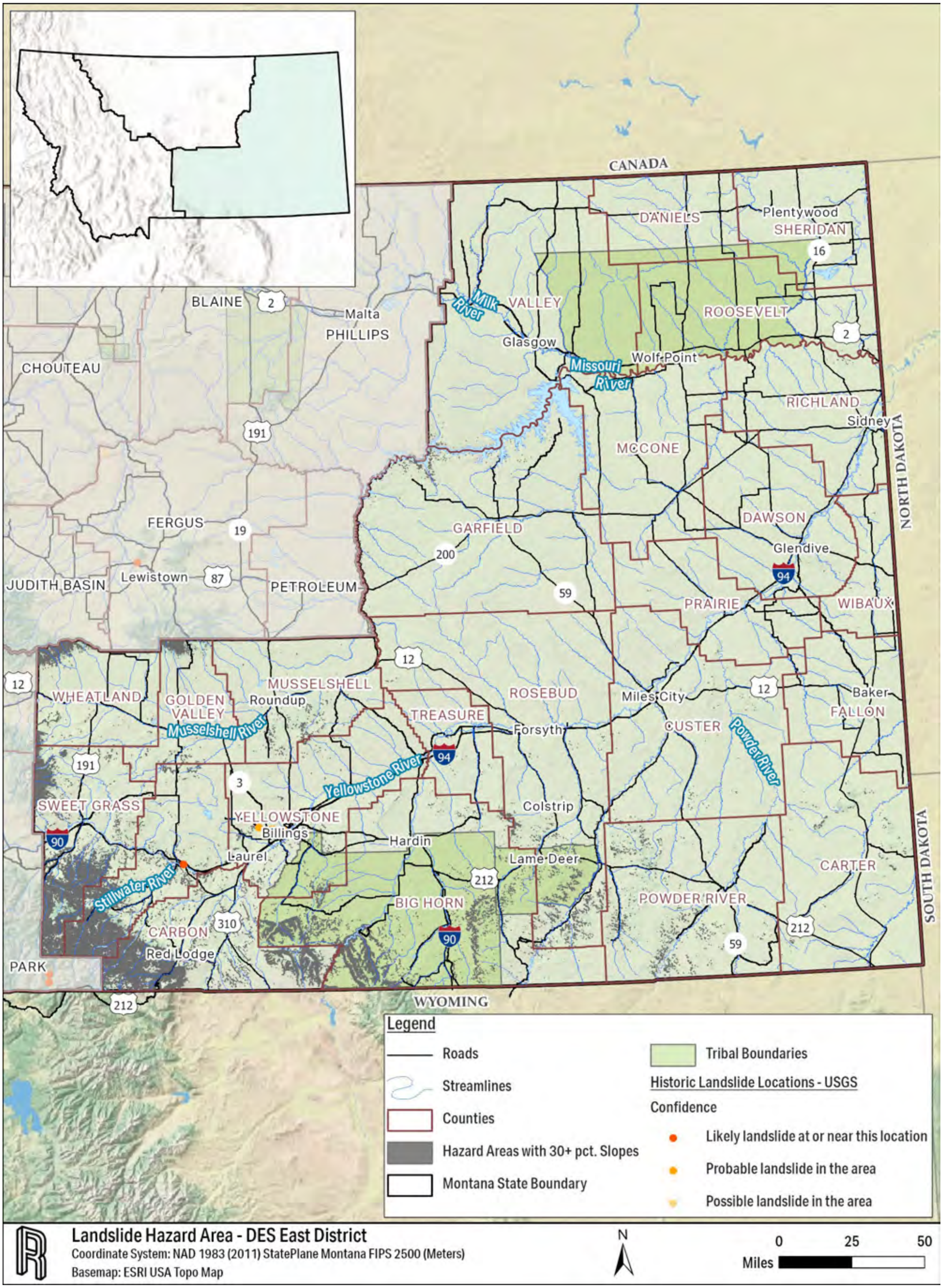


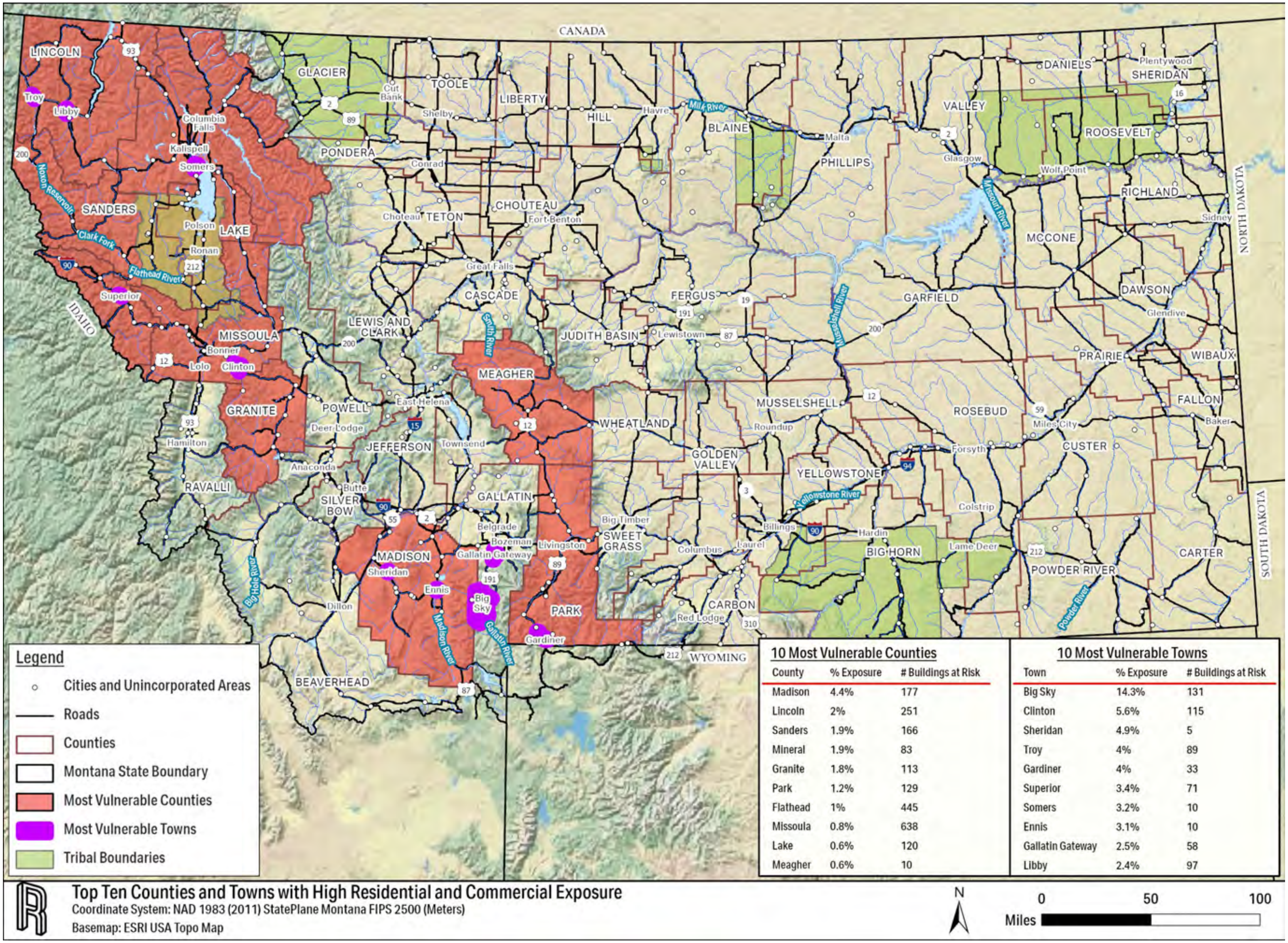
Figure 4.9-1C. Landslide Hazard Area DES East District, MHMP 2023 Update.

Table 4.9-4 presents a vulnerability summary of the landslide hazard as it relates to percent exposure in Montana's counties, cities and towns. Percent exposure was derived by dividing the value of residential and commercial/agricultural/industrial building stock exposed to the hazard into the total value of the building stock. Percent exposure is a more accurate way of displaying vulnerability than presenting jurisdictions with the highest exposure because it reflects areas with the greatest risk opposed to those with high value real estate. Percent exposure by County is presented in **Appendix B-10**.

Table 4.9-4. Landslide Exposure Summary for Top Counties, Cities and Towns

County/Town	% Landslide Exposure	% Growth (2016 to 2021)	$ Residential Exposure	# Residences at Risk	$ Commercial/ Ag/Industrial Exposure	# Commercial/ Ag/Industrial Buildings at Risk	$ Critical Facilities Exposure	# Critical Facilities at Risk
Counties with Highest Percent Exposure (Counties with Pop. > 1,000) ($ Residential + $ Commercial- Ag- Industrial Exposure in Hazard Area / Total Exposure)								
Madison	4.43%	10.4%	$211,233,464	76	$468,280	7		
Lincoln	2.01%	6.2%	$18,313,816	105	$338,980	2		
Sanders	1.88%	13.0%	$17,635,954	98	$0	0		
Mineral	1.85%	17.7%	$5,601,861	44	$0	0		
Granite	1.83%	2.1%	$7,419,396	57	$0	0		
Park	1.16%	8.3%	$25,542,641	76	$6,641,346	3		
Flathead	1.01%	10.8%	$149,902,795	246	$1,765,132	7		
Missoula	0.85%	2.5%	$97,583,466	357	$25,110	1		
Lake	0.63%	7.8%	$8,607,823	35	$1,529,112	2		
Meagher	0.61%	6.1%	$1,233,360	3	$0	0		
Cities/Towns with Highest Percent Exposure (Towns with Pop. > 500) ($ Residential + $ Commercial- Ag- Industrial Exposure in Hazard Area / Total Exposure)								
Big Sky	14.31%	10.4%	$233,467,048	55	$547,310	8		
Clinton	5.58%	-38.6%	$177,270	3	$0	0		
Sheridan	4.88%	4.3%	$10,411,711	56	$0	0		
Troy	3.98%	-9.9%	$4,953,596	45	$0	0		
Gardiner	3.97%	-21.8%	$19,940,353	46	$0	0		
Superior	3.37%	8.1%	$5,319,781	40	$0	0		
Somers	3.17%	27.5%	$8,141,561	8	$0	0		
Ennis	3.06%	6.5%	$2,567,582	6	$0	0		
Gallatin Gateway	2.54%	0.5%	$16,279,049	25	$0	0		
Libby	2.44%	8.6%	$9,076,084	42	$338,980	2		

Counties with the highest landslide exposure include Madison, Lincoln, Sanders, Mineral, and Granite; while the top towns included Big Sky (Gallatin Co.), Clinton (Co.), Sheridan (Madison Co.), Troy (Co.), and Gardiner (Park Co.). **Figure 4.9-2** presents loss estimates for the top counties and cities/towns showing regional vulnerability.



10 Most Vulnerable Counties

County	% Exposure	# Buildings at Risk
Madison	4.4%	177
Lincoln	2%	251
Sanders	1.9%	166
Mineral	1.9%	83
Granite	1.8%	113
Park	1.2%	129
Flathead	1%	445
Missoula	0.8%	638
Lake	0.6%	120
Meagher	0.6%	10

10 Most Vulnerable Towns

Town	% Exposure	# Buildings at Risk
Big Sky	14.3%	131
Clinton	5.6%	115
Sheridan	4.9%	5
Troy	4%	89
Gardiner	4%	33
Superior	3.4%	71
Somers	3.2%	10
Ennis	3.1%	10
Gallatin Gateway	2.5%	58
Libby	2.4%	97

Figure 4.9-2. Top ranked counties and towns/cities with high residential and commercial exposure , MHMP 2023 Update.

No risk assessment was completed for the avalanche hazard since avalanche vulnerability mapping does not exist for Montana. Much of the avalanche activity is human-caused and occurs in mountainous areas not developed with structures. In general, the avalanche hazard does not affect the general building stock, critical facilities, cultural resources, or population other than winter recreationists.

Review of Potential Losses in Local Hazard Mitigation Plans

Approximately 40 percent of the local hazard mitigation plans evaluated the landslide hazard in their risk assessment. The following local jurisdictions ranked landslide among their top five hazards: Flathead (#3), Garfield (#3), Lake (#3), Sanders (#5), Teton (#5) counties, and the Flathead Reservation (#3). Avalanche losses were not quantified in the local plans. **Appendix B-10** presents a summary of potential loss estimates due to landslides as calculated in the local Hazard Mitigation Plans.

Seven (7) local plans profiled the avalanche hazard including: Missoula and Stillwater counties which ranked avalanche as their #7 hazard, Madison (#13), Deer Lodge (#14), Granite (#15), Park (#18), and Carbon (no rank). Loss estimates were not provided in local plans for the avalanche hazard.

Vulnerability of State Property

Since past damages are a reflection on future vulnerability, Montana's state facilities do not appear to be highly vulnerable to the landslide hazard. There have been no insurance claims related to landslide damage for state-owned buildings in the past 10 years. Critical facilities located in the landslide hazard area are listed **Appendix B-10**.

The greatest exposure to state infrastructure is to roadways. Two of the major slides, the Beartooth Highway slide on U.S. Highway 212 and the Goat Lick slide on Highway 2, were discussed previously. Slides that bury and undermine roadways represent significant costs to the state. Although damages to public roads from landslides have occurred, the Montana Dept. of Transportation does not maintain a compilation of losses and repairs to roadways as a result of landslides.

State-owned property is generally not vulnerable to avalanche with the possibility of buildings adjacent to Mount Sentinel on the University of Montana campus. There is not historical record of damages from avalanches; however, the potential does exist.

FUTURE DEVELOPMENT

As urbanization and development increase in Montana, particularly in the mountainous regions, the potential for large losses from landslides also increases. Many local jurisdictions have subdivision regulations in place to limit development on steep slopes. Landslide risk should be evaluated on a case-by-case basis to reduce or eliminate exposure of public infrastructure and private development.

In many cases buyers are aware of the landslide problem and invest in engineering solutions, but in other cases they're in the dark. Geological surveys and soil-sampling are generally required as part of the subdivision approval process, but those reports are not always shared with buyers.

County subdivision regulations do not currently prevent new construction in avalanche prone areas as these areas have not been mapped. There is currently no disclosure requirement for properties located in areas subject to avalanche.

DATA LIMITATIONS

Risk assessment results are only a general representation of potential vulnerabilities. The landslide impact area could be improved for future MHMP updates with additional mapping of geologic units prone to slippage or mass movement. Mapping of avalanche prone areas in the State of Montana has not been completed and as such, a vulnerability analysis could not be performed for this Plan.

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4.10 DAM FAILURE

CPRI SCORE=2.56

DESCRIPTION

Dam failures are not a frequent occurrence but when they do occur, they can cause large scale damage and deaths. Failures in dams are typically caused by insufficient design capacity, construction error, operation error, or maintenance inadequacies. The greatest threat from dam failure is to people and property in areas immediately below the dam. There is a large vulnerability to Dam Failure in Montana due to the significant number of dams throughout the state. The Dams range significantly in size, volume, and ownership. Many of the dams throughout the state are privately owned and do not all have publicly available information. The figures and tables below reflect publicly available data.

According to FEMA, dams are classified into three categories, as outlined below:

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

PAST OCCURENCES

Montana has approximately 3,005 dams according to the USACE National Dam Inventory. Of these, 204 are "high-hazard dams".

The hazard categories of dams and ownership type are summarized in **Table 4.10-1**.

Table 4.10-1. Number of Dams within the State of Montana

Hazard Categories	Federal Dams	State Dams	Local Government Dams	Public Utility Dams	Private Dams	Misc.	Total
High	62	27	40	4	71	0	204
Significant	3	10	11	0	164	2	190
Low	222	112	33	0	2235	9	2611
TOTAL	**287**	**149**	**84**	**4**	**2470**	**11**	**3005**

Table 4.10-2. Montana High Hazard Dams >100 Feet High or with >100,000 Acre-Feet

Dam Name	River	Nearest City	NID Height (ft)	Maximum Storage (acre-ft)	Drainage Area (sq mi)	County(s)	Owner Name
Yankee Doodle Tailings Dam	N/A	Butte	570	7,200	---	Silver Bow	Montana Resources
Hungry Horse	South Fork Flathead River	Hungry Horse	564	3,588,000	1,640	Flathead	USBR
Yellowtail (Bighorn Lake)	Bighorn River	Saint Xavier	525	1,331,725	19,650	Big Horn	USBR
Libby (Lake Koocanusa)	Kootenai River	Libby	422	6,027,000	8,985	Lincoln	USACE
Fort Peck Dam	Missouri River	Nashua	256	19,100,000	57,725	McCone, Garfield, Valley	USACE
Canyon Ferry	Missouri River	Canyon Ferry	225	2,051,000	15,860	Lewis & Clark	USBR
Tiber	Marias River	Loma	206	1,424,478	4,393	Liberty	USBR
Swift (Pondera)	Birch Creek	Dupuyer	205	34,000	---	Pondera	Pondera Canal & RES. Co
Selis Ksanka Qlispe (Skq)	Flathead River	Kerr	186	1,791,000	7,096	Lake	Energy Keepers, Inc.
Noxon Rapids	Clark Fork, Pend Oreille River	Noxon	260	400,000	21,800	Sanders	Avista Corp.
Gibson	Sun River	Augusta	199	121,981	575	Teton	USBR
Kootenai Development Impoundment Dam	Rainy Creek	Libby	151	1,302	10	Lincoln	Kootenai Development Co.
Clark Canyon	Beaverhead River	Dillon	148	328,979	2,315	Beaverhead	USBR
West Fork Bitterroot (Painted Rocks)	West Fork Bitterroot	Darby	143	45,100	316	Ravalli	State Water Projects
Newlan Creek Dam	Newlan Creek	Ulm	131	15,600	43.4	Meagher	Newlan Creek Water District
Hubbart	Little Bitterroot River	Niarada	130	12,000	---	Flathead	BIA
Hauser Dam	Missouri River	Craig	125	139,890	16,876	Lewis & Clark	NWE
Holter Dam	Missouri River	Craig	124	306,000	17,150	Lewis & Clark	NWE
Hebgen Dam	Madison River	Ennis	120	525,620	905	Madison	NWE
Willow Creek (Lodge Grass Reservoir)	Willow Creek	Lodge Grass	113	23,000	---	Big Horn	BIA
Ruby Dam	Ruby River	Alder	111	56,355	595	Madison	State Water Projects
Fresno	Milk River	Havre	111	22,288	2,828	Hill	USBR
Lake Sherburne	Swiftcurrent Creek	Babb	109	110,679	--	Glacier	USBR
Beaver Creek Reservoir Dam	Beaver Creek	Havre	108	8,700	79	Hill	Local Government

Willow Creek Dam	Willow Creek	Willow Creek	105	26,600	155	Madison	State Water Projects
Morony	Missouri River	Fort Benton	107	13,889	23,292	Cascade	NWE
Bair	North Fork Musselshell River	Checkerboard	106	12,475	52	Meagher	State Water Projects
Nevada Creek Dam	Nevada Creek	Helmville	105	15,903	145	Powell	State Water Projects
Bonneau	Boxelder Creek	Box Elder	105	4,000	---	Choteau	BIA
Cochrane	Missouri River	Fort Benton	105	8,464	23,270	Cascade	NWE
Cooney	Red Lodge Creek	Joliet	102	28,230	206	Carbon	State Water Projects
Basin Creek Dam #1	Basin Creek	Butte	101	1,170	12	Silver Bow	Local Government
Tongue River Dam	Tongue River	Ashland	93	127,655	1,760	Big Horn	State Water Projects
Deadman's Basin Dam	Off stream-Musselshell River	Ryegate	60	100,000	8	Wheatland	State Water Projects
Bynum Reservoir Dam	Miller Creek	Bynum	60	107,000	32.6	Teton	Teton Cooperative Reservoir Company
Lake Frances East Dam	Off Stream-Hein Coulee	Ledger	59	133,619	14	Pondera	Pondera Canal & RES. Co
Lima	Red Rock River	Lima	56	133,000	570	Beaverhead	Local Government
Lake Frances North Dam	Off Stream-Birch Creek	Cut Bank	22	133,619	14	Pondera	Pondera Canal & RES. Co
Tiber Dike	Off Stream-Marias River	Loma	65	1,424,478	4,393	Liberty	USBR

Typically, floods in Montana are associated with riverine and flash flooding. However, floods can be a byproduct of dam failure due to the large volume of storage in larger dams. Depending on the severity and timeline of the failure, there can be massive flooding downstream of the dam. A partial list of historical Montana dam-failure flood events is presented in **Table 4.10-3.** Due to these, there have been 34 deaths and extensive property damage.

Table 4.10-3. Montana Dam Failures and Incidents

Date	Description of Event
4/14/1908	**Hauser Dam** north of Helena in Lewis and Clark County failed after water pressure undermined masonry footing of dam causing 300-foot breach.
6/4/1908	**White's Reservoir Dam** near Butte failed leaving the city without phones, telegraphs, electricity, street cars, or railroad service.
7/11/1916	**Superior Dam**, north of Meaderville, broke and flooded northeast Butte with mine tailings. $8,000 in damages.
1927	**Pattengail Creek Dam** in Beaverhead County failed causing 4 known deaths and near complete destruction of the towns of Dewey and Wise River.
March-1937	**Midway Dam**, 40 miles northwest of Nashua in Valley County, breached during the Porcupine Creek flood when the spillway was undermined by huge floating ice cakes. When the dam failed, a four-foot liquid wall swept down the valley causing extensive damage.
July-1946	**Carrol Dam**, located eight miles northwest of Plentywood (Sheridan Co.), failed following several inches of rain in a short timeframe. There were no fatalities, but destruction was evident throughout the 15-mile valley which took the brunt of the flood including the destruction of homes and farm building.
April-1952	**Frenchman Dam** on Frenchman Creek failed upstream of the Milk River, in Phillips County, 20 miles north of Saco. The dam failure caused the highest peak ever recorded on the Milk River below its confluence with Frenchman Creek. Damage was estimated at $150,000.
8/30/1959	**Hebgen Dam** in Gallatin County was damaged due to earthquake which killed 28 people. Four hydraulic gates failed which allowed 3,400 cfs of water to be released into Madison River.
8/6/1964	Failure of **Swift Reservoir** on Birch Creek in Pondera County and **Two Medicine Dam** on Two Medicine Creek in Glacier County resulted in the loss of 32 lives on the Blackfeet Reservation, 265 homes and 20,000 acres of hay land.
6/20/1984	**Browns Lake Dam**, located in Beaverhead County, was overtopped resulting in washed out roads and bridges downstream. Property damage was estimated at $100,000.
6/1/1998	Incident Response for **Tin Cup Dam** (EO 9-98). State response to a leak in Tin Cup Dam, located in the Selway-Bitterroot Wilderness Area of the Bitterroot National Forest, Ravalli County.
Spring 1998	**Anita Dam** outlet failure north of Chinook in Blaine County. Evacuation necessary.
6/23/2002	Failure of **Ross Dam** in Garfield County; evacuation necessary but limited damage downstream. One house flooded. Downstream stock dams broke, gravel roads washed out.
5/11/2018	**Badger Creek** irrigation reservoir dam (small low hazard dam) in Meagher County failed from dam overtopping during flood event.
11/30/2021	A malfunction at the **Hebgen Dam** caused the Madison River flows to drop significantly creating low water levels.

Aging infrastructure is the main cause of failed dams in Montana. There have been numerous minor failures related to the deterioration of corrugated metal pipe outlet works, leading to a slow release of reservoir contents along the outside of the outlet pipe, with minimal downstream property damage but serious damage to the structure.

Dams located in high-risk areas are subject to stringent permitting, inspection, operation, and maintenance requirements. Deficiencies and problems are identified in advance and actions are taken to mitigate the chance of failure. If a deficiency cannot be immediately addressed due to a lack of data or owner resources, risk reduction measures are taken.

The dam condition assessments, that were last completed between 2015 and 2022, revealed 19 of the high hazard dams are in poor condition. Further, 1 high hazard dam is in unsatisfactory condition. Table 4.10-4 summarizes the high hazard dams that are in unsatisfactory or poor condition.

Table 4.10-4. Dams with Poor Condition Assessment

Dam Name	River	Nearest City	NID Height (ft)	Maximum Storage (acre-ft)	County(s)	Hazard Potential	Condition Assessment
Melstone Detention Dam	Musselshell River	Melstone	23	209	Musselshell	High	Unsatisfactory (4/23/2015)
Kootenai Development Impoundment Dam	Rainy Creek	Libby	151	1,302	Lincoln	High	Poor (03/12/2021)
West Fork Bitterroot (Painted Rocks)	West Fork Bitterroot	Darby	143	45,100	Ravalli	High	Poor (04/06/2022)
Newlan Creek Dam	Newlan Creek	Ulm	131	15,600	Meagher	High	Poor (03/04/2021)
Willow Creek Dam	Willow Creek	Willow Creek	105	26,600	Madison	High	Poor (09/16/2019)
Basin Creek Dam #1	Basin Creek	Butte	101	1,170	Silver Bow	High	Poor (03/12/2021)
Lower Willow Creek Dam	Lower Willow Creek	Hall	96	6,230	Granite	High	Poor (03/12/2021)
Cataract Creek Dam	Cataract Creek	Pony	80	1,800	Madison	High	Poor (04/20/2020)
Three Mile Reservoir	Three Mile Creek	Helena Valley	70	300	Lewis & Clark	High	Poor (04/06/2022)
Moulton Creek Dam #1	Yankee Doodle Creek	Butte	67	860	Silver Bow	High	Poor (03/12/2021)
Powell	UT Powell Creek	Deer Lodge	52	250	Powell	High	Poor (06/12/2018)
Depression Detention Dam	S. Fork Bridger Creek	Bridger	46	148	Carbon	High	Poor (06/22/2016)
Jordan Dam	Tributary to Antelope Creek	Wilsall	38	1,260	Park	High	Poor (08/18/2015)
Little Sleeping Child Creek Dam	Little Sleeping Child Creek	Hamilton	34.5	73	Ravalli	High	Poor (04/06/2022)
Eureka Reservoir Dam	Teton River Off Stream	Choteau	32	6,800	Teton	High	Poor (06/21/2018)
Lower Glasston Dam	Sweetgrass Canal	Greycliff	30	7,317	Sweet Grass	High	Poor (04/06/2022)
Upper Glasston West Dam	Sweetgrass Canal	Greycliff	22	6,236	Sweet Grass	High	Poor (04/06/2022)
Kistner Hardy Dam	South Fork Muddy Creek	Wilsall	20	340	Gallatin	High	Poor (04/06/2022)
Upper Glasston North Dam	Sweetgrass Canal	Greycliff	20	1,805	Sweet Grass	High	Poor (04/06/2022)
Glen Lake	Lick Creek	Eureka	14	3,580	Lincoln	High	Poor (02/01/2021)

When combined, several low hazard private dams in sequence on the same drainage could be considered high hazard. The risk of a "domino effect" dam failure is a possibility with increased flooding.

Declared Disasters

Two State emergency orders have been issued due to pending dam failures in Montana: EO-16-96 for the East Fork of Rock Creek Dam in Granite County in 1996, and EO-9-98 for the Tin Cup Dam in Ravalli County near Hamilton in 1998. However, neither of these dams failed. No federal disaster declarations have been issued due to dam failure in Montana.

CLIMATE CHANGE CONSIDERATIONS

Changes in rainfall, runoff, and snowpack conditions may have significant impacts for water resources, including dams. Changes in weather patterns can have significant impact on dam design and operation due to the change in hydrology and hydrographs. If hygrographs change, it is conceivable that a dam can lose some or all of its freeboard. If freeboard is reduced, dam operators may be forced to release increased volumes earlier in a storm cycle to maintain the required margins of safety. Earlier releases of increased volumes can increase flood potential downstream in otherwise low-flow periods.

Spillways are put in place on dams as a safety measure in the event of the reservoir filling too quickly. Spillway overflow events, often referred to as "design failures," result in increased discharges downstream and increased flooding potential. Although climate change will not increase the probability of catastrophic dam failure, it may increase the probability of design failures. Dam owners and operators may need to alter maintenance and operations to account for changes in the design hydrograph and increased sedimentation.

FREQUENCY/LIKELIHOOD OF OCCURENCE

Probability of dam failure was assessed based on a 10-year period hazard frequency period, as dam failure occurs less than once every 10 years, it was given a "Possible" probability rating. However, the combination of increased precipitation due to climate change and the continued aging of dam infrastructure may increase the probability of dam failure.

POTENTIAL MAGNITUDE AND SEVERITY

The degree and extent of damage from dam failure depends on the size of the dam, its storage capacity, and the circumstances of failure. For example, a small dam retaining water in a stock pond may break causing little damage besides the loss of the structure itself. In contrast, a similar dam break could result in the loss of irrigation water for a season, causing extreme financial hardship to farmers. An even larger dam failure may cause considerable loss of property, destruction of cropland, roads, utilities, and even loss of life. Other consequences of dam failure include loss of income, disruption of services, and environmental devastation.

VULNERABILITY ASSESEMENT

Numerous factors contribute to dam vulnerability, including failure to meet design standards, poor construction practices, inattention to operation procedures, and lack of maintenance. The vulnerability of property and population in inundation areas downstream is related to flow velocity and depth, as well as the distance downstream from the dam.

The Dam Safety Act requires that owners of all high and significant hazard dams prepare Emergency Action Plans (EAPs). The objective of an EAP is to identify conditions that may lead to dam failure and proactively coordinate responsive actions by the dam owner and local emergency management officials to initiate measures to prevent or minimize the loss of life or property. The EAP also notifies citizens in the event of a dam emergency to begin evacuation.

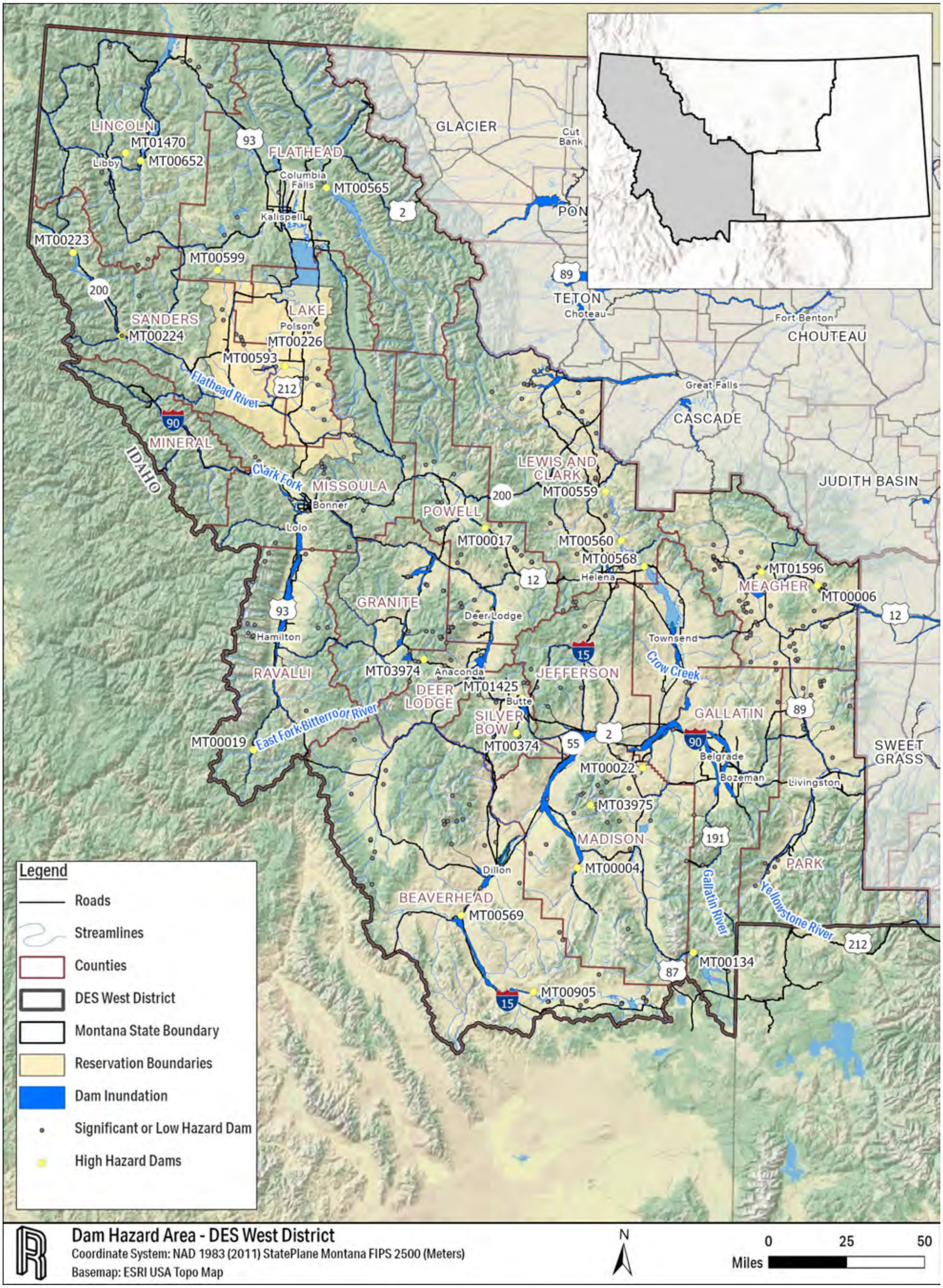
Buildings downstream of dams are at risk of flooding due to operational outlet flows. However, inundation maps only consider dam failure, and mapping of operation flows are typically not available. Inundation maps for many of the private dams are of poor quality or are not publicly available. The Montana Dam Safety program has also looked at the exposure of dam failure for high-risk category dams, but these studies are completed with simplified assumptions such as; 10 meter DEMs, ignored roads/bridges and the models are run under clear weather normal pool conditions. The assumptions are required for the Dam Safety department to complete the studies within a constrained budget.

Statewide Vulnerability

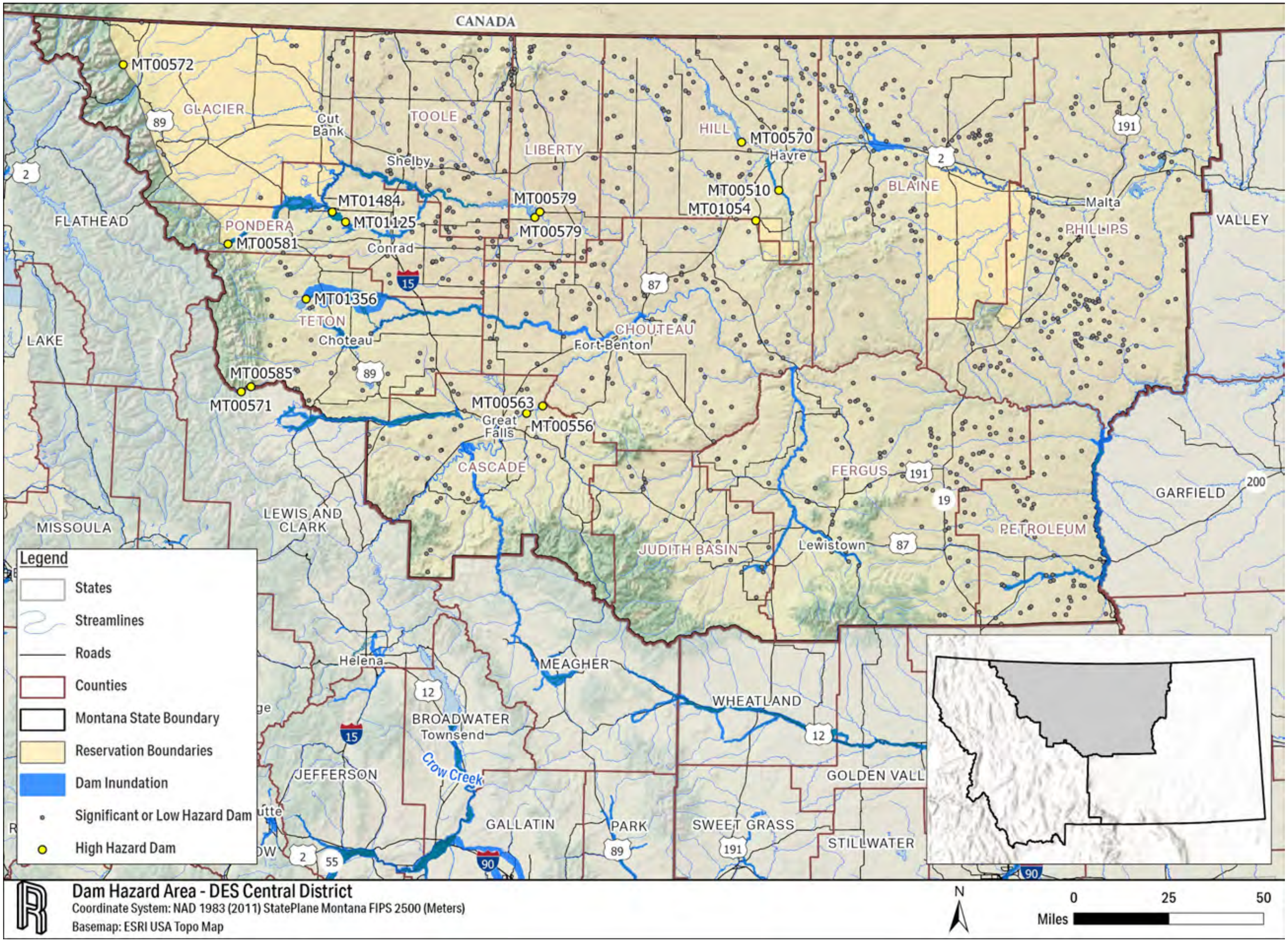
Vulnerability of dam failure is compounded by differences in the dam inundation areas compared to the 100-year floodplain. Floodplain development, in most cases, is regulated, whereas dam inundation areas are not. Extreme rain and snow melt events can exceed the flood storage capacity of large reservoirs. At such times, excess water that passes over the spillway (the primary purpose of which is to protect the dam) may cause damage downstream comparable to damages expected had the dam not been built. Further, failure of a dam can produce extreme, rapid flood damage outside the 100-year or even 500-year floodplains.

As part of this project, a GIS layer of the inundation areas associated with high hazard dam failure was created. Inundation maps, available from EAPs, were digitized and consolidated into a GIS layer with DNRC's inundation areas for state-owned dams additionally, DNRC provided inundation areas as part of the Dam Evaluation Guideline Improvement project for all DNRC regulated high hazard dams. Data for several federally- regulated dams were not available for the MHMP analysis. The dam failure hazard area is presented on maps by DES District (**Figures 4.10-1A through C**).

The Dam failure exposure analysis that was completed by the Montana Dam Safety Program was completed on high hazard Dams under state jurisdiction only. The analysis mainly looked at the estimated population that was at risk downstream of each dam. The Safety Program did not look at infrastructure value under the assumption that population at risk was a good indicator of the risk to these types of hazards. Infrastructure was utilized as a persons at risk multiplier. Exposure values are presented in **Table 4.10-5**. The table shows values for total persons at risk as well as screened persons at risk. The total value is for anyone within the overall inundation boundary. The screened value excludes the shallow depth areas that are not likely to cause any deaths



Figures 4.10-1A. Dam Hazard Area – West District



Figures 4.10-1B. Dam Hazard Area – Central District

Figures 4.10-1C. Dam Hazard Area – East District

Table 4.10-5. Dam Failure Exposure (Persons at Risk)

Dam Name	NID ID	Total Persons at Risk	School	Government Building	Hospital	Total Persons at Risk (Screened)	EAP Prepared	EAP Revision Date
Tongue River Dam	MT00002	31,233.5	13	6	8	4,817	YES	1/3/2022
Flower Creek Dam	MT01458	9,344.5	6	9	5	472	YES	5/26/2016
Ruby Dam	MT00004	7,466	11	28	2	3,713	YES	1/3/2022
Willow Creek Dam	MT00022	7,299	10	15	2	2,706.5	YES	1/3/2022
West Fork Bitterroot (Painted Rocks)	MT00019	6,094	1	12	13	1,708.5	YES	1/3/2022
Lima	MT00905	5,020.5	2	1	2	1,573	YES	4/22/2019
Bullhook Dam	MT00023	4,734	5	12	0	4,451.5	YES	11/25/2020
Scott Coulee Dam	MT00103	4,207.5	4	12	0	3,030	YES	11/25/2020
Cooney	MT00001	2,492.5	1	11	0	1,951.5	YES	1/3/2022
Nilan East Dam	MT00014	1,938.5	5	10	0	866.5	YES	1/3/2022
Deadman's Basin Dam	MT00011	1,926	4	1	0	1,238.5	YES	1/3/2022
Spartan/Playfair Park Retention Basins	MT03856	1,727.5	2	0	2	53	YES	11/21/2019
Sullivan Dam	MT02004	1,642	2	8	0	529.5	YES	9/24/2021
Chessman Main Dam	MT01090	1,574.5	1	3	0	432	YES	---
Costich Dam	MT01025	1,357.5	3	1	0	820	YES	8/1/2019
Cowpath Dam	MT03203	1,335.5	1	7	0	285	YES	9/24/2021
Box Elder Creek Dam	MT00934	1,140	3	0	0	755	YES	2/6/2019
Martinsdale, East Dam	MT00007	1,116	4	5	0	761	YES	1/3/2022
Martinsdale,North Dam	MT00020	1,116	4	5	0	761	YES	1/3/2022
Cataract Creek Dam	MT00005	1,037.5	4	9	1	123	YES	6/14/2021
Bullhook Lower Diversion	MT00024	756.5	0	2	0	371.5	YES	11/25/2020
Eureka Reservoir Dam	MT01354	734.5	0	0	0	32	YES	11/23/2020
Eureka Reservoir West Dike	MT01342	734.5	0	0	0	32	YES	11/23/2020
Delmoe Lake Dam	MT00117	571	1	0	0	90.5	YES	8/12/2015
East Fork Dam	MT01567	550.5	0	4	0	353	YES	2/6/2019
Bynum Reservoir Dam	MT01356	531	3	0	0	338.5	YES	4/20/2020

Review of Potential Losses in Local Hazard Mitigation Plans

Approximately 55 percent of local plans evaluated the dam failure hazard in their risk assessment. Roosevelt County identified dam failure as their #1 hazard. The following counties identified dam failure as their #4 hazard: Hill, Lincoln, and Sheridan. Blaine and Wheatland counties, as well as the Blackfeet, Crow and Rock Boys Reservations identified dam failure as their #5 hazard. **Appendix B-11** presents a summary of potential dam failure losses from the local Hazard Mitigation Plans.

Vulnerability of Facilities

In addition to people being at risk in the Dam failure hazard zones, there are also numerous critical facilities, residential buildings, commercial buildings, agricultural buildings, and industrial buildings in the hazard zones. In the event of a dam failure, these exposed buildings can result in significant financial loss to the owners and potential loss of life if the buildings are occupied. **Table 4.10-6** identifies the type of building and number of buildings located in the hazard zone per county, as well as the estimated financial value of the buildings. Beaverhead county has the highest number of critical facilities in the hazard area and Flathead County has the highest number of residential buildings in the hazard areas.

Table 4.10-6. Vulnerability of Facilities in Dam Failure Hazard Area

County	# Critical Facilities	Critical Facilities Exposure	# Residential Buildings	Residential Exposure	# Commercial, Agricultural, Industrial Buildings	Commercial, Agricultural, Industrial Buildings Exposure	Total Cultural Resource Exposure
Beaverhead	20	$141,855,709	1,724	$258,935,324	663	$208,782,256	2
Big Horn	1	$75,995	1,784	$234,944,655	447	$101,024,535	1
Blaine	0	$0	478	$48,793,572	261	$34,911,621	0
Broadwater	3	$34,323,921	1,982	$250,267,094	206	$38,406,323	1
Carbon	0	$0	1,393	$222,290,427	197	$54,123,828	1
Carter	0	$0	0	$0	0	$0	0
Cascade	0	$0	6,356	$1,070,612,621	1,211	$798,496,847	4
Chouteau	0	$0	832	$128,107,636	166	$25,305,330	1
Custer	11	$70,778,915	4,067	$529,738,603	856	$200,764,374	0
Daniels	0	$0	0	$0	0	$0	0
Dawson	2	$3,785,347	1,215	$171,657,522	277	$67,777,613	0
Deer Lodge	28	$82,075,855	368	$49,430,019	26	$27,033,385	0
Fallon	0	$0	519	$51,654,324	56	$24,002,349	0
Fergus	0	$0	6,946	$875,196,000	273	$85,871,909	2
Flathead	4	$23,306,628	10,859	$2,123,850,549	1,871	$870,644,384	1
Gallatin	1	$296,898	4,704	$1,855,108,491	843	$438,584,198	1
Garfield	0	$0	9	$1,120,500	0	$0	0
Glacier	0	$0	0	$0	22	$4,109,469	0
Golden Valley	0	$0	203	$22,263,906	61	$12,766,158	0
Granite	0	$0	705	$42,435,606	145	$66,412,195	0
Hill	0	$0	5,425	$313,552,382	465	$152,931,169	2
Jefferson	0	$0	490	$63,659,896	129	$25,868,728	0
Judith Basin	0	$0	2	$298,490	2	$401,844	0
Lake	0	$0	2,488	$529,360,535	311	$91,706,330	0
Lewis and Clark	9	$12,794,028	2,888	$460,366,231	197	$53,909,165	2
Liberty	0	$0	1	$139,622	0	$0	0

Lincoln	2	$3,143,501	5,285	$609,523,547	903	$244,443,511	0
Madison	0	$0	1134	$224,561,576	364	$112,606,158	1
McCone	0	$0	14	$1,299,171	38	$3,656,605	0
Meagher	0	$0	876	$72,949,792	85	$19,599,709	0
Mineral	0	$0	0	$0	0	$0	0
Missoula	0	$0	2,651	$273,703,540	121	$134,012,041	1
Musselshell	0	$0	636	$99,889,705	45	$8,884,240	0
Park	0	$0	87	$13,130,484	21	$8,158,605	0
Petroleum	0	$0	0	$0	11	$2,280,417	0
Phillips	0	$0	141	$9,446,832	69	$10,209,921	1
Pondera	0	$0	89	$12,958,821	34	$5,835,749	0
Powder River	0	$0	0	$0	0	$0	0
Powell	11	$20,460,281	758	$69,248,313	66	$38,984,160	1
Prairie	0	$0	171	$18,698,532	105	$12,405,285	2
Ravalli	1	$1,199,417	4,402	$867,210,239	610	$318,594,553	1
Richland	0	$0	67	$7,935,078	49	$9,478,954	0
Roosevelt	3	$4,328,906	1,364	$126,726,125	423	$70,407,294	0
Rosebud	0	$0	1,190	$107,863,209	648	$89,972,074	0
Sanders	0	$0	1,558	$207,048,222	301	$67,540,578	0
Sheridan	0	$0	930	$102,730,870	167	$24,963,637	0
Silver Bow	0	$0	2,991	$390,424,554	274	$268,912,748	2
Stillwater	0	$0	432	$66,234,038	71	$13,641,323	0
Sweet Grass	0	$0	0	$0	5	$1,189,669	0
Teton	0	$0	1,045	$14,328,536	97	$15,614,737	0
Toole	0	$0	629	$45,010,667	51	$10,049,245	1
Treasure	0	$0	183	$13,467,624	192	$29,822,118	1
Valley	1	$11,820	859	$96,854,642	260	$53,965,974	0
Wheatland	0	$0	1,055	$89,685,952	93	$32,000,244	0
Wibaux	0	$0	0	$0	0	$0	0
Yellowstone	2	$31,942,418	3,081	$350,705,604	480	$530,619,257	1

FUTURE DEVELOPMENT

Several areas experiencing growth and development in Montana are within dam inundation areas. Future development below dams can have significant financial impact on dam owners. When new development occurs in the inundation area below an existing dam, the dam could be reclassified as "high hazard". High hazard dams are required to meet stringent requirements for design, construction, inspection, and maintenance. For dams currently classified as high hazard, additional downstream development can cause a financial impact because as the population at risk increases, the spillway design standard increases. A dam that is currently in compliance with state design standards can be out of compliance after a subdivision is built downstream.

Rebuilding a spillway to provide additional capacity can be costly for dam owners, often exceeding a million dollars. In conjunction with spillway improvements, inundation areas must be evaluated for risk and hazard assessment. Development can lead to increased liability of the dam owner and increased insurance rates.

Aging infrastructure and the design life of dams is a critical issue to consider when reviewing subdivision applications. Without consideration of dam failure during the subdivision permitting process, future development could place residences and businesses in high hazard areas.

DATA LIMITATIONS

Inundations areas that were digitized for the dam failure impact were not continuous; showing mapped areas around centers of population and not rural areas where agricultural developments may be present. This could lead to an under reporting of building exposure to dam failure. Inundation maps utilized for the analysis were for clear weather breaches and did not consider the depth of inundation or warning time. Additionally, the cumulative effects of multiple dam failures on the same drainage were not considered.

Inundation maps from the USBR and USACE were not available for the analysis. The dam failure analysis could be enhanced with this information. It should also be noted that some inundation maps for private dam EAPs are of poor quality.

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4.11 TERRORISM, VIOLENCE, CIVIL UNREST, AND CYBER SECURITY CPRI SCORE =2.41

DESCRIPTION

Terrorism

Terrorism is defined in the Code of Federal Regulations as "the unlawful use of force and violence against persons or property to intimidate or coerce a government, the civilian population, or any segment thereof, in furtherance of political or social objectives". Terrorists look for visible targets where they can avoid detection before or after an attack. Targets may include international airports, large cities, major international events, resorts, and high-profile landmarks. Bombings involving detonated and undetonated explosive devices, tear gas, and pipe and firebombs have been the most frequently used terrorist method in the United States. Driving vehicles into large crowds to cause injuries and fatalities has also emerged as a terrorist technique. Other possible methods include attacks on transportation routes, utilities, public services, or incidents involving chemical or biological agents.

Lone gunman shootings (active shooters) are another form of terrorism. In the U.S., lone gunman shootings have occurred at schools, movie theaters, concert venues, grocery stores, and other locations. Most lone gunman attacks do not occur at a random site of opportunity, but instead at deliberately chosen locations. These locations are often those expected to have large concentrations of people. A mass shooting is defined by the U.S. Congress as a multiple homicide incident in which four or more victims are murdered with firearms, within one event, and within one or more locations in close proximity [Congressional Research Service, *Mass Murder with Firearms: Incidents and Victims*, 2015]. While mass shootings are statistically rare, they are becoming a more regular occurrence in certain public settings [Voice of America, *History of Mass Shooters*, 2021]. Both lone gunman and mass shootings have sparked a political debate over gun violence, and whether firearms should be allowed in the classroom or whether stricter gun control laws should be enforced.

Eco-terrorism is the use or threatened use of violence of a criminal nature against innocent victims or property by an environmentally oriented, subnational group for environmental-political reasons, or aimed at an audience beyond the target, often of a symbolic nature. Eco-terrorists have fought against many issues, including logging, drift-net fishing, nuclear energy, and road construction.

Violence and Civil Unrest

Often occurring as a product of a panic-causing event in the community, civil unrest usually presents in the form of protests, violence, or hate crimes, which are violent actions motivated by prejudice against and individuals' or groups' race, religion, gender, or another identifier. These panic-causing events are the response to political, economic, or social causes. Most instances of civil unrest occur when large groups, organizations, or individuals act. Although many instances of civil unrest in Montana occur through peaceful protests and riots, civil unrest can also present with violence. Because of how rural many Montana counties are, the potential exists for civil unrest to exceed the capabilities of the local government to handle.

Cyber Security

Cyberterrorism is the use of information technology by terrorist groups and individuals to further their agenda. Forms of cyberterrorism include the use of information technology to exchange information, make threats electronically, and to organize and execute attacks against networks, computer systems, and telecommunication infrastructure. Many cyber-attacks occur using hacking, which includes introducing viruses to vulnerable networks, website defacing, or making terroristic threats by electronically hacking into networks or websites.

Cyber-attacks also present in the form of internet fraud, which is the use of internet services or software to defraud victims or to otherwise take advantage of them. Often internet fraud involves the stealing of personal information for identity theft. The most widespread internet and mail scam today is called phishing, where digital thieves lure a victim into divulging their password information through convincing emails and web pages that resemble legitimate credit authorities. The email messages provide a link that directs the victim to a fake website closely resembling the real one. The victim may enter an ID and password and receive and incorrect login message. This information is intercepted by the scammers, who use it to access the victims' account and attempt to extort them for money. Another common form of internet fraud is the distribution of rogue security software. A specific type of rogue security software called ransomware is a type of malware that restricts access to the infected computer system and demands the victim pay a ransom to the malware operators to remove the restriction.

PAST OCCURENCES

Civil unrest, violence and terrorism are not common hazards affecting Montana, but over the short history of Montana, some events have occurred. Labor strikes have caused economic disruption, threats of terrorism have disrupted community security, and large scale violence has claimed several lives. Montana's sparse population and relatively small cities may limit the state as a terrorist target, however the state's rural nature has attracted terrorist and extremist groups. Violent racial, anti-government, and environmental extremist organizations have and continue to exist in Montana. Federal, state, and local law enforcement have thwarted several violent uprisings and plots based in Montana. Some of these incidents involving civil unrest, violence and terrorism in Montana are listed below:

1920 Anaconda Road Massacre - On April 21, 1920, the Anaconda Road Massacre occurred in Butte. Fifteen people were shot during this incident that occurred during an International Workers of the World strike. The US Military was used the following day to curb additional violence.

Rainbow Family Gatherings started in the late 1960s as an outgrowth of the anti-war and hippy movements and have occurred every July since 1972 in a different National Forest, bringing together upwards of 10,000 "Rainbows". Environmental impact and crime are difficulties associated with Rainbow Gatherings, which have resulted in strained relations between Rainbow Gathering participants and local communities. Media coverage is often unfavorable, focusing on drug use, nudity, assaults, fugitives, serious traffic charges such as drunken driving and the countercultural aspects of the assemblage.

Source: Montana Outdoor Radio Show, 2013. Rainbow Gathering in Beaverhead-Deerlodge National Forest in 2013.

In 2013, the Rainbow Gathering was held in the Beaverhead-Deer Lodge National Forest in Montana. Despite making only two arrests and 49 tickets, the Forest Service spent nearly $400,000 on law enforcement and more than $570,000 overall. The gathering near Saginaw Creek about 10 miles southwest of Jackson drew about 10,000 people. It officially ran from June 21-July 7, but Rainbow members were in the area for about a month. About 20,000 Rainbow people had gathered at the same site in 2000. (Montana Standard, *Rainbow Gathering Costs U.S. Forest Service $573,000,* 2013).

Unabomber Attacks - From 1978 to 1995, Ted Kaczynski, commonly known as the Unabomber, killed three people, and injured 22 others across the county with mail bombs while he resided in a cabin near Lincoln (Lewis and Clark Co.).

White Supremacists of the 1990s - The Creativity Movement, formerly known as the World Church of the Creator, a white supremacist group promoting and carrying out violence, held annual meetings in Superior (Mineral Co.) during the 1990s.

1996 Freemen Crisis - Garfield County made national news during the Montana Freemen Crisis. In the spring of 1996, hundreds of FBI agents surrounded the Ralph Clark ranch complex near Jordan for a total siege of 81 days. The government alleged that the nearly 30 people inside were of a radical anti-government and racist religious sect who had written bad checks and threatened judges, among other things.

1996 Bomb Threat - Amtrak offices in Philadelphia received notification by phone from a person claiming to have knowledge of a bomb placed on a train headed for western Montana. At that time, the train was 10 minutes out of Wolf Point (Roosevelt Co.). The decision was made to evacuate passengers from the train and to allow a search to take place. Once the train was evacuated, it was moved to the east end of town, where it was anticipated that an explosion would cause less property damage. Teams were sent from Great Falls, including a canine search team from Malmstrom and the Explosives Ordinance Disposal team from the Montana Air National Guard. No sign of explosives was found, and the train was cleared to continue its journey.

Project Seven 2002-2004 - A group called Project Seven in the Flathead Valley was broken up by Montana officials in February 2002 and additional arrests occurred in 2004. This militia organization is alleged to have stockpiled weapons and plotted to kill judges, prosecutors, and police officers in effort to activate the Montana National Guard and start a war.

2003 Ennis Shooting – A man opened fire in Ennis on a group of people outside of a bar. The shooting resulted in six injuries and one fatality. The shooter engaged in a high speed chase and was eventually caught and sentenced.

Oath Keepers - In August 2015, members of the Oath Keepers, self-described constitutional advocates, came to Lincoln (Lewis and Clark Co.) to intercede in a dispute between miners and the U.S. Forest Service. The noncompliance issues included construction of a garage without authorization, locking and posting gates into the claim, failure to remove explosives and needed reclamation of a road. The miners said that regulations do not apply because the mine claims predate 1955 regulations granting surface rights to the Forest Service. The Oath Keepers and other constitutionalist groups thereafter provided an armed security detail at the mine site [Independent Record, *Judge Urges Settlement in Lincoln-area Mining Dispute*, 2015].

Pipeline Protests – The Dakota Access Pipeline protests were grassroots movements that began in early 2016 in reaction to the approved construction of Energy Transfer Partners' Dakota Access Pipeline. The pipeline was projected to run from the Bakken oil fields in western North Dakota to southern Illinois, crossing beneath the Missouri and Mississippi Rivers, as well as under part of Lake Oahe near the Standing Rock Indian Reservation. Many in the Standing Rock tribe consider the pipeline and its intended crossing of the Missouri River to constitute a threat to the region's clean water and to ancient burial grounds. Many camps were established for protests for cultural preservation and spiritual resistance to the pipeline, alongside protesting for environmental concerns. Some camps reached over thousands of people, causing food shortages in surrounding towns and a strain on critical infrastructure. Although mostly peaceful protests occurred, there are several accounts of protests turning violent [CNN, *Sacred Ground, Inside the Dakota pipeline protests,* 2016].

Oil Field Violence - The Bakken Formation – tens of thousands of square miles of oil-bearing shale under the prairies of western North Dakota, eastern Montana, and part of Canada – was touted as a modern-day gold rush. In just five years, the region went from producing about 200,000 barrels to 1.1 million barrels of oil a day, making North Dakota the No. 2 oil-producing state and luring thousands of workers from around the country. The arrival of highly paid oil workers living in sprawling "man camps" with limited spending opportunities led to a crime wave – including murders, aggravated assaults, rapes, human trafficking, and robbers – fueled by a huge market for illegal drugs, primarily heroin and methamphetamine [The Washington Post, *Dark Side of the Boom*, 2014].

2019 Great Falls Shooting – A shooting at the Emerald City Casino in Great Falls occurred in December of 2019, causing one injury and three fatalities, not including the shooter. The shooter was later found and fatally shot by officers [Gun Violence Archive, 2022].

2021 US Capitol Attack – On January 6, 2021, an attack on the U.S. Capitol building occurred in attempt to disrupt a joint Congress session to certify the results of the 2020 elections. As of October of 2022, over 900 people have been charged with relation to the attack, six of which were Montana residents [NPR, *Where the Jan.6 insurrection investigation stands, one year later*, 2022].

DECLARED DISASTERS

Montana has had several emergency declarations for terrorism, civil unrest, and hostage situations which have allowed for incident response and/or deployment of the National Guard troops to assist the local communities. These incidents are listed below in **Table 4.11-1**. The disasters include state executive orders [Montana Executive Orders, 2022].

Table 4.11-1. Montana Emergency Declarations from Terrorism, Civil Unrest and Hostage Situations (1974-2022)

Date	Event
1/1979 & 2/1979	**Montana State Institution Strike.** National Guard Activation. State assistance: $1,393,714
4/1/1991	**Montana State Institution Strike** (EO 03-91). National Guard Activation and assistance statewide.
8/1/1995	**Tactical Incident** (EO 10-95). Prairie County and Town of Terry, activation of National Guard. State assistance: $11,042
4/23/1996	**Incident Response** (EO 10-96). Anniversary of Waco and Oklahoma City, affecting whole state. State assistance: $4,368
4/19/2000	**Incident Response**, Lincoln County (EO 9-00). State response to Civil Disobedience Rallies in Lincoln County.
6/10/2000	**North American Rainbow Gathering**, Beaverhead County (EO 15-00). Emergency declaration providing state assistance to Beaverhead County to meet the life threatening situations and imminent threat to the public health and safety. State assistance: $77,606. Local assistance: $23,911.
9/11/2001	**Terrorism Threats** (EO 23-01). Emergency declaration following terrorist attacks to the World Trade Center and Pentagon.
9/11/2001	**Terrorism Threats** (EO 28-01). Executive Order establishing the Montana Homeland Security Task Force and designating the Disaster and Emergency Services Division as lead agency.
9/28/2001	**Terrorism Threats** (EO 26-01). Executive Order proclaiming support to the President's request for security assistance at Montana Airports. MT National Guard provide personnel for up to 6 months.
9/2/2004	**Incident Response**, (EO 13-04). Executive Order authorizing Incident Response authority in the State of Montana due to an escape of Department of Corrections convict in the City of Helena
1/11/2006	**Incident Response**, (EO 26-2006) Executive Order authorizing Incident Response authority in the State of Montana due to a Department of Corrections prisoner escape from a prison transport vehicle within the City of Helena and Lewis & Clark County.
7/1/2013	**North American Rainbow Gathering**, Beaverhead County (EO 7-2013). Emergency declaration providing state assistance to Beaverhead County to meet the life threatening situations and imminent threat to the public health and safety. State assistance: $77,606.

PROBABILITY/LIKELIHOOD OF OCCURENCE

The probability of terrorism, violence, civil unrest, or a cyber breach affecting Montana directly is difficult to determine. The state is not considered a specific terrorist target nor is it an area of high risk for civil unrest. As with any area, a shooting by a disgruntled person, employee, or student is always possible. A large-scale attack cannot be ruled out, and therefore, a small probability exists. Of greater probability is a national terrorist incident or cyberattack that has an indirect effect on the state through its economy.

Terrorism and cyberattacks are considered emerging hazards with little to no history in the region but incidents occurring with more frequency across the globe. As such, the probability of terrorism, violence, civil unrest and cyberattacks in Montana is ranked as "Possible"; with less than one incident occurring every 10 years but greater than one incident every 100 years.

MAGNITUDE AND SEVERITY

Terrorism

Since 1916, there have been 189 public mass shootings that meet the U.S. Congress criteria, with many of the deadliest incidents occurring in the past few years [Washington Post, 2022]. According to the Gun Violence Archive, there were 269 mass shootings in the United States in 2014, compared to 611 in 2020, which is based on the definition of 4 or more shot or killed, not including the shooter. Between 2013 and 2019, Montana experienced 4 mass public shootings, causing 13 deaths and 6 injuries, with one shooting in 2015, one in 2017, and two in 2019 [GVPedia, 2020].

The recent increase in shootings has spurred national legislative action. In June of 2022, the Bipartisan Safer Communities Act was enacted, which provides funding for state crisis intervention orders, protections for victims of domestic violence, an enhanced review for individuals under 21, funding for community-based violence prevention initiatives, and more [U.S. Congress, 2022[1]]. As of 2022, the Protecting Our Kids Act has been introduced and passed in the House of Representatives. This legislation would raise age limit on the purchase of certain firearms, prevent gun trafficking, modernize the prohibition on untraceable firearms, and encourage the safe storage of firearms. Several states have enacted gun restrictions in 2022, not including Montana [CNN, 2022].

Incidents of school shootings have increased drastically in the past 5 years. More school shootings occurred in 2021 than any recorded year [Washing Post, 2022]. The first school shooting in Montana occurred in 1999, in which Jeremy Bullock, an 11-year-old student was killed [Montana Public Radio, *Montana Summit Addresses School Shootings*, 2019]. In 2019, the Jeremy Bullock Safe Schools Summit was held in Butte to address violence in schools. According to the Center for Homeland Defense and Security, since 1970 there have been nine school shootings, totally six fatalities or injuries [CHDS, 2022].

Violence and Civil Unrest

Protests

Largely peaceful protests and riots resulting from police brutality against African Americans gained widespread notoriety in the 2010s, although some of these protests involved vandalism by protesters. In the 2010s, tensions ignited after incidents such as the killings of Trayvon Martin (2012), Michael Brown, Jr (2014) and Freddie Gray (2015). However, protests against police brutality have been held since before the mid-1900s. The Black Lives Matter (BLM) Movement, originating in the African American community in 2013, campaigns against violence and systemic racism toward black people. The movement regularly protests police killings of Black people and broader issues of racial profiling, police brutality, and racial inequality in the U.S. criminal justice system. In the summer of 2020, the violent, racist murder of George Floyd by a police officer ignited widespread protests across the nation, which were attended by tens of millions of people, and associated with the BLM movement. In cities, some protests became violent, whether through police initiation of violent riot tactics on peaceful protesters or protester initiation through violent direct action. However, most of these protests were peaceful, including all those held in Montana. The Missoula protests were attended by armed counter protesters, but there were no violent conflicts.

Violence and Hate Crimes

The United States has historically *excluded, exploited, and dispossessed* certain populations based on race. The population of Montana is predominantly white and has comparatively low diversity to the rest of the United States. Lower diversity and exposure to other races is associated with higher rates of race essentialism, or perception of other races as 'different', and racially based stereotypes [Sage Journals, 2017]. Montanan resistance to refugees received national and international media attention in 2016. On January 31, 2016, over a hundred people gathered outside the County Courthouse in Missoula, Montana to protest the refugee resettlement, framing refugees as "a grave threat to the community" [Social and Cultural Geography Journal, 2020]. Xenophobia, or the distrust of foreigners or people from other countries, represents a potential hazard, particularly to minority and immigrant residents of Montana.

According to the Montana Board of Crime Control, there were 29 hate crimes reported in 2020, up from seven reported in 2018 and nine reported in 2019 [Montana Board of Crime Control, 2020]. While these numbers remain low, Montana hate crimes have seen a noteworthy increase of 400% between 2018 and 2020. A reported 4,645 violent crimes occurred in 2020, up from 4,085 in 2019, showing a 13.7% increase in just one year.

Reported by the Southern Poverty Law Center, an organization devoted to tracking hate groups in the U.S., 733 hate groups were identified across the country, as of the last report in 2021 [SPLC, 2021]. Four of these groups are based in Montana, including a general hate group, two white supremacist groups, and an anti-Muslim group. These hate groups are the Proud Boys, the American Front, the Radix Journal, and the Last Chance Patriots.

According to the 2020 Montana Census, people identifying as Black or African American represent 0.6% of the state population. Individuals identifying as American Indian, or Alaska Native represent 6.6% of the population. These individuals, despite low in population, are still the subject of discrimination and systemic racism.

Cyber Security

According to the Federal Bureau of Investigation Internet Crime Complaint Center's (IC3) 2021 Annual Report, a total of over $8.6 million of losses occurred in Montana because of cyber-attacks, with 46% of the losses experienced by individuals over 60 years of age [FBI IC3, 2021[1]]. The total loss was an increase of over $3.5 million from 2020, with the largest percentage increases seen in the age group from 40 to 59 years of age. These values, however, may not capture the entirety of losses as they are based on the losses reported to the IC3.

VULNERABILITY ASSESSMENT

Statewide Vulnerability

Terrorism

The origins and targets for terrorism and civil unrest are difficult to predict. Individuals or groups that feel oppressed on any issue can resort to violent acts to inflict harm and damage to gain publicity or affect policy. Montana has traditionally attracted activist/extremist individuals and groups because of its low population and large geographic area. Groups active in Montana vary from white supremacists to single issue groups, such as environmental extremists. According to the Southern Poverty Law Center, an organization that tracks hate groups in the U.S., several white nationalist and anti-Muslim groups are active in Montana.

The locations of terrorist attacks can occur anywhere, but often occur at symbols that represent a threat to their cause. From a historic perspective, these targets have often been government buildings, government officials, and university facilities. Other common targets include medical clinics, businesses, population concentrations, computer mainframes, or critical infrastructure with the ability to cause significant disruption and damage. Terrorists typically try to cross into and out of the United States through remote locations. Montana's sparsely populated international border is a potential access point for terrorists moving between countries. Montana has 545 miles of international border with Canada. Local, state, and federal law enforcement officials monitor suspected terrorist groups and try to prevent or protect against a suspected attack. Additionally, the U.S. government works with other countries to limit the sources of support for terrorism.

Violence and Civil Unrest

The effects of civil unrest and violence are typically felt by the population. The greatest risk is to human lives is during times of unrest. Civil unrest and riots are typically associated with large public gatherings and are initially peaceful protests, however, can evolve into destructive protests, large strikes, and law enforcement standoffs. Looting is commonly found in association with the non-peaceful incidents. Therefore, this hazard places both population and property at risk. Urban areas and places of public gathering are generally areas of greatest risk. Most of the potential violence and civil unrest in Montana is organization-driven versus social unrest from local events.

Large gatherings in Montana bring increased risk of violence. Many communities host annual events which draw thousands of participants, many from out-of-state, including Evil Knievel Days, St. Patrick's Day, and the Montana Folk Festival in Butte. Concerts in larger urban areas such as Billings, Missoula, and Bozeman also pose a risk. The Rainbow Family Gatherings have been held in Montana several times in the past 20 years and are another example of large gatherings which pose a risk of violence.

Indigenous women are at an elevated risk for suffering disproportionately higher rates of disappearances, murders, and violence. According to the National Congress of American Indians, American Indian and Alaskan Native (AI/AN) women are 1.7 times more likely than White women to have experienced violence in the past year. Additionally, AI/AN women are murdered at a rate nearly triple that of non-Hispanic White women, and they are nearly twice as likely to have been raped than non-Hispanic White women. Perpetrators of sexual violence against AI/AN women are 96% non-Native. On top of this, AI/AN women are 2.5 times as likely as non-Hispanic white women to lack access to needed services for injuries requiring medical treatment. In recent years, the Missing and Murdered Indigenous Women (MMIW) movement, a movement to get justice for the high proportion of missing and murdered Indigenous women, has become a more prominent in mainstream media [National Indigenous Women's Resource Center, *Understanding the Missing and Murdered Indigenous Women Crisis Beyond Individual Acts of Violence,* 2020]. In 2021, Indigenous people represented 30.7% of all missing person cases reported in Montana, despite that AI/AN population accounts for 6.6% of the total state population [U.S. Census Bureau, 2021]. Indigenous women are significantly more vulnerable to violence and lack access to resources which should be considered in hazard planning.

Cyber Security

The vulnerability of local communities to a breach in cyber security presents a serious business risk to government operations. Attacks have the potential to cripple vital government services and damage public infrastructure. All government agencies hold valuable or sensitive material, including citizen records, financial information, and procurement data. In today's highly interconnected world, each agency—no matter how small—is a steppingstone to another. So even a seemingly minor breach can have wide-ranging implications. [Governing Institute, 2017].

Cyber terrorism could involve destroying or remotely disrupting government computer networks, critical civilian systems such as financial networks or mass media. If cyber-terrorists managed to disrupt financial markets or media broadcasts, an attack could undermine confidence and cause panic. These attacks could have potentially extreme consequences, such as breaching dams, airplane collisions and accidents, or complete power grid shut down.

Senior citizens are also vulnerable to health care scams. Often scammers will call as healthcare or Medicare representatives to gain access to their personal or contact information. The scammers will use their contact information to call seniors back and falsely inform them they spoke with a family member who gave permission for them to provide their social security numbers, driver's license numbers, or other personal information. Senior citizens are also receiving phone calls from scammers who pretend to be Internal Revenue Service agents. They claim to be calling about unpaid taxes and proceed to threaten the senior citizen with arrest, lawsuits, suspension of their driver's license and more. All it takes to file a false return is a name, date of birth, and social security number; the type of information that is commonly taken when health care insurers are hacked.

Agencies also are under nearly constant assault. Hackers know that state and local governments often lag in comparison to commercial entities in cybersecurity readiness. Consequently, the number of attackers probing municipal systems for vulnerabilities is drastically increasing. Attackers range from small-time crooks equipped with black-market ransomware kits, to nation states and organized crime syndicates armed with sophisticated cyber weapons. [Governing Institute, 2017]. The attacks are widespread. Small towns and school districts are hit with ransomware that shuts down computer systems until they make a payment. Thieves steal citizen identities and financial information from state agency databases. Water authorities endure surgical strikes that use specialized computer code to destroy water pumps. [Governing Institute, 2017]. Because Montana has many small towns and counties with larger populations of elderly, the state is at risk for cyber-attacks to these populations. In addition, many of these small communities rely on larger governmental agencies, such as the county, and likely will feel impacts when the larger governmental agencies are attacked.

Healthcare also faces varied cybersecurity threats that continue to evolve and become more intricate. This includes, but is not limited to, insider threats, poorly secured web portals, improper data handling, and under-regulated medical data mining. Medical data is more valuable to attackers than financial data, and it can easily be stolen from vulnerable web portals.

Review of Potential Losses in Local Hazard Mitigation Plans

Approximately half of local hazard mitigation plans evaluated the disease hazard in their risk assessment. Five counties (Cascade, Daniels, Deer Lodge, Glacier, and Roosevelt) ranked it as their #4 hazard while seven local jurisdictions (Beaverhead, Flathead, Gallatin, Ravalli, Stillwater, and Sweetgrass Counties and the Fort Belknap Reservation) ranked it as #5. Chouteau and Judith Basin counties ranked Agro-Security as their #3 and #6 hazards, respectively. All jurisdictions ranked the public health aspect of the disease hazard as having a high societal exposure. Most local plans recognized the potential for economic impacts from the disease hazard. **Appendix B-9** presents an exposure summary from the local Hazard Mitigation Plans.

Vulnerability of State Facilities

The state building complexes, including the Capitol Complex and university facilities, could be targets for violence related to civil unrest or terrorist acts because they represent symbols of state government. State government strikes, although historically peaceful, can erupt into violence and vandalism, as witnessed in civil disturbances during the Vietnam War and civil rights protests in the 1960s. Based on the civil unrest that has occurred in the past, it is unlikely there would be widespread damage to state buildings.

Cyberspace and its underlying infrastructure are vulnerable to a wide range of risk stemming from both physical and cyber threats and hazards. Of growing concern is the cyber threat to critical infrastructure, which is increasingly subject to sophisticated cyber intrusions that pose new risks. As information technology becomes increasingly integrated with physical infrastructure operations, there is increased risk for wide-scale or high-consequence events that could cause harm or disrupt services upon which the economy and our daily lives depend.

The U.S. Department of Homeland Security coordinates with State agencies to share information on and analysis of cyber threats and vulnerabilities and to understand more fully the interdependency of infrastructure systems nationwide. This collective approach is consistent with the growing recognition that cyber and physical security are interdependent and must be core aspects of risk management strategies.

FUTURE DEVELOPMENT

As observed in Montana's history of events, development may cause economic, political, or social impacts to Montana and its communities. Based on this history, the most likely response to future development is through protests. However, as Montana continues to grow in population, especially within larger urban areas, those locations may become more likely targets for terrorist, physical or cyber attacks. Given the goals of eco-terrorists, future development within rural and controversial areas could serve as the basis for incidents.

CLIMATE CHANGE

Many academics and national security experts agree that climate change contributes to an uncertain world where terrorism can thrive. Climate change not only threatens the environment. It can lead to greater instability and fuel global conflict and terrorism. Some of the least stable states in the world will face changing weather patterns that reduce arable land and fresh-water supplies, in turn driving mass-migration, potentially causing racial based tensions, provoking resource conflicts, and fostering global health threats.

Both cyber threats and climate change are security risks that can affect the safety and security of our most basic resources, such as water, energy, and infrastructure, mostly due to a common factor: interconnectedness. As human beings and as nations, we are and always will be directly connected to our environment, as it provides us with the resources necessary for both survival and prosperity. We have also become intimately connected and dependent on our computer-based technologies, with cyberspace and the Internet being a primary conduit. And just as climate change can affect our access to (and supply of) water and energy, a cyber-attack on computers and industrial equipment that run water treatment facilities and power plants can have significant negative consequences [The Center for Climate and Security, 2014].

DATA LIMITATIONS

Terrorists, both domestic and international, will commonly act in unpredictable ways, and therefore all methods of attack cannot be specified. Because of this unpredictability, specific vulnerabilities cannot be determined without disclosing sensitive information. The *Capability Assessment* (Section 6) of this plan discusses Montana's preparedness efforts for resiliency in the occurrence of a terrorist attack, cyber-attack, or civil unrest events.

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4.12 VOLCANIC ASH

CPRI SCORE = 2.33

DESCRIPTION AND HISTORY

Volcanic eruptions are generally not a major concern in Montana due to the relatively low probability (compared with other hazards) of events in any given year. However, Montana is within a region with a significant component of volcanic activity and has experienced the effects of volcanic activity as recently as 1980 when Mount St. Helens erupted in Washington state.

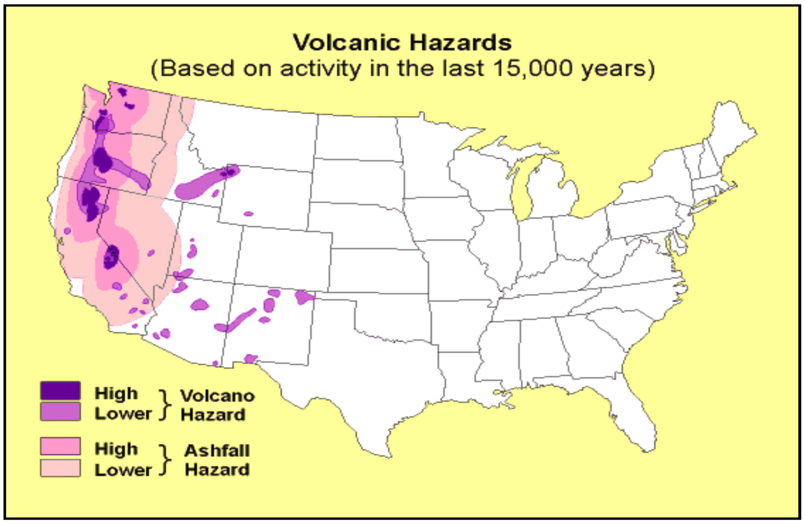
There are 20 active or potentially active volcanoes in the United States (**Figure 4.12-1**). The two volcanic centers affecting Montana in recent geologic time are:

- The Cascade Range of Washington, Oregon and California; and
- The Yellowstone Caldera in Wyoming and eastern Idaho.

Volcanic eruptions in the Cascade Mountains are more likely to impact Montana than Yellowstone eruptions, based on the historic trends of past eruptions. The primary effect of the Cascade volcanic eruptions in Montana would be ash fall.

The distribution of ash from a violent eruption is a function of the weather, particularly wind direction and speed and atmospheric stability, and the duration of the eruption. As the prevailing wind in the mid-latitudes of the northern hemisphere is generally from the west, ash is usually spread eastward from the volcano. Exceptions to this rule do, however, occur. Ash fall, because of its potential widespread distribution, offers some significant volcanic hazards.

Figure 4.12-1. Volcanic Hazards (based on activity in the last 15,000 years).

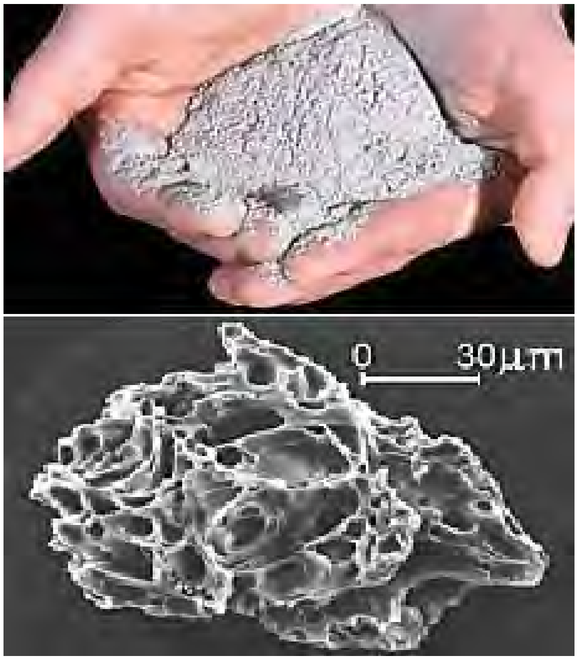


Areas in purple show regions at greater or lesser risk of volcanic activity, including lava flows, ashfall, lahar (volcanic mudflows) and debris avalanches, based on the record of the last 15,000 years, as compiled by Mullineaux (1976). Areas in pink show regions at risk of receiving 5 cm or more of ashfall from large or very large explosive eruptions originating at the volcanic centers shown in purple. These projected ashfall extents are based on observed ashfall distribution from a large eruption of Mt. St. Helens that took place 3,400 years ago, and the eruption of Mount Mazama that formed Crater Lake, Oregon, 6,800 years ago.

Volcanic ash can cause failure of electronic components, interrupt telephone and radio communications, and cause internal combustion engines to stall. Airborne particles of volcanic ash can pose a health risk to people with respiratory conditions. **Figure 4.12-2** describes the effects of volcanic ash.

Figure 4.12-2. Effects of Volcanic Ash

- Short-circuits and failure of electronic components, especially high-voltage circuits and transformers (wet ash conducts electricity).
- Eruption clouds and ashfall commonly interrupt or prevent telephone and radio communications.
- Volcanic ash can cause internal-combustion engines to stall by clogging air filters and damage the moving parts. Engines of jet aircraft have suddenly failed after flying through clouds of even thinly dispersed ash.
- Roads, highways, and airport runways can be made treacherous or impassable because ash is slippery and may reduce visibility to near zero.
- Cars driving faster than 5 miles per hour on ash-covered roads stir up thick clouds of ash, reducing visibility and causing accidents.
- Ash also clogs filters used in air ventilation systems to the point that airflow often stops completely, causing equipment to overheat.
- Crop damage can range from negligible to severe, depending on the thickness of ash, type and maturity of plants, and timing of subsequent rainfall.
- Like airborne particles from dust storms, forest fires, and air pollution, volcanic ash poses a health risk, especially to children, the elderly, and people with cardiac or respiratory conditions, such as asthma, chronic bronchitis, and emphysema.



Source: USGS, 2003. Volcanic ash from the Mount St. Helens eruption in 1980. The ash is made of tiny, jagged particles

Table 4.12-1 shows the thicknesses of recorded ash deposits in Montana. The most recent ash was deposited in May 1980 after the Mount St. Helens eruption in the state of Washington.

Table 4.12-1. Recent Volcanic Ash Events Affecting Montana

Volcano	Most Recent Eruption (Yrs before Present)	Location Affected	Thickness of Ash in Montana
Yellowstone Caldera	665,000	Eastern Montana	-
Glacier Peak	14,500	Western Montana	1.2 inches (compacted)
Crater Lake (Mt. Mazama)	7,600	Western Montana	Up to 6 inches (compacted)
Mount St. Helens	38	Entire State	Up to 0.2 inches (uncompacted)

Figure 4.12-3 shows the distribution of ash fall from some historic volcanic eruptions.

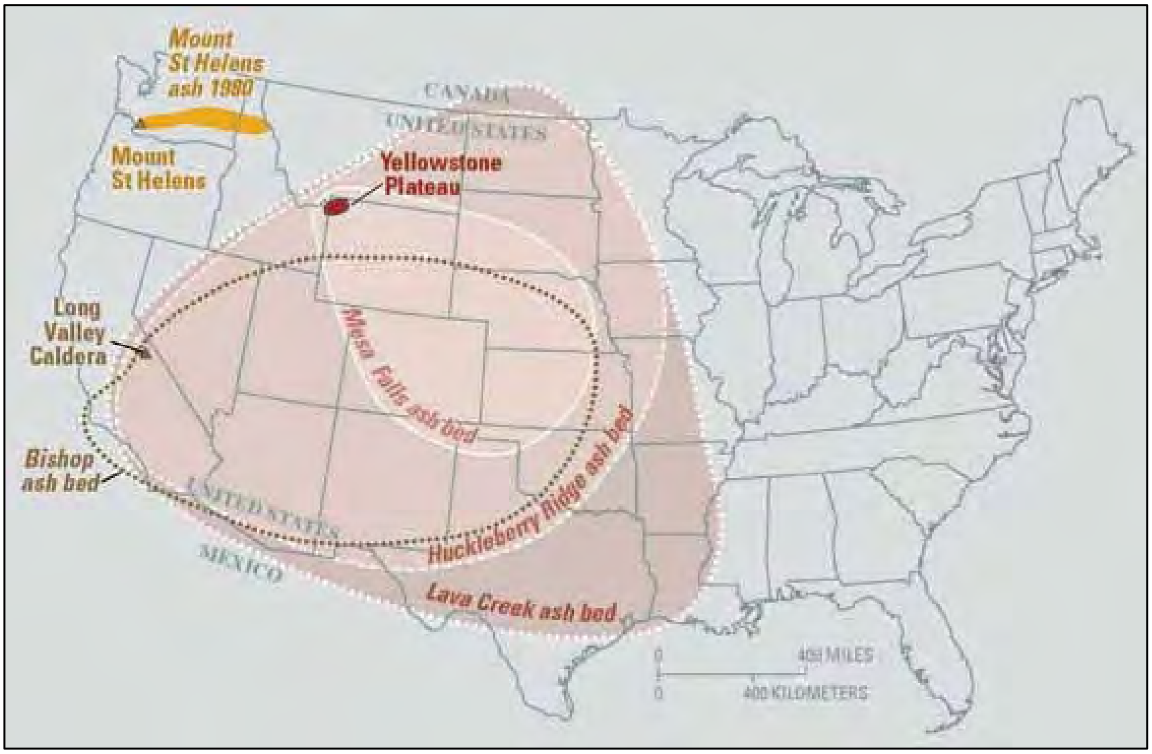


Figure 4.12-3. Areas of the U.S. Once Covered by Volcanic Ash [USGS, 2005].

Cascade Eruptions

The Cascade Range includes 27 volcanoes, many of which have been active in the last 4,000 years (Figure 4.12-4). The major threat these volcanoes pose to Montana is ashfall. The likely extent of such ashfall can be estimated on the basis of past eruptions.

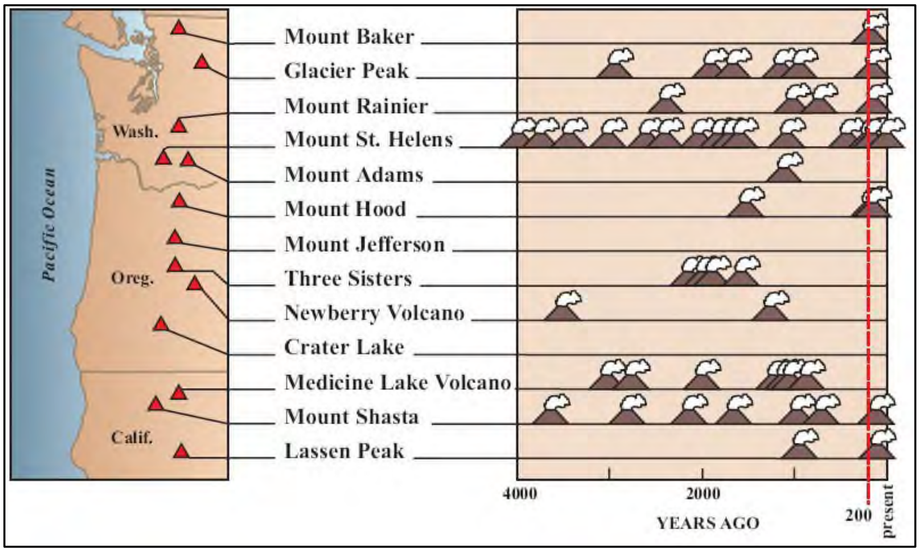


Figure 4.12-4. Cascade Eruptions during the Past 4,000 Years [USGS, 2008].

After the eruption of Mount St. Helens in May 1980, a coating of up to 0.2 inches of ash fell on Western Montana (Sarna-Wojcicki and others, 1981). Ash deposits were thickest in the western portions of the state, tapering to near zero on the eastern part of the state (**Figure 4.12-2**). It is estimated that the ashfall cost Missoula County nearly $6 million in cleanup and lost work time. Statewide cost from this event has been estimated at between $15 and $20 million [DES, 2004].

Travel was restricted in Western Montana for over a week because of concerns for public health; the ash was determined to be a physical respiratory irritant but not a toxic substance. The main hazards in western Montana included reduced visibility (and resulting closed roads and airports), clogging of air filters, and a health risk to children, the elderly, and people with cardiac or respiratory conditions, such as asthma, chronic bronchitis, and emphysema. Claims for State facilities totaled approximately $55,000 [DES, 2004].

The 1980 Mount St. Helens eruption was not a large eruption by world historical standards or even among prior Cascade eruptions. The amount of volcanic material ejected into the air from Mount St. Helens in 1980 (less than one-tenth cubic mile) was only about 1/80th of the volume ejected during the 1815 eruption of the Tambora volcano in Indonesia and less than 1/100th of the estimated ejecta from Mount Mazama during the eruption that formed Crater Lake. Therefore, future eruptions of large Cascade volcanoes, including Mount St. Helens, might be much larger than the May 18, 1980, eruption [Foxworthy and Hill, 1982].

Yellowstone Eruptions

Another area of volcanic activity that has affected Montana in the past and could pose a serious threat in the future is the Yellowstone Caldera in northwestern Wyoming, just south of the Montana border. A caldera is a term for a large volcanic crater. The Yellowstone Caldera is 45 miles across at its greatest diameter. The spectacular geysers, boiling hot springs, and mud pots that have made Yellowstone famous are surface manifestations of a magma chamber at depth.

Cataclysmic eruptions 2.0, 1.3, and 0.6 million years ago ejected huge volumes of rhyolite magma; each eruption formed a caldera and extensive layers of thick pyroclastic-flow deposits. The caldera is buried by several extensive rhyolite lava flows that erupted between 75,000 and 150,000 years ago. Fortunately for mankind, an eruption comparable in magnitude with those of Yellowstone has not occurred during recorded history. Initial lava flows were confined to the immediate area of the vent, but later flows inundated the headwaters of the Yellowstone River, near Gardiner. Pyroclastic flows (the Huckleberry Ridge Tuff) extended up to 55 miles from the vents. **Figure 4.12-5** shows distribution of ashfall from Yellowstone's giant eruptions 2 million and 630,000 years ago, compared with ashfall from the 760,000-year-old Long Valley caldera eruptions at Mammoth Lakes, California, and the 1980 eruption of Mount St. Helens, Washington [Sarna-Wojcicki, 1991].

DECLARED DISASTERS

The 1980 Mount St. Helens eruption covered most of the state with variable amounts of ash. Based on DES records, Lake County was the only county to apply for state assistance which also included losses associated with flooding (**Table 4.12-2**).

Table 4.12-2. State Declarations for Volcanic Hazards

Date	PA. No.	Applicant	State	Local	Comments
1980	ST-80-1	Lake County	$8,320	$47,102	Volcanic Ash Fallout (Mt. St. Helens) & Flooding

CLIMATE CHANGE CONSIDERATIONS

The effects of climate change will not increase volcanic activity; however, volcanic eruptions do have an effect on the climate.

Volcanic ash or dust released into the atmosphere during a volcanic eruption shade sunlight and cause temporary cooling. Larger particles of ash have little effect because they fall out of the air quickly. Small ash particles form a dark cloud in the troposphere can shade and cool the area directly below. Most of these particles fall out of the atmosphere with rain a few hours or days after an eruption. But the smallest particles of dust get into the stratosphere and are able to travel vast distances, often worldwide. These tiny particles are so light that they can stay in the stratosphere for months, blocking sunlight and causing cooling over large areas of the Earth.

Often, erupting volcanoes emit sulfur dioxide into the atmosphere. Sulfur dioxide is much more effective than ash particles at cooling the climate. The sulfur dioxide moves into the stratosphere and combines with water to form sulfuric acid aerosols. The sulfuric acid makes a haze of tiny droplets in the stratosphere that reflects incoming solar radiation, causing cooling of the Earth's surface. The aerosols can stay in the stratosphere for up to three years, moved around by winds and causing significant cooling worldwide. Eventually, the droplets grow large enough to fall to Earth.

Volcanoes also release large amounts of greenhouse gases such as water vapor and carbon dioxide. The amounts put into the atmosphere from a large eruption doesn't change the global amounts of these gases very much. However, there have been times during Earth history when intense volcanism has significantly increased the amount of carbon dioxide in the atmosphere and caused global warming [UCAR, 2018].

FREQUENCY/LIKELIHOOD OF OCCURRENCE

Although the probability is minimal, there is the potential for a catastrophic volcanic eruption in the vicinity of Yellowstone National Park that would have very serious consequences for Montana and neighboring states. The probability of the volcanic eruption hazard is ranked as "Unlikely"; with less than one event per 100 years. According to USGS scientists, of Yellowstone's volcano erupting in any year is extremely low, less than 0.00014 percent. Since the last large eruptions, there have been 50 to 70 smaller eruptions contained primarily in the Yellowstone caldera and more than a dozen small hydrothermal eruptions occur every year [Independent Record, 2016].

POTENTIAL MAGNITUDE AND SEVERITY

The most likely event affecting Montana would be a Cascade volcano eruption causing ash fall in the western portion of the state. An ash fall event could cause equipment failure to the state's motor- pool and other motorized equipment. Clearing ash fall from the state's highways would cause extra resources devoted to the cleanup. The overall impact to state-owned facilities would be minor and primarily a response and recovery operation. After the eruption of Mount St. Helens in May 1980, a coating of up to 0.2 inches cost the state between $15 and $20 million in cleanup and lost work time [DES, 2004]. The trajectory of ash fall events is heavily dependent upon the size of the eruption and the prevailing weather and ambient winds.

A Yellowstone eruption could be devastating. While the immediate area would have the greatest exposure to ash flows, tephra fallout, and mudflows, heavy ash fall could have severe impacts on areas within 100 miles of the eruption.

Volcanic eruptions, especially ones the size of Yellowstone's last explosion, would far exceed anything modern humans have experienced. The worst, most recent volcanic eruption took place in 1815 in Tambora, Indonesia, leading to the deaths of 92,000 people. That eruption was given a Volcanic Explosivity Index (VEI) of 7, with 1 being the least explosive. Mount St. Helens in Washington state was rated VEI 5 and killed 57 people. The latest Yellowstone volcanic eruption was a VEI 8 and occurred about 640,000 years ago. Another VEI 8 occurred about 74,000 years ago in Toba, Indonesia and killed an estimated 60 percent of the population. If such an eruption were to occur now with a much more populated Earth, it could return humanity to a pre-civilization state [European Science Foundation, 2015].

VULNERABILITY AND AREA OF IMPACT

Statewide Vulnerability

The USGS has determined that two areas in Montana may have exposure to volcanic hazards:

- The extreme western edge of Montana (Lincoln, Sanders, and Mineral Counties) could be subject to ash fall of 0.2 inches or greater from eruptions of the Cascade Volcanoes.
- The southwestern corner of the state (portions of Madison and Gallatin Counties) could be subject to ash flows, lava flows, and lahars (ash/mudflows) from a Yellowstone eruption.

The primary hazard to which the State may be vulnerable at some future time, is ash fall from a Cascade volcano. Eruptions in the Cascades have occurred at an average rate of 1-2 per century during the last 4,000 years, and future eruptions are certain. Seven volcanoes in the Cascades have erupted in the last 200 years. The next eruption in the Cascades could affect hundreds of thousands of people. The effect in Montana would depend on the interaction of such variables as source location, frequency, magnitude and duration of eruptions, the nature of the ejected material and the weather conditions. Therefore, the entire state may be considered vulnerable to ashfall to some degree in the event of a volcanic eruption.

There is evidence that ash fall from a Yellowstone eruption could impact a far greater area and have significant impact on the southern half of Montana. Three major periods of activity in the Yellowstone system have occurred at intervals of approximately 600,000 years, and the most recent was about 600,000 years ago. The evidence available is not sufficient to confirm that calderas such as the one in Yellowstone erupt at regular intervals, so the amount of time elapsed is not necessarily a valid indicator of imminent activity. There is no doubt, however, that a large body of molten magma exists, probably less than a mile beneath the surface of Yellowstone National Park. The presence of this body has been detected by scientists who discovered that earthquake waves passing beneath the Park behave as if passing through a liquid. The only liquid at that location that could absorb those waves is molten rock. The extremely high temperatures of some of the hot springs in the park further suggest the existence of molten rock at shallow depth. A small upward movement in the magma could easily cause this magma to erupt at the surface. If a major eruption occurred, the explosion would be "comparable to what we might expect if a major nuclear arsenal were to explode all at once, in one place" (Alt and Hyndman, 1986). **Figure 4.12-5** presents volcanic history and recent seismic activity in the Yellowstone region.

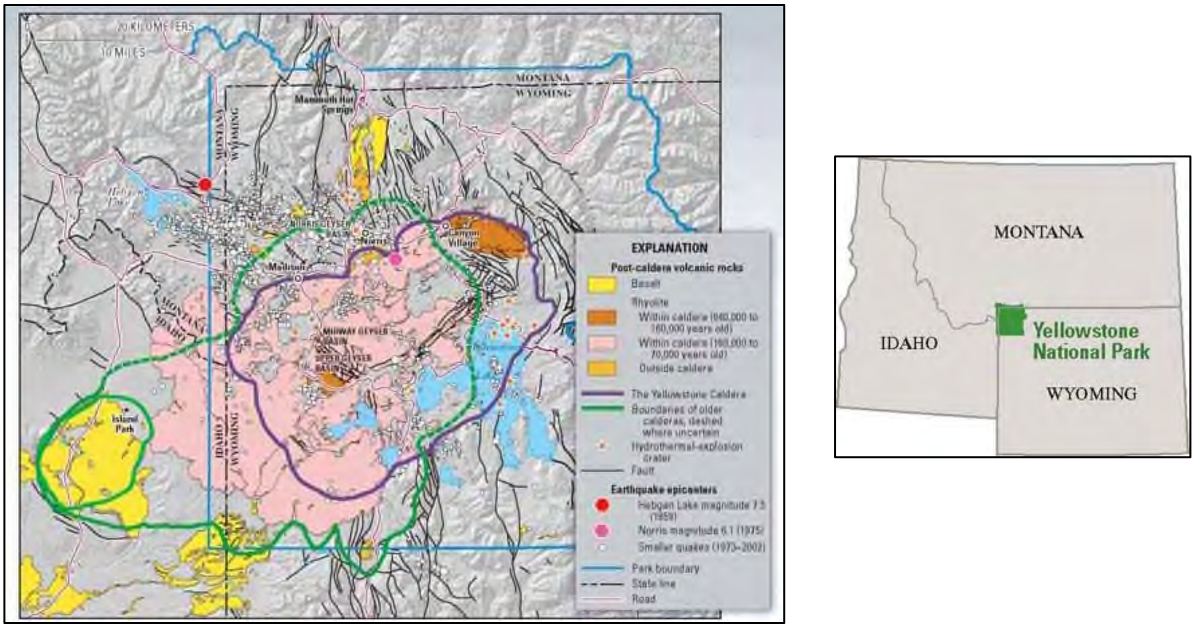


Figure 4.12-5. Volcanic History and Recent Seismic Activity in the Yellowstone Region [USGS, 2005].

According to the paper entitled "*Extreme Geohazards: Reducing the Disaster Risk and Increasing Resilience*", more attention should be focused on forecasting and preparing for such a cataclysmic event. Most of the big volcanoes around the world are not monitored. Yellowstone's volcano is an exception and has 35 seismographs, 45 GPS stations to detect horizontal and vertical displacement and even five seismographs installed in the ground. The monitoring has been largely funded by the National Science Foundation and USGS (Independent Record, *Report: Governments Need to be Prepared for Catastrophes*, January 19, 2016).

The importance of monitoring volcanoes can be measured in lives. A VEI 8 eruption could easily kill (through the many indirect effects, in particular, food scarcity) a higher percentage of the global population than the Spanish Flu if it occurred without any global preparation effort (European Science Foundation, 2015).

Vulnerability of State Property

Exposure to state-owned facilities can be classified into two types of events: a Yellowstone eruption causing ash flows and tephra fallout impacting the immediate area, and ash falls from either a Yellowstone eruption or a Cascade Volcano eruption blanketing portions of the state. Counties with greatest vulnerability are those that are located within 100 miles of Yellowstone Park. Those counties and the value of state-owned facilities are shown in **Table 4.12-3**.

Table 4.12-3. State Building Values in Counties Most Vulnerable to Yellowstone Eruption

County	Building Value	Contents Value	Total Value	State Employee Count
Gallatin	$963,969,286	$259,629,470	$142,380,350	9,013
Jefferson	$25,565,364	$5,044,592	$762,141	237
Madison	$31,888,918	$1,379,931	$1,189,518	25
Broadwater	$15,531,155	$11,584,991	$3,178,234	7
Park	$4,236,197	$985,974	$543,503	46
Carbon	$6,541,406	$346,750	$989,748	22
Stillwater	$1,190,782	$268,452	$211,744	13

TOTALS	$1,048,923,108	$279,240,160	$149,255,238	9,363

Review of Potential Losses in Local Hazard Mitigation Plans

Approximately, one-third of local plans evaluated the volcanic eruption hazard in their risk assessments and two-thirds did not. The majority of the local jurisdictions that evaluated the volcanic eruption hazard did so in a qualitative fashion ranking the hazard as low to moderate for building, societal and economic loss instead of giving loss estimates. **Appendix B-13** presents a summary of potential losses from the local Hazard Mitigation Plans.

FUTURE DEVELOPMENT

As population increases in west and southwest Montana, and recreational usage continues to expand, more and more people and property are at risk from ashfall associated with volcanic activity.

DATA LIMITATIONS

Volcanic eruptions are somewhat unpredictable events, and the ash fall is highly dependent on weather parameters. Generally, western, and southwestern Montana are considered more vulnerable than other parts of state given their proximity to volcanic areas; however, the science of volcanoes and related effects do not allow for more specific analysis.

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4.13 RISK ASSESSMENT SUMMARY

This section provides a summary of the risk assessment and vulnerability analysis. The discussion includes: projected changes to hazards due to climate change summary; a hazard exposure summary; and, an assessment of future development.

CLIMATE CHANGE SUMMARY

In 2017, FEMA Region VIII prepared a report entitled Montana – Assessing Future Conditions. The following table from this document summarizes what changes to hazards are expected due to climate change.

Table 4.13-1. Summary of Projected Changes to Hazards due to Climate Change in Montana

Hazard	Location	Extent/Intensity	Frequency/Duration
Avalanche	Avalanches are only a hazard in mountainous regions of the state. The area affected by avalanches is projected to shrink as warmer temperatures cause more precipitation to fall as rain.	It is unknown if or how the intensity of avalanches will change.	Additional research is needed to determine the effects of climate changes on avalanche frequency and duration.
Dam Failure	The area of the state at risk to dam failure is not projected to change.	There is no projected change in the extent or intensity of dam failure.	Flooding is projected to occur more frequently, increasing the risk for dam failure.
Disease	Projected increases in temperature may expand the reach of disease vectors and allow them to remain active for a longer period of the year.	There is no projected change in the extent or intensity of disease.	Frequency of some diseases is projected to increase due to more active disease vectors.
Drought	The area of the state at risk to drought is not projected to change.	Droughts are projected to increase in intensity.	Droughts are projected to increase in frequency and have a longer duration due to shifts in seasonal precipitation patterns, including dryer summers and less precipitation falling as snow in early spring/late fall.
Flood	Flood hazard zones are projected to increase in size across the state.	Flood extent and intensity are not projected to change, but additional research may be needed.	Intense storms are projected to occur more frequently, increasing the frequency of flood events.
Hail	The area of the state at risk to hail is not projected to change.	It is unknown if or how the intensity of hail events will change. Extent is not projected to change.	Intense summer storms are projected to occur more frequently, increasing the frequency of hail events.
Landslide	The area at risk to landslides is not projected to change.	There is no projected change in landslide extent or intensity.	Flood events are projected to occur more frequently, increasing the frequency, increasing the frequency of landslides.
Pest Infestation	Pests are projected to expand into a broader range of the state due to increased temperatures.	Pest infestations are projected to increase in intensity as average temperatures increase.	Pest infestations are projected to increase in frequency due to increased temperatures.
Severe Wind	The area of risk to severe wind events is not projected to change.	It is unknown if or how the intensity of severe wind events will change. Extent is not projected to change.	Intense winter and spring storms are projected to occur more frequently, increasing the frequency of severe wind events.
Tornado	The area of the state at risk to tornadoes is not projected to change.	There is no projected change in tornado extent or intensity.	Intense winter and spring storms are projected to occur more frequently, increasing the frequency of tornadoes.
Wildfire	The area at risk to wildfires is not projected to change.	Wildfire intensity is projected to increase due to additional dry vegetation that can fuel wildfires.	Droughts are projected to occur more frequently, increasing the frequency of wildfires.

Changes in hazard probability due to climate change are summarized in **Table 4.13-2.** Probability is evaluated in accordance with the methods outlined in *Section 4.1.3*.

Table 4.13-2. Hazard Summary

Hazard	# Incidents	Period of Record	Magnitude	Probability of Future Events	Probability Due to Climate Change
Wildfire	27,282	15 years	$668 M in suppression costs 6,338,545 acres burned 737 structures lost	Highly Likely	Highly Likely
Flooding	623	57 years	$87.1 M in property damage $19.7 M in crop damage 8 injuries; 11 fatalities	Likely	Likely
Earthquake	9	60 years	29 fatalities $11 M+ in property damage	Possible	Possible
Drought	13	15 years	$433.2 M in insurance claims	Likely	Highly Likely
Severe Weather	1,140 Hail	57 years	$150.7 M in crop damage; $158.8 M in property damage; 25 injuries and 1 fatality	Highly Likely	Highly Likely
	241 Lightning	57 years	$15.9 M in crop damage; $8.3 M in property damage; 69 injuries and 25 fatalities	Highly Likely	Highly Likely
	1,118 Severe Thunderstorm	57 years	$72 M in crop damage; $64.8 M in property damage; 25 injuries and 44 fatalities	Highly Likely	Highly Likely
	141 Tornadoes	57 years	$5.3 M in crop damage; $87.2 M in property damage; 21 injuries and 3 fatalities	Highly Likely	Highly Likely
	2,883 High Wind	57 years	$54.4 M in crop damage; $84.2 M in property damage; 132 injuries and 34 fatalities	Highly Likely	Highly Likely
	1,911 Winter Weather	57 years	$11.9 M in crop damage; $79.3 M in property damage; 543 injuries and 62 fatalities	Highly Likely	Highly Likely
Haz-Mat Incidents	501	10 years	$6.2 M in property damage	Highly Likely	Highly Likely
Disease	27,276	10 years	121 fatalities from influenza 2016-2018	Highly Likely	Highly Likely
Landslide & Avalanche	30 Avalanches	12 years	38 fatalities; $330 K in PD	Likely	Likely
	14 Landslides	23 years	$19.4 M in property damage	Possible	Possible
Dam Failure	21	66 years	58 fatalities >$250 K in property damage plus 265 homes & 20 K acres of hay	Possible	Possible
Terrorism, Violence, Civil Unrest, Cyber Security	5	39 years	NA	Possible	Possible
Volcanic Ash	1	100 years	$55 K in property damage	Unlikely	Unlikely

The probability of the drought hazard is expected to increase from "Likely", occurring more than once a decade but not every year, to "Highly Likely", occurring every year, due to climate change. The flooding and severe weather hazards are expected to increase but will remain in their assigned probability categories.

HAZARD EXPOSURE SUMMARY

Table 4.13-3 presents an exposure summary for the general building stock, critical facilities, cultural resources, and population for each hazard with annual loss estimates, for severe weather and flooding. For those hazards with unique areas of impact, severe weather exposes the most building stock and cultural features to damage, followed by wildfire. Critical facilities and population are most at risk from severe weather, followed by earthquake.

Table 4.13-3. Vulnerability Analysis Summary

Hazard	Building Value (Residential + Commercial/ Agricultural/ Industrial) Exposure n Hazard Area)	# Buildings (Residential + Commercial/ Agricultural/ Industrial) Exposure in Hazard Area	Critical Facility $ (Exposure in Hazard Area)	# Critical Facilities (Exposure in Hazard Area)	# Cultural Features in Hazard Area	Population in Hazard Area
Wildfire	$95,408,645,720	369,840			755	1,112,908
Flooding	$5,279,195,895	40,724			135	178,836
Earthquakes	$56,109,035,489	250,003			416	624,084
Drought	ND	ND	ND	ND	ND	ND
Severe Weather	$30,511,229,832	130,914			220	495,344
Hazardous Material & Transportation Accidents	$33,685,595,000	190,200			80	343,090
Disease	ND	ND	ND	ND	ND	ND
Landslide	$742,743,431	2,647			14	8,918
Dam Failure	$18,717,102,494	101,334	$430,379,639	99	30	97,681
Terrorism, Violence, Civil Unrest, Cyber Security	ND	ND	ND	ND	ND	ND
Volcanic Ash	ND	ND	ND	ND	ND	ND

FUTURE DEVELOPMENT

New buildings and additions to state buildings planned for the next 5 to 10 years are listed below. **Figures 4.13-1-3** present a composite of the hazard prone areas showing these future development projects. **Table 4.13-4** presents a matrix of each identified future development project, showing which hazards they will be exposed to. Data on proposed construction method and estimated cost were not available at this time.

- Equipment Storage Building, Augusta
- Equipment Storage Building, Big Timber
- MSU-B Science Building Addition, Billings
- SW Montana Veteran's Home, Butte
- MT Tech Dorm, Butte
- Natural Resource Research Addition, Butte
- Equipment Storage Building, Eureka

- Diesel Technology Center, Havre
- Montana Heritage Center, Helena
- Montana Law Enforcement Academy Dining Addition, Helena
- MLEA Ohs Building Addition, Helena
- Malta Readiness Center, Malta
- Music Building Addition, Missoula
- Equipment Storage Building, Noxon
- Equipment Storage Building, Roy
- Equipment Storage Building, Sidney
- Equipment Storage Building, Wolf Point
- Maintenance Shop, Wolf Point

Although future State-owned facilities will be exposed to various hazards, construction methods will be used to enhance their structural resiliency to minimize damage and protect building occupants.

Table 4.13-4. Future Development Summary

	Hazards										
Proposed Project	Wildfire	Flooding	Earthquake	Drought	Severe Weather	Disease	Haz-Mat & Transportation Accidents	Landslide	Dam Failure	Terrorism, Violence, Civil Unrest, Cyber	Volcanic Ash
Equipment Storage Building, Augusta											
Equipment Storage Building, Big Timber											
MSU Fitness Center Renovation, Bozeman											
MSU-B Science Building Addition, Billings											
SW Montana Veteran's Home, Butte											
MT Tech Dorm, Butte											
Natural Resource Research Addition, Butte											
Equipment Storage Building, Eureka											
Diesel Technology Center, Havre											
Montana Heritage Center, Helena											
MLEA Dining Addition, Helena											
MLEA Ohs Building Addition, Helena											
Readiness Center, Malta											
Music Building Addition, Missoula											
Equipment Storage Building. Noxon											
Equipment Storage Building. Roy											

Equipment Storage Building. Sidney											
Equipment Storage Building. Wolf Point											
Maintenance Shop, Wolf Point											