JEFFERSON COUNTY COLORADO

Jefferson County

Hazard Mitigation Plan

State Review Draft

July 2021

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1 Introduction

1.1 Executive Summary

The following jurisdictions have prepared and adopted this 2021 update of the Jefferson County Hazard Mitigation Plan (HMP):

- Jefferson County
- City of Arvada
- City of Edgewater
- City of Golden
- City of Lakewood
- Town of Morrison
- City of Wheat Ridge
- Arvada Fire Protection District
- Elk Creek Fire Protection District
- Evergreen Fire Protection District
- Fairmount Fire Protection District
- Foothills Fire Protection District
- Genesee Fire Protection District
- Golden Gate Fire Protection District
- Indian Hills Fire Protection District
- Inter-Canyon Fire Protection District
- Jefferson Conservation District
- Lookout Mountain Water District
- North Fork Fire Protection District
- West Metro Fire Protection District
- Denver Water

The purpose of hazard mitigation is to reduce or eliminate long-term risk to people and property from disasters or hazardous events. Studies have found that hazard mitigation is extremely cost-effective, with every dollar spent on mitigation saving an average of $6 in avoided future losses. The Federal Emergency Management Agency (FEMA) requires that hazard mitigation plans be updated every five years for the jurisdictions to be eligible for federal mitigation assistance. All sections of the 2016 Jefferson County Hazard Mitigation Plan were reviewed and updated to address natural and human-caused hazards for the purpose of saving lives and reducing losses from future disasters or hazard events.

This Plan will serve as a blueprint for coordinating and implementing hazard mitigation policies, programs, and projects in Jefferson County. It provides a list of mitigation goals and related actions that may assist Jefferson County and its municipalities in reducing risk and preventing loss from future hazard events. The impacts of hazards can often be lessened or even avoided if appropriate actions are taken before events occur. By reducing exposure to known hazard risks, communities will save lives and property and minimize the social, economic, and environmental disruptions that commonly follow hazard events.

This Plan was also developed to maintain Jefferson County's and participating jurisdictions' eligibility for federal disaster assistance, specifically the Federal Emergency Management Agency's (FEMA), Hazard Mitigation Assistance (HMA) grants including the Hazard Mitigation Grant Program (HMGP), Flood Mitigation Assistance (FMA), and Building Resilient Infrastructure and Communities (BRIC) grant program, as well as the Rehabilitation of High Hazard Potential Dam (HHPD) grant program.

Section 1 contains the Plan Introduction and Executive Summary.

Section 2 Community Profile describes the planning area, consisting of Jefferson County and the participating jurisdictions listed above, with updated information on demographics, social vulnerability, and changes in development. It includes an assessment of programs and policies currently in place across the County to reduce hazard impacts or that could be used to implement hazard mitigation activities, and identifies opportunities to enhance those capabilities.

Section 3 Planning Process describes the process followed to update the Plan. A broad range of public and private stakeholders, including agencies, local businesses, nonprofits, and other interested parties were invited to participate. Public input was sought throughout the planning process including online surveys and public review of the draft Plan.

Section 4 Hazard Identification and Risk Assessment identifies the natural and human-caused hazards of greatest concern to the County, and describes the risk from those hazards. The information generated through the risk assessment helps communities to prioritize and focus their efforts on those hazards of greatest concern and those assets or areas facing the greatest risk(s). The best available information on

the impacts of changing weather conditions were taken into account for each hazard. The hazards profiled in the 2021 Plan and their assessed significance are shown in the following table.

Table 1-1 Hazards Identification Summary

Hazard	Geographic Extent	Probability of Future Occurrence	Potential Severity/Magnitude	Overall Significance
Avalanche	Negligible	Unlikely	Negligible	Low
Cyber Attack	Significant	Likely	Limited	Medium
Dam Failure	Significant	Occasional	Critical	High
Drought	Extensive	Likely	Critical	Medium
Earthquake	Significant	Unlikely	Catastrophic	Medium
Erosion and Deposition	Significant	Likely	Critical	Medium
Expansive Soils	Extensive	Likely	Limited	Medium
Extreme Temperatures	Extensive	Likely	Limited	Low
Flood	Limited	Likely	Critical	High
Hailstorm	Significant	Likely	Critical	High
Landslide/Debris/Rockfall	Limited	Likely	Limited-Negligible	Medium
Lightning	Limited	Highly Likely	Limited	Medium
Pandemic	Extensive	Occasional	Critical	High
Severe Winter Storms	Extensive	Likely	Critical	High
Subsidence	Limited	Occasional	Limited	Medium
Tornado	Limited	Likely	Limited	Medium
Wildfire	Significant	Highly Likely	Critical	High
Windstorm	Significant	Highly Likely	Limited	Medium

Section 5 Mitigation Strategy describes what the County and jurisdictions will do to reduce their vulnerability to the hazards identified in Section 4. It presents the goals and objectives of the mitigation program, and details a broad range of targeted mitigation actions to reduce losses from hazard events.

Section 6 Plan Implementation and Maintenance details how the Plan will be implemented, monitored, evaluated, and updated, as well as how the mitigation program will be integrated into other planning mechanisms.

Following the base plan, annexes for each participating jurisdiction go into greater detail about how the risk from natural and human-caused hazards varies across the planning area, and lists each jurisdictions' identified mitigation actions.

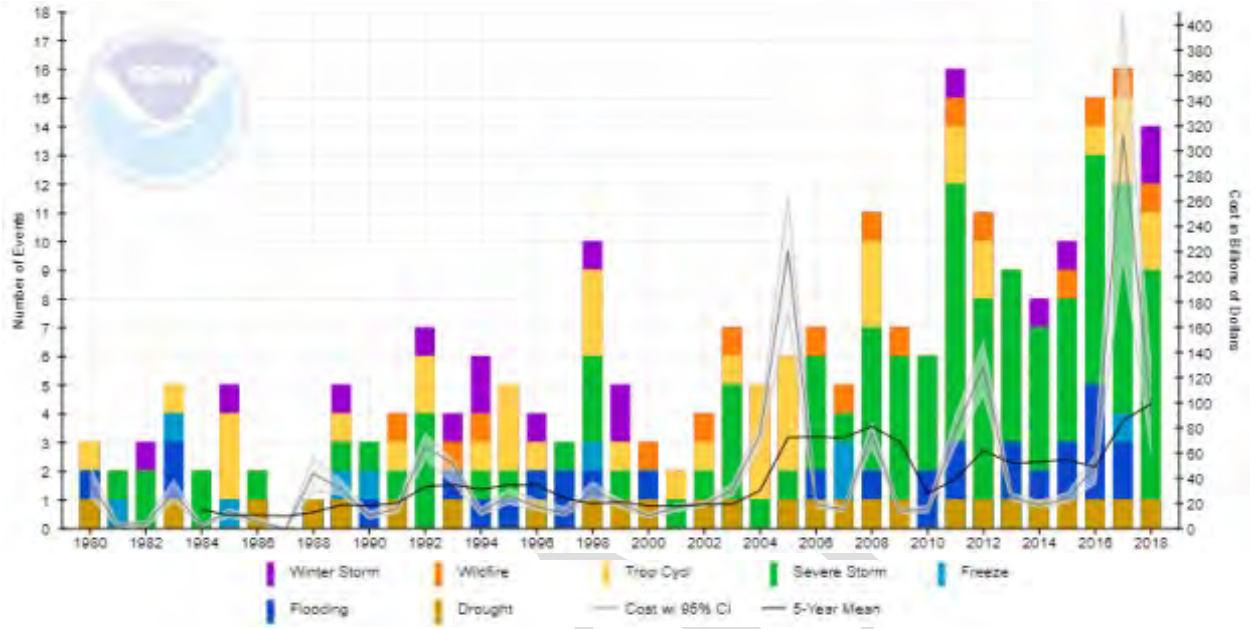
It is important that local decision-makers stay involved in mitigation planning to provide new ideas and insight for future updates to the Jefferson County Hazard Mitigation Plan. As a long-term goal, the Hazard Mitigation Plan and the mitigation strategies identified within will be fully integrated into daily decisions and routines of local government. This will continue to require dedication and hard work, and to this end, this Plan update continues efforts to further strengthen the resiliency of Jefferson County.

1.2 Background

Each year in the United States, disasters take the lives of hundreds of people and injure thousands more. Nationwide, taxpayers pay billions of dollars annually to help communities, organizations, businesses, and individuals recover from disasters. Additional expenses to insurance companies and

nongovernmental organizations are not reimbursed by tax dollars, making the costs of disasters several times higher than calculated amounts. Figure 1-1 shows the number and type of natural disasters in the US that have done more than one billion dollars in damage, showing how the frequency and cost of major disasters have risen over the past several decades.

Figure 1-1 Billion-Dollar Disasters in the US, 1980-2018

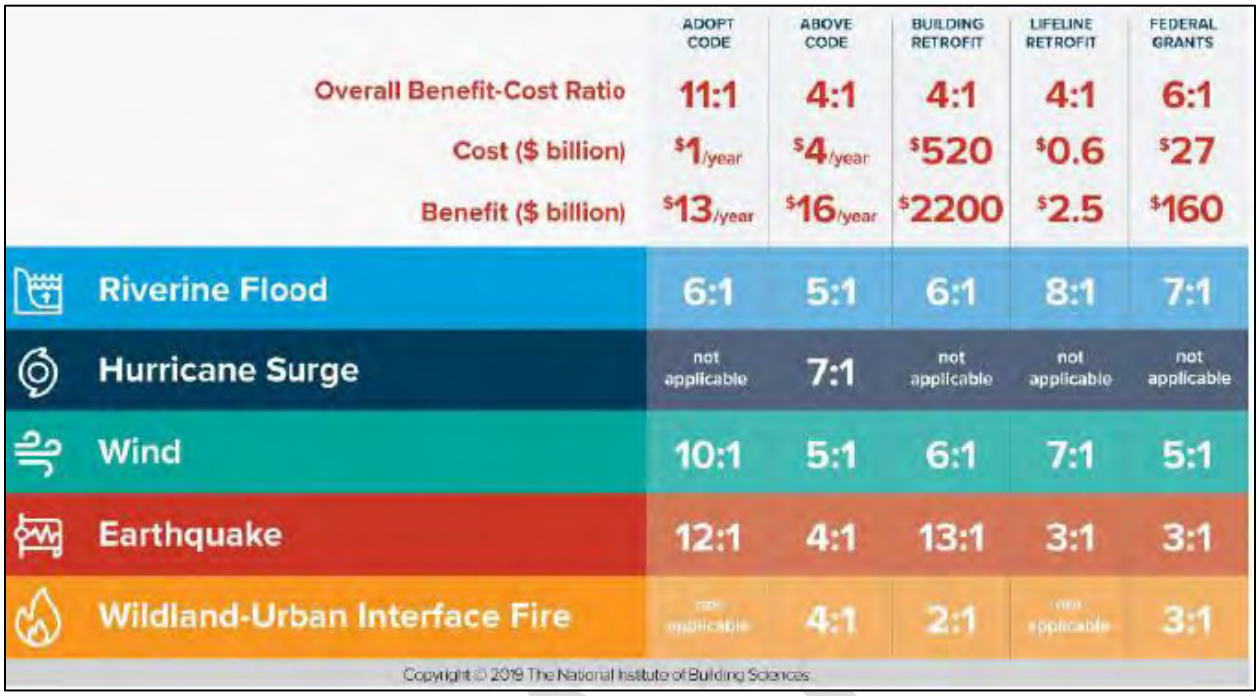


Source: NOAA

However, some types of hazards are predictable, and much of the damage caused by these events can be mitigated through the use of various zoning, construction and permitting vehicles and other preventative actions. Hazard mitigation planning is the process through which hazards that threaten communities are identified, likely impacts of those hazards are determined, mitigation goals are set, and appropriate strategies to lessen impacts are determined, prioritized, and implemented. Hazard mitigation is defined by FEMA as "any sustained action taken to reduce or eliminate long-term risk to human life and property from a hazard event." The results of a three-year, congressionally mandated independent study to assess future savings from mitigation activities provides evidence that mitigation activities are highly cost-effective. On average, each dollar spent on mitigation saves society an average of $6 in avoided future losses in addition to saving lives and preventing injuries, as illustrated in Figure 1-2.

This plan was prepared pursuant to the requirements of the Disaster Mitigation Act of 2000 (Public Law 106-390) and the implementing regulations set forth by the Interim Final Rule published in the *Federal Register* on February 26, 2002 (44 CFR §201.6) and finalized on October 31, 2007. Hereafter, these requirements and regulations will be referred to collectively as the Disaster Mitigation Act or DMA. While the act emphasized the need for mitigation plans and more coordinated mitigation planning and implementation efforts, the regulations established the requirements that local hazard mitigation plans must meet in order for a local jurisdiction to be eligible for certain federal disaster assistance and hazard mitigation funding under the Robert T. Stafford Disaster Relief and Emergency Act (Public Law 93-288).

Figure 1-2 Financial Benefits of Hazard Mitigation



Source: National Institute of Building Sciences, Natural Hazard Mitigation Saves: 2019 Report

This plan builds on almost 20 years of mitigation planning in Jefferson County, starting with participation in the 2003 Denver Regional Council of Governments (DRCOG) Hazard Mitigation Plan. Jefferson County developed its first stand-alone HMP in 2010, updated the plan in 2016, and has again updated it in 2021.

This plan is a comprehensive update to the 2016 plan. Information in this plan will be used to help guide and coordinate mitigation activities and decisions for local land use policy in the future. Proactive mitigation planning will help reduce the cost of disaster response and recovery to the community and its property owners by protecting critical community facilities, reducing liability exposure, and minimizing overall community impacts and disruption. The Jefferson County planning area is committed to reducing future disaster impacts and maintaining eligibility for federal funding.

1.3 Purpose and Scope

Jefferson County and the participating jurisdictions have prepared this multi-hazard mitigation plan to better protect the people and property of the County from the effects of hazard events. This plan demonstrates the community's commitment to reducing risks from hazards and serves as a tool to help decision-makers direct mitigation activities and resources. This plan was also developed to position Jefferson County and its participating jurisdictions for the eligibility of certain federal mitigation funding assistance, specifically, the Federal Emergency Management Agency's (FEMA) Hazard Mitigation Assistance grant programs (HMA), which include Hazard Mitigation Grant Program (HMGP), Pre-Disaster Mitigation (PDM), and Flood Mitigation Assistance (FMA). This plan also aligns with the planning elements of the National Flood Insurance Program's Community Rating System (CRS), which provides for lower flood insurance premiums in CRS-participating communities.

Jefferson County remains dedicated to implementing the actions and strategies outlined in this updated Hazard Mitigation Plan. The Plan will be maintained regularly to address changes in hazards or vulnerabilities, and will be updated within the next five years.

2 Community Profile

2.1 Geography and Climate

Situated in the north-central part of Colorado, west of the City of Denver, Jefferson County is split between foothills on the west and plains on the east. The majority of the population is located in the northern portion of the county, while the southern portion is dominated by Pike National Forest. The county is 773 square miles in size, and 653 square miles are unincorporated areas. The landscape is comprised of approximately 72% mountains and 28% plains. The ecologies located in the County include prairies, and forests. This area includes a significant intermix between developed and forest areas, which increases the wildfire risks in those regions. Table 2-1 breaks down land ownership in the County.

Table 2-1 Jefferson County Land Ownership

Land Ownership	Acres	% of Total
Private Lands	289,480	58.4%
Conservation Easement	9,737	2.0%
Federal Lands	111,966	22.6%
Forest Service	103,248	20.8%
BLM	355	0.1%
National Park Service	0	0.0%
Military	3,093	0.6%
Other Federal	5,270	1.1%
State Lands	10,412	2.1%
State Trust Lands*	3,087	0.6%
Other State	7,325	1.5%
Tribal Lands	0	0.0%
City, County, Other	83,542	16.9%
Total	**495,399**	

Source: U.S. Geological Survey Protected Areas Database of the United States (PADUS)

Approximately 40% of the unincorporated areas of the County are reserved as parks, open space, and open land. Jefferson County is home to three state parks: Golden Gate Canyon State Park, Staunton State Park, and Chatfield State Park offer a variety of activities, trails, boating, and other events. The County also has a robust network of open space parks (Jefferson County Open Space, or JCOS) with 27 regional park units, 252 miles of trails, and 56,000 acres preserved. Additionally, the Denver Mountain Park system includes 10,271 acres in Jefferson County.

Jefferson County is marked by some distinctive geologic features. The hogback formations, rock formations that rise sharply just at the base of the foothills, provide a steep valley between the formation and the formal foothill regions, are unique in appearance, and easily identified by travelers. One of the most notable elements of the hogback is the Dinosaur Ridge formation, where fossils and dinosaur tracks are easily accessible. Other notable geologic features include Green Mountain, North and South Table Mountains, and Red Rocks Amphitheater and Park. Several large reservoirs are located in the County as well, including, Blunn, Chatfield, Bear Creek, Ralston, Marston, Bow Mar, Sloan, and Standley Lake. The site of the former Rocky Flats facility is also located in the County and is now a National Wildlife Refuge (US Fish and Wildlife Service).

Jefferson County's climate is fairly temperate but demonstrates four distinct seasons. The average temperature in July (the hottest month) is 74°F and in January (the coldest month) is 30°F. The county averages 15.4 inches of precipitation and 60.3 inches of snow. There are periods of extreme temperature variations, but they are generally accompanied by other climactic considerations such as drought or winter storms. A base map of Jefferson County is shown in Figure 2-1. Figure 2-2 shows the various fire protection districts that serve the County.

Figure 2-1 Jefferson County Base Map

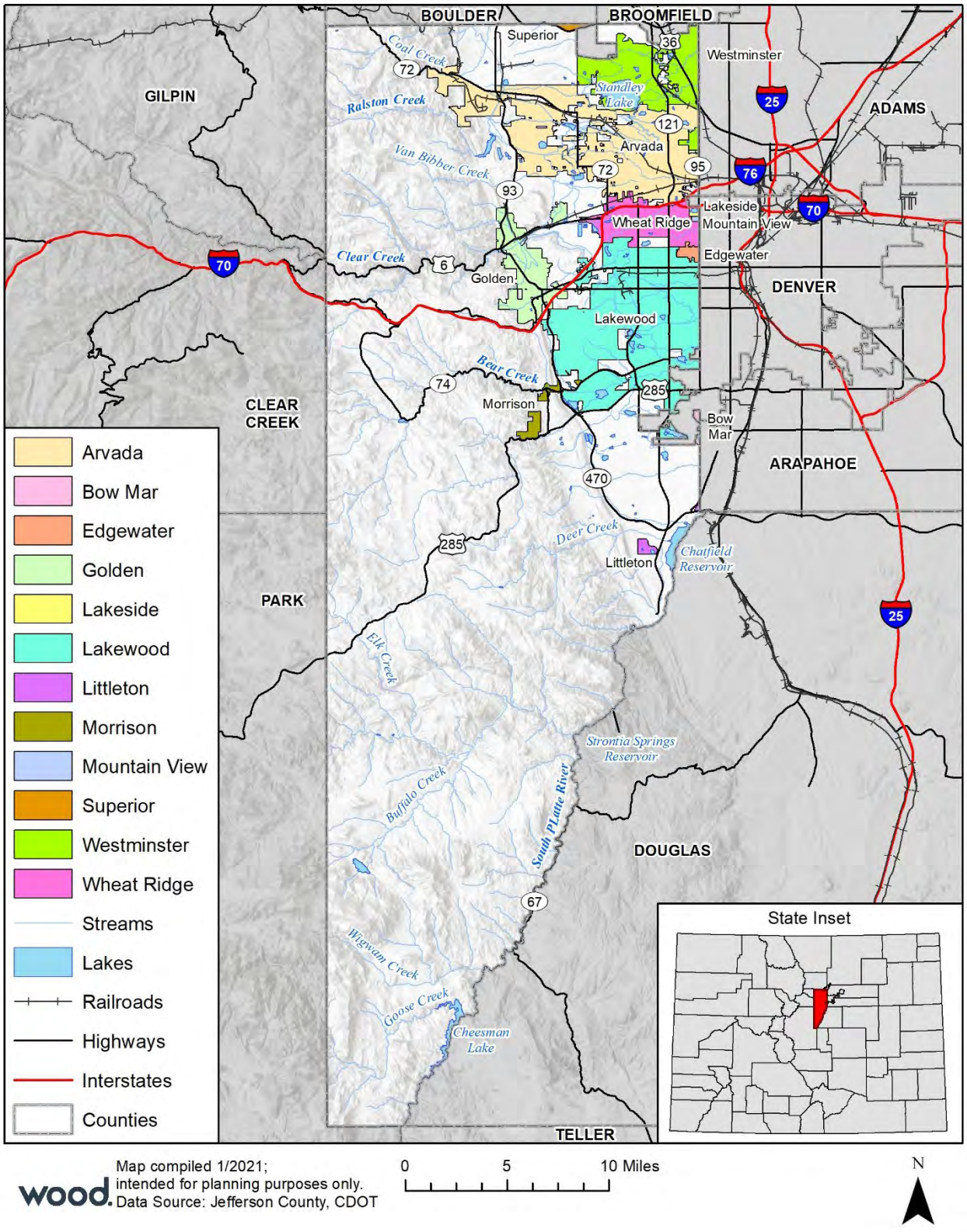
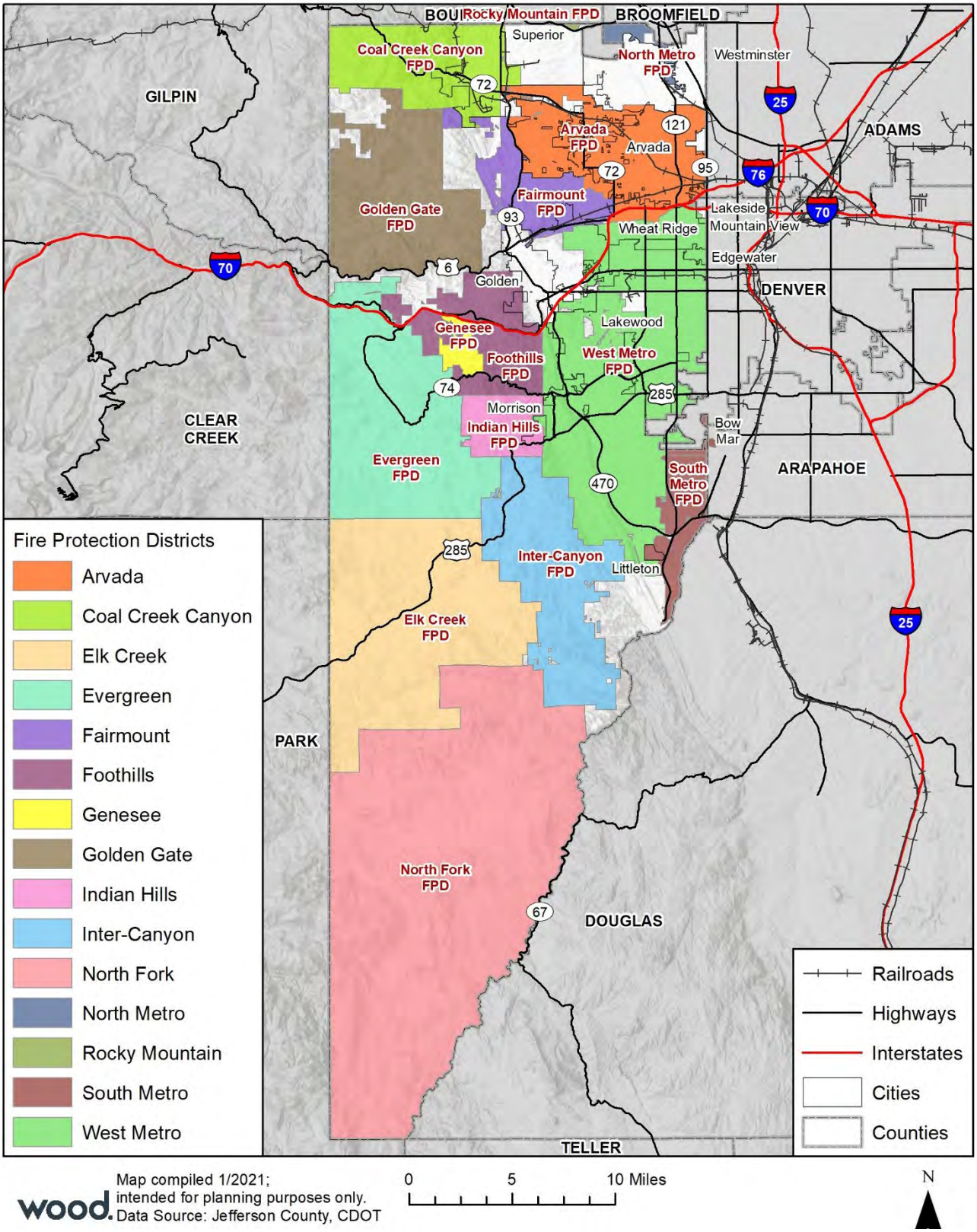


Figure 2-2 Jefferson County Fire Protection Districts



2.2 Population

Jefferson County has grown by an estimated 39,969 residents since the 2010 U.S. Census, totaling 574,798 people in 2019. This equals an average yearly growth rate of 0.6% for this 9-year period. The majority of the population resides in the unincorporated areas of the county and the cities of Westminster, Lakewood, Arvada, and Littleton. Population estimates for 2015 and 2019 are provided in Table 2-2.

Table 2-2 Jefferson County Population

Jurisdiction	2015 Population (est.)	2019 Population (est.)	% Change 2015 to 2019
Arvada	111,658	118,746	6.35%
Edgewater	5,237	5,328	1.74%
Golden	19,780	20,693	4.62%
Lakewood	147,836	155,146	4.94%
Morrison	394	415	5.33%
Wheat Ridge	30,863	31,331	1.52%
Unincorporated	236,566	243,139	2.78%
Total	552,334	574,798	4.07%

Source: Quickfacts.census.gov

Select Census and American Community Survey demographic and social characteristics for Jefferson County are shown in Table 2-3, with comparisons to the State and the Country summarized in Table 2-4. Characteristics are for the entire County.

Table 2-3 Jefferson County Demographic and Social Characteristics, 2015-2019

Jefferson County	2015	2019	% Change
Population	552,334	574,798	4.07%
Median Age	40.4	40.3	-0.2%
Total Housing Units	232,477	240,956	3.6%
Housing Occupancy Rate	95.9%	96.4%	0.5%
% of Housing Units with no Vehicles Available	4.3%	3.9%	-9.3%
Median Home Value	$279,500	$397,700	42.3%
Unemployment Rate	4.1%	3.6%	-12.2%
Mean Travel Time to Work (minutes)	27	28	3.7%
Median Household Income	$70,164	$82,986	18.3%
Per Capita Income	$37,065	$44,119	19.0%
% of Individuals Below Poverty Level	8.5%	7.1%	-16.5%
% Without Health Insurance	14.2%	5.5%	-61.3%
# of Households	222,892	232,284	4.2%
Average Household Size	2.4	2.4	0.0%
% of Population Over 25 with High School Diploma or Higher	94.0%	94.5%	0.5%
% of Population Over 25 with Bachelor's Degree or Higher	41.6%	45.2%	8.7%
% with Disability	9.6%	10.0%	4.2%
% Speak English less than "Very Well"	3.1%	3.0%	-3.2%

Source: US Census and American Community Survey

Table 2-4 Jefferson County Demographic and Social Characteristics Compared to the State and the Nation

Demographic & Social Characteristics (as of 2019)	County	Colorado	U.S.
Median Age	40.3	36.7	38.1
Housing Occupancy Rate	96.4%	90.0%	87.9%
% of Housing Units with no Vehicles Available	3.9%	5.1%	8.6%
Median Home Value	$397,700	$343,300	$217,500
Unemployment	3.6%	4.3%	5.3%
Mean Travel Time to Work (minutes)	28	25.8	26.9
Median Household Income	$82,986	$72,331	$62,843
Per Capita Income	$44,119	$38,226	$34,103
% of Individuals Below Poverty Level	7.1%	10.3%	13.4%
% Without Health Insurance	5.5%	7.6%	5.1%
Average Household Size	2.40	2.56	2.62
% of Population Over 25 with High School Diploma or Higher	94.5%	91.7%	88.0%
% of Population Over 25 with bachelor's degree or Higher	45.2%	40.9%	32.1%
% with Disability	10.0%	10.6%	12.6%
% Speak English less than "Very Well"	3.0%	5.8%	8.4%

Source: US Census and American Community Survey.

2.3 Social Vulnerability

Local vulnerability to disasters depends on more than the relationship between a place and its exposure to hazards. Social vulnerability to disasters refers to the characteristics and situation of a person or group that influence their capacity to anticipate, cope with, resist, or recover from the impact of a hazard. It is determined by a number of pre-existing social and economic characteristics, including race, age, income, renter status, or institutionalized living. Very often, the impacts of hazards fall disproportionately on the most underserved or marginalized people in a community – people with low income, children, people who are aging, people with disabilities, and minorities. During emergencies, for example, self-evacuation can be difficult or nearly impossible for individuals who are disabled or institutionalized. Additionally, the willingness of an individual/family to invest in residential mitigation actions is often limited if their home is a rental and they are averse to investing money in long-term mitigation activity. Not only do conditions like these limit the ability of some communities to get out of harm's way, they also decrease the ability of communities to recover from and thrive in the aftermath of a disaster event.

The term social vulnerability is used here to describe communities more vulnerable to a risk or hazard, such as high vulnerability due to wildfires or floods based upon geography, topography, hydrology or weather. Referencing people themselves directly with the term vulnerable can cause individual community members to be seen with a deficit lens, leaving the impression that the vulnerability is a result of the lack of responsibility and/or adequate planning of the individual. Instead, vulnerability occurs when the system that the individual is part of fails to provide equitable accessibility to resources or services, known as access and functional needs, for the individual to survive, respond to, and recover from an event. Barriers that may be exacerbated by certain social and economic factors – including race, age, income, renter status, or institutionalized living – directly affect a community's ability to prepare for, respond to, and recover from hazards and disasters. The concept of social vulnerability helps explain why communities often experience a hazard event differently, even when they experience the same amount of physical impacts or property loss.

For the 2021 plan update, the concept of social vulnerability has been introduced into the hazard risk analysis to more effectively identify hazard risk experienced by the most vulnerable residents and communities within the county. The social vulnerability assessment is designed to improve local decision making, hazard prioritization, and emergency management activities. By incorporating social vulnerability

into the risk assessments of individual hazards, local communities can identify more vulnerable areas and tailor their mitigation actions to accommodate all members of their community, including the most sensitive groups.

Social vulnerability analysis is particularly useful in the context of hazard mitigation planning because it can reveal disparities within a community that make a difference when it comes to the ability of residents to mitigate, prepare, evacuate, mobilize resources, and recover from disasters. Areas on the map that have medium to high social vulnerability represent areas where age, poverty, race/ethnicity, or special needs factors may make it more difficult for people to prepare, respond, and recover from hazard events. Social vulnerability information can also be used to help communities design effective and appropriate local risk communication and hazard mitigation outreach activities.

The Center for Disease Control and Prevention (CDC) has developed a social vulnerability index (SoVI) as a way to measure the resilience of communities when confronted by external stresses such as natural or human-caused disasters or disease outbreaks. The SoVI is broken down at the census tract level and provides insight into particularly vulnerable populations to assist emergency planners and public health officials identify communities more likely to require additional support before, during, and after a hazardous event. The SoVI index combines four main themes of vulnerability, which are in turn broken down into subcategories for a total of 15 vulnerability factors. Table 2-5 displays those 15 factors and shows how Jefferson County compares to other counties in Colorado and nationally. The rankings show the percentage of counties that Jefferson County is more vulnerable than, i.e. – high numbers reflect greater relative vulnerability.

Table 2-5 Social Vulnerability in Jefferson County

Variable	Ranking Compared to Colorado Counties	Ranking Compared to US Counties	Relative Vulnerability
Socioeconomic status	**13%**	**2%**	**Low**
Below poverty	16%	6%	Low
Unemployment	32%	21%	Low
Income	11%	3%	Low
No high school diploma	29%	5%	Low
Household composition and disability	**32%**	**2%**	**Low**
Age 65 or older	38%	26%	Below Average
Age 17 or younger	49%	25%	Below Average
Disability	29%	6%	Low
Single-parent households	40%	21%	Low
Minority status and language	**46%**	**67%**	**Above Average**
Minority	49%	59%	Above Average
Speaking English “less than well”	44%	69%	Above Average
Housing and transportation	**21%**	**20%**	**Low**
Multi-unit structures	81%	95%	High
Mobile homes	3%	4%	Low
Crowding	17%	30%	Below Average

Variable	Ranking Compared to Colorado Counties	Ranking Compared to US Counties	Relative Vulnerability
No vehicle	40%	21%	Low
Group quarters	43%	35%	Below Average
Overall Social Vulnerability	**24%**	**6%**	**Low**

Source: CDC SoVI Data

Figure 2-3 displays the overall SoVI data for Jefferson County broken down by census tract. Figure 2-4 through Figure 2-7 breaks the data down by the four main themes described above. Most of the areas with the highest level of social vulnerability are in the northeastern portions of the County in the metro area, where the majority of the population is concentrated.

Additional information on the CDC's Social Vulnerability Index can be found at https://svi.cdc.gov.

Figure 2-3 Jefferson County Overall Social Vulnerability

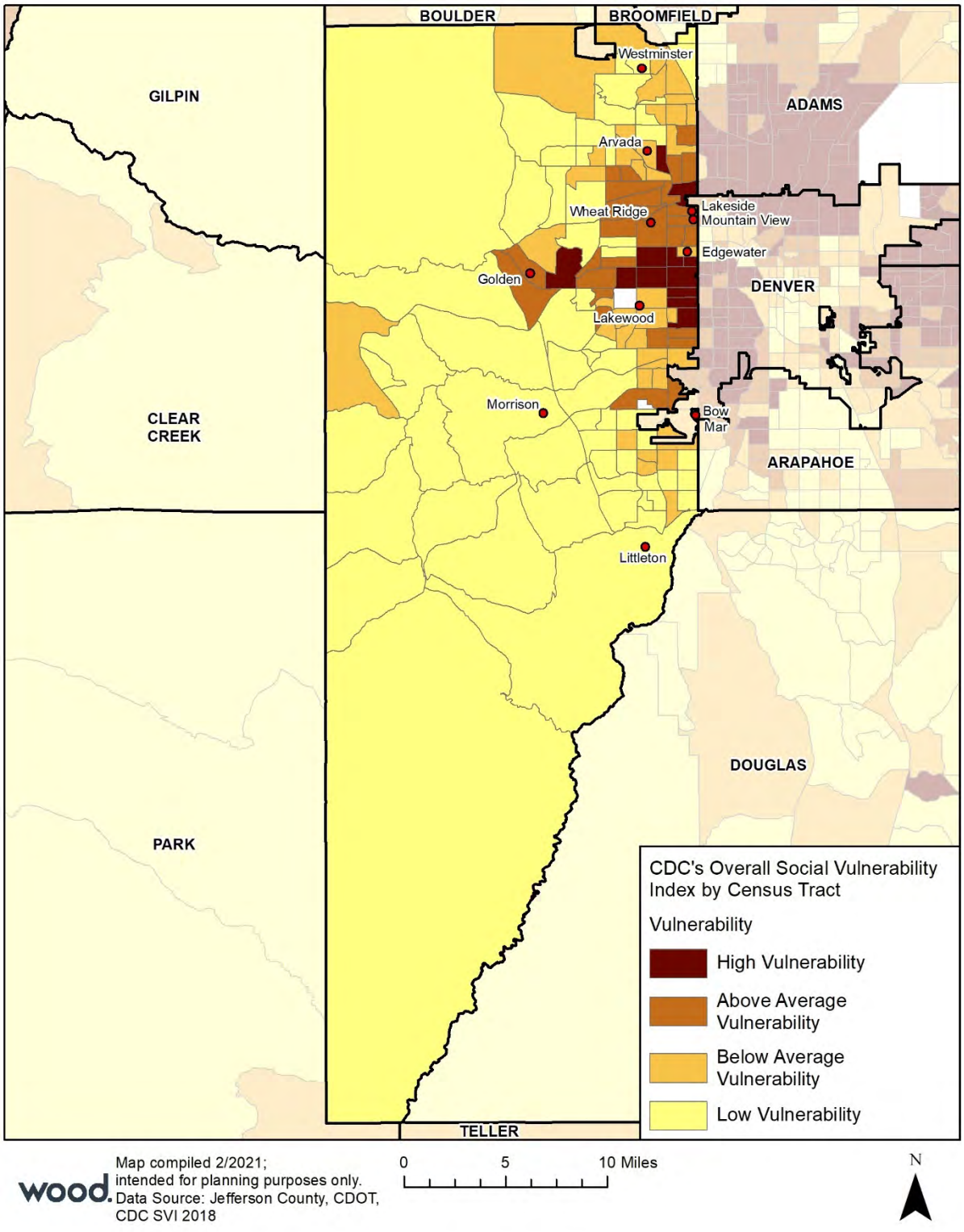


Figure 2-4 Jefferson County Socioeconomic Vulnerability

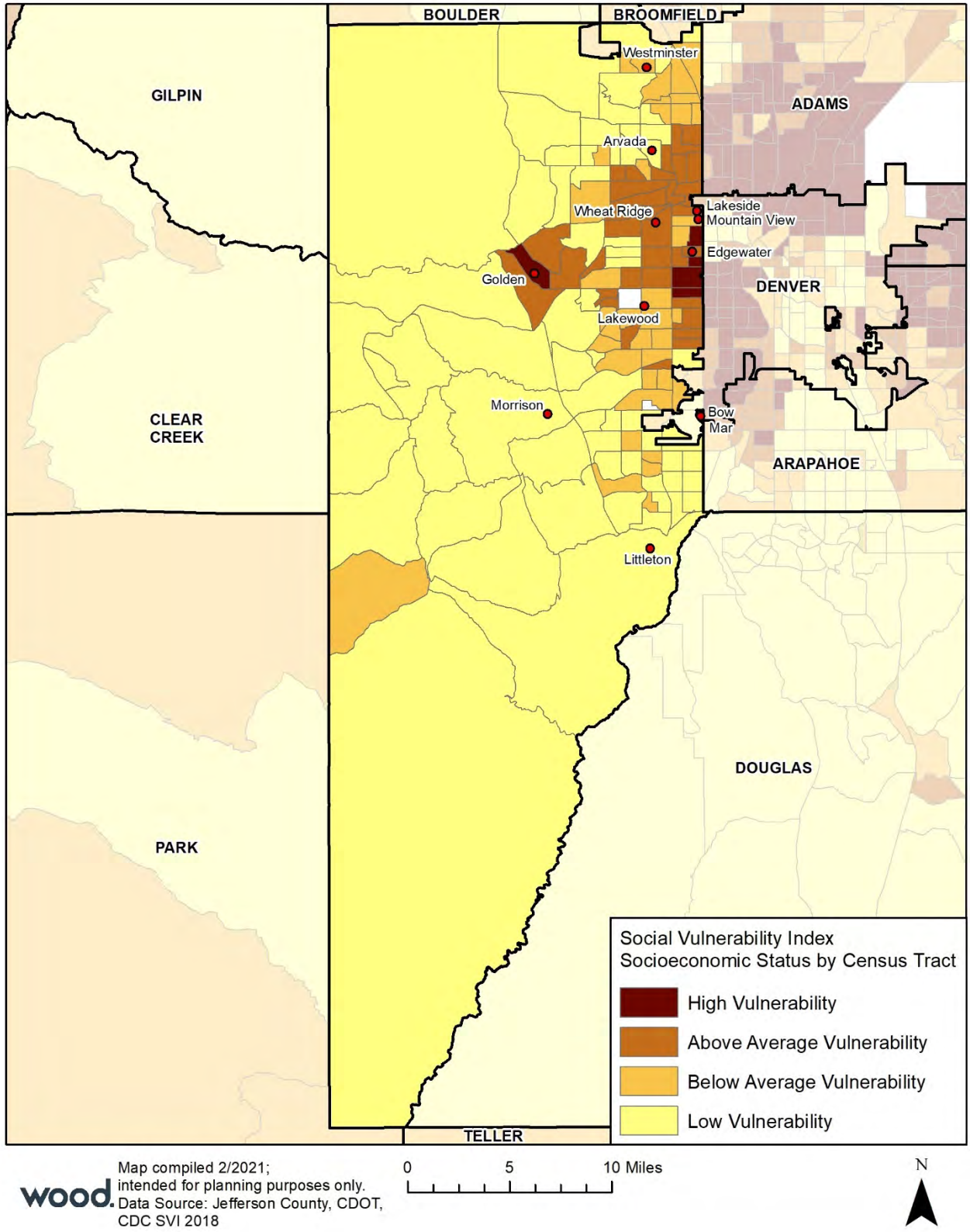


Figure 2-5 Jefferson County Household Composition and Disability Vulnerability

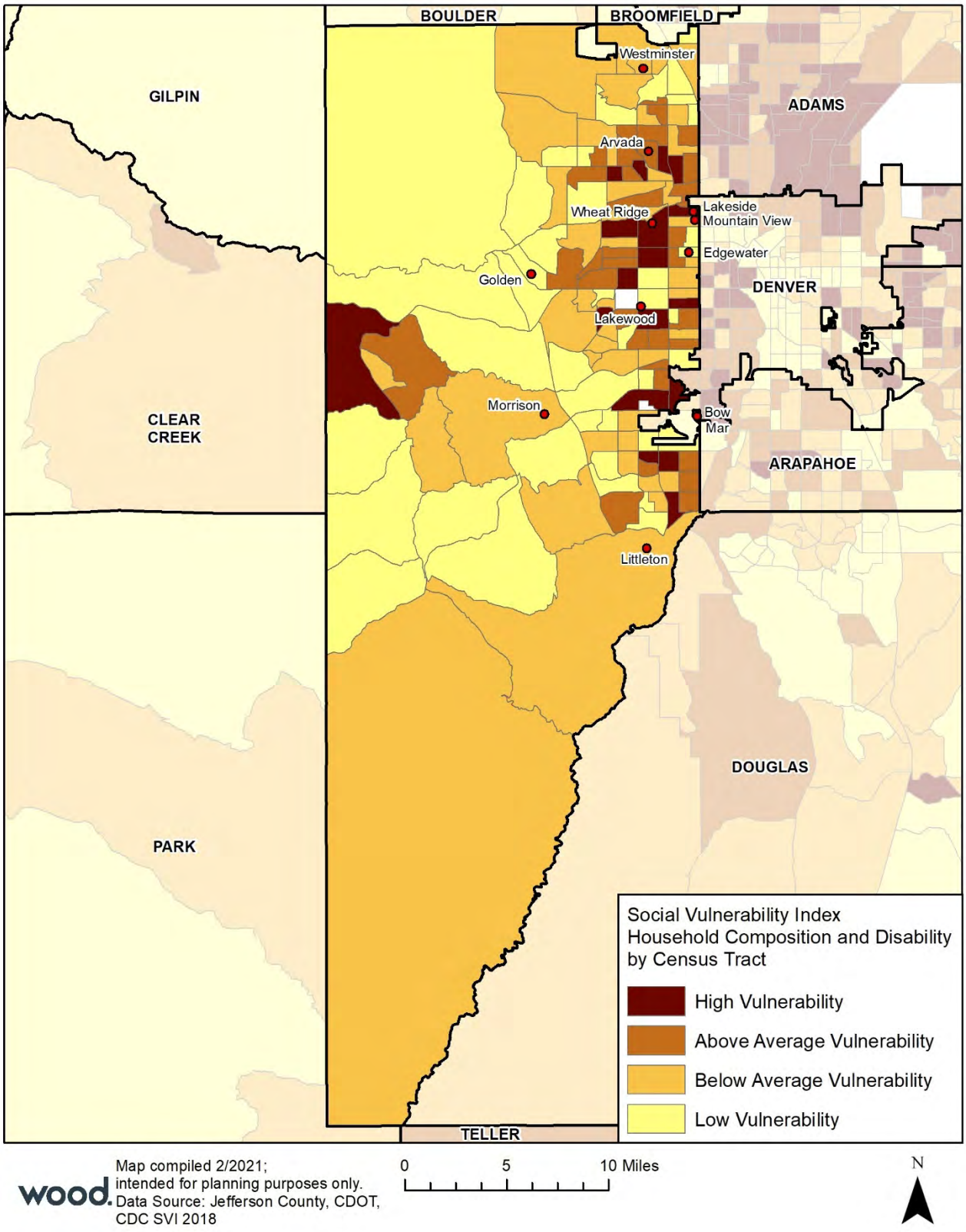


Figure 2-6 Jefferson County Minority Status and Language Vulnerability

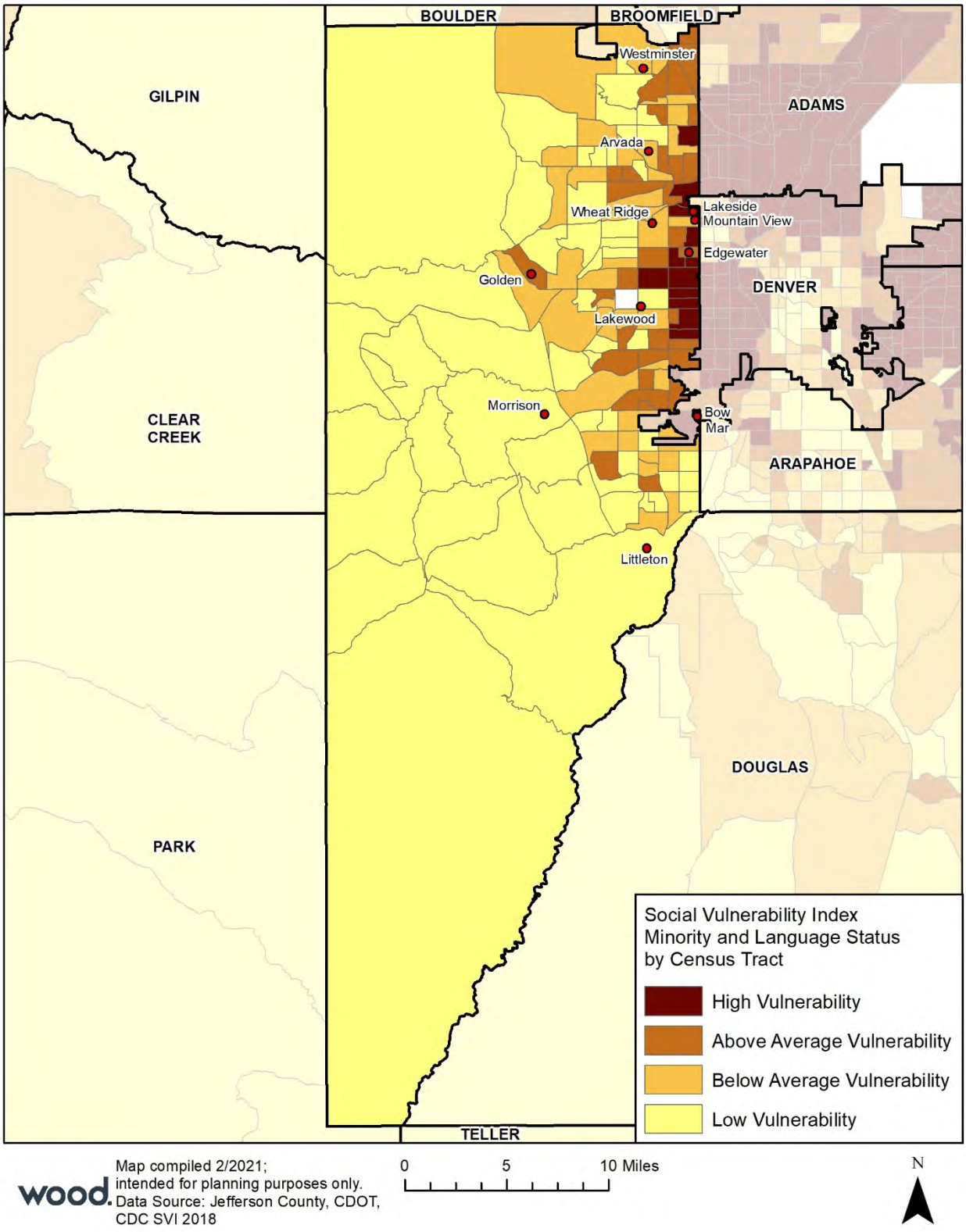
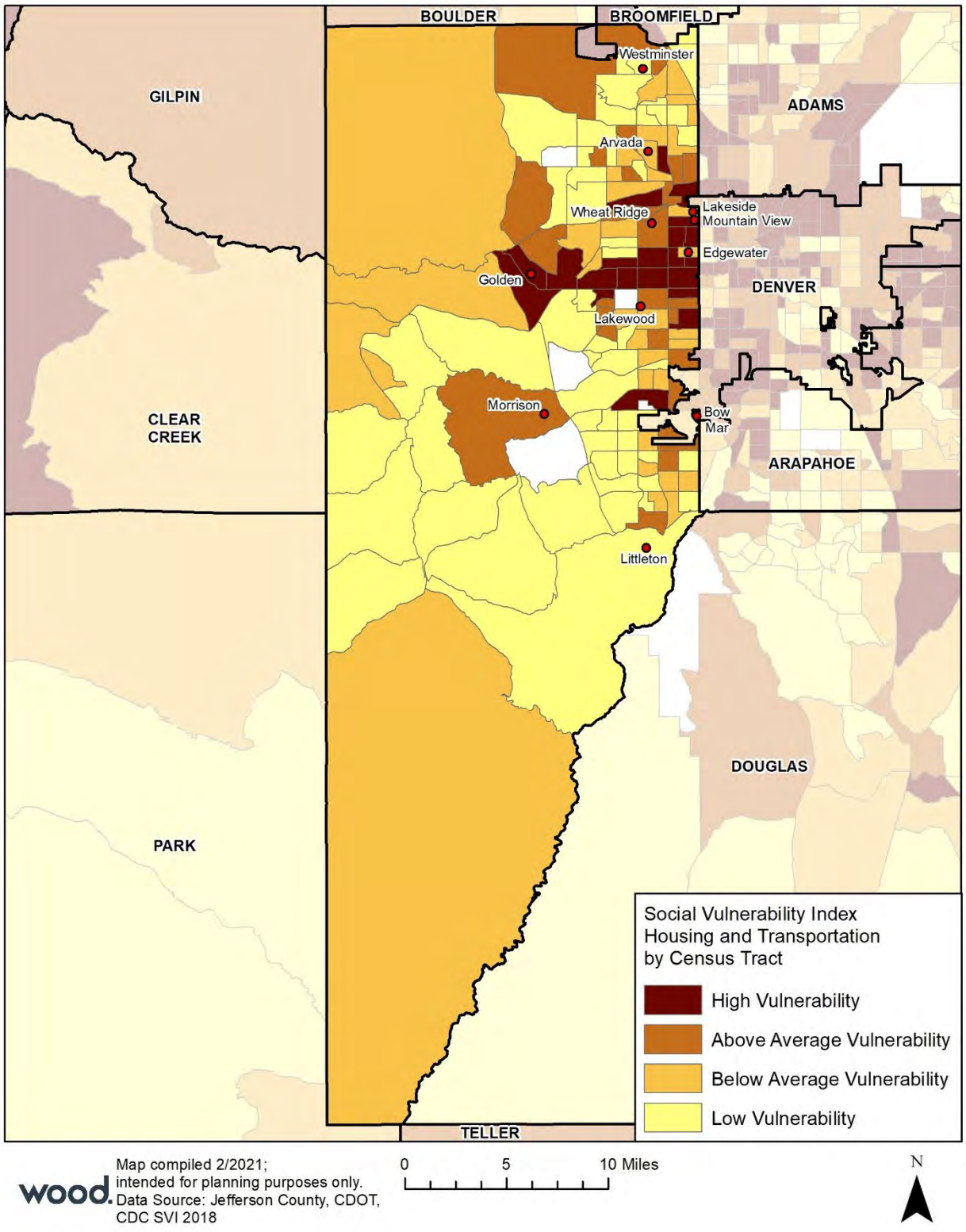


Figure 2-7 Jefferson County Housing and Transportation Vulnerability



2.4 History

Jefferson County has a history rich in people, events and progress. Taking the name of the third U.S. President Thomas Jefferson, the County was formally organized in 1861 by the Colorado Territorial Legislature. The need for an organized local government began in the late 1850s when droves of gold-seeking settlers came west. In 1858, when gold was discovered in the Rocky Mountains, there were fewer than 200 settlers in the area. An influx of nearly 35,000 people arrived two years later, lured by the glitter of gold. The first provisional governor of Jefferson Territory was Robert W. Steele, who lived at Mount Vernon. County offices were located in Loveland Hall until 1877 when the first Jefferson County Courthouse was built. Commissioners in 1862 were paid $3 per day for their meetings plus mileage to the meeting hall. The City of Golden served as the capital for the Colorado Territory from 1862 to 1867.

The county tax in 1862 was 6 mills and the school tax was 2.5 mills. County taxes for that year amounted to $1,594.61. By comparison, in 1996 Jefferson County's mill levy was 25.584 and property taxes alone exceeded $96,000,000. In the early years, farmers and ranchers thrived by supplying food and supplies to the mining towns scattered throughout the mountains. Mining occurred along the Hogback in Idledale, on Lookout Mountain, and in Genesee. Contemporary elements within the County include a variety of industries. Some of these are aerospace engineering from companies such as Lockheed Martin, environmental engineering from Ball Corp., the Coors brewery, the Colorado School of Mines, local grocery chains, and numerous private, locally owned, or large corporate businesses. Many of these, such as the School of Mines and Coors Brewery, were established in the late 1800s and are nearly as old as the territory itself. Dinosaur Ridge, where fossils were first discovered in 1877, remains a prominent and archaeologically significant resource. Mount Olivet Cemetery, which opened in 1892 and was called "The New City of the Dead", remains one of the largest cemeteries in Colorado and is still active.

2.5 Economy

According to the Jefferson County Economic Development Corporation, as of 2020, the top employers in the county are:

- Lockheed Martin 6,200 employees
- St. Anthony Hospital 2,400 employees
- Terumo BCT 2,400 employees
- Lutheran Medical Center/SCL Health 2,300 employees
- MillerCoors Brewing 2,080 employees
- National Renewable Energy Lab 1,750 employees
- Ball Corporation 1,700 employees
- FirstBank Holding Co. of Colorado 1,480 employees
- Coorstek 1,300 employees
- HomeAdvisor 1,130 employees

Select economic characteristics for Jefferson County from the 2018-2019 American Community Survey Estimates are shown in Table 2-6. Characteristics for Jefferson County are for the entire County.

Table 2-6 Jefferson County Economic Characteristics

Characteristic	Jefferson County	Arvada	Edgewater	Golden	Lakewood	Morrison	Wheat Ridge
Individuals below poverty level (%)	7.1	5.8	9.6	15.8	9.1	3.2	12.9
Median home value ($)	$397,700	$384,500	$408,500	$522,200	$364,800	$541,700	$383,900
Median household income ($)	$82,986	$84,717	56,028	$72,349	$66,740	$105,536	$57,659
Per capita income ($)	$44,119	$42,921	$33,529	$39,184	$38,612	$40,900	$33,956
Housing Occupancy Rate (%)	96.4	96.9	95.8	94.6	96.5	94.4	95.8
Unemployment rate (%)	3.6	3.8	4.8	4.6	3.5	2.1	3.7

Source: US Census American Community Survey

2.6 Land Use and Development Trends

A key strategy for reducing future losses in a community is to avoid development in known hazard areas and to enforce the development of safe structures in other areas. The purpose of this strategy is to keep people, businesses, and buildings out of harm's way before a hazard event occurs.

Countywide, there have been 8,501 new buildings constructed between 2015 and 2020. Thousands of these new structures have been constructed in areas exposed to one or more hazards. As discussed below in Section 2.7, the County and jurisdictions have land-use regulations in place that require mitigation when building in floodplains and geologic hazard areas, reducing the vulnerability of these new structures. Table 2-7 and Table 2-8 summarize this trend in greater detail.

Table 2-7 New Structures Built in Hazard Areas, 2015 to 2020

Hazard	New Structures
1% Chance Flood	21
0.2% Chance Flood	71
Local Flood Layers	9
Dam Inundation	784
Landslide	0
Rockfall	0
Slope Failure	3
Subsidence	1,392
Dipping Bedrock	1,297
Total	**3,577**

Source: Wood analysis based on Jefferson County Assessor's Office, Colorado Geological Survey, FEMA NFIP Floodplain data, Colorado DWR Dam Safety

Table 2-8 New Structures Built in Wildfire Zones, 2015 to 2020

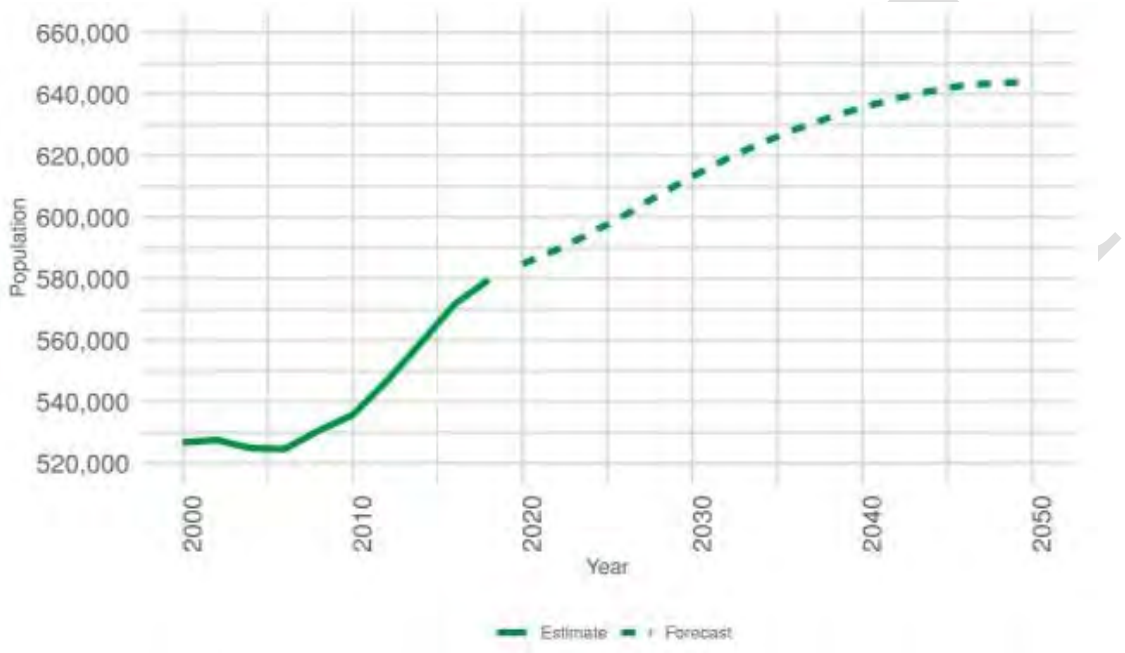
Wildfire Risk	New Structures
Lowest	2,022
Low	663
Moderate	2,948
High	589

Wildfire Risk	New Structures
Highest	15
Total	**6,237**

Source: Wood analysis based on Jefferson County Assessor's Office, Colorado State Forest Service

According to the Colorado State Demography Office, between 2020 and 2030 Jefferson County's population is projected to grow at an average of 0.7% a year, with the overall growth rate expected to slow to 0.27% between 2030 and 2040. The county's population is projected to be 643,945 by 2050. Figure 2-8 shows the population forecast for the next 30 years.

Figure 2-8 Jefferson County Population Forecast, 2000 to 2050



Source: Colorado State Demography Office

2.7 Capabilities Assessment

The following section assesses the County's and jurisdictions' existing capabilities to pursue hazard mitigation. The capability assessment analyzes Jefferson County's capabilities that can be leveraged to mitigate hazards. Combining the risk assessment with the mitigation capability assessment results in the County's "net vulnerability" to disasters, and more accurately focuses the goals, objectives, and proposed actions of this plan.

The HMPC used a two-step approach to conduct this assessment for the County and jurisdictions. First, an inventory of common mitigation activities was made through the use of a matrix. The purpose of this effort was to identify policies and programs that were either in place, needed improvement, or could be undertaken if deemed appropriate. Second, the HMPC conducted an inventory and review of existing policies, regulations, plans, and programs to determine if they contributed to reducing hazard-related losses or if they inadvertently contributed to increasing such losses.

This assessment is divided into four sections: regulatory mitigation capabilities; administrative and technical mitigation capabilities; fiscal mitigation capabilities; and mitigation outreach and partnerships. Additional information on jurisdiction capabilities can also be found in the Annexes.

2.7.1 Regulatory Mitigation Capabilities

Table 2-9 lists planning and land management tools typically used by local jurisdictions to implement hazard mitigation activities and indicates those that are in place in Jefferson County. Excerpts from

applicable policies, regulations, and plans and program descriptions follow to provide more detail on existing mitigation capabilities. Because many of these capabilities do not apply to non-municipal jurisdictions, information on their mitigation capabilities are described in their annexes.

Table 2-9 Regulatory Mitigation Capabilities

Regulatory Tool (ordinances, codes, plans)	Jefferson County	Arvada	Edgewater	Golden	Lakewood	Morrison	Wheat Ridge
General or Comprehensive plan	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Zoning ordinance	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Subdivision ordinance	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Growth management ordinance	Yes	No	No	Yes	Yes	No	Yes
Floodplain ordinance	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Floodplain Management Plan	Yes	No	No	No	No	Yes	No
Other special purpose ordinance (stormwater, steep slope, wildfire)	Yes	Yes	No	Yes	Yes	Yes	Yes
Building code	Yes 2018	Yes 2018	Yes 2015	Yes 2018	Yes 2015	Yes 2020	Yes 2018
BCEGS Ratings (1-10, 1 being best)	4/3	4/3	No	4/4	4/3	5/5	5/4
Fire department ISO rating	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Erosion or sediment control program	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Storm water management program	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Site plan review requirements	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Capital improvements plan	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Economic development plan	No	Yes	Yes	Yes	Yes	Yes	Yes
Local emergency operations plan	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Community Wildfire Protection Plan (CWPP)	Yes 2012	No	No	Yes 2007	Yes 2006*	No	No
Other special plans	Yes	Yes	No	Yes	Yes	No	Yes
National Flood Insurance Program	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Community Rating System	Yes: 5	Yes: 5	No	Yes: 7	Yes: 6	Yes: 8	Yes: 5
Flood insurance study or other engineering study for streams	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Elevation certificates (for floodplain development)	Yes	Yes	No	Yes	Yes	Yes	Yes

Regulatory Tool (ordinances, codes, plans)	Jefferson County	Arvada	Edgewater	Golden	Lakewood	Morrison	Wheat Ridge
Other							

Source: HMPC. * Covered under West Metro Fire CWPP

Jefferson County Comprehensive Master Plan

Jefferson County adopted its first Comprehensive Master Plan in 1961, with the most recent update completed in 2017 and another plan update currently ongoing. Since then, master planning in Jefferson County has taken many different approaches, but all of the approaches have recognized that good planning involves evaluating a multitude of different factors when making land use decisions, such as transportation, geologic hazards and compatibility. The Land Use chapter of the Development Review section (Page 18) includes: guidelines for all development, infill and redevelopment, business and industry, housing, mixed-use, community uses, livestock, renewable and alternative energy, extractive resources, solid wastes and hazardous materials, activity centers, and site design. The Development Review section also addresses physical constraints. Physical constraints are those physical features that due to safety or cost concerns may potentially restrict where and how development occurs. For purposes of this Plan, physical constraints include geologic hazards and constraints, floodplains, wetlands, wildfire, radiation, landfills, abandoned mines, and wildlife. The overall vision projects a balance of residential, commercial, community, recreational, agricultural and open land uses, which protects and maintains the quality of the mountain and plains environment, provides economic vitality for current and future generations, respects private property rights, and maintains Jefferson County as a place of choice to live, work, and recreate.

This balance protects and maintains the quality of the mountain and plains environment, provides economic vitality for current and future generations, and maintains Jefferson County as a place of choice to live, work, and recreate. The plan identifies that location, availability and the convenience of goods and services is an important element in the quality of life, and that a balance of such key services as an educated workforce, schools, commercial services, and recreational and employment opportunities are vital. Well-planned retail and service levels provide a source of community identity. The roads, rivers, and trails that connect homes, offices, stores, schools, and parks are the conduits for social interaction that knit together a community. Ensuring that residential areas are balanced by commercial and service centers can contribute to an orderly pattern of development and sense of place.

The general land use management goal is to encourage diversity of residential, commercial, community, recreational, and open land uses. The plan identifies Urban and Non-Urban Interface development with an objective to accommodate higher intensity uses in areas with adequate infrastructure and minimal hazards and provide decreasing land use intensity where constraints exist and as distance to services increases. There are policies that protect important wildlife habitats and avoid development or mitigate impacts in severe wildfire areas, such as steep forested canyons and slopes greater than 30%. The plan includes provisions for infill and redevelopment, which supports adaptive reuse of historical and outdated buildings; and future growth, which complements the existing community character with efforts to accommodate anticipated growth in the Denver metro area over the next 30 years. The policy states that the County should incorporate land planning techniques that manage resources effectively.

In addition, the Comprehensive Master Plan includes goals and policies oriented towards several long-range planning issues to guide the County's future growth and development. One such issue is environmental stewardship. This section integrates hazard mitigation with the goal to "protect people and property from hazardous conditions and events", which includes specific policies intended to mitigate the impacts of geologic hazards, flood, wildfire, and hazardous materials. Other goals and policies seek to support water conservation measures which supports mitigation of drought risk, such as the goal to "promote the education of residents, businesses, and appropriate agencies about water issues affecting the County".

The Water Quality policy implements State law (CRS 30-28-133(3)) which requires that local governments "shall not approve an application for a development permit unless…the applicant has satisfactorily demonstrated that the proposed water supply will be adequate."

The ongoing update to the comp plan will further these efforts by specifically including water usage policies based on input from the public in 2019.

Building Codes

The Jefferson County Building Department enforces building codes in Jefferson County. Listed below are the codes effective January 2019.

- 2018 International Building Code
- 2018 International Residential Code
- 2018 International Fuel Gas Code
- 2018 International Mechanical Code
- 2018 International Plumbing Code
- 2018 International Existing Building Code
- 2018 International Energy Conservation Code
- 2020 National Electrical Code

In addition, the County has adopted an addendum to the 2018 Jefferson County Code Supplement - Appendix Z - Special Building Construction Regulations in Wildfire Zone 1 - Effective Date January 1, 2020. All adopted building codes can be accessed at https://www.jeffco.us/2055/Adopted-Building-Codes. Local fire districts have individual authority to enforce fire code standards beyond the County's requirements.

Climatic and Geographic Design Criteria: The updated Climatic and Geographic Design Criteria for 2018 includes building standards for wind design (including wind speeds, special wind regions, and wind-borne debris), snow load, seismic design, temperature extremes, and flood hazards. The code contains provisions for additional criteria to be established by the local jurisdiction.

Wildfire: Jefferson County has two wildfire hazard overlay zones that have mitigation requirements for construction. The wildfire hazard overlay zones line generally follow what is called the "mountain front." The State Forest Service concurs that this line indicates the predominant change from plain to mountain topography. The canyons are within wildfire zone 1 because of the chimney-effect of the terrain. The location of the wildfire zone line recognizes vegetation, slope, fire department accessibility, water supply, response time and infrastructure.

R901.1.1.1 Buildings located in more than one Wildfire Zone: A building or structure which is located partly in one Wildfire Zone and partly in another shall be considered to be in the Wildfire Zone in which more than one-half of its total floor area is located.

R901.1.1.2 Moved buildings: Any building or structure moved within or into any Wildfire Zone shall be made to comply with all the requirements for new buildings in that Wildfire Zone.

R901.1.2.1 General: Buildings hereafter erected, constructed, enlarged, altered, repaired or moved into Wildfire Zone 1 shall comply with the following: 2015 IRC Supplement Jefferson County, Colorado Page 20 of 35

R901.1.3.2 Roof coverings, material Zone 2: Except where this code requires greater protection, roof coverings for new buildings, structures or additions, roof coverings utilized for re-roofing shall be Class A, Class B or Class C, or any other roof covering permitted by this code.

Community Wildfire Protection Plans (CWPPs)

In addition to the building codes and wildfire zones, the County has a number of Community Wildfire Protection Plans (CWPPs) that assess wildfire risk and provide specific recommendations for mitigation based on scientifically sound wildfire management principles. In general, these plans are consistent with the National Fire Plan (2000) and the Healthy Forests Restoration Act (2003) both of which are federal level frameworks for wildfire hazard evaluation and strategic planning. There are several plans which are undergoing an update as of the drafting of this plan.

The following jurisdictions and communities in Jefferson County have CWPPs in place:

- Jefferson County CWPP, ALL (2012)
- City of Golden CWPP (2007)
- Coal Creek Canyon Fire Protection District CWPP (2008)
- Elk Creek Fire Protection District CWPP (2005)
- Evergreen Fire Protection District CWPP (2020)
- Fairmount Fire Protection District CWPP (2007)
- Foothills Fire Protection District CWPP (2020)
- Genesee Fire Protection District CWPP (2008)
- Golden Gate Fire Protection District CWPP (2011)
- Indian Hills Fire Protection District CWPP (2007)
- Inter-Canyon Fire Protection District CWPP (2007)
- Lower North Fork CWPP (2007)
- North Fork Fire Protection District CWPP (2011)
- South Platte CWPP (2007)
- West Metro Fire Protection District CWPP (2006)

Slash Collection Program

Slash is debris, from nature, such as tree limbs, pruning's and pine needles. If not removed, slash can add to potential fire hazards. Wildfires have become more common in Jefferson County and clearing this debris can prevent fire damage to structures and spread of wildfire. In 2015, the County expanded its slash collection program which helps homeowners to mitigate fire risk by collecting and removing loads of slash at predetermined collection sites around the County. The cost to drop off a single truckload is $20 (2015) and is used to partially cover the administrative costs of the program. Locations and dates of collection sites are updated and posted at: ***https://www.jeffco.us/2493/Slash-Collection***

Foundations and Soils Investigation

The Designated Dipping Bedrock Area is determined by the Planning and Zoning Department. The building codes identify specific pier length, as well as diameter and support penetration for building in dipping bedrock areas. The codes also identify specifications for foundation walls and structural basement floors.

Flood Loads

Planning and Zoning Department approval required pursuant to other County regulations.

Floodplain Management

In accordance with the National Flood Insurance Act of 1968 and the Flood Disaster Protection Act of 1973, Jefferson County has applied and subsequently qualified for participation in the National Flood Insurance Program. Jefferson County joined the NFIP on August 5, 1986 and the Community Rating System (CRS) on October 1, 2005. Detailed information on the Jefferson County and its communities' participation in CRS can be found below in Section 2.7.4.

The County requires developments that impact floodplains to comply with the floodplain regulations of the Zoning Resolution and Regulation. Although in many circumstances it may be desirable to leave the floodplain in its natural state, it is evident that development in areas encumbered by floodplains often results in alterations within the floodplain limits. The County has adopted floodplain regulations as part of its Zoning Resolution and Regulation. These regulations should be referenced when alterations within floodplains are proposed.

Stormwater Management

Jefferson County is responsible for the stormwater quality that drains from property into the storm sewer system and discharges to state waters. As part of the Stormwater Phase II Regulations, Jefferson County must apply to the State of Colorado Department of Public Health and Environment for a Municipal Separate Storm Sewer System (MS4) Permit. The five-year permit was first granted to Jefferson County in March 2003. Under this permit, Jefferson County is mandated to improve the quality of stormwater.

Jefferson County has created stormwater management regulations. These regulations together with all future amendments are known as the "Jefferson County Storm Drainage Design and Technical Criteria" adopted March 24th, 2009 and referenced in the Jefferson County Land Development Regulation. The criteria apply to all lands within the unincorporated areas of the County, including all public lands. A revision to this document was published on December 17, 2019. Policies and technical criteria not specifically addressed in these criteria will follow the provisions of the Mile High Flood District "Urban Storm Drainage Criteria Manual."

Stormwater runoff is a by-product of urbanization. Drainage planning is required for all new developments. These plans define major drainage facilities, including those that are required public improvements for new developments. Drainage reports and plans, construction drawings, specifications, and as-built information will be submitted and approved as required by the Regulation and Building Permit Procedure. AutoCAD example drawings are available from the County at:

https://www.jeffco.us/2629/Storm-Drainage-Design-Technical-Criteria

For drainage basins less than five square miles, a two-hour storm distribution without area adjustment of the point rainfall values will be used for the Colorado Urban Hydrograph Profile. For drainage basins between five and ten square miles, a two-hour storm distribution is used but the incremental rainfall values are adjusted for the large basin area in accordance with suggested procedures in the NOAA Atlas for Colorado.

Wildfire Hazard Overlay District Zoning Resolution – Section 39 of Jefferson County Zoning Resolution (2020)

This District is intended to promote the public health, safety and welfare of the citizens of Jefferson County, minimize the risk of loss of life and property in Wildfire Hazard Overlay Zone District; encourage and regulate prudent land use in the Wildfire Hazard Overlay Zone District so as not to increase the danger to the public health, safety and property; reduce the demands for public expenditures for relief and protection of structures and facilities permitted in the Wildfire Hazard Overlay Zone District; regulate buildings and structures so as to minimize the hazard to public health, safety, welfare, and to public or private property.

No building permit may be issued for a new dwelling, the replacement of an existing dwelling, or for additional space of 400 square feet or more (cumulatively measured) from May 21, 2002, the date of this regulation's adoption, until written evidence has been submitted and approved by the Zoning Administrator or his/her appointed designee stating that the following have been satisfied:

- Defensible space and associated fuel break thinning's have been created around the dwelling, or a wildfire mitigation site plan has been reviewed and a special exception granted by the Board of Adjustment for the property for which a building permit has been requested.
- Access standards as specified in the General Provisions and Regulations section of the Zoning Resolution have been satisfied.

Grading, Erosion, and Sediment Control Regulation – Section 17 of the Jefferson County Land Development Regulation

Grading, erosion, and sediment control plans shall be submitted as required by the Submittal Requirements Section in accordance with the following standards.

- The existing and final contours shall be shown at 2-foot intervals for subdivisions within the plains area and contours at 5-foot intervals for subdivisions within the mountain areas including the method utilized to obtain all contour intervals. Contours shall be accurate to within 0.5 contour. Elevations shall be based on USGS sea level datum. The USGS quad maps shall not be accepted as evidence for topographic contours.
- Grading, erosion and sediment control plans shall be prepared in accordance with and in compliance with the standards in the Land Disturbance Section of the Zoning Resolution.
- Grading, erosion and sediment control plans must include the following:
  - Plans for all private and public streets/roads in accordance with the Roadway Design and Construction Manual and the Circulation Section.

  - Conceptual driveway plans if existing slopes exceed 30%.
  - Overlot grading plans for all non-residential, multi-family, manufactured home developments, and single-family residential developments with lot sizes under ½ acre. Overlot grading plans are not required for single-family residential lots over ½ acre in size if the developer is not proposing Overlot grading, grading is not required and/or shown on the drainage plan, and the slopes in the buildable areas do not exceed 30%. Overlot grading plans must be consistent with the grading and basin boundaries shown on the drainage plan.
  - Plans for all drainage improvements including but not limited to detention/ water quality facilities, drainage channels, storm sewer, and outlet protection.
  - Grading, erosion and sediment control plans for each lot in residential developments with lot sizes under ½ acre shall be prepared in accordance with and in compliance with the Notice of Intent standards in the Land Disturbance Section of the Zoning Resolution.

- Approvals: The Planning and Zoning Division shall approve the plans prior to development approval. The Jefferson Conservation District shall approve the seed mix and mulching rates.

The intent of these specifications is to ensure excavation and grading occur according to the approved plan and to establish minimum materials, methods, and standards to be used in the construction of site grading fills for support of residences and other structures, embankments or excavations for streets, roads, drainage channels, structures, or other purposes. The work covered by these specifications includes excavation, embankment, grading, compaction, clearing and grubbing, removal of topsoil, trees, stumps, vegetation, removal and/or resetting of minor obstructions, and any other work incidental to the construction of site grading fills.

Geologic and Geotechnical Regulations – Section 25 of the Jefferson County Land Development Regulation

The geologic and geotechnical standards were adopted to protect lots, tracts, and structures from geologic hazards, including, but not limited to, dipping bedrock, rockfall, potentially unstable slopes, swelling soils, and subsidence. Buildable areas within lots, tracts, and areas designated for streets/roads and drainage improvements shall be:

- Reasonably free from geologic hazards or adequately mitigated from geologic hazards.
- Free of adverse soil conditions, constructed away from adverse soil conditions, or constructed in areas where adverse soil conditions have been abated.
- All areas which fall within the Dipping Bedrock Overlay District shall be subject to the restrictions in the Dipping Bedrock Overlay District of the Jefferson County Zoning Resolution.

Detailed grading plans shall be submitted which show overburden soil or fill at least ten (10) feet thick beneath the anticipated level of the bottom of the structure foundation(s) and the top of bedrock. If deep (pier) foundations are proposed, the Zoning Administrator may require a review of such plans by the Engineering Advisory Board.

Or: If ten (10) feet of overburden or fill are not proposed, detailed engineering plans shall be submitted to the Engineering Advisory Board. The alternate mitigation plans shall contain the information necessary to determine that potential hazards can be adequately mitigated by other methods.

Land Disturbance Regulation – Section 16 of the Jefferson County Zoning Resolution

The purpose of the Land Disturbance Section is to:

- Enhance the quality of water in the County's drainage ways and surface waters;
- Protect life, property, and the environment from loss, injury, and damage by stormwater runoff, erosion, sediment transport, ponding, flooding, landslides, accelerated soil creep, settlement and subsidence, excessive dust, and other potential hazards caused by grading, construction activities, and denuded soils;
- Allow a temporary land use for land disturbance activities; and
- Establish performance standards to:

  - Define grading, drainage, erosion and sediment control, and waste disposal requirements;
  - Ensure mitigation of adverse impacts; and (orig. 10-12-04)

- Ensure the reclamation of disturbed land. (orig. 10-12-04)

All land disturbance activities must conform to the performance standards as detailed in this Section. These standards apply whether or not a grading permit or Notice of Intent is required.

It shall be unlawful for any person, firm or corporation to do or authorize any land disturbance in the unincorporated area of Jefferson County without first obtaining a grading permit from the County or submitting a Notice of Intent to the County to authorize temporary land disturbance activities unless specifically exempted by this section. The applicant, the landowner, and the contractor are responsible if a land disturbance activity is undertaken in contravention of the performance standards, or if a land disturbance activity is undertaken beyond the scope of the grading permit or Notice of Intent without County approval. Land disturbance activities must be completed in compliance with the approved plans.

Roadway Design and Construction Regulations

Jefferson County has adopted a Major Thoroughfare Plan based on traffic volumes, existing land use and anticipated growth. The Major Thoroughfare Plan designates streets/roads as freeway, parkway, arterial (principal and minor), or collector.

Jefferson County has also adopted a Roadway Design and Construction Manual (2009) that provides geometric standards for construction, reconstruction and rehabilitation of roadway and transportation facilities. The County also supplies AutoCAD format drawings for template examples on the County website.

2.7.2 Administrative/Technical Mitigation Capabilities

Table 2-10 identifies the County personnel responsible for activities related to mitigation and loss prevention in Jefferson County.

Table 2-10 Administrative and Technical Mitigation Capabilities

Personnel Resources	Jefferson County	Arvada	Edgewater	Golden	Lakewood	Morrison	Wheat Ridge
Planner/engineer with knowledge of land development/land management practices	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Planner/engineer/scientist with an understanding of natural hazards	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Resiliency Planner	No	Yes	No	No	Yes	Yes	No
Transportation Planner	Yes	Yes	Yes	No	Yes	Yes	Yes
Engineer/professional trained in construction practices related to buildings and/or infrastructure	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Personnel skilled in GIS	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Full time building official	Yes	Yes	Yes	Yes	Yes	No	Yes
Floodplain manager	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Emergency manager	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Grant writer	Yes	Yes	No	No	Yes	Yes	No

Personnel Resources	Jefferson County	Arvada	Edgewater	Golden	Lakewood	Morrison	Wheat Ridge
Other personnel	Yes	Yes	No	Yes	No	Yes	Yes
GIS Data Resources (Hazard areas, critical facilities, land use, building footprints, etc.)	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Mass/Emergency Notification Systems (Reverse 9-11, etc.)	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Other	Sustainability Coordinator, Operations Coordinator (assigned to emergency ops, stormwater, debris management) & Forester (Forest health and fuel mitigation)			Homeless Navigator – Homeless liaison to mitigate and facilitate impacts to the homeless population		Town Clerk	Parks & Recreation and Public Works Staff

Source: HMPC

2.7.3 Fiscal Mitigation Capabilities

Table 2-11 identifies financial tools or resources that the County and municipalities have used in the past to fund mitigation activities, and highlights resources that may not have been used but are available for future use.

Table 2-11 Financial Capabilities That Have Been Used to Fund Mitigation Activities

Financial Resources	Jefferson County	Arvada	Edgewater	Golden	Lakewood	Morrison	Wheat Ridge
Community Development Block Grants	Yes	Yes	No, but available	No, but available	No, but available	Yes	Yes
Capital improvements project funding	Yes	Yes	Yes	No, but available	No, but available	Yes	Yes
Authority to levy taxes for specific purposes	Yes	No	No, but available	No, but available	No, but available	Yes	Yes
Fees for water, sewer, gas, or electric services	No	Yes	Yes	No, but available	No, but available	Yes	No
Stormwater Service Fees	No	Yes	No	Yes	Yes	No	No
Impact fees for new development	Yes	Yes	No	No, but available	No	Yes	Yes

Financial Resources	Jefferson County	Arvada	Edgewater	Golden	Lakewood	Morrison	Wheat Ridge
Incur debt through general obligation bonds	Yes	No	No, but available	No, but available	No, but available	Yes	Yes
Incur debt through special tax bonds	Yes	No	No, but available	No, but available	No	Yes	Yes
Incur debt through private activities	No	Yes	No	No, but available	No	Yes	Yes
Withhold spending in hazard prone areas	No	No	No	No, but available	No	Yes	No

Source: HMPC

2.7.4 Other Mitigation Efforts

Public Education and Outreach

Successful sustained mitigation depends upon robust collaboration between the public and private sector, different levels of government, municipal jurisdictions, departments, agencies, and community groups within Jefferson County. The participating jurisdictions have several active public education programs to educate the public about hazards and actions they can take to mitigate against those hazards, as shown in

Table 2-12 Education & Outreach Capabilities

Education & Outreach Capabilities	Jefferson County	Arvada	Edgewater	Golden	Lakewood	Morrison	Wheat Ridge
Local Citizen Groups That Communicate Hazard Risk	Yes	Yes	No	Yes	Yes	Yes	No
Firewise	Yes	No	No	Yes	No	No	No
StormReady	Yes	Yes	No	Yes	Yes	No	No
Other?		Yes[1,2]			Yes[2]	Yes[3]	No

Notes: 1- Ready, Set, Go! Program; 2 –Community Emergency Response Team (CERT); 3 – Annual Public Works pick up slash and limbs for residents free of charge, Annual Town Clean-Up Day where access to dumpsters is provided to residents free of charge for the disposal of any/all trash including tree limbs, etc.

Wildland Risk Reduction Task Force

To ensure a thoughtful, collaborative approach to addressing the risk of wildfires in Jefferson County, in November 2019 the Board of County Commissioners established the Jefferson County Wildfire Risk Reduction Task Force. Members represent community leaders, fire rescue districts, county government, law enforcement, business, forestry, water districts, and others – as well as geographic diversity. After in-depth discussion and a prioritization process, task force members identified three goals:

- Mitigation
- Community education (to raise awareness about mitigation)
- Revenue streams (to fund more mitigation)

Other issues such as fire suppression, evacuation routes and emergency notification also were raised.

The Task Force's recommendations report *Working Together to Reduce the Risk of Wildfire in Jefferson County* released on November 10, 2020, opens by noting that "Investment upfront in mitigation and community education can save lives, property and firefighting costs later." The Task Force Mitigation Team identified defensible space and forest management as key mitigation activities, and made a number of recommendations. Implementing these recommendations has been adopted as Objective 3g, and several recommendations been incorporated into the Mitigation Action Plan in Section 5.4.

National Flood Insurance Program (NFIP) and the Community Rating System (CRS)

Jefferson County has been mapped for flood hazards and participates in the National Flood Insurance Program (NFIP). Details of local jurisdiction participation status, policy and claims data from the NFIP's Community Information System (CIS) are shown in Table 2-13.

Table 2-13 Communities Participating in the FEMA NFIP

CID	Community	Initial FIRM Identified	Current Effective Map Date	Policies in Force	Total Coverage	# of Claims Paid	Total Losses Paid
080087	Jefferson County	08/05/1986	01/15/2021	409	$111,193,700	138	$1,407,173
085072	City of Arvada	07/01/1974	01/15/2021	359	$95,813,400	71	$66,412
080089	City of Edgewater	08/15/1989	02/05/2014	32	$8,709,500	27	$51,637
080090	City of Golden	05/18/1985	12/20/2019	88	$25,874,000	14	$48,938
085075	City of Lakewood	12/31/1974	02/05/2014	344	$104,242,800	157	$649,523
080092	Town of Morrison	12/01/1982	02/05/2014	7	$2,481,300	2	$1,232
085079	City of Wheat Ridge	05/26/1972	02/05/2014	219	$54,870,100	45	$97,251
Total				**1,458**	**$403,184,800**	**454**	**$1,022,166**

Source: FEMA, Current as of April 1, 2021

In addition to participating in the NFIP, Jefferson County, the Cities of Arvada, Golden, Lakewood, and Wheat Ridge, and the Town of Morrison all participate in the Community Rating System (CRS). CRS is a voluntary program for NFIP participating communities focused on reducing flood damages to insurable property and encouraging a comprehensive approach to floodplain management. The CRS provides incentives in the form of insurance premium discounts to communities that go above and beyond the minimum floodplain management requirements and develop extra measures to reduce flood risk. There are 10 CRS classes, and the classification determines the insurance premium discount for policyholders, as shown in Table 2-14.

Table 2-14 CRS Premium Discounts

Class	Discount	Class	Discount	
1	45%	6	20%	**SFHA (Zones A, AE, A1-A30, V, V1-V30, AO, and AH): Discount varies depending on class. SHFA (Zones A99, AR/A, AR/AE. AR/A1-A30, AR/AH, and AR/AO): 10% discount for Classes 1-6; 5% discount for Classes 7-9. Non-SFHA (Zones B, C, X, D): 10% discount for Classes 1-6; 5% discount for Classes 7-9. In determining CRS premium discount, all AR and A99 Zones are treated as non-SFHAs.**
2	40%	7	15%	
3	35%	8	10%	
4	30%	9	5%	
5	25%	10	--	

Source: FEMA CRS Coordinators Manual

All CRS participating communities start out with a Class 10 rating (which provides no premium discount). Class 1 requires the most credit points and offers the largest premium discount. Within the CRS program,

there are 18 activities recognized as measures for eliminating local exposure to flooding. Credit points are assigned to each activity, which have been organized under four main categories:

- Public Information
- Mapping and Regulation
- Flood Damage Reduction
- Flood Preparedness

The participating communities and their relative CRS classes and discounts are summarized in Table 2-15 below. Since 2010, the County has made significant progress in implementing flood capabilities, which is reflected in the updated Community Rating System (CRS) classification. Unincorporated Jefferson County went from CRS 9 to 6 in 2014, a 3 class increase which results in a 20% discount (previously 5%) for flood insurance policies in SFHA, and 10% premium reduction (previously 5%) for non-SFHA policies.

Table 2-15 Current CRS Participation and Summary Information

Community	Current Rating	Policies	Total Premiums	Discount	Current Annual Saving
Jefferson County	5	409	$373,384	25%	$82,904
Arvada	5	359	$491,302	25%	$138,434
Wheat Ridge	5	219	$237,721	25%	$62,731
Lakewood	6	344	$339,271	20%	$57,588
Golden	7	88	$90,692	15%	$12,041
Morrison	8	7	$61,036	10%	$6,782

Source: FEMA CRS

Code RED

Jefferson County participates in the Code RED emergency communications network which is a service that places calls, texts and/or emails to subscribers within the direct path of the storm in the event of a severe weather alert from the National Weather Service. Notifications are sent in an effort to provide residents extra time to prepare that could save lives. Types of alerts include tornado warnings, severe thunderstorm warnings, flash flood warnings, tsunami warnings and winter storm warnings.

2.7.5 Opportunities for Enhancement

Based on the capability assessment, Jefferson County has several existing mechanisms in place that already help to mitigate hazards, including numerous planning tools and many available funding mechanisms. The tables above show a consistently high level of capabilities across the County and participating jurisdictions, to include adoption of building codes, floodplain regulations, and CRS participation.

There are also opportunities for the County to expand or improve on its capability to further protect the community. Opportunities include the continuation of incorporating updated risk information into updates of the County's Comprehensive Plan and other regulatory documents. As well as ensuring risk information is taken into consideration in the Land Use Code updates and during the development review process. Jefferson County has a very active Local Emergency Planning Committee (LEPC), which can help coordinate mitigation goals and programs.

The HMPC recognizes that lack of implementation of the 2016 Plan over the past five years has limited the effectiveness of a sustained mitigation program. The County and jurisdictions have committed to improving this going forward, as described in Section 6.

An additional opportunity for capability enhancement includes leveraging ongoing recovery efforts to implement a focus on working with impacted community members to further identify ways to create equitable processes and policies for disaster management and decrease barriers to resources for marginalized and underserved communities that are traditionally disproportionately affected by a crisis.

Another opportunity being considered to reduce flood losses is for jurisdictions within Jefferson County that participate in the Community Rating System (CRS) to work towards increasing their rating. As discussed in Table 2-13, there are already several jurisdictions, including Jefferson County, who are participants in the CRS program. For each jurisdiction, the annual savings to their flood insurance policyholders is shown in Table 2-15 above.

Table 2-16 shows the potential annual savings to policyholders for each CRS Rating, along with the current ratings and savings for comparison. Improving a communities standing in the CRS program must be based on balancing those benefits against the staff time and jurisdictional commitments required to achieve and maintain certification, however, as summarized below the potential savings for each community could be in the tens of thousands of dollars.

Table 2-16 Potential Benefits of CRS Ratings By Jurisdiction

Community	Class 9 Annual Savings	Class 8 Annual Savings	Class 7 Annual Savings	Class 6 Annual Savings	Class 5 Annual Savings	Class 4 Annual Savings	Class 3 Annual Savings	Class 2 Annual Savings	Class 1 Annual Savings
Jefferson County	$18,096	$33,667	$49,237	$67,333	$82,904*	$98,475	$114,046	$129,617	$145,187
Arvada	$28,706	$55,713	$82,720	$111,427	$138,434*	$165,441	$192,448	$219,455	$246,462
Edgewater	$2,589	$4,927	$7,264	$9,853	$12,190	$14,528	$16,865	$19,202	$21,539
Golden	$4,505	$8,273*	$12,041	$16,546	$20,314	$24,082	$27,850	$31,617	$35,385
Lakewood	$15,200	$28,794	$42,388	$57,588*	$71,182	$84,776	$98,369	$111,963	$125,557
Morrison	$3,391	$6,782*	$10,173	$13,564	$16,954	$20,345	$23,736	$27,127	$30,518
Wheat Ridge	$13,986	$25,572	$37,159	$51,145	$62,731*	$74,318	$85,904	$97,491	$109,077

Source: FEMA, as of 4/19/2021; * indicates current savings based on 2020 CRS status.

3 Planning Process

Requirements §201.6(b) and §201.6(c)(1) of the 2000 Disaster Mitigation Act (DMA): An open public involvement process is essential to the development of an effective plan. In order to develop a more comprehensive approach to reducing the effects of natural disasters, the planning process shall include:

1) *An opportunity for the public to comment on the plan during the drafting stage and prior to plan approval;*
2) *An opportunity for neighboring communities, local and regional agencies involved in hazard mitigation activities, and agencies that have the authority to regulate development, as well as businesses, academia, and other private and nonprofit interests to be involved in the planning process; and*
3) *Review and incorporation, if appropriate, of existing plans, studies, reports, and technical information.*

The plan shall document the planning process used to develop the plan, including how it was prepared, who was involved in the process, and how the public was involved.

3.1 Background on Mitigation Planning in Jefferson County

The primary purpose of the Jefferson County Hazard Mitigation Plan (HMP) update is to reduce or eliminate long-term risk to people and property from natural and human-caused hazards and their effects on the Jefferson County planning area. Recognizing the importance of hazard mitigation planning, Jefferson County and the cities of Arvada, Lakewood and Wheat Ridge participated in the 2003 Denver Regional Council of Governments (DRCOG). In order to develop a more specific risk assessment, goals, and mitigation projects, the County and the jurisdictions noted previously, developed their own Jefferson County specific multi-jurisdictional plan in 2009-2010 with an additional ten jurisdictions participating in the planning process. In 2015-2016 the plan underwent a comprehensive five-year update as required by the DMA.

The Hazard Mitigation Plan (HMP) underwent a comprehensive update in 2021. The planning process followed during the update was similar to what was used in the original plan development. This planning process utilized the input from a multi-jurisdictional Hazard Mitigation Planning Committee (HMPC). A consultant, Wood Environment & Infrastructure Solutions, Inc (Wood) was hired to assist with the update in 2021. The plan update process is described further in this section and documented in Appendix C.

Jefferson County and its communities has been an integral constituent in nurturing partnerships across boundaries for decades. This proactive approach established the County as a leader to the Front Range communities for hazard mitigation and overall emergency management program planning. This plan builds from the accumulated efforts of previous planning mechanisms that clearly align with the planning regulations set forth by the Disaster Mitigation Act of 2000 (DMA).

3.2 What's New in the Plan Update

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

This HMP update involved a comprehensive review and update of each section of the 2016 plan and includes an assessment of the progress of the participating communities in evaluating, monitoring and implementing the mitigation strategy outlined in the initial plan. Only the information and data still valid from the previous plan was carried forward as applicable into this HMP update.

One significant change to the 2021 plan update process was the inclusion of five new participating jurisdictions, each listed below under Section 3.3 Local Government Participation. Three jurisdictions (Lakeside, Mountain View, and Pleasant View Metropolitan District) that participated in 2016 chose not to patriciate in the 2021 plan update due to other priorities and limited resources.

Wood developed a summary of each section in the plan and guided the HMPC through the elements that needed updating during the kickoff meeting in December 2020. This included analyzing each section using FEMA's local plan update guidance (2013) as well as guidance from the National Flood Insurance (NFIP) Community Rating System (CRS), to ensure that the plan met the latest requirements. The HMPC and Wood determined that nearly every section of the plan would need revision to align the plan with the latest FEMA planning guidance and requirements. A summary of the changes in this plan update is highlighted in the table below.

Table 3-1 Jefferson County Hazard Mitigation Plan Update Highlights

Plan Section	Summary of Plan Review, Analysis, and Updates
1. Introduction	Added an Executive Summary section. Verified/updated purpose, scope, etc. Updated Background.
2. Community Profile	Updated demographic, social & economic data, including the results of any recent annexations or new development. Expanded on social vulnerability analysis. Moved capability assessment section here (previously in Risk Assessment) and update data using Plan Update Guide.
3. Planning Process	Described and documented the planning process for the 2021 update, including coordination among agencies and integration with other planning efforts. Updated summary of changes. Described any changes in jurisdictional priorities. Described any changes in participation in detail. Described 2021 public participation process.
4. Risk Assessment	Revisited 2016 hazards list for possible modifications including possible human-caused hazards. Reviewed hazards from current Colorado State Hazard Mitigation Plan for consistency. Updated list of disaster declarations to include 2016-2021 data. Updated hazards data to include 2016-2021 data. Updated past occurrences for each hazard to include 2016-2021 data. Incorporated new hazard studies since 2016 and/or CWPPs/wildfire risk mapping. Added information on impacts of climate change on hazard frequency and severity. Updated critical facilities data. Provided/Updated replacement cost details to critical facilities, as data permits. Updated development and land use trends to include Census data, state, county, and local data sources. Updated historic and cultural resources. Updated current property values using 2021 Assessor's data. Estimated flood losses using the latest flood hazard mapping and building counts and values. Updated NFIP data, CRS information, and Repetitive Loss data. Incorporated new hazard loss estimates since 2016, as applicable. Examined changes in growth and development will be examined; especially changes in the context of hazard-prone areas and how the changes may affect loss estimates and vulnerability. Conducted a HAZUS-MH Level I earthquake vulnerability analysis. Updated information regarding specific vulnerabilities to hazards, including maps and tables of specific assets at risk, specific critical facilities at risk, and specific populations at risk including social vulnerability. Updated maps in plan where appropriate Moved Capability Assessment to community profile section and update.
5. Mitigation Strategy	Updated based on the results of the updated risk assessment, completed mitigation actions, and implementation obstacles and opportunities over the last five years.

Plan Section	Summary of Plan Review, Analysis, and Updates
	Reviewed goals and objectives to determine if they are still representative of the County's mitigation strategy, and update/revise as needed. Reviewed mitigation actions from the 2016 plan and develop a status report for each; identify if action has been completed, deleted, or deferred. Updated section on progress made since 2016 to include activities other than 2016 actions. Identified and detail new mitigation actions for all participating jurisdictions. Identified projects that have been submitted for funding and those that will be likely candidates for this funding.
6. Plan Maintenance	Moved to Planning Process section; Kept adoption resolutions in Appendix.
Jurisdictional Annexes	Updated previous participants' annexes with recent Census data. Updated past event history and hazard loss estimates. Added new maps and updated old maps as needed. Updated mitigation actions from 2016 and added new mitigation actions.
Appendices	Updated as needed

3.3 Local Government Participation

44 CFR Requirement §201.6(a)(3): Multi-jurisdictional plans may be accepted, as appropriate, as long as each jurisdiction has participated in the process and has officially adopted the plan.

The DMA planning regulations and guidance requires each local government seeking FEMA approval of its mitigation plan must participate in a planning process effort in the following ways:

- Participate in the process as part of the Hazard Mitigation Planning Committee (HMPC),
- Differentiate geographical locations or jurisdictions within the planning area where the hazard risk differs from that facing the entire planning area,
- Identify mitigation projects, specific to each jurisdictional entity, to be eligible for funding, and
- Engage the governing body for formal adoption of the plan.

For the Jefferson County HMPC, "participation" meant:

- Attending and participating in the HMPC meetings,
- Providing available data requested of the HMPC,
- Reviewing and providing comments on the plan drafts,
- Collecting and providing other requested data (as available);
- Managing administrative details;
- Making decisions on plan process and content;
- Identifying mitigation actions for the plan;
- Reviewing and providing comments on plan drafts; including annexes
- Informing the public, local officials, and other interested parties about the planning process, and providing opportunity for them to comment on the plan;
- Coordinating, and participating in the public input process; and
- Coordinating the formal adoption of the plan by the governing boards.

The County and all jurisdictions with annexes to this plan seeking FEMA approval met all of these participation requirements. In most cases, one or more representatives for each jurisdiction attended the HMPC meetings described in Appendix B and also brought together a local planning team to help collect data, identify mitigation actions and implementation strategies, and review and provide data on plan drafts. Appendix C provides additional information and documentation of the planning process.

3.4 The 10-Step Planning Process

Wood established the planning process for Jefferson County's plan using DMA planning requirements and FEMA's associated guidance. This guidance is structured around a four-phase process:

1. Organize Resources
2. Assess Risks
3. Develop the Mitigation Plan
4. Implement the Plan and Monitor Progress

Into this four-phase process, Wood integrated a more detailed 10-step planning process used for FEMA's Community Rating System (CRS) and Flood Mitigation Assistance programs. Thus, the modified 10-step process used for this plan meets the funding eligibility requirements of the Hazard Mitigation Assistance grants (including Hazard Mitigation Grant Program, Building Resilient Infrastructure and Communities grant, High Hazard Potential Dams grant, and Flood Mitigation Assistance grant), Community Rating System, and the flood control projects authorized by the U.S. Army Corps of Engineers (USACE). Jefferson County, the City of Arvada, Golden, Lakewood, Wheat Ridge, and the Town of Morrison participate in the CRS, and thus could potentially earn planning credits from the development of this plan. Table 3-2 shows how the modified 10-step process fits into FEMA's four-phase process, and how these elements correspond to the tasks in the FEMA "Mitigation Planning Handbook."

Table 3-2 Jefferson County Hazard Mitigation Planning Process

FEMA's 4-Phase DMA Process	Modified 10-Step CRS Process	FEMA Local Mitigation Planning Handbook Tasks
1) Organize Resources		
201.6(c)(1)	1) Organize the Planning Effort	1: Determine the planning area and resources
201.6(b)(1)	2) Involve the Public	2: Build the planning team - 44 CFR 201.6 (C)(1)
201.6(b)(2) and (3)	3) Coordinate with Other Departments and Agencies	3: Create an outreach strategy - 44 CFR 201.6(b)(1)
		4: Review community capabilities - 44 CFR 201.6 (b)(2)&(3)
2) Assess Risks		
201.6(c)(2)(i)	4) Identify the Hazards	5: Conduct a risk assessment - 44 CFR 201.6 (C)(2)(i) 44 CFR 201.6(C)(2)(ii)&(iii)
201.6(c)(2)(ii)	5) Assess the Risks	
3) Develop the Mitigation Plan		
201.6(c)(3)(i)	6) Set Goals	6: Develop a mitigation strategy - 44 CFR 201.6(c)(3)(i); 44 CFR 201(c)(3)(ii) and 44 CFR 201.6(c)(3)(iii)
201.6(c)(3)(ii)	7) Review Possible Activities	
201.6(c)(3)(iii)	8) Draft an Action Plan	
4) Implement the Plan and Monitor Progress		
201.6(c)(5)	9) Adopt the Plan	7: Review and adopt the plan

FEMA's 4-Phase DMA Process	Modified 10-Step CRS Process	FEMA Local Mitigation Planning Handbook Tasks
201.6(c)(4)	10) Implement, Evaluate, and Revise the Plan	8: Keep the plan current
		9: Create a safe and resilient community - 44 CFR 201.6(c)(4)

3.4.1 Phase 1: Organize Resources

Planning Step 1: Organize the Planning Effort

The Jefferson County Sheriff's Office of Emergency Management (OEM) worked to establish the framework and organization for the development of the plan update. This process began with the FEMA planning grant application in 2018. Participating jurisdictions indicated their commitment to participate as evidenced by executing a letter of commitment as a component of the FEMA planning grant. Award of the grant in October 2019 allowed the planning consultant, Wood, to be procured through a competitive bid process.

Wood worked with the County to get organized for the plan update. Organizational efforts were initiated with the County and participating jurisdictions in December 2020 to inform and educate the plan participants of the purpose and need for updating the countywide hazard mitigation plan. An initial meeting between Wood and County OEM was held to discuss the organizational aspects of this plan update process. Invitations to the kickoff meeting for this plan update were extended to key County departments, the eight incorporated communities, and representatives from special districts for the County and municipalities, as well as to other federal, state, and local stakeholders that might have an interest in participating in the planning process. Representatives from participating jurisdictions and HMPC members to the 2016 plan were used as a starting point for the invite list, with additional invitations extended as appropriate throughout the planning process. The list of initial invitees is included in Appendix C.

Key stakeholders were identified including representatives from the various county departments, each municipal jurisdiction, and other state and local government agencies. An email was sent from County OEM to describe the upcoming mitigation planning efforts and invite potential members to participate in a kickoff meeting where the HMPC would be formally organized. Suggested representation from each municipality included city/town manager, emergency manager, floodplain manager, public works/engineering, building department and fire department/district representative. Table 3-3 lists the HMPC participants and their respective jurisdiction in the development of the plan. Other stakeholders that participated in the planning process are discussed under Planning Step 3: Coordinate with Other Departments and Agencies.

In the 2020-2021 plan update, the following communities and jurisdictions participated in the process.

Lead Jurisdiction

- Jefferson County

Municipalities

- City of Arvada
- City of Edgewater
- City of Golden
- City of Lakewood
- City of Wheat Ridge
- Town of Morrison

Special Districts

- Denver Water
- Arvada Fire Protection District (New)
- Elk Creek Fire Protection District (New)

- Evergreen Fire Protection District
- Fairmount Fire Protection District
- Foothills Fire Protection District (New)
- Genesee Fire Protection District (New)
- Golden Gate Fire Protection District (New)
- Indian Hills Fire Protection District
- Inter-Canyon Fire Protection District (New)
- Jefferson Conservation District
- Lookout Mountain Water District
- North Fork Fire Protection District
- West Metro Fire Protection District

The Town of Bow Mar, Town of Lakeside, Town of Mountain View, and Pleasant View Metropolitan District elected not to participate in the Jefferson County multi-jurisdictional planning process. The City of Westminster has its own hazard mitigation plan and did not participate in the Jefferson County multi-jurisdictional planning process since the City lies within both Jefferson and Adams County. The Town of Superior has a portion of their Town in Jefferson County but opted to participate in the Boulder County Hazard Mitigation Plan. The City of Littleton also has a small area in Jefferson County but participated in the Arapahoe County Multi-Hazard Mitigation Plan update.

The Disaster Mitigation Act requires that each jurisdiction participate in the planning process and officially adopt the multi-jurisdictional hazard mitigation plan. A planning committee was created that includes representatives from each participating jurisdiction, departments of the County, and other local, state, and federal organizations responsible for making decisions in the plan and agreeing upon the final contents. Kickoff meeting attendees discussed potential participants and made decisions about additional stakeholders to invite to participate on the HMPC.

The HMPC contributed to this planning process by:

- Providing facilities for meetings,
- Attending meetings,
- Collecting data,
- Managing administrative details,
- Making decisions on plan process and content,
- Submitting mitigation action implementation worksheets,
- Reviewing and editing drafts, and
- Coordinating and assisting with public involvement and plan adoptions

The HMPC was comprised of two groups, a Steering Committee that led the planning and decision-making efforts throughout the planning process, and a Working Group comprised of additional local staff that provided information to the Steering Committee. The Steering Committee is the group responsible for the 10-Step CRS planning process outlined in the 2017 CRS Coordinator's Manual. The Working Group supported the overall HMP process by providing information and data to the CRS Steering Committee for consideration and decision-making. Membership and participation in both the Steering Committee and Working Group are listed in Appendix B.

The HMPC communicated during the planning process with a combination of meetings, phone interviews, and email correspondence. All meetings were held virtually due to social distancing requirements associated with the ongoing COVID-19 pandemic. A folder on Google Drive was hosted by Wood and a SharePoint site hosted by the County were both used to share drafts of the plan and its annexes for jurisdictional review and input. Three planning meetings with the Planning Team were held during the plan's development between December 2020 and February 2021. The meeting schedule and topics are listed in the following table; all 10 planning process steps were covered in these three meetings. Agendas, meeting summaries, and attendance records for each of the meetings are included in Appendix C.

Table 3-3 Schedule of HMPC Meetings

Meeting Type	Meeting Topic	CRS Steps	Meeting Date(s)
HMPC #1 Kick-off Meeting	Introduction to DMA and the planning process Overview of current HMP; Organize Resources: the role of the HMPC, planning for public involvement, coordinating with other agencies/stakeholders Introduction to Hazard Identification	1,2,3	December 7, 2020
HMPC #2 Risk Assessment	Risk assessment overview and work session Development of mitigation goals and objectives;	2,4,5,6	January 11, 2021
HMPC #3 Mitigation Strategy and Goals Update	Identification, prioritization, and status update of mitigation actions; Discussion of process to monitor, evaluate, and update plan	7,8,9,10	February 11, 2021

HMPC Meeting #1 – Kickoff Meeting

On December 7, 2020, the HMPC convened virtually with 85 people participating, to kick off the plan update process. Wood presented information on the scope and purpose of the plan update, participation requirements of HMPC members, and the proposed project work plan and schedule. Plans for public involvement (Step 2) and coordination with other agencies and departments (Step 3) were discussed. Wood also introduced the hazard identification requirements and data. The HMPC discussed past events and impacts and future probability for each of the hazards required by FEMA for consideration in a local hazard mitigation plan. The HMPC made two revisions to the hazards list from the 2016 plan, adding Pandemic and Cyber Attacks. Each jurisdiction provided updates to the plan and their respective annexes via a plan update guide and mitigation action tracker.

HMPC Meeting #2 – Risk Assessment Update

On January 11, 2021, the HMPC convened virtually to review and discuss the results of the risk and vulnerability assessment update (Steps 4 and 5). There were 81 members of the HMPC and stakeholders were present for the discussion. Wood presented the results the risk assessment for natural and human-caused hazards. The group went through each hazard together and discussed the results as well as shared any local insight to inform the HIRA update. Refer to the meeting summary in Appendix C for notes related to each hazard discussed. Some of this discussion was also related to the reviewing and updating the 2015-2016 goals.

HMPC Meeting #3 – Mitigation Strategy and Goals Update

The HMPC convened virtually on February 11, 2021 with 69 people participating to update the plan's mitigation strategy. The group finalized the plan's goals and objectives (Step 6) and discussed the criteria for mitigation action selection and prioritization using a worksheet provided by Wood. The group reviewed each possible new mitigation action and additional details were provided by the Planning Team (Step 7). The meeting ended with a review of the next steps and planning process schedule. Wood provided the Planning Team with a link to an online form to submit new mitigation actions. During the Planning Team review of the full plan, each member was provided a handout on prioritizing new mitigation actions and asked to focus on prioritizing each new mitigation action for their jurisdiction.

Planning Step 2: Involve the Public

Involving the public assures support from the community at large and is a part of the planning process. At the kickoff meeting, strategies to involve the public were discussed for soliciting public input on the mitigation plan and developed an outreach strategy by consensus. The fact that the process was conducted during the COVID-19 pandemic, with attendant restrictions on public gatherings, made it difficult to use many traditional outreach methods such as in-person public gatherings or discussions at other forums. The HMPC adapted by leveraging virtual meetings and other online messaging, which in

many cases resulted in greater public attendance and involvement than more traditional face-to-face meetings. An online public survey was developed by Wood and shared with the Planning Team to share through their respective public information channels. In addition to the online public survey, two virtual public workshops were held in January and June 2021.

These outreach efforts are summarized in Table 3-4 and discussed below.

Table 3-4 Summary of Public Outreach and Involvement Efforts

Event/Effort	Message	Dates	Methods Advertised
Online Public Survey	Personal experience with hazard events; public perception of hazard significance; what mitigation measures should be pursued.	January 6, - January 31, 2021	Website posting, Facebook, Twitter
Public Workshop #1 (virtual)	Overview of mitigation planning and plan update process; introduction to hazards and risk assessment; mitigation goals and objectives.	January 21, 2021	Website posting, Facebook, Twitter, YouTube
Public Workshop #2 (virtual)	Overview of draft plan; solicitation of feedback.	June 8, 2021	Website posting, Facebook, Twitter, YouTube
Public Review Draft	Public review and comment on the draft plan.	June 7-25, 2021	Website posting, Facebook
Virtual Public Room	Virtual room for the public to educate the public on mitigation planning and the 2021 plan update, as well as providing opportunities to review and comment on the draft plan.	June 7-25, 2021	Website posting, Facebook
YouTube	Videos of public workshops posted.	Ongoing	NA
Website notices	Notices of process, survey, public workshops, and public review draft posted at Jeffco.us	December 2020 – June 2021	NA
Facebook posts	Updates on process, survey, public workshops, and public review draft posted on County Facebook page.	December 2020 – June 2021	NA
Twitter posts	Updates on process, survey, public workshops, and public review draft posted on County Twitter account.	December 2020 – June 2021	NA
Newspaper article	Arvada Press article “Working Together to Reduce Wildfire Risk in Jefferson County”	March 16, 2021	NA

Online Public Survey

During the plan update’s initial drafting stage, an online public survey was used to gather public input to the Planning Team. The survey provided an opportunity for public input during the planning process, prior to finalization of the plan update. The survey gathered public feedback on concerns about hazards and input on mitigation strategies to reduce their impacts. The survey was released on January 6, 2021 and closed on January 31, 2021. The Planning Team provided links to the public survey by distributing it using social media, email, and posting the link on websites. A link to the survey was also posted on some of the participating jurisdictions’ websites as well as through social media posts; screenshots from both can be found in Appendix C. A total of 953 people filled out the survey online. Results showed that the public perceives the most significant hazards to be wildfire, drought, hailstorm and pandemic/public health. Question 4 of the survey asked the public’s opinion on what mitigation actions that should have the highest priority in the updated hazard mitigation plan; wildfire fuels treatment projects, forest health/watershed protection, water conservation, evacuation route development and public health incident preparedness were cited as the most popular mitigation actions. This information was shared with the Planning Team during the update of the mitigation strategy to consider when evaluating hazard rankings

and as a source of potential mitigation ideas. A summary of all the survey data and documentation of the public feedback can be found in Appendix D.

Figure 3-1 Hazard Mitigation Planning Survey Link on Jefferson County Twitter

Online Public Workshops

Two online public workshops were held during the planning process to inform the public, receive input to integrate into the plan update, and keep the public updated on the progress being made in the planning process. Both workshops were held virtually as webinars due to social distancing requirements associated with the ongoing COVID-19 pandemic.

The workshop took place on January 14, 2021 through Zoom. The workshop introduced the public to the hazard mitigation planning process for the County's Plan Update and answered any questions and gather public input to be integrated into the plan update. In addition, it was an opportunity to help staff identify risks, hazards and vulnerabilities from the public's perspective. In total 26 individuals participated in the virtual workshop. Members of the public were able to submit comments verbally or via the chat function. The Planning Team received four comments from the meeting that helped to inform the Planning Team on the public initial thoughts on hazard mitigation and hazards in their community. A recording of the meeting was subsequently posted on Jefferson County's YouTube channel, where it has an additional 128 views as of July 1st, 2021.

The second virtual public workshop was held on June 8, 2021, again conducted via Zoom. Eight members of the public attended this meeting, which gave an update on the planning process, reviewed the results of the public survey, and introduced the updated Plan. The purpose, contents, and key components of the updated plan were described, and participants were encouraged to review and comment on the draft plan. A recording of the meeting was subsequently posted on Jefferson County's YouTube channel, where it has an additional 10views as of July 1st, 2021.

Figure 3-2 Public Meeting #1 Screenshot, January 14, 2021

Public Review Period

Following the HMPC draft review a public review draft of the plan was prepared. The public was given an opportunity to provide input on this draft of the complete plan prior to its submittal to the State and FEMA. A virtual public engagement room was created for people to learn about the plan, download and review copies of the draft plan and annexes, and upload comments and feedback using an online survey tool. The draft plan and annexes were also made available on the County's emergency management web page from June 7th–25th, 2021. The comment period was advertised extensively through the jurisdictions' websites and social media accounts. The City of Arvada also made the plan available through their Speak Up Arvada platform. A total of eleven comments were received, which are included in Appendix B. The comments were reviewed with the Planning Team and used to inform revisions to the draft Plan.

Figure 3-3 Virtual Public Engagement Room

Planning Step 3: Coordinate with Other Departments and Agencies

Requirements §201.6(b): [T]he planning process shall include: (2) An opportunity for neighboring communities, local and regional agencies involved in hazard mitigation activities, and agencies that have the authority to regulate development, as well as businesses, academia and other private and non-profit interests to be involved in the planning process. (3) Review and incorporation, if appropriate, of existing plans, studies, reports, and technical information.

There are numerous organizations whose goals and interests interface with hazard mitigation in Jefferson County. Coordination with these organizations and other community planning efforts is vital to the success of this plan update. The Jefferson County Office of Emergency Management invited other local, state, and federal departments and agencies to the kickoff meeting to learn about the hazard mitigation planning initiative. Many of the agencies participated throughout the planning process in meetings described in Step 1: Organize the Planning Effort.

Stakeholders include local and regional agencies involved in hazard mitigation activities or those beyond the County and local government that have the authority to regulate development. Stakeholders could participate in various ways, either by contributing input at HMPC meetings, being aware of planning activities through an email group, providing information to support the effort, or reviewing and commenting on the draft plan. Based on their involvement in other hazard mitigation planning efforts, and status in the County, representatives from the following agencies and organizations were invited to participate as stakeholders in the process; an asterisk indicates they participated in HMPC meetings:

- Special Districts
  - Mile High Flood District*
  - Evergreen Metropolitan District*
- Neighboring county/municipality emergency management and floodplain management
  - Adams County*
  - Arapahoe County
  - Boulder County
  - Broomfield County*
  - Clear Creek County
  - Denver City and County
    - Denver Mountain Parks*
  - Douglas County
  - Gilpin County*
  - Park County
  - Westminster, City of*
- Nonprofits
  - Consolidated Mutual Water Company
- State Agencies
  - Colorado Division of Homeland Security and Emergency Management*
  - Colorado Division of Fire Prevention and Control (DFPC)*
  - Colorado Department of Parks and Wildlife*
    - Chatfield State Park*
  - Colorado Division of Water Resources – Dam Safety*
- Federal Agencies
  - US Forest Service*
- Universities
  - Colorado State University Extension

***** Participated in HMPC meetings

The majority of the listed stakeholders were invited to participate through an email from the Jefferson County Emergency Manager on November 17, 2020, which included an invitation to the kickoff meeting. A complete list of agencies and persons invited to the kick off meeting, plus the invitation itself, can be referenced in Appendices B & C. As part of the public review and comment period for the draft plan, key agencies were again specifically solicited to provide any final input to the draft plan document. This input was solicited both through membership on the HMPC and by direct emails to key groups and associations to review and comment on the plan. As part of this targeted outreach, these key stakeholders were also specifically invited to attend the HMPC and public meeting to discuss any outstanding issues and to provide input on the draft document and final mitigation strategies.

Coordination with key agencies, organizations, and advisory groups throughout the planning process allowed the HMPC to review common problems, development policies, and mitigation strategies as well as identifying any conflicts or inconsistencies with regional mitigation policies, plans, programs and regulations. Phone calls and emails were used during plan development to directly coordinate with key individuals representing other regional programs.

The HMPC also used technical data, reports, and studies from the following agencies and groups, just to name a few:

- Colorado Water Conservation Board
- Colorado Geological Survey
- FEMA
- Mile High Flood District

Appendix F References provides a detailed list of references used in the preparation of this plan update. Specific references relied on in the development of this plan are also sourced throughout the document as appropriate.

Several opportunities were provided for the groups listed above to participate in the planning process. At the beginning of the planning process, invitations were extended to these groups to actively participate on the HMPC. Specific participants from these groups are detailed in Appendix B. Others assisted in the process by providing data directly as requested or through data contained on their websites or as maintained by their offices. Further, as part of the public outreach process, all groups were invited to attend the public meetings and to review and comment on the plan prior to submittal to DHSEM and FEMA. In addition, as part of the review of the draft plan, key agency stakeholders were contacted, and their comments specifically solicited.

This process was accomplished as part of planning tasks two and three in the FEMA Local Mitigation Planning Handbook.

Incorporation of Existing Plans and Other Information

The coordination and synchronization with other community planning mechanisms and efforts are vital to the success of this plan. To have a thorough evaluation of hazard mitigation practices already in place, appropriate planning procedures should also involve identifying and reviewing existing plans, policies, regulations, codes, tools, and other actions are designed to reduce a community's risk and vulnerability from natural hazards. Jefferson County uses a variety of mechanisms to guide growth and development. Integrating existing planning efforts, mitigation policies, and action strategies into this plan establishes a credible, comprehensive document that weaves the common threads of a community's values together. The development of this plan involved a comprehensive review of existing plans, studies, reports, and initiatives from Jefferson County and each participating municipality.

The following table includes a comprehensive list of the documents reviewed and how they informed the HMP update.

Table 3-5 Incorporated Plans, Studies, and Reports

Plan	How Incorporated
Jefferson County Comprehensive Master Plan (CMP) 2013	Used as baseline for update and incorporated into Community Profile, Planning Process, Risk and Vulnerability Assessment, Capabilities Assessment, Mitigation Strategy, and Implementation
Jefferson County Comprehensive Master Plan Findings for 2019 Update	Informed growth and development trends and demographics for Community Profile.
Jefferson County Emergency Preparedness Guide (2018)	Incorporated into Risk and Vulnerability Assessment
Jefferson County Open Space Master Plan 2014-2019	Incorporated into Community Profile, Capabilities Assessment and Wildfire Vulnerability Assessment
Individual Community Land Use Plans (12 separate documents)	Incorporated data into Jurisdictional Annexes for Future Planning and Development patterns
Jefferson County Economic Profile, JeffCo Economic Development Corporation 2015	Incorporated into Community Profile and Risk and Vulnerability Assessment
County Community Wildfire Protection Plan (2012)	Incorporated into Community Profile and Wildfire Vulnerability Assessment
Individual Community Wildfire Protection Plans (16 separate documents)	Incorporated data into Jurisdictional Annexes and Wildfire Vulnerability Assessment
Jefferson County Land Development Regulation	Informed Capabilities, Risk and Vulnerability Assessments and goals update in Section 5
Jefferson County Zoning Resolution	Incorporated into Capabilities Assessment
Addendum to 2018 Jefferson County Residential Code and Supplement – Appendix Z Special Building Construction Regulations in Wildfire Zone 1 (Effective January 1, 2020)	Incorporated into Capabilities Assessment
Jefferson County Floodplain Regulations	Incorporated into Capabilities Assessment
Grading, Erosion, and Sediment Control Regulation – Section 17 of the Jefferson County Land Development Regulation	Incorporated into Capabilities Assessment
Construction/Land Disturbance Activities Section 16	Incorporated into Capabilities Assessment
Jefferson County Roadway Design and Construction Manual	Incorporated into Capabilities Assessment
2018-2023 State of Colorado Hazard Mitigation Plan	Informed data sources and information gathering and goals update
Colorado Drought Mitigation & Response Plan 2018	Informed data sources and information gathering
City of Arvada Comprehensive Plan	Used as baseline for Annex update and incorporated into Community Profile, Planning Process, Risk and Vulnerability Assessment, Mitigation Strategy, and Implementation
City of Arvada Sustainable Action Plan (ASAP)	Informed Annex update
City of Arvada Land Development Code	Informed Annex update
City of Arvada Parks and Open Space Master Plan	Informed Annex update
City of Lakewood Community Resources Master Plan	Informed Annex update
City of Lakewood Comprehensive Plan	Used as baseline for Annex update and incorporated into Community Profile, Planning Process, Risk and

Plan	How Incorporated
	Vulnerability Assessment, Mitigation Strategy, and Implementation
City of Lakewood Zoning Ordinance/Floodplain Management	Informed Annex update
City of Wheat Ridge Strategic Plan	Informed Annex update
City of Wheat Ridge Comprehensive Plan	Informed Annex update
City of Wheat Ridge Parks and Recreation Master Plan	Informed Annex update
City of Wheat Ridge Zoning and Development Code	Informed Annex update
City of Golden Comprehensive Plan	Used as baseline for Annex update and incorporated into Community Profile, Planning Process, Risk and Vulnerability Assessment, Mitigation Strategy, and Implementation
City of Golden Land Use Plan	Informed Annex update
City of Edgewater Master Plan	Informed Annex update
Town of Morrison Ordinances	Informed Annex update
Town of Mountain View Master Plan	Informed Annex update

Other documents were reviewed and considered, as appropriate, during the collection of data to support Planning Steps 4 and 5, which include the hazard identification, vulnerability assessment, and capability assessment. See also Appendix F for other references.

2016 Mitigation Plan Inclusion in Other Planning Mechanisms

The 2016 HMP was integrated into other planning mechanisms in the County. The risk assessment portion of the 2016 plan was integrated into the other planning mechanisms listed in Table 3-6. The table lists the jurisdiction and what planning mechanism the 2016 Plan was integrated into. In some cases, communities have deferred this for future planning mechanisms, as discussed in the Section 6 Plan Implementation and Maintenance.

Table 3-6 2016 Mitigation Plan Inclusion in Other Planning Mechanisms

Jurisdiction	Planning Mechanism
Jefferson County	Goals and approaches from 2016 HMP were included in the Jefferson County Comprehensive Master Plan (CMP) and regulation updates.
	The 2016 Jefferson County HMP was made available on the Emergency Management and Preparedness page on the Sheriff's Office web portal
Wheat Ridge	City of Wheat Ridge Local Energy Assurance Plan 2012. Hazard Mitigation Plan is cross referenced in several sections. Provided the basis for hazard profiles in the vulnerability assessment
State of Colorado	The 2018-2023 Colorado Hazard Mitigation Plan provides a meta-level analysis of local and multi-jurisdictional hazards profiled (with rankings for each hazard in each jurisdiction) in respective plans. Jefferson County's 2016 plan is included in this analysis.
	The 2018 Colorado Drought Mitigation Response Plan references local hazard mitigation plans and efforts, including Jefferson County.
Lakewood	Adopted by referenced in City Emergency Operations Plan as an important planning element and background on the various natural hazards and risks in the City.

Jurisdiction	Planning Mechanism
Arvada	2016 HIRA was incorporated into the City's Emergency Operations Plan. Floodplain regulations were updated and adopted in 2020. Incorporation into the Comprehensive Plan was deferred for incorporation by reference in future planning mechanisms (2023 Update).
Edgewater	Information from 2016 HMP was incorporated into Comprehensive Plan and is considered when updating local codes and plans.
Golden	Information from the 2016 HMP was incorporated into the City's Emergency Operations Plan
Morrison	Deferred for incorporation by reference in future planning mechanisms
Fire Districts	Fairmount FPD incorporated 2016 HMP into Strategic Plan and Standards of Coverage, which describes the District's response plans within the community. West Metro FPD considers and references the 2016 HMP where applicable.
Jefferson Conservation District	Deferred for incorporation by reference in future planning mechanisms, where applicable

3.4.2 Phase 2: Assess Risks

Planning Step 4 Identify the Hazards

Wood led the HMPC in an effort to identify and document all the hazards that have, or could, impact the planning area, including documenting recent drought, flood, wildfire and winter storm events. Data collection worksheets were used in this effort to aid in determining hazards and vulnerabilities and where risk varies across the planning area. The profile of each of these hazards was then developed and updated for 2021 with information from the HMPC and additional sources. Web resources, existing reports and plans, and existing GIS layers were used to compile information about past hazard events and determine the location, previous occurrences, probability of future occurrences, and magnitude/severity of each hazard. Geographic information systems (GIS) were used to display, analyze, and quantify hazards and vulnerabilities. A more detailed description of the hazard identification and risk assessment process and the results are included in Section 4 Risk Assessment.

Planning Step 5 Assess the Risks

After updating the profiles of the hazards that could affect the County, the HMPC collected information to describe the likely impacts of future hazard events on the participating jurisdictions. This step included two parts: a vulnerability assessment and a capability assessment.

Vulnerability Assessment—Participating jurisdictions updated their assets at risk to natural hazards—overall and in identified hazard areas. These assets included the total number and value of structures; critical facilities and infrastructure; natural, historic, and cultural assets; and economic assets. The HMPC also analyzed development trends in hazard areas. The DFIRM was used to refine the estimated flood losses during the update, where available for the NFIP participating communities. The results of the vulnerability assessment are included in Section 4 Risk Assessment.

Capability Assessment— The HMPC also conducted a capability assessment update to review and document the planning area's current capabilities to mitigate risk and vulnerability from natural hazards. By collecting information about existing government programs, policies, regulations, ordinances, and emergency plans, the HMPC can assess those activities and measures already in place that contribute to mitigating some of the risks and vulnerabilities identified. This information for is included in Section 2.7 and in the respective jurisdictional annexes.

Wood provided the draft risk assessment to the HMPC in March 2021 for review and comment. Results of the risk assessment were presented and comments discussed at the second meeting of the HMPC.

3.4.3 Phase 3: Develop the Mitigation Plan

Planning Step 6: Set Goals

Wood facilitated a discussion session with the HMPC to review the 2016 plan's goals and objectives. The HMPC discussed definitions and examples of goals, objectives, and actions and considered the goals of

the state hazard mitigation plan and other relevant local plans when reviewing and revising the goals and objectives. The resulting updated goals and objectives are presented in Section 5 Mitigation Strategy.

Planning Step 7: Review Possible Activities

Wood facilitated a discussion at an HMPC meeting to review the alternatives for mitigating hazards. This included a brainstorming session with the HMPC to identify a comprehensive range of mitigation actions for each identified hazard, and a method of selecting and defending recommended mitigation actions using a series of selection criteria. More specifics on the process and the results of this collaborative process are captured in Section 5 Mitigation Strategy.

Planning Step 8: Draft an Action Plan

Based on input from the HMPC regarding the draft risk assessment and the goals and activities identified in Planning Steps 6 and 7, Wood produced a complete first draft of the plan. This complete draft was delivered electronically for HMPC review and comment. HMPC and agency comments were integrated into the second draft, which was advertised and distributed to collect public input and comments. Other agencies were invited to comment on this draft as well. Wood integrated comments and issues from the public, as appropriate, along with additional internal review comments and produced a final draft for the Colorado Division of Homeland Security and Emergency Management (DHSEM) and FEMA Region VIII to review and approve, contingent upon final adoption by the governing boards of each participating jurisdiction.

3.4.4 Phase 4: Implement the Plan and Monitor Progress

Planning Step 9: Adopt the Plan

In order to secure buy-in and officially implement the plan, the plan was re-adopted by the governing boards of each participating jurisdiction on the dates included in the adoption resolutions in Appendix A Plan Adoption.

Planning Step 10: Implement, Evaluate, and Revise the Plan

The true worth of any mitigation plan is in the effectiveness of its implementation. Up to this point in the planning process, all of the HMPC's efforts have been directed at researching data, coordinating input from participating entities, and developing appropriate mitigation actions. Each recommended action includes key descriptors, such as a lead manager and possible funding sources, to help initiate implementation. An overall implementation strategy is described in Section 6 Plan Implementation and Maintenance.

Finally, there are numerous organizations within the Jefferson County planning area whose goals and interests interface with hazard mitigation. Coordination with these other planning efforts, as addressed in Planning Step 3, is vital to the ongoing success of this plan and mitigation in Jefferson County and is addressed further in Section 6. A plan update and maintenance schedule and a strategy for continued public involvement are also included in Section 6.

Implementation and Maintenance Process: 2016 Plan

The 2016 Hazard Mitigation Plan included a process for implementation and maintenance which was generally followed, with some variation. Implementation of the plan including the status of mitigation actions is captured in Section 5 and the jurisdictional annexes. In general, the County and participating jurisdictions have made good progress in the implementation of the plan. Successes of note are detailed in Section 5. As a result of revisiting the implementation and maintenance section some modifications were made including:

- Changed annual review from October to January.

An updated implementation and maintenance section can be referenced in Section 6.

4 Risk Assessment

- DMA Requirement §201.6(c)(2):
[The plan shall include] A risk assessment that provides the factual basis for activities proposed in the strategy to reduce losses from identified hazards. Local risk assessments must provide sufficient information to enable the jurisdiction to identify and prioritize appropriate mitigation actions to reduce losses from identified hazards. The risk assessment shall include: *(i) A description of the type, location, and extent of all natural hazards that can affect the jurisdiction. The plan shall include information on previous occurrences of hazard events and on the probability of future hazard events.* *(ii) A description of the jurisdiction's vulnerability to the hazards described in paragraph (c)(2)(i) of this section. This description shall include an overall summary of each hazard and its impact on the community. The plan should describe vulnerability in terms of:* *(A) The types and numbers of existing and future buildings, infrastructure, and critical facilities located in the identified hazard areas;* *(B) An estimate of the potential dollar losses to vulnerable structures identified in paragraph (c)(2)(ii)(A) of this section and a description of the methodology used to prepare the estimate;* *(C) Providing a general description of land uses and development trends within the community so that mitigation options can be considered in future land use decisions.* *(iii) For multi-jurisdictional plans, the risk assessment section must assess each jurisdiction's risks where they vary from the risks facing the entire planning area.*

As defined by the Federal Emergency Management Agency (FEMA), risk is a combination of hazard, vulnerability, and exposure. "It is the impact that a hazard would have on people, services, facilities, and structures in a community and refers to the likelihood of a hazard event resulting in an adverse condition that causes injury or damage."

The risk assessment process identifies and profiles relevant hazards and assesses the exposure of lives, property, and infrastructure to these hazards. The process allows for a better understanding of a jurisdiction's potential risk to natural hazards and provides a framework for developing and prioritizing mitigation actions to reduce risk from future hazard events.

This risk assessment followed the methodology described in the FEMA publication: Local Mitigation Planning Handbook (March 2013), which breaks the risk assessment down to a four-step process:

1. Describe Hazards
2. Identify Community Assets
3. Analyze Risks
4. Summarize Vulnerability

A key step in preventing disaster losses in Jefferson County is developing a comprehensive understanding of the hazards that pose risks to its communities. The following terms facilitate comparisons between communities and can be found throughout the Plan.

- **Hazard:** Event or physical condition that has the potential to cause fatalities, injuries, property damage, infrastructure damage, agricultural loss, damage to the environment, interruption of business, other types of harm or loss
- **Risk:** Product of a hazard's likelihood of occurrence and its consequences to society; the estimated impact that a hazard would have on people, services, facilities, and structures in a community
- **Vulnerability:** Degree of susceptibility to physical injury, harm, damage, or economic loss; depends on an asset's construction, contents, and economic value of its functions.

Data collected through this process has been incorporated into the following sections of this section:

- **Section 4.1 Hazard Identification** identifies the hazards that threaten the planning area and describes why some hazards have been omitted from further consideration.
- **Section 4.2 Asset Summary** describes the people, property, infrastructure, and resources potentially exposed to risk across Jefferson.
- **Section 4.3 Hazard Profiles** discusses the hazards that threaten the county, describes previous occurrences, their geographic extent, potential magnitude, and assesses their probability of future occurrence. It also includes a vulnerability assessment for each hazard, considering assets at risk, critical facilities, and future development trends.
- **The Jurisdictional Annexes** discuss each participating jurisdiction's individual exposure to natural hazards, including how the threat of hazards varies across the planning area along with each jurisdiction's specific vulnerabilities.

4.1 Hazard Identification

The Hazard Mitigation Planning Committee (HMPC) conducted a hazard identification study to determine the hazards that threaten the planning area.

4.1.1 Results and Methodology

Using existing hazards data, plans from participating jurisdictions, and input gained through planning and public meetings, the HMPC agreed upon a list of hazards that could affect Jefferson County. Hazards data was obtained from various federal, state, and local sources such as FEMA, the Colorado Geological Survey (CGS), the Colorado Dam Safety Branch (DSB), the National Oceanic and Atmospheric Administration's (NOAA) National Center for Environmental Information (NCEI), the United States Geological Survey (USGS), and the Colorado Division of Homeland Security and Emergency Management (including the 2018 Colorado State Hazard Mitigation Plan), among others. The hazards evaluated in this plan include those that have occurred historically or have the potential to cause significant human and/or monetary losses in the future.

Sixteen natural hazards were profiled in the 2016 Jefferson County Hazard Mitigation Plan. The HMPC reviewed all of these hazards and determined they were all still relevant and should be continued into the 2021 Plan update. Additionally, the HMPC reviewed a number of human-caused hazards and elected to include the two of greatest concern as hazards new to the plan: cyber attack and pandemic.

Each of the hazards were identified based on geographic extent, previous occurrences, potential for future occurrence, and a discussion on the potential severity and magnitude of the event. The potential impacts of climate change on each hazard were also considered. Once these elements were examined, each hazard was assigned an overall rating for the County.

The following hazards were determined to have a high significance:

- Dam Failure
- Flood
- Hailstorm
- Wildfire
- Severe Winter Storms

The following hazards were determined to have a medium significance:

- Cyber Attack (new)
- Drought
- Earthquake
- Erosion and Deposition
- Expansive Soils
- Landslides/Debris Flows/Rockfalls
- Lightning
- Pandemic (new)
- Subsidence
- Tornado
- Windstorm

The following hazards were determined to have a low significance:

- Avalanche
- Extreme Temperatures

For many hazards, the risk varies between jurisdictions; the jurisdictional annexes provide more explicit detail to explain the variance levels.

4.1.2 Hazard Identification Summary

Table 1-1 reflects the hazard identification summaries discussed in detail in the rest of this section. The table is based on the Jefferson County Hazards Identification Worksheet, but also reflects the input from the HMPC to address magnitude and severity, which in some cases altered the overall rating of the hazard compared to the other hazards profiled. When viewing these ratings, it is particularly important to remember that the hazards are all possible in the planning area, and therefore are potentially dangerous. The overall rating is a method of prioritizing hazards relative to one another for the development of mitigation actions and goals.

Table 4-1 Hazards Identification Summary

Hazard	Geographic Extent	Probability of Future Occurrence	Potential Severity/Magnitude	Overall Significance
Avalanche	Negligible	Unlikely	Negligible	Low
Cyber Attack	Significant	Likely	Limited	Medium
Dam Failure	Extensive	Occasional	Critical	High
Drought	Extensive	Likely	Critical	High
Earthquake	Significant	Unlikely	Catastrophic	Medium
Erosion and Deposition	Significant	Likely	Critical	Medium
Expansive Soils	Extensive	Likely	Limited	Medium
Extreme Temperatures	Extensive	Likely	Limited	Low
Flood	Limited	Likely	Critical	High
Hailstorm	Significant	Likely	Critical	High
Landslide/Debris/Rockfall	Limited	Likely	Limited-Negligible	Medium
Lightning	Limited	Highly Likely	Limited	Medium
Pandemic	Extensive	Occasional	Critical	High
Severe Winter Storms	Extensive	Likely	Critical	High
Subsidence	Limited	Occasional	Limited	Medium
Tornado	Limited	Likely	Limited	Medium
Wildfire	Significant	Highly Likely	Critical	High
Windstorm	Significant	Highly Likely	Limited	Medium

Geographic Extent
Negligible: Less than 10 percent of planning area or isolated single-point occurrences
Limited: 10 to 25 percent of the planning area or limited single-point occurrences
Significant: 25 to 75 percent of planning area or frequent single-point occurrences
Extensive: 75 to 100 percent of planning area or consistent single-point occurrences

Potential Severity/Magnitude
Negligible: Less than 10 percent of property is severely damaged, facilities and services are unavailable for less than 24 hours, injuries and illnesses are treatable with first aid or within the response capability of the jurisdiction.
Limited: 10 to 25 percent of property is severely damaged, facilities and services are unavailable for between 1 and 7 days, injuries and illnesses require sophisticated medical support that does not strain the response capability of the jurisdiction, or results in very few permanent disabilities.
Critical: 25 to 50 percent of property is severely damaged, facilities and services are unavailable or severely hindered for 1 to 2 weeks, injuries and illnesses overwhelm medical support for a brief period of time, or result in many permanent disabilities and a few deaths.
Catastrophic: More than 50 percent of property is severely damaged, facilities and services are unavailable or hindered for more than 2 weeks, the medical response system is overwhelmed for an extended period of time or many deaths occur.

Probability of Future Occurrences
Unlikely: Less than 1 percent probability of occurrence in the next year, or has a recurrence interval of greater than every 100 years.
Occasional: Between a 1 and 10 percent probability of occurrence in the next year, or has a recurrence interval of 11 to 100 years.
Likely: Between 10 and 90 percent probability of occurrence in the next year, or has a recurrence interval of 1 to 10 years
Highly Likely: Between 90 and 100 percent probability of occurrence in the next year, or has a recurrence interval of less than 1 year.

Overall Significance
Low: Two or more of the criteria fall in the lower classifications or the event has a minimal impact on the planning area. Also used for hazards with a minimal or unknown record of occurrences and impacts or for hazards with minimal mitigation potential.
Medium: The criteria fall mostly in the middle ranges of classifications and the event's impacts on the planning area are noticeable but not devastating. Also used for hazards with a high impact rating but an extremely low frequency.
High: The criteria consistently fall along the high ranges of the classification and the event exerts significant and frequent impacts on the planning area. Also used for hazards with a high psychological impact or for hazards that the jurisdiction identifies as particularly relevant.

4.1.3 Hazards Not Profiled

Other hazards were discussed by the HMPC but ultimately not included in this plan. Thunderstorm is not identified as an individual hazard, but is recognized for its role in the flood, lightning, and windstorm hazards, and addressed accordingly in those hazard profiles. Fog was also discussed and determined that it is not a true disaster-level hazard for the planning area. The volcano hazard was also removed due to the extraordinary circumstances required for such a disaster event to severely impact the planning area. The natural hazards of coastal erosion, coastal storm, hurricane, and tsunami were excluded from this plan because they are not applicable in Jefferson County.

Several other human-caused hazards were also considered, to include hazardous materials incidents, active threats, transportation accidents, and infrastructure failures. While all those hazards have the potential to impact Jefferson County, the HMPC elected to focus mitigation efforts on the two human-caused hazards that present the greatest risk: cyber attack and pandemic.

It is important to be aware that hazard events that happen outside of the County boundaries also can have direct and indirect impacts to Jefferson County. For instance, transportation routes or power supply could be interrupted by severe winter storms or wildfire hazards outside of the County.

4.1.4 Disaster Declaration History

One method the HMPC used to identify hazards was the researching of past events that triggered federal and/or state emergency or disaster declarations in the planning area. Federal and/or state disaster declarations may be granted when the severity and magnitude of an event surpasses the ability of the local government to respond and recover. Disaster assistance is supplemental and sequential. When the local government's capacity has been surpassed, a state disaster declaration may be issued, allowing for the provision of state assistance. Should the disaster be so severe that both the local and state governments' capacities are exceeded, a federal emergency or disaster declaration may be issued allowing for the provision of federal assistance.

The federal government may issue a disaster declaration through FEMA, the U.S. Department of Agriculture (USDA), and/or the Small Business Administration (SBA). FEMA also issues emergency declarations, which are more limited in scope and without the long-term federal recovery programs of major disaster declarations. The quantity and types of damage are the determining factors. The Fire Management Assistance Grant Program provides funding "for the mitigation, management, and control of fires on publicly or privately owned forests or grasslands, which threaten such destruction as would constitute a major disaster." The quantity and types of damages, as well as the type of event, determine the source of federal aid.

Table 4-2 provides information on the 13 federal emergencies and disasters declared in Jefferson County between 1953 and January 2021.

Table 4-2 Federal Disaster Declarations in Jefferson County

Year	Declaration	Disaster Type
1969	Federal Disaster Declaration	Severe Storms and Flooding
1973	Federal Disaster Declaration	Heavy Rains, Snowmelt
2000	Fire Management Assistance Declaration	High Meadows Fire
2002	Fire Management Assistance Declaration	Schoonover Fire, Black Mountain Fire, Snaking Fire, and Hayman Fire
2003	Emergency Declaration	Snow
2005	Emergency Declaration	Hurricane Katrina Evacuation*
2007	Emergency Declaration	Snow
2011	Fire Management Assistance Declaration	Indian Gulch Fire
2012	Fire Management Assistance Declaration	Lower North Fork Fire
2012	USDA Drought Declaration (Primary S3260)	Drought, excessive heat, high winds
2013	Emergency Declaration Federal Disaster Declaration	Severe Storms, Flooding, Landslides and Mudslides
2020	Emergency Declaration and Federal Disaster Declaration	COVID-19 Pandemic

Source: State of Colorado Natural Hazards Mitigation Plan, 2013; Federal Emergency Management Agency, PERI Presidential Disaster Declaration Site. U.S. Department of Agriculture; (*) indicates that Jefferson County was included in the declaration but did not receive funding.

A USDA declaration will result in the implementation of the Emergency Loan Program through the Farm Services Agency. The SBA also offers low interest loans for eligible businesses that suffer economic losses in declared and contiguous counties that have been declared by the USDA. This program enables eligible farmers and ranchers in the affected county as well as contiguous counties to apply for low interest loans. In 2012 the USDA streamlined the declaration process which now provides for nearly an automatic designation for any county in which drought conditions, as reported in the U.S. Drought Monitor when any portion of a county meets the D2 (Severe Drought) drought intensity value for eight consecutive weeks. A county that has a portion of its area in a drought intensity value of D3 (Extreme Drought) or higher at any time during the growing season also would be designated as a disaster area. USDA Declarations since that covered Jefferson County are shown in **Table 4-3**.

Table 4-3 USDA Declarations Including Jefferson County

Year	Declaration	Disaster Type
2012	S3260	Drought, excessive heat, high winds
2013	S3456	Drought, excessive heat, high winds, wildfire, insects
2013	S3548	Drought, excessive heat, high winds, wildfire, insects
2018	S4365	Hail and high wind
2018	S4386	Drought
2018	S4408	Drought
2019	S4468	Drought
2019	S4481	Drought

Year	Declaration	Disaster Type
2020	S4798	Drought
2020	S4848	Drought

Source: U.S. Department of Agriculture https://www.fsa.usda.gov/programs-and-services/disaster-assistance-program/disaster-designation-information

4.2 Asset Summary

4.2.1 Population and Structures

Table 4-4 shows the estimated total population and number of housing units for each jurisdiction based on the most recent American Community Survey and Colorado State Demography Office data. Jurisdictions that straddle County boundaries are indicated by an asterisk, and the numbers listed for these jurisdictions only represent the Jefferson County portion.

Table 4-4 Population and Housing Unit Exposure by Jurisdiction

Jurisdiction	2019 Population Estimate	2019 Housing Units Estimate
Arvada*	117,859	42,558
Bow Mar*	300	95
Edgewater	5,352	1,697
Golden	20,828	6,134
Lakeside	8	1
Lakewood	158,410	51,150
Littleton*	2,683	800
Morrison	436	135
Mountain View	536	241
Westminster*	44,162	15,090
Wheat Ridge	31,273	12,141
Unincorporated	201,234	76,455
Grand Total	**583,081**	**206,497**

Source: Colorado Department of Local Affairs Demography Section. * Only includes the portion within Jefferson County.

Building value assessments in this plan are based on data from the Jefferson County's Assessor's Office. Table 4-5 shows the total property inventory from the Assessor's Office. (The Assessor's Office assigns values to buildings for the specific purpose of valuation for ad valorem tax purposes, and values represented may not reflect actual building replacement values.) An address points layer was used as the basis for estimating building counts. The Assessor does not maintain data about the contents of structures, therefore the contents values shown in the table are estimates based upon the structure value using FEMA recommended values (typically 50% for residential structures, 100% for commercial, 100% for agricultural, 150% for industrial, 100% for mixed use and 100% for exempt). **Table 4-6** summarizes the property inventory for the County and each participating jurisdiction with detail by property type, including jurisdictions which may not be participating in the plan.

Table 4-5 Jefferson County's Building Inventory and Value Summary by Jurisdiction

Jurisdiction	Improved Parcels	Building Count	Improved Value	Content Value	Total Value
Arvada*	42,022	43,997	$14,257,089,578	$7,838,936,533	$22,096,026,111
Bow Mar*	95	95	$54,914,896	$27,457,448	$82,372,344
Edgewater	1,480	1,807	$442,322,263	$256,618,931	$698,941,194
Golden	5,866	6,955	$3,581,405,037	$2,429,883,569	$6,011,288,606
Lakeside	14	27	$28,589,790	$28,589,790	$57,179,580
Lakewood	49,390	54,129	$18,577,041,933	$10,715,684,254	$29,292,726,187
Littleton*	803	803	$352,400,836	$352,400,836	$704,801,672
Morrison	155	188	$65,397,995	$42,262,140	$107,660,135
Mountain View	246	273	$46,888,818	$27,130,145	$74,018,963
Westminster*	15,050	15,691	$5,793,485,591	$3,387,532,303	$9,181,017,894
Wheat Ridge	11,165	13,505	$3,635,566,208	$2,219,156,222	$5,854,722,430
Unincorporated	76,220	79,412	$29,606,470,107	$15,953,167,281	$45,559,637,388
Grand Total	**202,506**	**216,882**	**$76,441,573,052**	**$43,278,819,451**	**$119,720,392,503**

Source: Jefferson County Assessor October 2020, FEMA HAZUS
* Only includes the portion within Jefferson County.

Table 4-6 Jefferson County's Building Inventory and Value Detail by Jurisdiction

Jurisdiction	Property Type	Improved Parcels	Building Count	Improved Value	Content Value	Total Value
Arvada*	Agriculture	8	8	$2,760,667	$2,760,667	$5,521,334
	Commercial	515	856	$550,997,194	$550,997,194	$1,101,994,388
	Exempt	125	144	$312,137,969	$312,137,969	$624,275,938
	Industrial	199	247	$212,035,772	$318,053,658	$530,089,430
	Mixed Use	147	184	$130,816,114	$130,816,114	$261,632,228
	Residential	41,028	42,558	$13,048,341,862	$6,524,170,931	$19,572,512,793
	Total	**42,022**	**43,997**	**$14,257,089,578**	**$7,838,936,533**	**$22,096,026,111**
Bow Mar*	Residential	95	95	$54,914,896	$27,457,448	$82,372,344
	Total	**95**	**95**	**$54,914,896**	**$27,457,448**	**$82,372,344**
Edgewater	Commercial	45	79	$35,300,820	$35,300,820	$70,601,640
	Exempt	12	13	$24,162,201	$24,162,201	$48,324,402
	Industrial	2	2	$304,000	$304,000	$608,000
	Mixed Use	10	16	$11,148,577	$11,148,577	$22,297,154
	Residential	1,411	1,697	$371,406,665	$185,703,333	$557,109,998
	Total	**1,480**	**1,807**	**$442,322,263**	**$256,618,931**	**$698,941,194**
Golden	Agriculture	1	1	$35,437	$35,437	$70,874
	Commercial	277	377	$530,314,287	$530,314,287	$1,060,628,574
	Exempt	61	126	$331,145,437	$331,145,437	$662,290,874
	Industrial	171	189	$288,997,711	$288,997,711	$577,995,422
	Mixed Use	111	128	$127,869,228	$127,869,228	$255,738,456
	Residential	5,245	6,134	$2,303,042,937	$1,151,521,469	$3,454,564,406

Jurisdiction	Property Type	Improved Parcels	Building Count	Improved Value	Content Value	Total Value
	Total	**5,866**	**6,955**	**$3,581,405,037**	**$2,429,883,569**	**$6,011,288,606**
Lakeside	Commercial	13	26	$22,234,756	$22,234,756	$44,469,512
	Mixed Use	1	1	$6,355,034	$6,355,034	$12,710,068
	Total	**14**	**27**	**$28,589,790**	**$28,589,790**	**$57,179,580**
Lakewood	Agriculture	1	1	$46,378	$46,378	$92,756
	Commercial	1,235	2,115	$2,012,874,841	$2,012,874,841	$4,025,749,682
	Exempt	159	229	$412,727,409	$412,727,409	$825,454,818
	Industrial	165	269	$179,504,955	$179,504,955	$359,009,910
	Mixed Use	301	365	$249,172,992	$249,172,992	$498,345,984
	Residential	47,529	51,150	$15,722,715,358	$7,861,357,679	$23,584,073,037
	Total	**49,390**	**54,129**	**$18,577,041,933**	**$10,715,684,254**	**$29,292,726,187**
Littleton*	Commercial	2	2	$3,201,717	$3,201,717	$6,403,434
	Exempt	1	1	$1,565,994	$1,565,994	$3,131,988
	Residential	800	800	$347,633,125	$347,633,125	$695,266,250
	Total	**803**	**803**	**$352,400,836**	**$352,400,836**	**$704,801,672**
Morrison	Commercial	20	36	$6,526,206	$6,526,206	$13,052,412
	Exempt	6	6	$9,920,151	$9,920,151	$19,840,302
	Industrial	2	2	$482,576	$482,576	$965,152
	Mixed Use	8	9	$2,197,352	$2,197,352	$4,394,704
	Residential	119	135	$46,271,710	$23,135,855	$69,407,565
	Total	**155**	**188**	**$65,397,995**	**$42,262,140**	**$107,660,135**
Mountain View	Commercial	16	28	$6,507,708	$6,507,708	$13,015,416
	Exempt	2	2	$359,593	$359,593	$719,186
	Mixed Use	2	2	$504,171	$504,171	$1,008,342
	Residential	226	241	$39,517,346	$19,758,673	$59,276,019
	Total	**246**	**273**	**$46,888,818**	**$27,130,145**	**$74,018,963**
Westminster*	Commercial	195	402	$381,774,297	$381,774,297	$763,548,594
	Exempt	24	26	$104,426,475	$104,426,475	$208,852,950
	Industrial	77	127	$124,568,101	$124,568,101	$249,136,202
	Mixed Use	45	46	$370,810,142	$370,810,142	$741,620,284
	Residential	14,709	15,090	$4,811,906,576	$2,405,953,288	$7,217,859,864
	Total	**15,050**	**15,691**	**$5,793,485,591**	**$3,387,532,303**	**$9,181,017,894**
Wheat Ridge	Agriculture	2	2	$22,618	$22,618	$45,236
	Commercial	414	723	$416,007,224	$416,007,224	$832,014,448
	Exempt	59	76	$114,136,176	$114,136,176	$228,272,352
	Industrial	279	391	$214,853,118	$214,853,118	$429,706,236
	Mixed Use	134	172	$57,727,100	$57,727,100	$115,454,200
	Residential	10,277	12,141	$2,832,819,972	$1,416,409,986	$4,249,229,958
	Total	**11,165**	**13,505**	**$3,635,566,208**	**$2,219,156,222**	**$5,854,722,430**
Unincorporated	Agriculture	67	70	$7,972,025	$7,972,025	$15,944,050
	Commercial	907	1,480	$1,311,289,870	$1,311,289,870	$2,622,579,740

Jurisdiction	Property Type	Improved Parcels	Building Count	Improved Value	Content Value	Total Value
	Exempt	247	310	$453,766,591	$453,766,591	$907,533,182
	Industrial	612	777	$289,775,043	$289,775,043	$579,550,086
	Mixed Use	296	320	$237,060,925	$237,060,925	$474,121,850
	Residential	74,091	76,455	$27,306,605,653	$13,653,302,827	$40,959,908,480
	Total	**76,220**	**79,412**	**$29,606,470,107**	**$15,953,167,281**	**$45,559,637,388**
Grand Total		**202,506**	**216,882**	**$76,441,573,052**	**$43,278,819,451**	**$119,720,392,503**

Source: Jefferson County Assessor 2020, FEMA HAZUS * Only includes the portion within Jefferson County.

4.2.2 Critical Facilities, Infrastructure, and Other Important Community Assets

For the purposes of this plan, a critical facility is defined as one that is essential in providing utility or direction either during the response to an emergency or during the recovery operation. FEMA sorts critical facilities into seven lifeline categories as shown in **Figure 4-1**.

Figure 4-1 Lifeline Categories

These lifeline categories standardize the classification of critical facilities and infrastructure that provide indispensable service, operation, or function to a community. A lifeline is defined as providing indispensable service that enables the continuous operation of critical business and government functions, and is critical to human health and safety, or economic security. These categorizations are particularly useful as they:

- Enable effort consolidations between government and other organizations (e.g. infrastructure owners and operators).
- Enable integration of preparedness efforts among plans; easier identification of unmet critical facility needs.
- Refine sources and products to enhance awareness, capability gaps, and progress towards stabilization.
- Enhance communication amongst critical entities, while enabling complex interdependencies between government assets.

Highlight lifeline related priority areas regarding general operations as well as response efforts.
To develop a comprehensive list of critical facilities in Jefferson County (Table 4-7), two data sources were compiled and broken down along the aforementioned critical asset categories: Jefferson County's GIS databases of critical facilities and infrastructure and the 2020 Homeland Infrastructure Foundation-Level Data (HIFLD) data.

The best available data was used, but some limitations include lack of complete or comprehensive data and values such as replacement costs. These databases were used in vulnerability assessments for hazards such as wildfire and flood, and are represented in maps and tables in the vulnerability by hazard section that follows.

Table 4-7 Summary of Critical Facilities by Jurisdiction and Lifeline

Jurisdiction	Communications	Energy	Food, Water, Shelter	Hazardous Material	Health and Medical	Safety and Security	Transportation	Total
Arvada	93	8	-	15	42	51	80	**289**
Edgewater	4	-	1	-	1	7	1	**14**
Golden	76	2	2	24	4	26	19	**153**
Lakewood	216	10	8	24	66	85	47	**456**
Morrison	8	-	-	3	1	2	8	**22**
Wheat Ridge	68	1	-	11	24	22	35	**161**
Unincorporated	705	23	24	51	48	135	267	**1253**
Total	**1,170**	**44**	**35**	**128**	**186**	**328**	**457**	**2,348**

Source: HIFLD and CERC

A 2020 Federal Highway Administration report found 22 bridges in Jefferson County in poor condition and in need of repairs. An additional 259 were found to be in fair condition, with only 166 being in good condition.

Maps of critical facilities in Jefferson County can be found in Appendix H (not for public release).

4.2.3 Natural, Historic, and Cultural Resources

Assessing the vulnerability of Jefferson County to different disasters also involves inventorying the natural, historical, and cultural assets of the area. This step is important for the following reasons:

- The community may decide that these types of resources warrant a greater degree of protection due to their unique and irreplaceable nature and contribution to the overall economy.
- If these resources are impacted by a disaster, knowing so ahead of time allows for more prudent care in the immediate aftermath, when the potential for additional impacts are higher.

- The rules for reconstruction, restoration, rehabilitation, and/or replacement are often different for these types of designated resources.
- Natural resources can have beneficial functions that reduce the impacts of natural hazards, such as wetlands and riparian habitat, which help absorb and attenuate floodwaters.

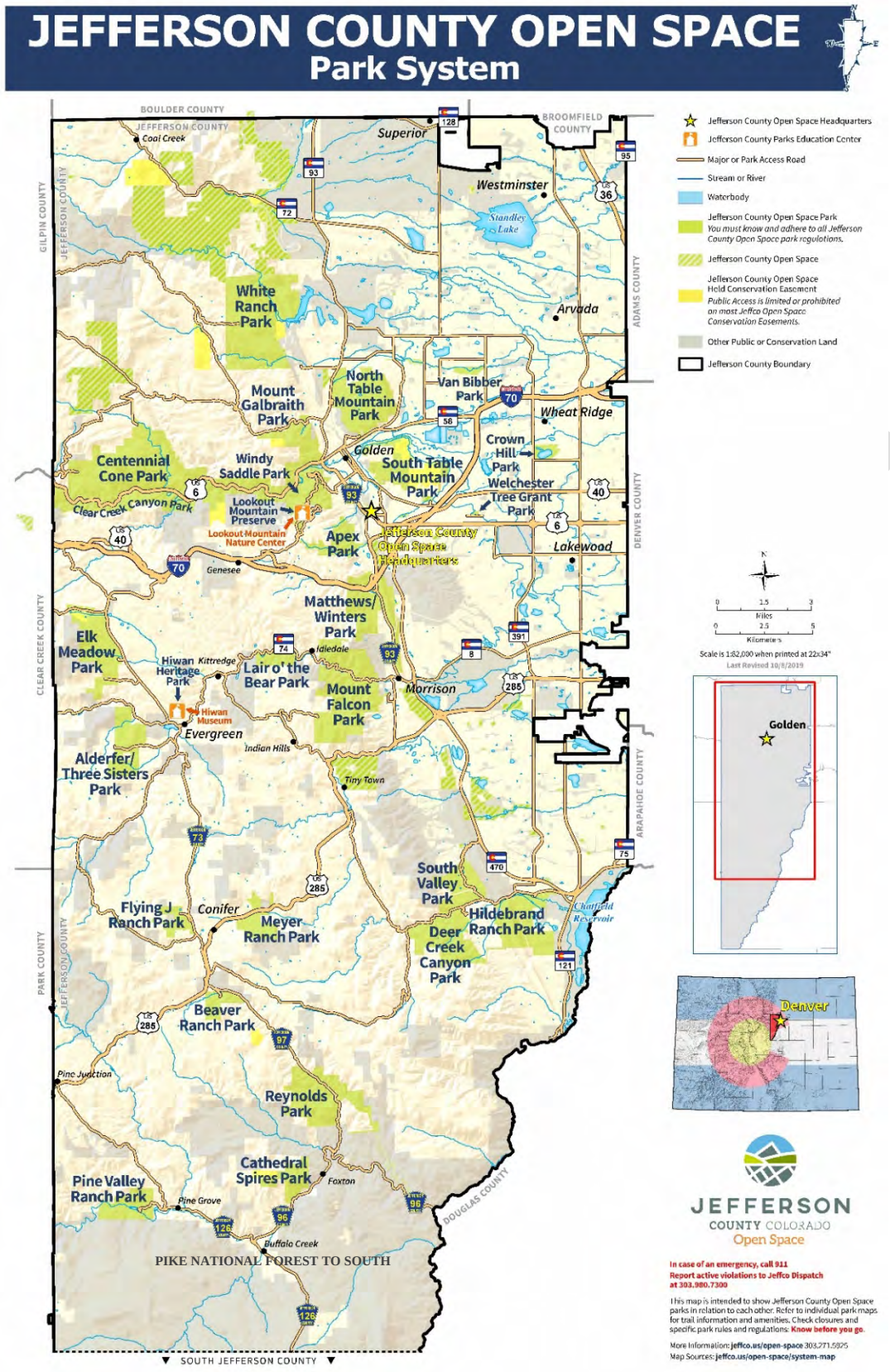
Natural Resources

Natural resources are important to include in benefit-cost analyses for future projects, and may be used to leverage additional funding for projects that also contribute to community goals for protecting sensitive natural resources. Awareness of natural assets can lead to opportunities for meeting multiple objectives. For instance, protecting wetlands areas protects sensitive habitat as well as attenuates and stores floodwaters.

Jefferson County contains a unique combination of prairie, forest, and tundra environments. The HMPC recognizes three types of valuable natural resources worthy of protection: environmental conservation areas, natural landmarks, and natural areas. These areas are described below and mapped in Figure 4-2.

- **Environmental conservation areas** are so designated because of the value they provide in the perpetuation of those species, biological communities, and ecological processes that function over large geographic areas and require a high degree of naturalness.
- **Natural landmarks** are defined as prominent landscape features that distinguish a specific locality in Jefferson County and are important because of the views they afford, their value as scenic vistas and backdrops, and the intrinsic value they hold as wildlife or plant habitats, natural areas, park and open space preserves, and open land areas.
- **Natural areas** are physical or biological areas that either retain or have reestablished their natural characters, although they need not be completely undisturbed, and that typify native vegetation and associated biological and geological features or provide habitat for rare or endangered animal or plant species or include geologic or other natural features of scientific or educational value.

Figure 4-2 Jefferson County Public Lands



Wetlands

Wetlands are a valuable natural resource for communities, due to their benefits to water quality, wildlife protection, recreation, and education. Wetlands also play an important role in hazard mitigation by reducing flood peaks and slowly releasing floodwaters to downstream areas. When surface runoff is dampened, the erosive powers of the water are greatly diminished. Furthermore, the reduction in the velocity of inflowing water as it passes through a wetland helps remove sediment being transported by the water. They also provide drought relief in water-scarce areas where the relationship between water storage and streamflow regulation are vital.

Jefferson County has numerous freshwater lakes and freshwater emergent wetlands in the various creeks and ditches scattered throughout the northeast (mostly urbanized) part of the County. These areas provide critical habitat as well as help mitigate flooding.

Endangered Species and Imperiled Natural Plant Communities

To further understand natural resources that may be particularly vulnerable to a hazard event, as well as those that need consideration when implementing mitigation activities, it is important to identify at-risk species (i.e., endangered species) in the planning area. An endangered species is any species of fish, plant life, or wildlife that is in danger of extinction throughout all or most of its range. A threatened species is a species that is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range. Both endangered and threatened species are protected by law and any future hazard mitigation projects are subject to these laws. Candidate species are plants and animals that have been proposed as endangered or threatened but are not currently listed. Species listed as resolved taxon have received a finding of Not Warranted or Not Substantial or have been removed from the candidate list.

According to the U.S. Fish and Wildlife Service (FWS), as of February 2021, there were 27 federal endangered, threatened, or candidate species that may be present Jefferson County. These species are listed in Table 4-8. Note that the FWS is based on the existence of potential habitat for the species, and not all listed species may actually be present in the County.

Table 4-8 Threatened, Endangered, or other Listed Species Potentially Found in Jefferson County

Type of Species	Common Name	Scientific Name	Status
Amphibians	Northern leopard frog	Rana pipiens	Resolved Taxon
Birds	Whooping crane	Grus americana)	Experimental Population, Non-Essential
Birds	Bald eagle	Haliaeetus leucocephalus	Recovery
Birds	American peregrine falcon	Falco peregrinus anatum	Recovery
Birds	Southern white-tailed ptarmigan	Lagopus leucura altipetens	Resolved Taxon
Birds	Swainson's hawk	Buteo swainsoni	Resolved Taxon
Birds	Ferruginous hawk	Buteo regalis	Resolved Taxon
Birds	White-faced ibis	Plegadis chihi	Species of Concern
Birds	Western burrowing owl	Athene cunicularia ssp. hypugaea	Species of Concern
Birds	Mexican spotted owl	Strix occidentalis lucida	Threatened
Flowering Plants	Colorado Butterfly plant	Gaura neomexicana var. coloradensis	Recovery
Flowering Plants	Bell's Twinpod	Physaria bellii	Species of Concern
Flowering Plants	Ute ladies'-tresses	Spiranthes diluvialis	Threatened
Flowering Plants	Western prairie fringed Orchid	Platanthera praeclara	Threatened

Type of Species	Common Name	Scientific Name	Status
Insects	Pawnee montane skipper	Hesperia leonardus montana	Threatened
Mammals	Swift fox	Vulpes velox	Resolved Taxon
Mammals	Black-tailed prairie dog	Cynomys ludovicianus	Resolved Taxon
Mammals	Gunnison's prairie dog	Cynomys gunnisoni	Resolved Taxon
Mammals	North American wolverine	Gulo gulo luscus	Resolved Taxon
Mammals	American pika	Ochotona princeps	Resolved Taxon
Mammals	Fringed myotis	Myotis thysanodes	Species of Concern
Mammals	Long-legged myotis	Myotis volans	Species of Concern
Mammals	Long-eared myotis	Myotis evotis	Species of Concern
Mammals	Preble's meadow jumping mouse	Zapus hudsonius preblei	Threatened
Mammals	Canada Lynx	Lynx canadensis	Threatened
Mammals	Little brown bat	Myotis lucifugus	Under Review
Reptiles	Eastern short-horned lizard	Phrynosoma douglassii brevirostra	Species of Concern

Source: U.S. Fish & Wildlife Service https://ecos.fws.gov/ecp/

Historic and Cultural Resources

Information about historic assets in Jefferson County came from local sources, as well as two historic inventories:

The National Register of Historic Places is the Nation's official list of cultural resources worthy of preservation. The National Register is part of a national program to coordinate and support public and private efforts to identify, evaluate, and protect historic and archeological resources. Properties listed include districts, sites, buildings, structures, and objects that are significant in American history, architecture, archaeology, engineering, and culture. The National Register is administered by the National Park Service, which is part of the U.S. Department of the Interior.

The Colorado State Register of Historic Properties is a listing of the state's significant cultural resources worthy of preservation for the future education and enjoyment of Colorado's residents and visitors. Properties listed in the Colorado State Register include individual buildings, structures, objects, districts, and historic and archaeological sites. The Colorado State Register program is administered by the Office of Archaeology and Historic Preservation within the Colorado Historical Society. Properties listed in the National Register of Historic Places are automatically placed in the Colorado State Register.

Table 4-9 lists the 113 properties and districts in Jefferson County that are on the National Register of Historic Places and/or the Colorado State Register of Historic Properties.

Table 4-9 Jefferson County Historic Properties in National & State Registers

Property Name	City	Register	Listed Date
Arvada Downtown	Arvada	National	7/15/1998
Arvada Flour Mill	Arvada	National	4/24/1975
Churches Ranch	Arvada	National	7/23/1998
Enterprise Grange No. 15	Arvada	State	8/11/1999
Ralston Cemetery	Arvada	State	6/30/2011
Ralston Gold Discovery Site (Gold Strike Park)	Arvada	State	12/13/1995
Reno Park Addition Historic District	Arvada	National	9/29/1999
Russell-Graves House	Arvada	National	5/9/1983

Property Name	City	Register	Listed Date
Seventh Day Adventist Church – Arvada Jaycee Hall	Arvada	State	2/24/2011
Stocke--Walter Addition Historic District	Arvada	National	9/24/1999
Silver Spruce Ranch	Bailey	State	6/12/1996
Blue Jay Inn	Buffalo Creek	National	10/1/1974
Green Mercantile Store	Buffalo Creek	National	10/1/1974
Green Mountain Ranch	Buffalo Creek	National	10/1/1974
La Hacienda	Buffalo Creek	National	7/20/1973
Bradford Junction	Conifer	State	1/23/2014
Conifer Junction Schoolhouse	Conifer	National	2/10/2014
Midway House	Conifer	National	9/18/1990
Pleasant Park School	Conifer	State	6/12/1996
Tower of Memories	Denver	National	9/25/1987
Bergen Park	Evergreen	National	11/15/1990
Bergen Park Church	Evergreen	State	6/1/2018
Brook Forest Inn	Evergreen	National	7/29/2009
Corwina Park, O'Fallon Park, Pence Park	Evergreen	National	12/28/1990
Dedisse Park	Evergreen	National	11/15/1990
Evergreen Conference District	Evergreen	National	5/1/1979
Everhardt Ranch	Evergreen	National	5/7/1980
Fillius Park	Evergreen	National	2/24/1995
Hiwan Homestead	Evergreen	National	4/9/1974
Humphrey House	Evergreen	National	12/31/1974
Ammunition Igloo	Golden	National	5/20/1993
Astor House Hotel	Golden	National	3/1/1973
Barnes--Peery House	Golden	National	10/12/2001
Calvary Episcopal Church	Golden	National	3/3/1995
Camp George West Historic District	Golden	National	2/11/1993
Colorado Amphitheater	Golden	National	5/20/1993
Colorado Midland Railway Observation Car No. 111	Golden	State	12/11/1996
Colorado National Guard Armory	Golden	National	12/18/1978
Colorow Point Park	Golden	National	11/15/1990
Coors, Herman, House	Golden	National	10/17/1997
Deaton Sculptured House	Golden	National	2/24/2004
Denver & Rio Grande Railroad Cars (13 entries)	Golden	State	various
Denver and Rio Grande Western Railroad Caboose No. 0578	Golden	National	11/4/2003
First Presbyterian Church of Golden--Unger House	Golden	National	3/14/1991
Genesee Park	Golden	National	11/15/1990
Golden Cemetery	Golden	National	4/18/2012
Golden High School	Golden	National	3/14/1997
Golden Welcome Arch	Golden	State	6/14/2000
Great Western Railway Combine No. 100	Golden	State	9/11/1996

Property Name	City	Register	Listed Date
Lariat Trail Scenic Mountain Drive	Golden	National	11/15/1990
Lookout Mountain Park	Golden	National	11/15/1990
Lorraine Lodge	Golden	National	1/18/1984
Loveland Building and Coors Building	Golden	National	5/16/1996
Magic Mountain Site	Golden	National	8/21/1980
Mount Vernon House	Golden	National	11/20/1970
Oscar Barber House	Golden	State	6/13/1994
Quaintance Block	Golden	National	3/25/1994
Queen of Heaven Orphanage Summer Camp	Golden	National	1/14/2000
Rio Grande Southern Railroad Cars (4 entries)	Golden	State	various
Rio Grande Southern Railroad Engine No. 20	Golden	National	12/14/2000
Rio Grande Southern Railroad, Motor No. 2	Golden	National	2/14/1997
Rio Grande Southern Railroad, Motor No. 6	Golden	National	2/19/1997
Rio Grande Southern Railroad, Motor No. 7	Golden	National	2/28/1997
Rockland Community Church and Cemetery	Golden	National	8/5/2009
Rocky Flats Plant	Golden	National	5/19/1997
Romano, Samuel and Albina, House	Golden	National	9/26/2016
Rooney Ranch	Golden	National	2/13/1975
Tallman Ranch	Golden	State	6/14/1995
Thiede Ranch	Golden	National	1/11/1996
Twelfth Street Historic Residential District	Golden	National	9/22/1983
Little Park	Idledale	National	2/24/1995
Starbuck Park	Idledale	National	6/30/1995
Indian Hills Community Hall & Firehouse	Indian Hills	State	5/14/1997
Bonfils-Stanton Belmar Estate Outbuildings	Lakewood	State	5/23/2013
Building 710, Defense Civil Preparedness Agency, Region 6 Operations Center	Lakewood	National	3/2/2000
Country Club Garden Apartments	Lakewood	State	8/27/2009
Davies' Chuck Wagon Diner	Lakewood	National	7/2/1997
Denver and Intermountain Railroad Interurban No. 25	Lakewood	National	1/12/2012
Hill Section, Golden Hill Cemetery	Lakewood	National	7/31/1995
Howell House	Lakewood	State	9/11/1996
Jewish Consumptives'' Relief Society	Lakewood	National	6/26/1980
Office of Civil Defense Emergency Operations Center	Lakewood	National	12/16/1999
Peterson House	Lakewood	National	9/10/1981
Schnell Farm	Lakewood	National	2/14/1997
South Ranch	Lakewood	National	4/18/2003
Stone House	Lakewood	National	5/1/1975
Washington Heights School	Lakewood	State	6/13/1994
Bradford House II	Littleton	National	2/2/2001
Bradford-Perley House	Littleton	State	2/2/2015
Hildebrande Ranch	Littleton	National	3/13/1975

Property Name	City	Register	Listed Date
Shaffer, John C., Barn	Littleton	National	7/12/2019
Bear Creek Canyon Scenic Mountain Drive	Morrison	National	11/15/1990
Bradford House III Archeological Site	Morrison	National	4/8/1980
Bradford, Robert Boyles, Property	Morrison	National	2/2/2015
Craig, Katherine, Park	Morrison	National	6/30/1995
Dinosaur Ridge	Morrison	State	3/10/1993
District No. 17 – Medlen School	Morrison	State	4/14/2015
District No. 17 School--Medlen School	Morrison	National	4/14/2015
Fort, The	Morrison	National	7/14/2006
LoDaisKa Site	Morrison	National	9/25/2003
Morrison Historic District	Morrison	National	9/28/1976
Morrison Schoolhouse	Morrison	National	9/4/1974
Red Rocks Park District	Morrison	National	5/18/1990
Baehr Lodge / Baehr Den of the Rockies (Pine Valley Lodge)	Pine	State	6/10/1998
Staunton Ranch Rural Historic Landscape	Pine	National	12/4/2012
North Fork Historic District	Pine and South Platte	National	10/9/1974
North Fork Historic District (Boundary Increase)	Pine and South Platte	National	10/8/2008
Baugh, James H., House	Wheat Ridge	National	8/14/2012
Crown Hill Burial Park	Wheat Ridge	National	7/24/2008
Fruitdale Grade School	Wheat Ridge	National	3/20/2013
Pioneer Sod House	Wheat Ridge	National	3/14/1973
Richards Mansion	Wheat Ridge	National	9/15/1977
Wheat Ridge Post Office	Wheat Ridge	State	8/12/1992

Sources: National Register of Historic Places, https://www.nps.gov/subjects/nationalregister/ and Colorado State Register of Historic Properties: https://www.historycolorado.org/colorado-state-register-historic-properties

It should be noted that as defined by the National Environmental Policy Act (NEPA), any property over 50 years of age is considered a historic resource and is potentially eligible for the National Register. Thus, in the event that the property is to be altered, or has been altered, as the result of a major federal action, the property must be evaluated under the guidelines set forth by NEPA. Structural mitigation projects are considered alterations for the purpose of this regulation.

Economic Assets

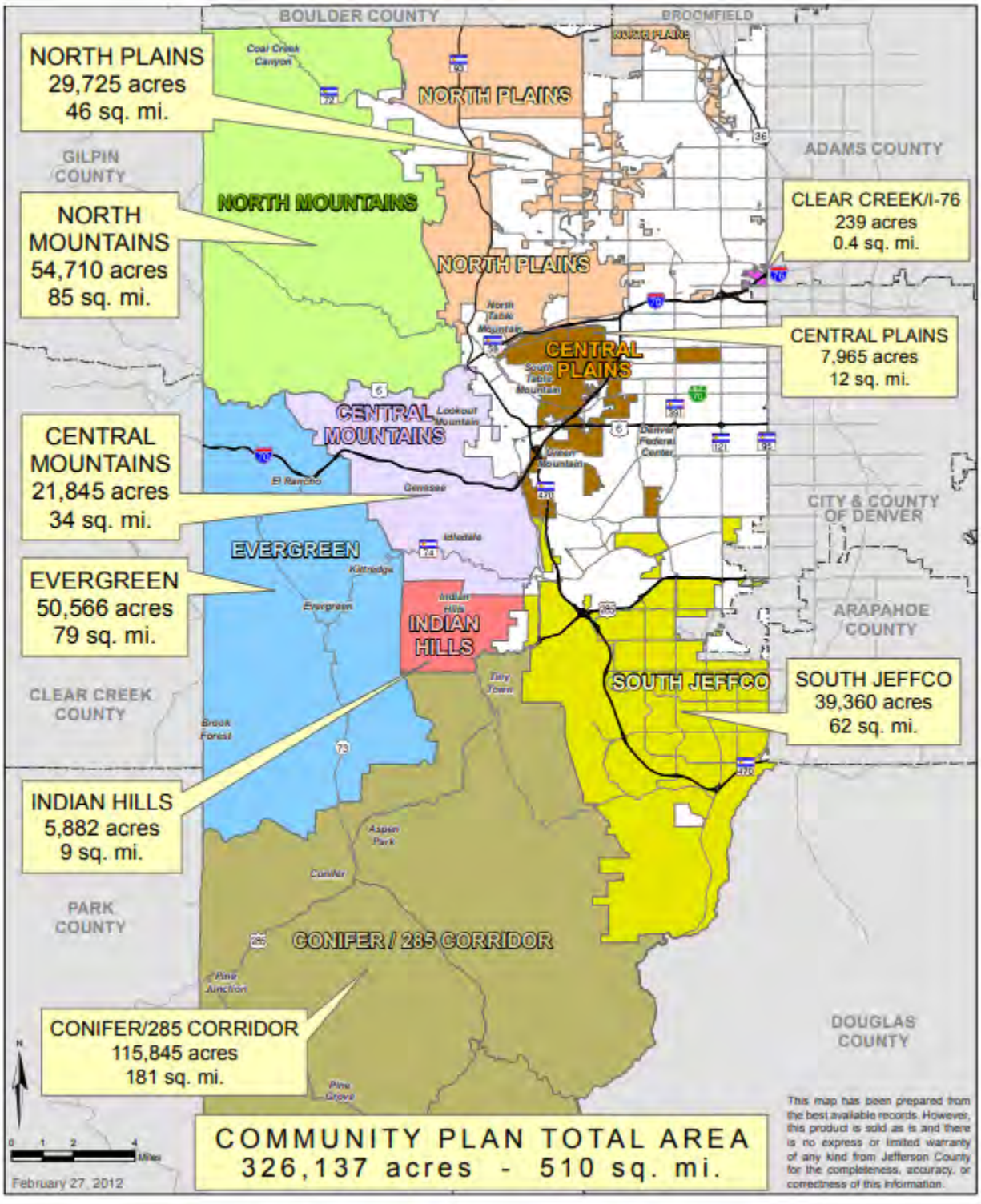
Economic assets at risk may include major employers or primary economic sectors, such as agriculture, whose losses or inoperability would have severe impacts on the community and its ability to recover from disaster. After a disaster, economic vitality is the engine that drives recovery. Every community has a specific set of economic drivers, which are important to understand when planning ahead to reduce disaster impacts to the economy. When major employers are unable to return to normal operations, impacts ripple throughout the community. A list of the top employers in Jefferson County by number of employees can be found in Section 2.

4.2.4 Growth and Development Trends

A key strategy for reducing future losses in a community is to avoid development in known hazard areas while enforcing the development of safe structures in other areas. The purpose of this strategy is to keep people, businesses, and buildings out of harm's way before a hazard event occurs. The 2021 Jefferson County Hazard Mitigation Plan highlights areas where future development can be expected and areas

where mitigation options can be considered in future land use decisions to ensure safe, smart growth in the county.

Figure 4-3 Jefferson County Community Plan Areas



Source: Jefferson County, JEFFCO demographics, https://www.jeffco.us/2394/Demographics

Jefferson County has grown significantly in the past decade and is one of the fastest growing counties in the State. Between 2000 and 2019 Jefferson County's total population increased by 10.7% (DOLA 2021). The amount of growth that County has seen over the past twenty years has been dictated by the availability of undeveloped land. Based on observed population growth trends, housing demand within Jefferson County is expected to remain steady over the next decade.

Land use patterns and cover varies across the County. Approximately 40% of the land in unincorporated Jefferson County is protected by the Jefferson County Open Space Division (Jefferson County 2018). In addition to the Jefferson County Comprehensive Master Plan, which helps guide development in the County, there are also eight Area Plans (North Plains, Central Plains, South Plains, North Mountains, Central Mountains, Indian Hills, Evergreen Area and Conifer/285 Corridor Area) that provide land use recommendations for each of these unique areas in Jefferson County. While most of the total land area (72%) in County is located in the Mountains Areas, most development in the County between 2010 and 2018 has taken place in the South Plains Areas (Jefferson County 2019). **Figure 4-3** shows the location and general size of each Area Plan in the county.

4.3 Hazard Profiles

The hazards identified in **Section 4.1: Hazard Identification** are profiled individually in this section. Much of the profile information came from the same sources used to initially identify the hazards.

4.3.1 Profile Methodology

Each hazard is profiled in a similar format that is described below. It is important to note that the profiles are data driven, and that potential errors or omissions may exist in the data. In particular, there is a time variance between the different data sets. For example, winter storms have been tracked in the planning area for a longer period of time than swelling soils hazards have been documented, so the comparison of severity, previous occurrences, and rates of future occurrences between the two hazards is somewhat skewed. This variance exists between all known hazards in this plan. The information presented is for planning level assessments only.

Description

This subsection gives a generic description of the hazard and associated problems, followed by details on the hazard specific to Jefferson County.

Geographic Extent

This subsection discusses how extensive the hazard is expected to be relative to Jefferson County. It may also include specific discussions regarding which areas of the County are most likely to be affected by the profiled hazard. An extent rating is assigned based on the following methodology:

- **Negligible:** Less than 10 percent of planning area or isolated single-point occurrences
- **Limited:** 10 to 25 percent of the planning area or limited single-point occurrences
- **Significant:** 25 to 75 percent of planning area or frequent single-point occurrences
- **Extensive:** 75 to 100 percent of planning area or consistent single-point occurrences

Percent of planning area is calculated by comparing the amount of area affected to the total county area: (*affected acres/total county acres) * 100 = percent of affected planning area*. Single point events, such as lightning, are evaluated for geographic extent by examining the density of the events collectively.

Previous Occurrences

This subsection contains an overview history of the hazard's occurrences, compiled from multiple data sources. This includes information provided by the HMPC. Significant or historic incidents are profiled in greater detail and include scope, severity, and magnitude, and known impacts.

Probability of Future Occurrences

This subsection utilizes the frequency of past (known) events to calculate a probability of future occurrences. The likelihood is categorized into four different classifications:

- **Unlikely**: Less than 1 percent probability of occurrence in the next year, or has a recurrence interval of greater than every 100 years.
- **Occasional:** Between a 1 and 10 percent probability of occurrence in the next year, or has a recurrence interval of 11 to 100 years.
- **Likely**: Between 10 and 90 percent probability of occurrence in the next year, or has a recurrence interval of 1 to 10 years
- **Highly Likely:** Between 90 and 100 percent probability of occurrence in the next year, or has a recurrence interval of less than 1 year.

Each hazard is calculated for a probability of future occurrence by comparing the known number of events to the available historic record: *(# of known events/years on historic record) * 100 = Probability of Future Occurrence*. Stated mathematically, the methodology for calculating the probability of future occurrences is:

$$\frac{\text{\# of known events}}{\text{years of historic record}} \times 100$$

This formula evaluates that the probability of a given hazard occurring in any given year in Jefferson County. The period of record will vary for each hazard and is based upon available data. In some instances, additional prediction methods are also measured by recurrence intervals, such as floods or hazards where the events occur more than once a year.

Magnitude and Severity

This subsection summarizes the anticipated magnitude and severity of a hazard event based largely on previous occurrences and specific aspects of risk as it relates to the planning area. Magnitude and Severity are classified in the following manner:

- **Negligible:** Less than 10 percent of property is severely damaged, facilities and services are unavailable for less than 24 hours, injuries and illnesses are treatable with first aid or within the response capability of the jurisdiction.
- **Limited:** 10 to 25 percent of property is severely damaged, facilities and services are unavailable for between 1 and 7 days, injuries and illnesses require sophisticated medical support that does not strain the response capability of the jurisdiction, or results in very few permanent disabilities.
- **Critical:** 25 to 50 percent of property is severely damaged, facilities and services are unavailable or severely hindered for 1 to 2 weeks, injuries and illnesses overwhelm medical support for a brief period of time, or result in many permanent disabilities and a few deaths.
- **Catastrophic:** More than 50 percent of property is severely damaged, facilities and services are unavailable or hindered for more than 2 weeks, the medical response system is overwhelmed for an extended period of time or many deaths occur.

The rating is calculated by evaluating the event of record against these criteria. Since most events incur different levels of severity for each element, the rating is assigned to the classification with the most documented occurrences. The purpose of a magnitude and severity rating is to establish the highest known potential threshold of an event to help guide the mitigation goals and actions development. If there are significant events with much lower magnitude and severity ratings than the event of record, this discrepancy will be noted.

Climate Change Considerations

Climate includes patterns of temperature, precipitation, humidity, wind and seasons. Climate plays a fundamental role in shaping natural ecosystems, and the human economies and cultures that depend on them. “Climate change” refers to changes over a long period of time. It is generally perceived that climate change has had and will continue to have measurable impacts on the occurrence and severity of natural hazards around the world. Impacts include the following:

- Snow cover losses will continue, and declining snowpack will continue to affect snow-dependent water supplies and stream flow levels around the world.
- The risk of drought and the frequency, intensity, and duration of heat waves are expected to continue to increase.
- More extreme precipitation events will continue to be likely, increasing the risk of flooding.
- The Earth’s average temperature is expected to continue to increase.

In 2018, the U.S. Global Change Research Program released the Fourth National Climate Assessment (NCA4), the authoritative and comprehensive report on climate change and its impacts in the United States. Not only did the report confirm that climate induced hazards continues to affect Americans in every region of the U.S., the report identifies increased heat, drought, insect outbreaks, wildfire, and flooding as key climate-related concerns for the Southwest region of the U.S., which includes Colorado. The following is a summary of climate change impacts from the Fourth National Climate Assessment.

Recent warming in the southwest region is among the most rapid in the nation and is significantly greater than the global average, and the period since 1950 has been hotter than any comparable long period in at least 600 years. Summer temperatures across the state are expected to warm more than winter temperatures and projections suggest that typical summer months will be as warm as (or warmer than) the hottest 10% of summers that occurred between 1950 and 1999. Under the higher emissions scenario (RCP8.5) climate models predict an increase of 8.6°F in the southwest regional annual average temperature by 2100.

Projected increases in temperatures in the southwest region are also projected to increase probabilities of natural events such as wildfires, drought, and extreme precipitation. These temperature changes have great potential to directly affect public health through increased risk of heat stress and infrastructure through increased risk of disruptions of electric power generation. Water supplies are also vulnerable to impacts of higher temperatures. While water supplies generally change year-to-year due to variabilities in water use and precipitation, higher temperatures are projected to increase evapotranspiration, reducing the effectiveness of precipitation in replenishing surface water and soil moisture. This will have direct impacts on crop yields and productivity of key regional crops and livestock a major risk for the agricultural industry and food security nationwide.

The impacts of climate induced hazards already pose a threat to people and property in the southwest region of the United States, including Jefferson County. Vulnerable populations, in particular those who are low-income, children, elderly, disabled and minorities will likely be impacted by the effects of climate induced hazards disproportionately than other populations (Refer to Section 2 for more information on social vulnerability in the county). Together, these impacts represent a slow-onset disaster that is likely to manifest and change over time. Current projections predict even more rapid changes in the near future, which are likely to affect many of the natural hazards that Jefferson County has historically dealt with. According to HMPC the County is already experiencing some hazards with more frequency and intensity than in years past, such as drought, flooding, wildfire and extreme heat.

Jefferson County's two most frequent and devastating hazards are wildfire and flood, both of which are expected to be impacted by our changing climate. The nature of erosion and public health hazards are also likely to evolve in intensity and character due to a changing regional climate. For these reasons, the hazard identification and risk assessment for the 2021 Jefferson County Hazard Mitigation Plan update includes climate change considerations discussion on how climate change may impact the frequency, intensity, and distribution of specific hazards within the county. Because many impacts of climate induced hazards cross county boundaries, some of the discussion looks at impacts on a regional scale. As climate science evolves, future mitigation plan updates may consider including climate change projections in the risk rankings and vulnerability assessments of the hazards included in the Plan.

Vulnerability Assessment

With Jefferson County's hazards identified and profiled, the HMPC conducted a vulnerability assessment to describe the impact that the significant hazards would have on the County. The vulnerability assessment quantifies, to the extent feasible, assets at risk to natural hazards and estimates potential losses. This vulnerability assessment followed the methodology described in the FEMA publication Understanding Your Risks—Identifying Hazards and Estimating Losses, as well as Tasks 5 and 6 of the 2013 FEMA Local Mitigation Planning Handbook. The vulnerability assessment first describes the total vulnerability and values at risk and then discusses vulnerability by hazard.

The vulnerability assessment was conducted based on the significance of the hazard utilizing best available data. This assessment is an attempt to quantify assets at risk, by jurisdiction where possible, to further define populations, buildings, and infrastructure at risk to natural hazards. The methods of analysis vary by hazard type and data available and are discussed further in 4.3.4 with each hazard analyzed. The information presented is for planning level assessments only. Avalanche is omitted from this vulnerability assessment due to the relatively low significance, lack of previous damages based on research, and a lack of data to support quantifying future losses. Data to support the vulnerability assessment was collected and compiled from the following sources:

- Current County and municipal GIS data (hazards, base layers, critical facilities and assessor's data)
- 2010 US Census, 2019 American Community Survey, and 2019 CO Department of Local Affairs (DOLA) data
- 2020 Homeland Infrastructure Foundation-Level Data (HIFLD) data
- Written descriptions of inventory and risks provided by participating jurisdictions;
- A refined flood loss estimation by jurisdiction with the use of geospatial analysis for both 1% and 0.2% annual chance flooding
- Updated modeling of earthquake loss potential with HAZUS-MH 2.2, including a 2,500 year probabilistic scenario and a hypothetical M 6.5 event on the Golden Fault

- Existing plans and studies, and applicable regulations
- Personal interviews with planning team members, hazard experts, and County and municipal staff.

The scope of the vulnerability assessment is to describe the risks to the County as a whole. The vulnerability assessment first describes the assets in Jefferson County, including the total exposure of people and property; critical facilities and infrastructure; natural, historic, and cultural resources; and economic assets. Development trends, including population growth and land status, are analyzed in relation to hazard-prone areas. Next, where data was available, hazards are evaluated in more detail and potential losses are estimated. Data from each jurisdiction was also evaluated and is integrated here but specific variations of risk are noted in the appropriate annex. The methods to assess vulnerability presented here include an updated analysis from the 2016 Jefferson County Multi-Hazard Mitigation Plan. This includes a detailed risk assessment for all hazards based on advanced methods and updated hazard and inventory data. Thus this 2021 plan should be considered the baseline for measuring changes in vulnerability during future updates, recognizing that vulnerability information should become more refined as data sources and methodologies improve over time. Examples of refinements and changes made in this plan include:

- Updated population and building inventory information, including most recent values and 2020 assessor data;
- An updated and more comprehensive inventory of critical facilities;
- An updated inventory of natural, historic, and cultural resources;
- A refined flood loss estimation by jurisdiction with the use of geospatial data provided by the Assessor's office and FEMA NFHL to perform GIS analysis for both 1% and 0.2% annual chance flooding, supplemented by local flood payers;
- Updated modeling of earthquake loss potential with HAZUS-MH 2.2, including a 2,500 year probabilistic scenario M7.25 and a hypothetical M 6.5 event on the Golden Fault;
- Detailed inventory by jurisdiction of potential structures and critical facilities at risk to hazards

Overall Hazard Significance

Overall potential impact of each hazard is summarized in this subsection, based on geographic extent, probability of future occurrences, and the magnitude and severity of the event of record. These ratings are averaged to provide an overall hazard significance rating, which is useful for comparing the hazards to one another and for guiding the development of actions and priorities. The overall hazard significance ratings are classified as follows:

- **Low:** Two or more of the criteria fall in the lower classifications, or the event has a minimal impact on the planning area. This rating is also sometimes used for hazards with a minimal or unknown record of occurrences and impacts or for hazards with minimal mitigation potential.
- **Medium:** The criteria fall mostly in the middle ranges of classifications, and the event's impacts on the planning area are noticeable but not devastating. This rating is also sometimes utilized for hazards with a high impact rating but an extremely low occurrence rating.
- **High:** The criteria consistently fall along the high ranges of the classification and the event exerts significant and frequent impacts on the planning area. This rating is also sometimes utilized for hazards with a high psychological impact or for hazards that the jurisdiction identifies as particularly relevant.

4.3.2 Avalanche

Description

Avalanche hazards occur predominantly in the mountainous regions of Colorado above 8,000 feet. The vast majority of avalanches occur during and shortly after winter storms. Avalanches typically occur when loading of new snow increases stress to a snow covered slope at a rate faster than strength in the snowpack develops. Critical stresses develop more quickly on steeper slopes, and where deposition of wind-transported snow is common. While most avalanches are caused simply by the weight of accumulated snow, other triggers can be a human (e.g., skier, snowshoer, snowmobiler), or animals.

According to the Colorado Avalanche Information Center (CAIC), about 98 percent of all avalanches start on slopes of 25-50 degrees. Avalanches release most often on slopes above timberline that face away from prevailing winds (leeward slopes collect snow blowing from the windward sides of ridges). Avalanches can also run on small slopes well below timberline, such as gullies, road cuts, and small openings in the trees. Very dense trees can anchor the snow to steep slopes and prevent avalanches from starting; however, avalanches can release and travel through a moderately dense forest. An average-sized avalanche travels around 80 mph; the typical range of impact pressure from an avalanche is from 0.5 to 5.0 tons per square foot.

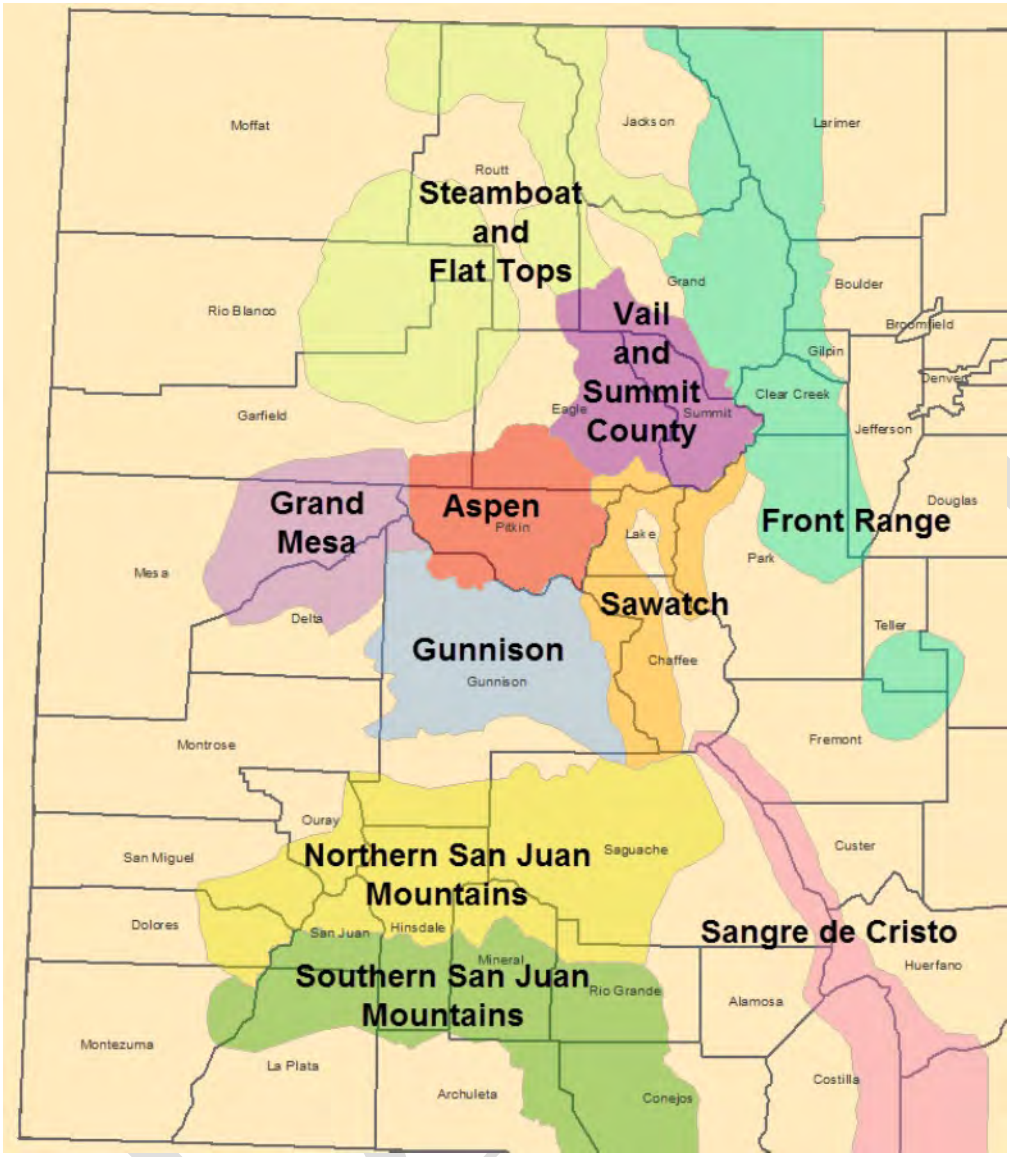
Avalanches in Colorado occur during the winter and spring, mainly between November and April. The most avalanche-prone months are February, March, and January. Avalanches caused by thaw occur most often in April. The avalanche danger increases with major snowstorms and periods of thaw followed by heavy snows. About 2,300 avalanches are reported to the CAIC during an average winter. More than 80 percent of these fall during or just after large snowstorms.

Statistics and reporting from the CAIC indicate that between the winter of 1950/1951 and 2019/2020, Colorado suffered the highest number of avalanche fatalities (293) in the United States. On average over the past 10 winters, 27 people have died in avalanches in the United States each winter (CAIC 2020). This hazard generally affects climbers, backcountry skiers, snowmobilers, and skiers and snowboarders. A smaller number of motorists along highways are also at risk of injury and death due to avalanches, as are residents who live in avalanche-prone areas and other individuals working in those areas. Road and highway closures, damaged structures, and destruction of forests are also a direct result of avalanches. Some residents may live in areas prone to avalanches and may be impacted directly if an avalanche occurs on their property, or indirectly if an avalanche limits or removes accessibility to the property, both for the resident(s) and for emergency response personnel. Recognizing areas prone to avalanches is critical in determining the nature and type of development allowed in a given area.

Geographic Extent

Avalanches typically occur above 8,000 feet and on slopes ranging between 25 and 50 degrees incline. The CAIC website provides backcountry forecasts for avalanche conditions for various forecast zones within the state, as depicted in Figure 4-4. The Front Range zone extends from the Wyoming border south, west to Loveland Pass, and includes the Pikes Peak Area. Almost all of Jefferson County falls outside of the zone boundaries. Only a small portion located just south of I-70, along the southeastern border of Clear Creek County, falls into the Front Range forecast zone. The Front Range zone extends from the Wyoming border south, west to Loveland Pass, and includes the Pikes Peak Area. Overall, this equates to far less than 10% of the planning area.

Figure 4-4 Colorado Avalanche Information Center Forecasts Zones



Source: Colorado Avalanche Information Center

There are few areas of the County where slopes are 30% higher. The majority of vulnerable area in the County lies west of the C-470 corridor, with isolated areas along North and South Table Mountains, the hogback formations and Green Mountain. Most of the areas east of the foothills have strict development restrictions, which minimizes the exposure of the population. In the mountainous areas, the greatest areas of potential occurrence which may impact developments lie along Highway 6, Bear Creek Canyon, Coal Creek Canyon, Ralston Creek Road, and Clear Creek Canyon. Not unexpectedly, these areas are also the areas with greatest potential for rock falls, landslides, or unstable slope events. However, while these areas demonstrate a slope with a known vulnerability to avalanches, the occurrence and tracking records indicate that the areas lack some other element that contributes to avalanche events, such as consistent snowpack.

Based on this information, the geographic extent rating for avalanches in Jefferson County is **negligible** or, at most, **limited**.

Previous Occurrences

The Colorado Avalanche Information Center (CAIC) database recorded 298 occurrences in the State of Colorado between late 1996 and January 2021. However, the database only captures accidents with unusual circumstances, fatalities, and injuries, and therefore represents only a fraction of occurrences.

According to the 2018 State Hazard Mitigation Plan, Jefferson County has had 4 avalanches that caused damage between 1960 and 2008, causing $8,333 in damage. The HMPC could not find any additional details on these, likely due to the small amount of damage. There have been many more occurrences in neighboring Clear Creek County, which have indirect impacts on Jefferson County. Clear Creek County falls almost entirely in the Front Range forecast zone, with the western-most area falling into the Vail-Summit forecast zone. These zones are explained in the Geographic Extent section below. Impacts from avalanches as far away as Summit County can also impact Jefferson County. Avalanches along the I-70 corridor and US Highway 6 threaten transportation routes into Jefferson County from the Western Slope, and may threaten water supplies for downstream residents by jamming creeks, damaging dams, or destroying infrastructure. Several previous occurrences which indirectly impacted the planning area are recounted below, but none of them were within Jefferson County. These occurrences help establish the threat of secondary impacts of avalanches on Front Range counties.

March 23, 2003. The CAIC database recounts a very large avalanche just west of Silver Plume. The avalanche extended all the way down the mountain into Clear Creek and across I-70, spilling into the eastern lanes of the highway and damming the creek, which in turn threatened down-stream water supplies. The event was considered unusual because of its long run out in an area that normally is not avalanche prone.

December 30, 2007. The Channel 7 website reported that avalanche dangers and high winds closed all six lanes of I-70 stranding almost 2,000 travelers along the highway from Floyd Hill to Vail. Interviews with stranded travelers indicate a range of destinations, including the Denver International Airport, sporting events, and New Year's Eve celebration destinations, which underscores the economic impact of the danger on the entire state.

January 7, 2008. The Channel 7 website records avalanche mitigation efforts along I-70 halfway between the Eisenhower Tunnel and Silverthorne covered all six lanes of the highway and ranged from 6 to 10 feet deep. Other efforts closed down I-70 over Vail Pass and various other Colorado and U.S. highways across the western slope, heightening the dangers that avalanche conditions pose to travelers.

March 3 and 7, 2019. Media broadcasts reported avalanches on March 3rd and March 7th which swept across Interstate-70 in the Ten Mile Canyon between Frisco and Copper Mountain and trapped vehicles in several inches of avalanche debris. Fortunately, no injuries or property damages were reported but a large stretch of I-70 required closing down for several hours due to avalanche remediation work.

Probability of Future Occurrences

Jefferson County has only experienced four recorded avalanches in the past 60 years. This corresponds to a probability of future occurrences rating of **unlikely**.

Magnitude and Severity

According to the CAIC, there have been no reported deaths in Jefferson County due to avalanches between 1950 and 2014. Indirect impacts of avalanches on the planning area, such as economic losses due to road closures, are a matter of speculation rather than quantifiable data. With no reported damage amounts and no impact to the operation and delivery of critical services and functions it is difficult to consider the hazard very severe.

Information from the event of record is used to calculate a magnitude and severity rating for comparison with other hazards, and to assist in assessing the overall impact of the hazard on the planning area. In some cases, the event of record represents an anticipated worst-case scenario, and in others, it is a reflection of common occurrence. There is no record of damages for Jefferson County; therefore the magnitude and severity ratings for avalanches must remain **negligible** until additional information becomes available.

Climate Change Considerations

Climate change is likely to continue to alter the frequency and severity of avalanches in the future. In the last decade many experts in western states have pointed out increased avalanche risk associated with a changing snow, precipitation, accumulation, and overall warmer winter patterns. Snow may fall early in the winter and is then followed by a long period without snow. This creates a thin snowpack that becomes structurally weaker as winter goes on. New layers of snow may not bond well to the weak base layer, creating prime conditions for avalanches. Periods of sporadic snowfall in early and mid-spring in Colorado also contribute to this process of creating structurally weaker snowpack, which can lead to avalanche activity as snow accumulation has already begun to thaw with the warmer season. As Colorado experiences winters with higher average temperatures and lower average precipitation, these conditions that increase avalanche risk become more common. More intense and continuous storms over multiple days can also increase the potential for major avalanche cycles, as was experienced in March 2019.

Vulnerability Assessment

Due to limited available data, few recorded impacts, and the low significance rating, a detailed vulnerability assessment was not conducted for avalanche.

Overall Hazard Significance

Avalanches in Jefferson County do not have a significant impact on the planning area. In general, the impacts of avalanches for Jefferson County will be secondary. Avalanches in counties with a higher risk or vulnerability, such as Clear Creek County, may close roads and access points into Jefferson County or those counties may request mutual aid assistance to deal with the event occurrence. The geographic extent of the hazard is considered **negligible**. The probability of future occurrences is considered **unlikely** and the magnitude/severity for the event of record is **negligible**. In addition, the HMPC considers the hazard to have a **low** impact on the County. This equates to an overall impact rating of **low**.

4.3.3 Dam Failure/Incidents

Description

Dams are human-built structures built for a variety of uses, including flood protection, power, agriculture, water supply, and recreation. Dams typically are constructed of earth, rock, concrete, or mine tailings. Two factors that influence the potential severity of a full or partial dam failure are the amount of water impounded and the density, type, and value of development and infrastructure located downstream.

Dam failures can result from any one or a combination of the following causes:

- Prolonged periods of rainfall and flooding, which result in overtopping
- Earthquake
- Inadequate spillway capacity resulting in excess overtopping flows
- Internal erosion caused by embankment or foundation leakage or piping or rodent activity
- Improper design
- Improper maintenance
- Negligent operation
- Failure of upstream dams on the same waterway

Dam failure occurs when the retention function of the dam is compromised, in part or in its entirety. Damage to a dam structure that may result in a failure may be caused by many sources. Possible damages include poor maintenance, age, animal incursion (particularly in earthen dams), erosion, and damages sustained as a result of seismological activity. A dam failure is not the only type of emergency associated with dams. Spillway discharges that are large enough to cause flooding in downstream areas or flooding upstream of dams due to backwater effects or high pool levels are both considered dam emergencies and may cause significant property damage and loss of life (USACE 1980).

Dam failures result in a unique source of flash flooding, when a large amount of previously detained water is suddenly released into a previously dry area due to a failure in some way of the dam. Dams are classified into four classes. The U.S. Army Corps of Engineers and the Colorado State Engineer classify dams into four categories based on the potential consequences should the dam fail:

- **High Hazard:** A dam for which life loss is expected to result from failure of the dam.
- **Significant Hazard:** A dam for which significant damage, but no life loss is expected to result from failure of the dam. Significant damage is defined as damage to structures where people generally live, work, or recreate, including public and private facilities. Significant damage is determined to be damage sufficient to render structures or facilities uninhabitable or inoperable.
- **Low Hazard:** A dam for which neither life loss nor significant damage as defined for a Significant Hazard dam are expected to result from failure of the dam.
- **No Public Hazard (NPH):** A dam for which neither life loss nor significant damage as defined for a Significant Hazard dam are expected to result from failure of the dam.

It is important to keep in mind that the hazard classification of a dam is a measure of the consequences if the dam were to fail, not a measure of how likely the dam is to fail.

Privately owned High and Significant hazard potential dams are required by Colorado regulations to have Emergency Action Plans (EAPs) in place. Class I dams are required to have inundation maps as well. Federally owned High hazard dams are also required to have EAPs by Federal Regulations (USACE). According to the 2018 State Hazard Mitigation Plan, all high-hazard dams in Colorado have EAPs in place, which provide for the emergency response procedures in the event of a dam emergency event.

Dam inundation can also occur from non-failure events or incidents such as when outlet releases increase during periods of heavy rains or high inflows. Controlled releases to allow water to escape when a reservoir is overfilling can help prevent future overtopping or failure. When outlet releases are not enough, spillways are designed to allow excess water to exit the reservoir and prevent overtopping. This can protect the dam but result in flooding downstream.

A low head dam is an engineered structure built into and across stream and river channels. Low head dams were historically built for a variety of purposes to support industrial, municipal, and agricultural

water usage through the diversion of water from streams. Low head dams have also been built to provide recreational amenities for boating, rafting and tubing as well as improve aquatic habitats (Colorado DNR). Water flows over the dams creating a recirculating current that can trap unknowing river users. Due to the low height of this type of dam, low head dams can be difficult to see by river users that are not aware of them and because of the tranquil pool that gives the appearance there is no danger. There are 49 identified low head dams located on the South Platte River, Clear Creek and Ralston Creek in Jefferson County. These low head dams in the County are used as diversion, grade control structures and for recreation purposes. The low head dams along each stream in the County are summarized in Table 4-10 and mapped in Figure 4-8.

Table 4-10 Low Head Dams in Jefferson County

Stream Name	Low Head Dam Category	Count
South Platte River	Grade Control Structure	3
	Diversion Dam	1
Clear Creek	Grade Control Structure	15
	Diversion Dam	16
	Recreation	1
Ralston Creek	Grade Control Structure	9
	Diversion Dam	4

Source: Colorado Department of Natural Resources, Dam Safety Branch

Levees are defined by the Army Corps of Engineers as “earthen embankments whose primary purpose is to furnish flood protection from seasonal high water for a few days or weeks a year. Levees are broadly classified as either urban or agricultural because of different requirements from each” (USACE 2007). Riverine levees are those built to protect from flooding of river ways, whereas coastal levees are those built to protect from coastal water flooding. Levee failures can occur when a flood occurs that exceeds the designed level of protection. In this case the levee may fail or be overtopped. Levees that are not maintained are at risk from failure due to erosion, rodent activity, or piping along roots from vegetation growing on the levee. According to the U.S. Army Corp of Engineers (USACE) and FEMA National Levee Database there are no levees in Jefferson County.

Geographic Extent

Jefferson County contains 30 high hazard, 11 significant hazard and 70 low hazard dams. In addition, one high hazard dam and two low hazard dams have been identified as potentially impacting areas of Jefferson County if breached. Dams outside the county along the in the South Platte River watershed to the south would impact the southern, unincorporated areas of Jefferson County; dams located to the north would affect the more-populated jurisdictions along Clear Creek.

This data indicates that a large portion of the County and County population centers, certainly more than 25%, are exposed to potential dam failures. For example, in a failure of both the Ralston Reservoir Dam and Blunn Dam at Arvada Reservoir, almost 5% of the County would be impacted. Based on this information, the geographic extent rating for dam failure is **significant**.

Table 4-11 lists the high and significant hazard dams within Jefferson County. Dam Names with an asterisk (*) next to them have been given a conditionally satisfactory or unsatisfactory rating by the State Engineer, meaning they have storage restrictions due to structural concerns. As of February 2021, 33 dams in Jefferson County were given the conditionally satisfactory or unsatisfactory ratings. While 23 of these are low hazard dams, 2 are rated significant hazard and 8 are rated high hazard.

Figure 4-5 High and Significant Hazard Dams with Potential to Impact Jefferson County

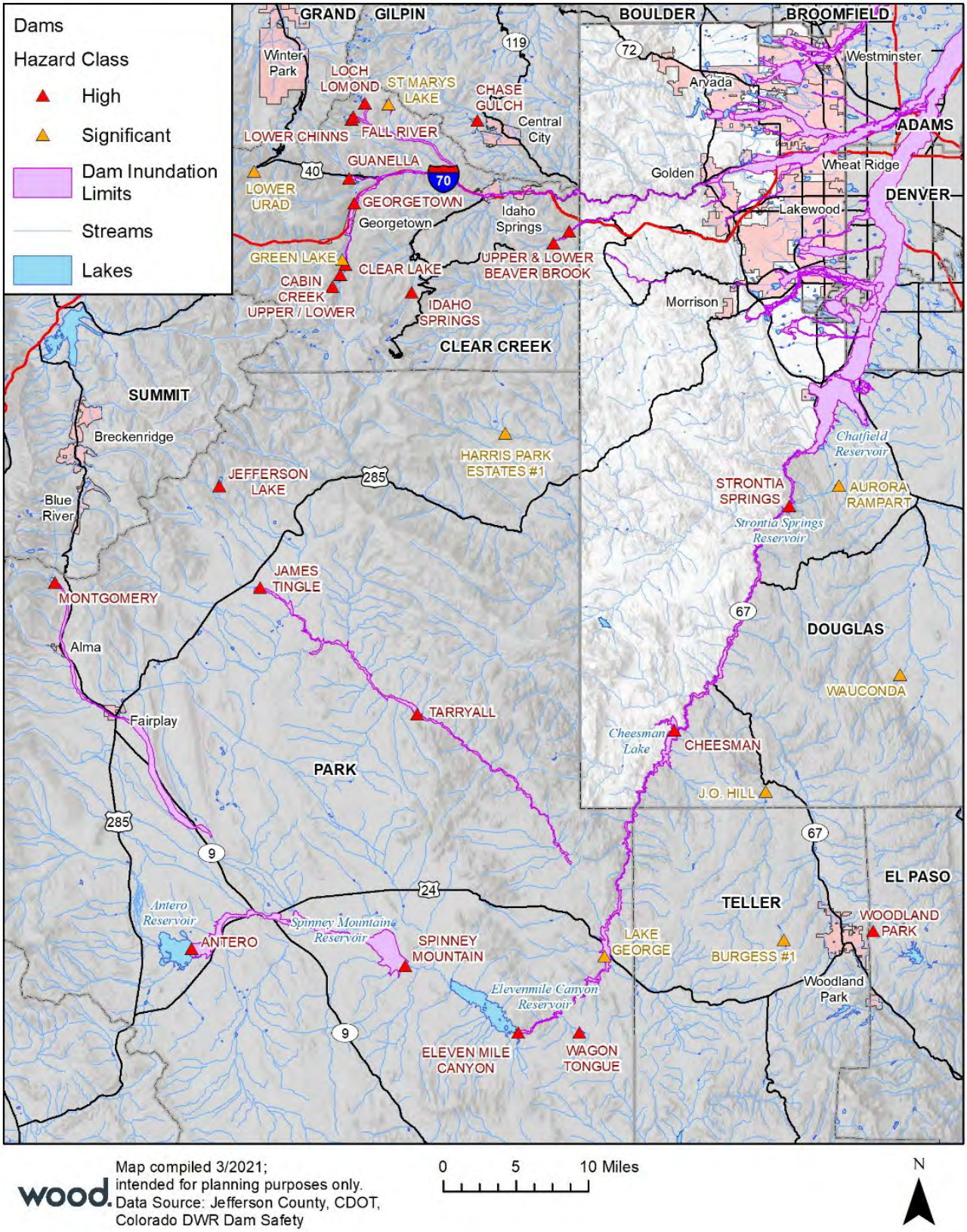


Figure 4-6 shows where the high and significant hazard dams are located. Table 4-12 lists the high and significant hazard dams that are located outside the County, but whose failure could have impacts inside the County. These regional dams are presented in Figure 4-5.

Table 4-11 High and Significant Hazard Dams in Jefferson County

Dam Name	Stream	Downstream Community	Storage Capacity (Acre-Feet)	Emergency Action Plan?	Hazard Rating
Bear Creek	Bear Creek	Lakewood	2,000	Yes	High
Bergen East	Weaver Gulch	Morrison	706	Yes	High
Blunn	Ralston Creek	Arvada	6,361	Yes	High
Chatfield	South Platte River	Littleton	26,600	Yes	High
Cheesman	South Platte River	Deckers	79,064	Yes	High
East	Weir Gulch	Lakewood	102	Yes	High
Evergreen*	Bear Creek	Evergreen	669	Yes	High
Fairmount Reservoir	Clear Creek	Wheat Ridge	981	Yes	High
Fortune	Big Dry Creek	Westminster	9,800	Yes	High
Genesee No. 2			101	Yes	High
Harriman	Weaver Creek	Lakewood	762	Yes	High
Hyatt*	Van Bibber Creek	Arvada	760	Yes	High
Ketner	Walnut Creek	Westminster	166	Yes	High
Leyden	Leyden Creek	Arvada	90	Yes	High
Lookout Mountain	Clear Creek	Golden	101	Yes	High
Lower Long Lake*	Ralston Creek	Arvada	292	Yes	High
Magic Mountain #1	Jackson Gulch	Pleasant View	145	Yes	High
Main	Weir Gulch	Lakewood	583	Yes	High
Maple Grove	Lena Gulch	Lakewood	1,123	Yes	High
Morrison Raw Water	Bear Creek	Morrison	29	Yes	High
Polly A. Deane*	Dutch Creek	Littleton	512	Yes	High
Ralston	Ralston Creek	Arvada	10,749	Yes	High
Smith*	Bear Creek	Lakewood	638	Yes	High
Standley Lake	Big Dry Creek	Westminster	43,344	Yes	High
Strontia Springs	South Platte River	Kassler	7,700	Yes	High
Tucker Lake - North Dam	Ralston Creek	Arvada	586	Yes	High
Tucker Lake - South Dam	Ralston Creek	Arvada	882	Yes	High
Upper Long Lake*	Ralston Creek	Arvada	1,500	Yes	High
Wellington*	S. Fork Buffalo Creek	Buffalo Creek	4,399	Yes	High
Willow Springs #1*	Turkey Creek	Lakewood	108	Yes	High
Woman Creek	Woman Creek	Westminster	836	Yes	High
Beers Sisters Lake	S. Platte River	Littleton	39	Yes	Significant
Bergen West*	Weaver Gulch	Lakewood	370	Yes	Significant
Bowles #1	South Platte River	Bowmar	2,475	Yes	Significant
Carmody	Sanderson Gulch	Lakewood	22	Yes	Significant

Dam Name	Stream	Downstream Community	Storage Capacity (Acre-Feet)	Emergency Action Plan?	Hazard Rating
Devinney	S. Lakewood Gulch	Lakewood	10	Yes	Significant
Harwood S Storage Reservoir	Weaver Gulch	Lakewood	143	Yes	Significant
Johnston	Lilley Gulch	Littleton	547	Yes	Significant
Kendrick	Sanderson Gulch	Lakewood	242	Yes	Significant
Lockport	Troublesome Creek	Kittredge	36	Yes	Significant
Meadow View	North Turkey Creek		51	No	Significant
Pomona No. 2 And No. 3*	Little Dry Creek	Arvada	114	Yes	Significant

Source: National Inventory of Dams, NHD
Note: * represents dams that have been rated as unsatisfactory or conditionally satisfactory by the State Engineer

Table 4-12 Other High and Significant Hazard Dams That May Impact Jefferson County

Dam Name	Stream	Downstream City	Storage Capacity (Acre-Feet)	Emergency Action Plan?	Hazard Rating
Lower Beaver Brook	Beaver Brook	Golden	30	Yes	High
Upper Beaver Brook	Beaver Brook	Golden	397	Yes	High
Upper Cabin Creek	South Clear Creek	Georgetown	1,602	Yes	High
Lower Cabin Creek	South Clear Creek	Georgetown	1,988	Yes	High
Idaho Springs	Chicago Creek	Idaho Springs	230	Yes	High
Lower Chinns	Fall River	Idaho Springs	108	Yes	High
Clear Lake	South Clear Creek	Georgetown	703	Yes	High
Fall River	Fall River	Idaho Springs	890	Yes	High
Georgetown	South Clear Creek	Lawson	386	Yes	High
Loch Lomond	Fall River	Idaho Springs	875	Yes	High
Chase Gulch	Chase Gulch	Black Hawk	602	Yes	High
Guanella	West Fork Of Clear Creek	Empire	1,340	Yes	High
Woodland Park	Loy Gulch	Woodland Park	60	Yes	High
Antero	S. Fork S. Platte River	Hartsel	44,733	Yes	High
Eleven Mile Canyon	South Platte River	Lake George	97,800	Yes	High
Jefferson Lake	Jefferson Creek	Jefferson	2,560	Yes	High
Montgomery	Middle Fork S. Platte	Alma	5,088	Yes	High
Tarryall	Tarryall Creek	Deckers	1,963	Yes	High
Wagon Tongue	Wagon Tongue Gulch	Lake George	130	Yes	High
Spinney Mountain	South Platte River	Lake George	53,873	Yes	High
James Tingle	Michigan Creek	Jefferson	400	Yes	High
Green Lake	South Clear Creek	Georgetown	96	Yes	Significant
St. Marys Lake	Silver Creek	Idaho Springs	38	Yes	Significant
Lower Urad	Woods Creek	Empire	252	Yes	Significant
Aurora-Rampart	Willow Creek	Kassler	1,200	Yes	Significant

Dam Name	Stream	Downstream City	Storage Capacity (Acre-Feet)	Emergency Action Plan?	Hazard Rating
J. O. Hill	West Creek	Deckers	154	Yes	Significant
Wauconda	Bear Creek	Sedalia	336	Yes	Significant
Burgess #1	Rule Creek	Deckers	210	Yes	Significant
Lake George	S. Platte River	Lake George	270	Yes	Significant
Harris Park Estates #1	Elk Creek	Shaffers Crossing	101	Yes	Significant

Source: National Inventory of Dams, NHD

Figure 4-5 High and Significant Hazard Dams with Potential to Impact Jefferson County

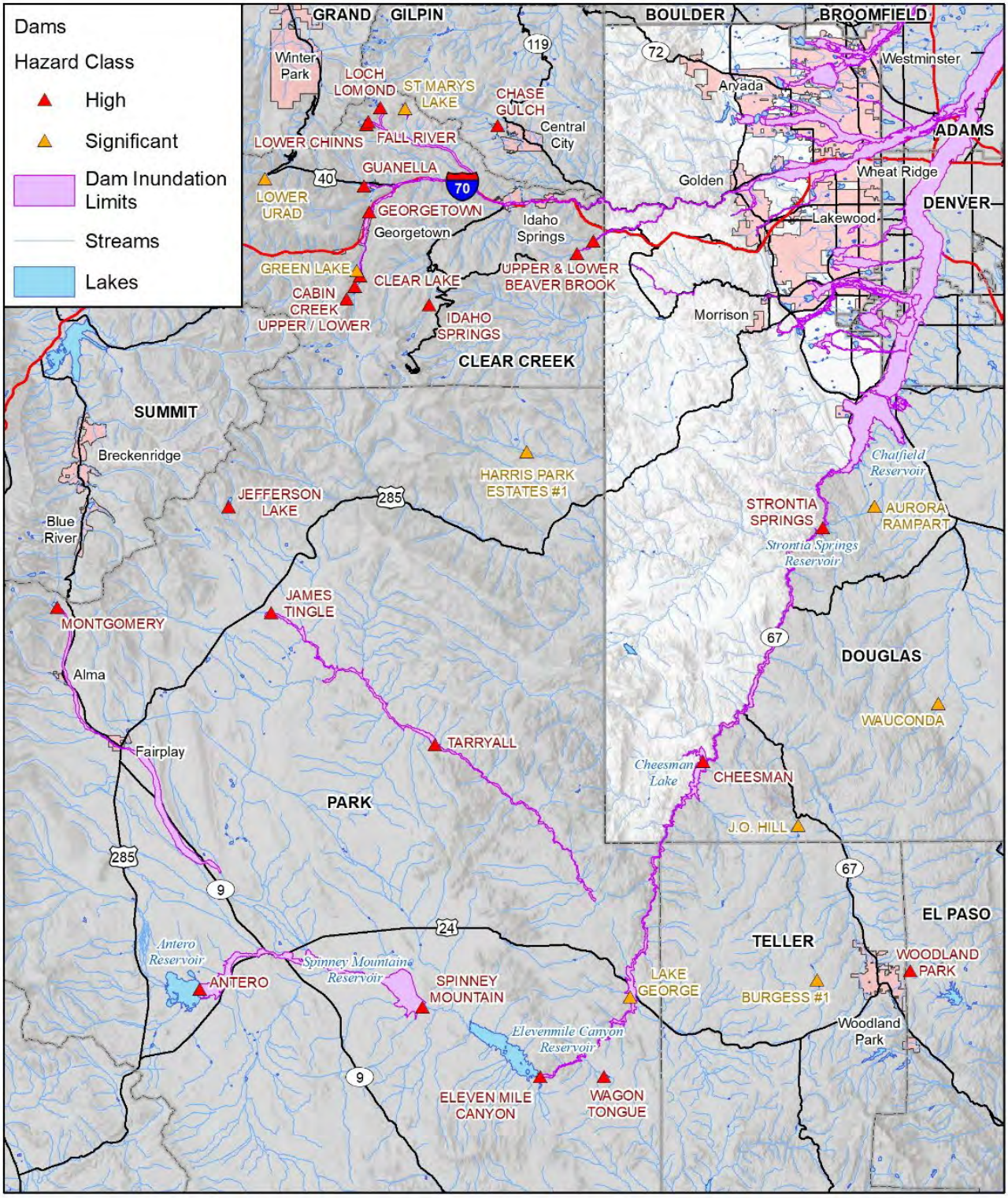


Figure 4-6 Potential Dam Inundation Areas

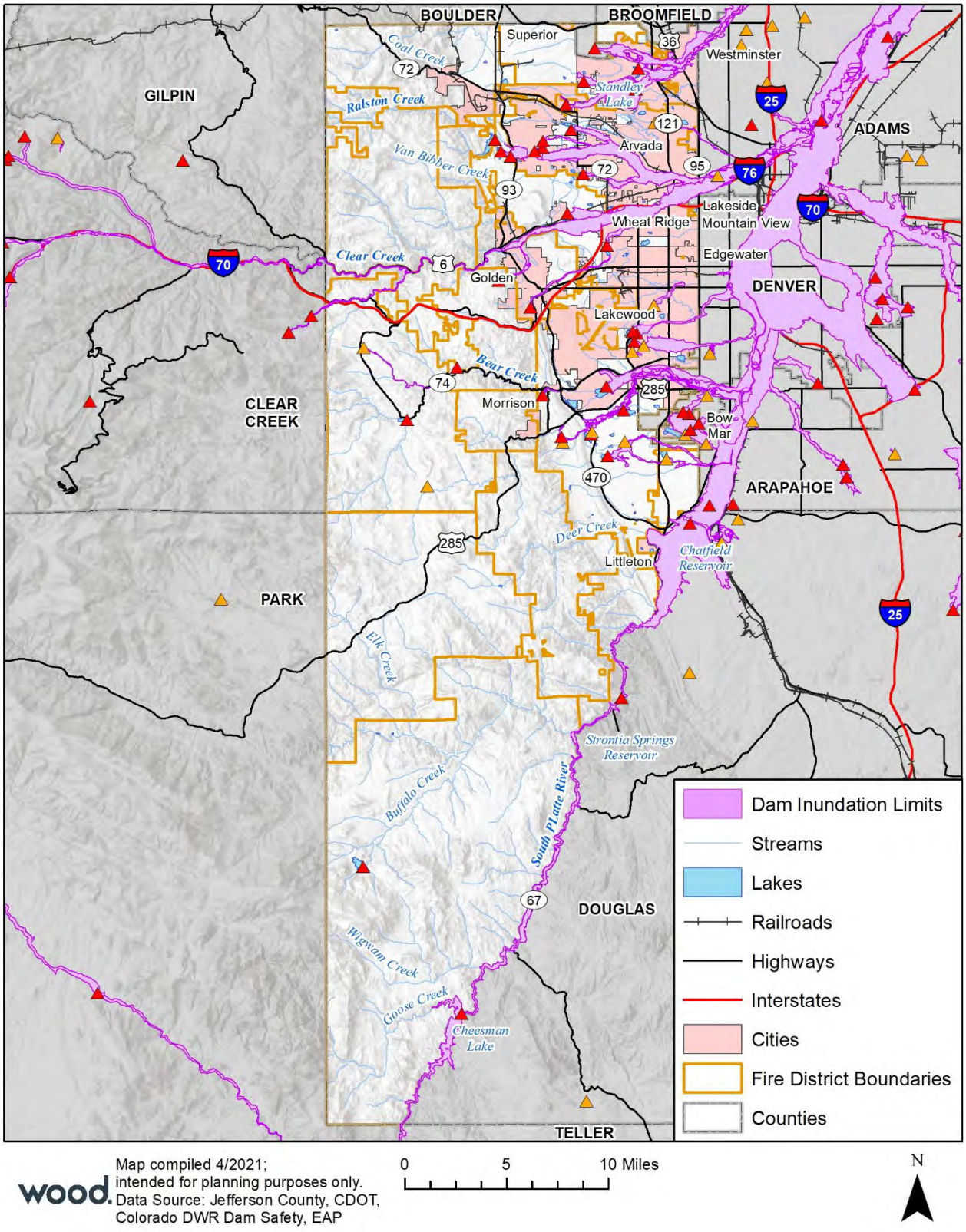
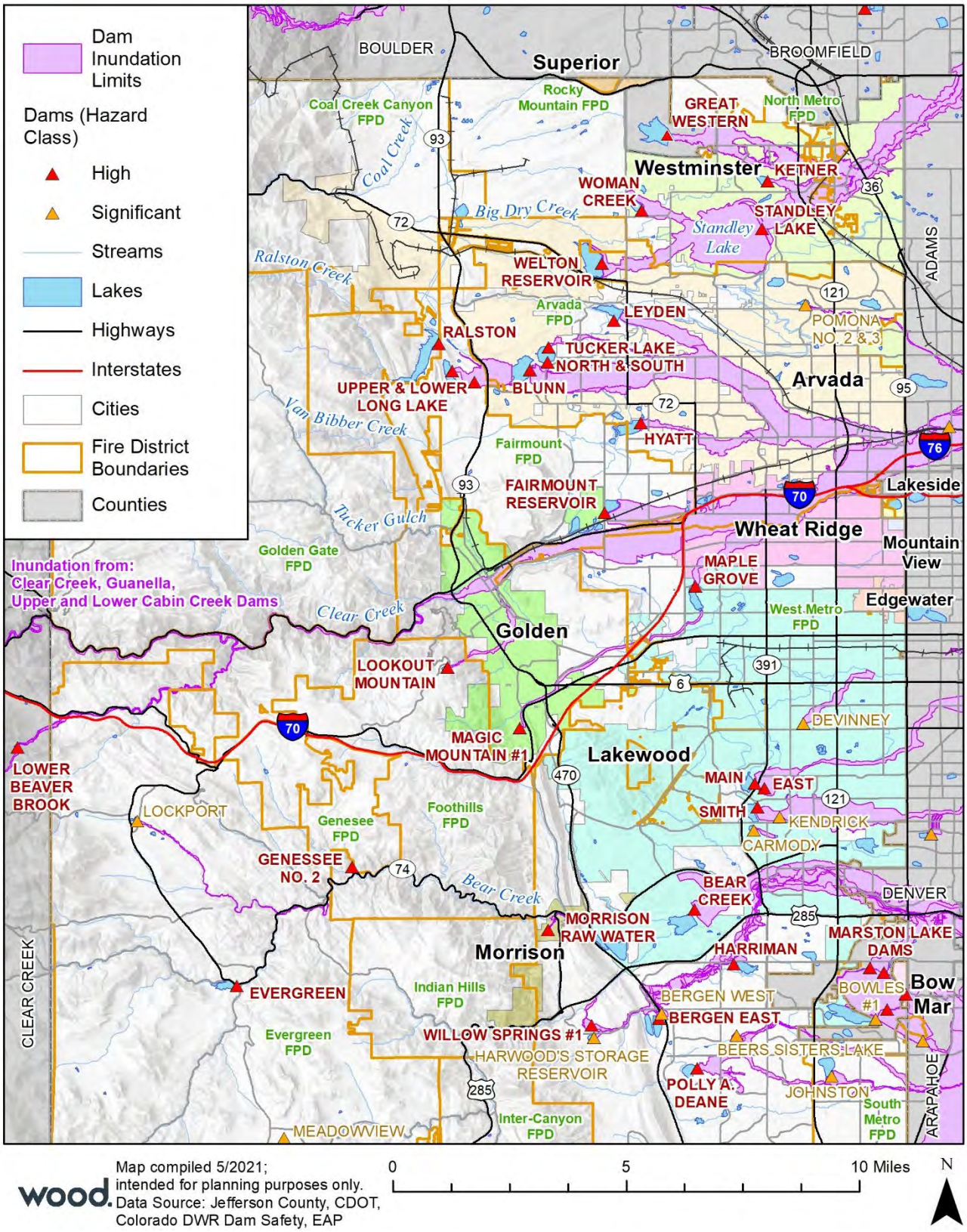
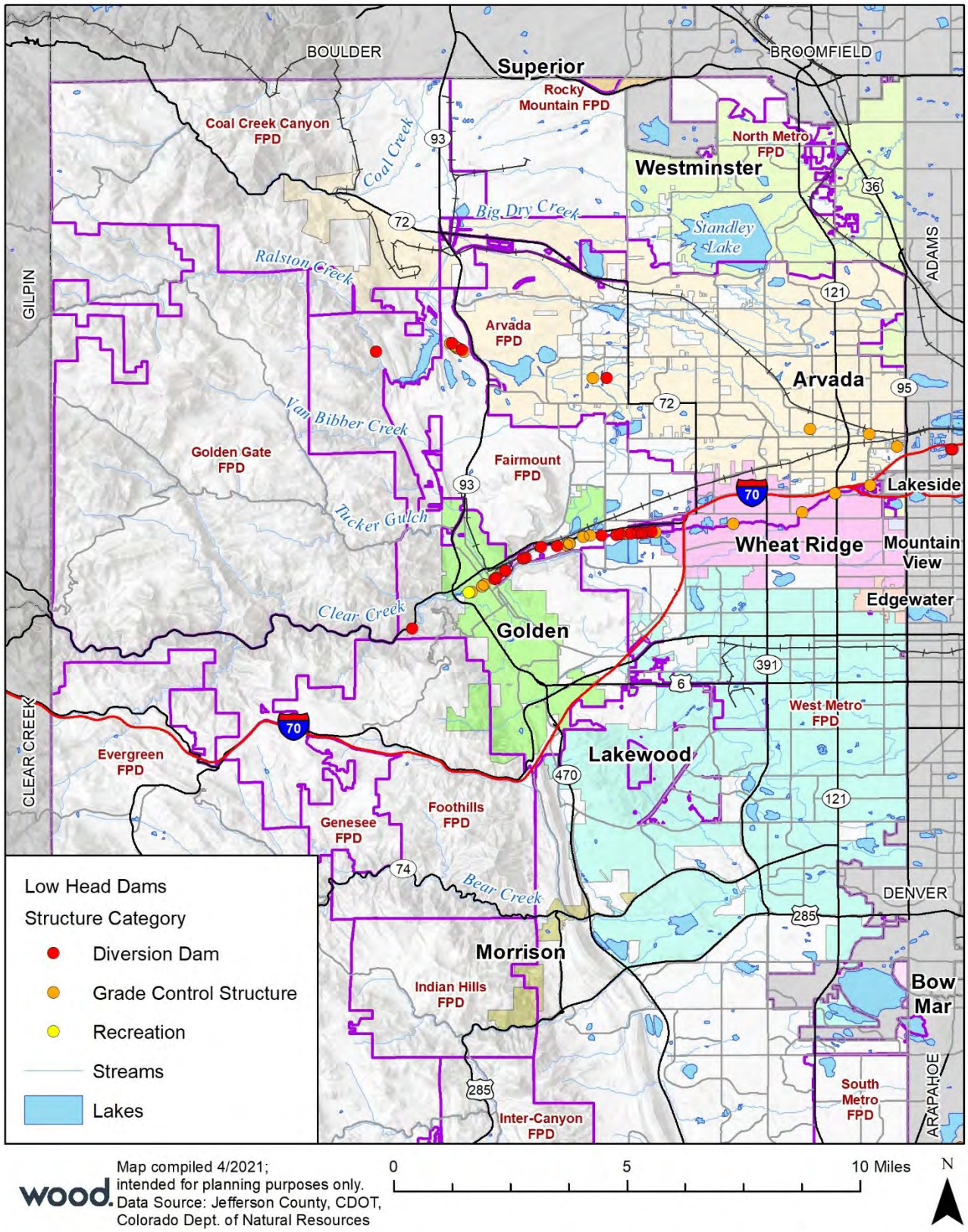


Figure 4-7 Potential Dam Inundation Areas (Northern Half)



Map compiled 5/2021; intended for planning purposes only. Data Source: Jefferson County, CDOT, Colorado DWR Dam Safety, EAP

Figure 4-8 Low Head Dams in Jefferson County



Non-Failure Dam Incidents:

The Colorado DNR has a statewide database that identifies the potential for non-failure dam inundation to show potential areas of flooding where outlet capacity exceeds the downstream channel capacity. The dams at the highest risk of non-failure inundation are shown in Table 4-13. The ranking shown in the table represents the likelihood of hazardous conditions existing below the dams during a worst case, maximum outlet release scenario. Dams are ranked as high, moderate, or low likelihood for outlet releases to cause conditions that could require an emergency response to reduce potential downstream consequences. The ranking is based on a statewide database of high hazard dams that includes 441 high hazard dams that have been analyzed by the Colorado DNR for this aspect of dam incident flooding. The high, moderate, or low designations were assigned by DNR by dividing the total number of ranked dams across the state into thirds. Should there be a need to relieve pressure on the dam (e.g. if there was excess inflow from high rains or snowmelt) releases from the dams ranked as high or moderate may result in downstream flooding.

Table 4-13 Dam with Risk of Non-Failure Inundation

Dam ID	Dam Name	Outlet Description	Max Outlet Release Capacity (cfs)	Ranking	Outlet Release Hazard Rating
090112	Bear Creek	7 FT X 10.5 FT*	2,000	3	High
070302	Blunn	48" RCP	420	6	High
080324	Chatfield	2-10' X 15.5' *	8,300	4	High
800102	Cheesman	78" steel + upper level tunnel	2,382	137	High
090111	Evergreen	12" steel pipe	425	30	High
090240	Genesee No. 2	DIP with multi-level intake	22	119	High
070209	Leyden	36" CIP	193	23	High
070214	Magic Mountain #1	30" CMP w/ 24-INCH HDPE LINING	67	123	High
070219	Maple Grove	30" STEEL	102	2	High
070224	Ralston	60" STEEL	650	8	High
020326	Standley Lake	new outlet constructed 2004, 2 - 72" dia steel intake pipes, 102" tunnel along toe	700	7	High
080401	Strontia Springs	2-48",2-18",2-*	4,000	59	High
020633	Woman Creek	30" STEEL & RCP	75	62	High
090104	Bergen East	12" CIP	45	157	Moderate
020635	Fortune	30 inch steel pipe encased in concrete	107	189	Moderate
020226	Ketner	12" CMP w/ insituform liner	6	210	Moderate
090208	Morrison Raw Water	8" D.I.P.	4	207	Moderate
090131	Polly A. Deane	18" RCP	25	216	Moderate
075311	Smith	12" CIP; installed in 1940	12	228	Moderate
070232	Tucker Lake - South Dam	2- 15" RCP	34	246	Moderate
800116	Wellington	6'W X 8'H rock tunnel	162	161	Moderate
075309	East	18" RCP	22	280	Low
070312	Fairmount Reservoir	24" DIP	30	309	Low
090115	Harriman	37" Steel	63	323	Low

Dam ID	Dam Name	Outlet Description	Max Outlet Release Capacity (cfs)	Ranking	Outlet Release Hazard Rating
070136	Hyatt	8"&10" PVC, sliplined old pipes	18	296	Low
070104	Lookout Mountain	2-8" DIP	5	343	Low
070115	Lower Long Lake	12" CIP	18	341	Low
075310	Main	20" CIP	32	284	Low
070320	Tucker Lake - North Dam	12" RCP	0	348	Low
070114	Upper Long Lake	18" CIP	61	367	Low
090204	Willow Springs #1	6" steel	2	358	Low

Source: State of Colorado Department of Natural Resources, Dam Safety

Previous Occurrences

While there are numerous dams in and around Jefferson County, there have only been thirteen incidents reported to the National Performance of Dams database, three of which were failures. Those incidents are recorded in Table 4-14. Specifics related to these dam failures are not available, but a brief profile of the anticipated impacts for dam failures for the high hazard dams, based on the contents of the dam emergency action plans (EAP) is discussed.

Table 4-14 Jefferson County Dam Failures and Incidents

Date	Dam Name	Waterway	Nearest Town	Dam Hazard Potential	Event	Failure?
1952	Clear Lake[1]	Clear Creek	Georgetown	Significant	Inflow flood-hydrologic event	Yes
1974	Oberon Lake No. 1	Ralston Creek	Arvada	Significant	Inflow flood-hydrologic event	Yes
February 1979	Maple Grove	Lena Gulch	Lakewood, Wheat Ridge	High	Vandalism	Yes
January 1993	Standley Lake	Big Dry Creek	Westminster	High	Reservoir-Wind Waves	No
April 1998	Fairmount	Clear Creek	Wheat Ridge	High	Reservoir Incident	No
June 5, 2013	Montgomery[2]	Middle Fork S. Platte	Unincorporated County	High	Seepage/Internal Erosion	No
Sept. 12, 2013	Chase Gulch[2]	S. Platte	Golden	High	Seepage/Internal Erosion	No
Sept. 12, 2013	Leyden	Chase Gulch	Arvada	High	Hydrologic/flooding	No
Sept. 13, 2013	Tucker Lake – South Dam	S. Platte River	Arvada	High	Hydrologic/flooding – High Reservoir Level	No
May 22, 2015	Strontia Springs	S. Platte River	Littleton	High	High Reservoir Level	No
June 16, 2015	Eleven Mile Canyon[2]	S. Platte	Unincorporated County	High	Hydrologic/flooding – High Reservoir Level	No
June 17, 2015	Cheesman	S. Platte River	Unincorporated County	High	Hydrologic/flooding – High Reservoir Level	No

Date	Dam Name	Waterway	Nearest Town	Dam Hazard Potential	Event	Failure?
June 22, 2017	Jefferson Lake[2]	Jefferson Creek	Unincorporated County	High	Seepage/Internal Erosion – Excessive/increased Seepage	No

Source: National Performance of Dams database, Stanford University and Association of State Dam Safety Officials Dam Incident Database [1]This dam is located in Clear Creek County, but the dam failure affected the City of Golden in Jefferson County
[2] These dams are located outside of Jefferson County but have the potential to impact the County.

2013 Flooding Event: In September 2013, Jefferson County and the entire Front Range experienced heavy rainfall over an eight-day period from the 11th to the 18th. The rainfall caused many dam spillways to flow in Jefferson County and the surrounding area. The dam spillway overflows mitigated structural damage to the dam but was cause for concern for some downstream communities not used to seeing spillways full of water. There was also concern that spillway flows and outlet discharges could cause flooding downstream. Per a CBS Denver report, residents living near Leyden Dam in Arvada were voluntarily evacuated on September 12th, 2013. While there was no fear of the dam failure, concern was centered around excess runoff from the spillway creating dangerous flooding on roadways. The event caused damage to Indiana Street that caused the road to be closed for several weeks for repairs. According to the Urban Drainage and Flood Control District "*A September to Remember*" document the flooding exposed an 18-inch water main encased in a 36-inch concreate pipe, overtopped the upstream embankment of the Croke Canal, and resulted in shallow flooding of several homes and businesses along Leyden Creek. The document also suggests that dam improvements in 2001 likely averted a catastrophic dam failure, which would have caused severe property damage and likely cost lives.

Ralston Reservoir is owned by Denver Water and is a water supply reservoir on Ralston Creek west of Arvada. Because it has no flood storage it released water over its emergency spillway on September 12, 2013, causing significant erosion on a steep hillside near Highway 93. The spillway discharge added to the downstream watershed contribution, causing substantial channel and erosion damage before reaching Arvada/Blunn Reservoir.

For the most part, communities in Jefferson County had seen substantial investment in dam improvements prior to the 2013 floods, which paid off when the storm and its impacts arrived. Pat Dougherty, Arvada City Engineer was quoted in "*A September to Remember*" as saying "the story is that there is no story, because the story is what we did over the years to prevent flood damages." Bear Creek Reservoir was constructed to protect Lakewood and Denver from flooding. A significant amount of water was impounded during 2013 and 2015 flood events. While this caused some damage to the City of Lakewood's park facilities it likely prevented flood damage to residents and businesses downstream.

Non-jurisdictional dams or impoundments did not fare so well. These are low hazard dams that are not inspected by the State Engineer. At least two of these structures breached, both located west of Highway 93 near Leyden. One of these created severe erosion that was visible from the highway.

Probability of Future Occurrences

There have been 13 dam incidents in Jefferson County since 1890. The methodology for calculating the probability of future occurrences is described in Section 4.3.1. This formula evaluates that the probability of a dam failure occurring in any given year is 6%. This corresponds to a probability of future occurrences rating of **occasional**.

Magnitude and Severity

Information from the event of record is used to calculate a magnitude and severity rating for comparison with other hazards, and to assist in assessing the overall impact of the hazard on the planning area. In some cases, the event of record represents an anticipated worst-case scenario, and in others, it is a reflection of common occurrence. There is no event of record for Jefferson County with a sufficiently detailed profile that allows for a specific discussion on the severity and magnitude of such an event. However, the rating systems utilized in dam classification is a useful measurement for assessing the

potential magnitude and severity of a dam failure. In addition, all high-hazard dams in Colorado are required to have Emergency Action Plans (EAPs) that include predicted inundation maps for dam failure scenarios. These tools allow planners to measure the estimated worst-case or event-of-record occurrences for a dam failure.

Water released by a failed dam generates tremendous energy and can cause a flood that is catastrophic to life and property located in the inundation area (downstream). The largest four dams in terms of maximum storage are the Cheesman (79,064), Standley Lake (43,344), Chatfield (26,600), and the Ralston Dams (10,749). Chatfield and Cheesman Dams both are located on the South Platte River and a failure to either could be catastrophic for Jefferson County. A failure of the Chatfield Dam would impact the City of Littleton but would also affect unincorporated areas of the County. Unincorporated areas of the County, specifically Deckers, would also be impacted if Cheesman Dam were to fail. Failure of the Standley Lake Dam would affect Westminster and the Ralston Dam would have the greatest impact on the City of Arvada if it were to fail.

Police stations, fire stations, or health care facilities are located directly in the inundation areas, they would be indirectly impacted by the event, which would not only overwhelm local emergency response capabilities (who would be entirely consumed in the evacuation process and require additional assistance from neighboring counties to assist in both the evacuation and routine calls), but hinder response activities through the direct impacts on roads, bridges and railways.

Potential injuries caused by a failure are considered numerous and severe, and the high-hazard rating placed on the dam indicates that human fatalities are anticipated during a failure. The medical response of the County would be severely impacted or overwhelmed, though nearby jurisdictions are anticipated to help. However, the dam break would also impact Denver, Adams, and Weld Counties directly, which would stretch support resources even thinner. Based on these factors, the magnitude severity ratings for dam failure are considered **critical** and perhaps even **catastrophic**.

Climate Change Considerations

The potential for climate change to affect the likelihood of dam failure has been incorporated into the 2020 Rules and Regulations for Dam Safety and Dam Construction. The climate-change related Rule is based on a state-of-the-practice regional extreme precipitation study completed in 2018 (DWR, 2018). This study determined a very high likelihood of temperature increases, resulting in increased moisture availability to extreme storms. As such, an atmospheric moisture factor of 7% is required to be added to estimates of extreme rainfall for spillway design.

Vulnerability Analysis

The impacts of a dam failure to existing development in Jefferson County could be catastrophic. Specific inundation maps and risk information are included in the dam-specific emergency action plans housed the Jefferson County Office of Emergency Management. The estimated impacts to property within the County and its municipalities from a dam failure are discussed in this vulnerability analysis. However, dam failures would potentially result in a much greater loss of life and more extensive destruction to property and infrastructure due to the potential speed of onset; greater depth, extent, and velocity of flooding; and the wider damage areas caused by the ability of dam failures to flood areas outside of mapped floodplains. For reference, high hazard dams threaten lives and property, significant hazard dams threaten property only.

In general, communities located below a dam and along a waterway are likely to be exposed to the impacts of a dam failure. The reservoirs located in the foothills and Rocky Mountains have the greatest potential impacts; this includes reservoirs located in the planning area, and reservoirs that may be located outside and upstream of the planning area but could still have impacts in Jefferson County. The dams within the planning area include the large reservoirs of Arvada, Ralston, and Standley Lake. Bear Creek Dam is primarily a flood control dam. Antero, Chatfield, Cheesman, Eleven Mile, Strontia Springs, Marston Lake, and Spinney Lake are mostly outside of the planning area on the South Platte River. The South Platte River is also the southeast border of Jefferson County. Impacts in the South Platter River Canyon could be severe if any of these dams failed, but fortunately most of this area is sparsely developed. The impacts of any of these dam failures would be great in the Denver Metropolitan Area, but

this would mostly be outside of Jefferson County. Jefferson County's first responders would likely be heavily involved in mutual aid assistance should an event occur.

The portions of the planning area exposed to significant impacts by a dam failure are numerous. Within the planning area (the County limits) there are 30 high hazard and 11 significant hazard dams. The jurisdictions and the number of dams upstream of them are listed in Table 4-15 and Figure 4-8; dam locations are shown in the maps in the hazard profile earlier in this section. The table notes the first jurisdiction to be impacted by dams. Note that the dams that threaten communities such as Golden in the Clear Creek watershed may also impact Wheat Ridge or other parts of the unincorporated areas.

There are numerous dams outside the county limits whose failure could have impacts inside the county. An analysis of all the watersheds that drain into Jefferson County revealed that there is one high hazard dam and one significant hazard dam whose failure could have impacts in unincorporated Jefferson County.

Table 4-15 Summary of High and Significant Hazard Dams Inside Jefferson County

First Downstream Area At-Risk	# of High Hazard Dams Upstream	# of Significant Hazard Dams Upstream
Arvada	8	1
Bow Mar	0	1
Golden	1	0
Lakewood	7	5
Littleton	2	2
Morrison	2	0
Pleasant View	1	0
Unincorporated Jefferson County	4	2
Westminster	4	0
Wheat Ridge	1	0
Total	**30**	**11**

Source: Jefferson County, National Inventory of Dams, NHD

General Property

Losses from a dam failure vary based on the dam, cause of failure, warning time for impacted communities, and time of day. Potential property loss estimates are in the billions, along with multiple anticipated deaths and injuries. Inundation maps that identify anticipated flooded areas (which may not coincide with known floodplains) are produced for all high hazard dams and are contained in the Emergency Action Plan (EAP) required for each dam. However, the information contained in those plans is considered sensitive and is not widely distributed. Therefore, structures and potential loss estimates in the county are based on approximate estimates for some of the dams present countywide and are provided in Table 4-16 and Table 4-17.

The total properties at risk and their improvements were found by counting the number of parcels intersecting with the dam inundation extents available and summing those improvement values.

Table 4-16 Dam Inundation Risk to Properties and Population by Jurisdiction

Jurisdiction	Improved Parcels	Building Count	Improved Value	Content Value	Total Value	Population
Arvada	6,921	7,427	$2,576,108,097	$1,563,274,479	$4,139,382,576	16,194

Jurisdiction	Improved Parcels	Building Count	Improved Value	Content Value	Total Value	Population
Golden	522	572	$338,765,969	$237,380,701	$576,146,670	883
Lakewood	5,120	5,473	$1,595,152,222	$834,074,380	$2,429,226,602	11,461
Morrison	6	6	$1,851,531	$1,031,533	$2,883,064	10
Wheat Ridge	2,373	3,072	$786,308,504	$523,827,235	$1,310,135,739	4,418
Unincorporated	3,083	3,283	$1,246,893,571	$779,693,472	$2,026,587,043	7,387
Total	**18,025**	**19,833**	**$6,545,079,894**	**$3,939,281,799**	**$10,484,361,693**	**40,354**

Source: Jefferson County Assessor, National Inventory of Dams, NHD

Based on the above results, Arvada has over 6,000 parcels potentially exposed to dam inundation hazards, followed by Lakewood (5,120 parcels exposed), Wheat Ridge (2,373 parcels exposed) and the unincorporated areas of the county (3,083 parcels). Further analysis shows Wheat Ridge has the greatest total percentage (21%) of parcels at risk to inundation, followed by Arvada (16%) and Lakewood (10%), refer to Table 4-17.

Table 4-17 summarizes parcels at risk by property type and jurisdiction. The table below indicates that Residential properties are at highest risk based on their total counts and total values, followed by Commercial, Exempt, Industrial and Mixed Use parcels. The estimated total value exposed to the available dam inundation layers amount to over $10 billion based on the available data, which again may be limited in detail and extent.

Table 4-17 Dam Inundation Effects on Parcels – Estimates by Parcel Type

Jurisdiction	Property Type	Improved Parcels	Building Parcels	Improved Value	Content Value	Total Value	% of Parcels at Risk
Arvada	Agriculture	3	3	$265,224	$265,224	$530,448	
	Commercial	174	238	$191,228,879	$191,228,879	$382,457,758	
	Exempt	23	26	$35,076,293	$35,076,293	$70,152,586	
	Industrial	135	174	$140,155,569	$210,233,354	$350,388,923	
	Mixed Use	56	75	$43,559,327	$43,559,327	$87,118,654	
	Residential	6,530	6,911	$2,165,822,805	$1,082,911,403	$3,248,734,208	
	Total	**6,921**	**7,427**	**$2,576,108,097**	**$1,563,274,479**	**$4,139,382,576**	**16%**
Golden	Commercial	65	92	$68,831,101	$68,831,101	$137,662,202	
	Exempt	12	13	$42,696,376	$42,696,376	$85,392,752	
	Industrial	3	3	$3,441,445	$5,162,168	$8,603,613	
	Mixed Use	48	54	$17,585,066	$17,585,066	$35,170,132	
	Residential	394	410	$206,211,981	$103,105,991	$309,317,972	
	Total	**522**	**572**	**$338,765,969**	**$237,380,701**	**$576,146,670**	**9%**
Lakewood	Agriculture	1	1	$46,378	$46,378	$92,756	
	Commercial	56	149	$32,534,002	$32,534,002	$65,068,004	
	Exempt	8	13	$32,249,867	$32,249,867	$64,499,734	
	Industrial	1	3	$1,087,099	$1,630,649	$2,717,748	
	Mixed Use	5	6	$5,992,092	$5,992,092	$11,984,184	
	Residential	5,049	5,301	$1,523,242,784	$761,621,392	$2,284,864,176	
	Total	**5,120**	**5,473**	**$1,595,152,222**	**$834,074,380**	**$2,429,226,602**	**10%**
Morrison	Commercial	1	1	$211,534	$211,534	$423,068	
	Residential	5	5	$1,639,997	$819,999	$2,459,996	

Jurisdiction	Property Type	Improved Parcels	Building Parcels	Improved Value	Content Value	Total Value	% of Parcels at Risk
	Total	**6**	**6**	**$1,851,531**	**$1,031,533**	**$2,883,064**	**4%**
Wheat Ridge	Agriculture	1	1	$11,380	$11,380	$22,760	
	Commercial	107	159	$90,654,979	$90,654,979	$181,309,958	
	Exempt	18	22	$8,220,916	$8,220,916	$16,441,832	
	Industrial	150	197	$78,103,977	$117,155,966	$195,259,943	
	Mixed Use	13	14	$6,250,736	$6,250,736	$12,501,472	
	Residential	2,084	2,679	$603,066,516	$301,533,258	$904,599,774	
	Total	**2,373**	**3,072**	**$786,308,504**	**$523,827,235**	**$1,310,135,739**	**21%**
Unincorporated	Agriculture	2	2	$249,352	$249,352	$498,704	
	Commercial	54	79	$162,511,303	$162,511,303	$325,022,606	
	Exempt	14	17	$19,518,307	$19,518,307	$39,036,614	
	Industrial	88	171	$61,105,441	$91,658,162	$152,763,603	
	Mixed Use	28	30	$8,003,529	$8,003,529	$16,007,058	
	Residential	2,897	2,984	$995,505,639	$497,752,820	$1,493,258,459	
	Total	**3,083**	**3,283**	**$1,246,893,571**	**$779,693,472**	**$2,026,587,043**	**4%**
Grand Total		**18,025**	**19,833**	**$6,545,079,894**	**$3,939,281,799**	**$10,484,361,693**	**9%**

Source: Jefferson County Assessor, National Inventory of Dams, NHD

Each dam owner is responsible for having an EAP and inundation map for their facility. These documents are regularly updated and shared with Jefferson County Emergency Management and other governmental entities that have a direct role in emergency response. Emergency Management and response entities use the EAPs and inundation maps when developing response plans. Questions should be directed to the Emergency Management Department or the facility owner.

People

Persons located downstream of a dam are at risk of a dam failure, though the level of risk can be tempered by topography, amount of water or material in the reservoir/dam/structure, and time of day of the breach. Injuries and fatalities can occur from debris, drowning, or release of sludge or other hazardous material. People in the inundation area may need to be evacuated, cared for, and possibly permanently relocated. Impacts could include hundreds of evacuations and possibly casualties, depending on the dam involved. Specific population impacts are noted in Table 4-16; total people at risk were calculated by multiplying the average number of persons per household in Jefferson County based on Census estimates times the number of properties where the dam inundation extents were available. An estimated total of 40,354 people could be at risk countywide based on the rough estimation used, though again it is unlikely that all the parcels or properties found to overlap with dam inundation extents will be populated by the total persons estimated or actually affected by a dam failure event simultaneously. This estimate does not account for non-resident or visitor population.

Low head dams pose a risk to even the most experienced recreational users of rivers due to the difficultly to detect the dams when approaching from upstream and risk of becoming trapped in the low head dams recirculating currents. According to the Colorado Department of Natural Resources, Dam Safety Division, in recent years Colorado has experienced 1 fatality annually and there have been a total of 13 fatal incidents recorded since 1986 (Zimmer 2019). The Dam Safety Division, Low Head Dam Inventory Final Report (October 2019), notes an increase of low head dam incidents in the state directly correlated to increased recreational water usage by out-of-state tourists, new residents, and long-term residents (Zimmer 2019). As the population increases in Colorado and in Jefferson County there is the potential for increased fatalities from low head dams.

Critical Facilities and Infrastructure

A total dam failure can cause catastrophic impacts to areas downstream of the water body, including critical infrastructure. Any critical asset located under the dam in an inundation area would be susceptible to the impacts of a dam failure. Of particular risk would be roads and bridges that could be vulnerable to washouts, further complicating response and recovery by cutting off impacted areas. Based on the critical facility inventory considered in the updating of this plan and intersected with the dam inundation extents available, 316 critical facilities were found to be at risk. These at-risk facilities are listed in the tables below by jurisdiction and critical facility classification as based on the FEMA Lifeline categories (FEMA Community Lifelines, 2019).

Table 4-18 Dam Inundation Effects on Critical Facilities – Estimates by FEMA Lifeline

FEMA Lifeline	Critical Facility Type	Count
Communications	Land Mobile Private Towers	62
	Microwave Service Towers	21
	Paging Transmission	1
	Total	84
Energy	Electric Substation	3
	Power Plant	3
	Total	6
Food, Water, Shelter	Wastewater Plant	2
	Water Facility	2
	Total	4
Hazardous Material	RMP Facility	1
	Tier II	30
	Total	31
Health and Medical	Nursing Home	15
	Total	15
Safety and Security	EOC	2
	Fire Station	5
	Government Facility	4
	Law Enforcement	3
	School	16
	Total	30
Transportation	Bridge	146
	Total	146
Grand Total		316

Source: National Inventory of Dams, HIFLD, CERC

Economy

Extensive and long-lasting economic impacts could result from a major dam failure or inundation event, including the long-term loss of water in a reservoir, which may be critical for potable water needs, agriculture, or local wildlife. A major dam failure and loss of water from a key structure could bring about direct business and industry damages and potential indirect disruption of the local economy, and potentially affect important transportation routes enabling business and tourism into the county.

Historical, Cultural, and Natural Resources

Dam or reservoir failure effects on the environment would be similar to those caused by flooding from other causes. Water could erode stream channels and topsoil and cover the environment with debris. For the most part the environment is resilient and would be able to rebound from whatever damages occurred, though this process could take years. However, historic and cultural resources could be affected just as housing or critical infrastructures would, were a dam to fail and cause downstream inundation that could further erode surfaces or cause scouring of structural foundations.

Future Development

An analysis of the Year Built field in County Assessor's Office data shows that from 2015 through 2020, 784 new structures have been built in dam inundation areas. While not a large number compared to the total structures at risk described above, it does show that new development is continuing in areas potentially at risk of dam related flooding.

It is important that the County and municipalities keep the dam failure hazard in mind when permitting new development, particularly downstream of the high and significant hazard dams present in the County. New residential development is occurring in western Arvada in the vicinity of Indiana and County Road 19, west of Standley Lake and below Welton reservoir. This development increases the number of properties, population, and infrastructure vulnerable to a dam failure, and may even change the ratings of upstream dams.

There are currently 72 low hazard dams within the County boundaries. These could become significant or high hazard dams if development occurs below them and the consequences of failure increase. Regular inspection and monitoring of dams, exercising and updating of EAPs, and rapid response to problems when detected at dams are ways to mitigate the potential impacts of these rare but potentially catastrophic events.

Overall Hazard Significance

Dam failures in Jefferson County have a large potential impact on the planning area. The geographic extent of the hazard is considered **significant**. The probability of future occurrences is considered **occasional** and the magnitude/severity for the event of record is **critical** or even **catastrophic**. The HMPC considers the hazard to have a **medium** overall impact rating on the County. This corresponds to the available data drawn from known occurrences; however, the potential record of event equates to an overall impact rating of **high**.

An event that would cause all dams in the planning area to fail is extremely unlikely. However, events which may impact the structural integrity of dams, such as earthquakes, may also be region-wide and therefore it is important to assess the planning-area wide impact of all dams, not just incident-specific occurrences. Furthermore, the failure of any high-hazard dam in the planning area is considered an event of critical magnitude and severity, and therefore, despite having a more limited geographic extent, is still a significant planning consideration.

4.3.4 Drought

Description

Drought is a gradual phenomenon. Although droughts are sometimes characterized as emergencies, they differ from typical emergency events. Most natural disasters, such as floods or forest fires, occur relatively rapidly and afford little time for preparing for disaster response. Droughts occur slowly, over a multi-year period, and it is often not obvious or easy to quantify when a drought begins and ends.

Drought is a complex issue involving many factors, but in general terms it occurs when a normal amount of moisture is not available to satisfy an area's usual water-consuming activities. Drought can often be defined regionally based on its effects:

- **Meteorological** drought is usually defined by a period of below average water supply.
- **Agricultural** drought occurs when there is an inadequate water supply to meet the needs of the area's crops and other agricultural operations such as livestock.
- **Hydrological** drought is defined as deficiencies in surface and subsurface water supplies. It is generally measured as stream flow, snowpack, and as lake, reservoir, and groundwater levels.
- **Socioeconomic** drought occurs when a drought impacts health, well-being, and quality of life, or when a drought starts to have an adverse economic impact on a region.

With its semiarid conditions, drought is a natural part of the Colorado climate cycle. Due to natural variations in climate and precipitation sources, it is rare for all of Colorado to be deficient in moisture at the same time. However, single season droughts over some portion of the state are quite common. Defining when a drought begins is a function of drought impacts to water users. Hydrologic conditions constituting a drought for water users in one location may not constitute a drought for water users elsewhere, or for water users that have a different water supply. Individual water suppliers may use criteria, such as rainfall/runoff, amount of water in storage, or expected supply from a water wholesaler, to define their water supply conditions. Drought is further compounded by the complexity of water rights throughout the Western U.S.

Drought impacts are wide-reaching and may be economic, environmental, and/or societal. The most significant impacts associated with drought in Colorado are those related to water intensive activities such as agriculture, wildfire protection, municipal usage, commerce, tourism, recreation, and wildlife preservation. A reduction of electric power generation and water quality deterioration are also potential problems. Drought conditions can also cause soil to compact and not absorb water well, potentially making an area more susceptible to flash flooding and erosion. A drought may also increase the speed at which dead and fallen trees dry out and become particularly dangerous as fuel sources in wildfires. Drought may also weaken trees in areas already affected by mountain pine beetle infestations, causing more extensive damage to trees and increasing wildfire risks. An ongoing drought which severely inhibits natural plant growth cycles may increase the susceptibility of the area to wildfire for a period of time. Drought impacts increase with the length of a drought, as carry-over supplies in reservoirs are depleted and water levels in groundwater basins decline.

Geographic Extent

Droughts are regional events, sometimes impacting multiple states simultaneously. Therefore, as the climate of the planning region is fairly continuous, it is reasonable to assume that a drought will impact the entire planning region simultaneously. Based on this information, the geographic extent rating for drought is **extensive**.

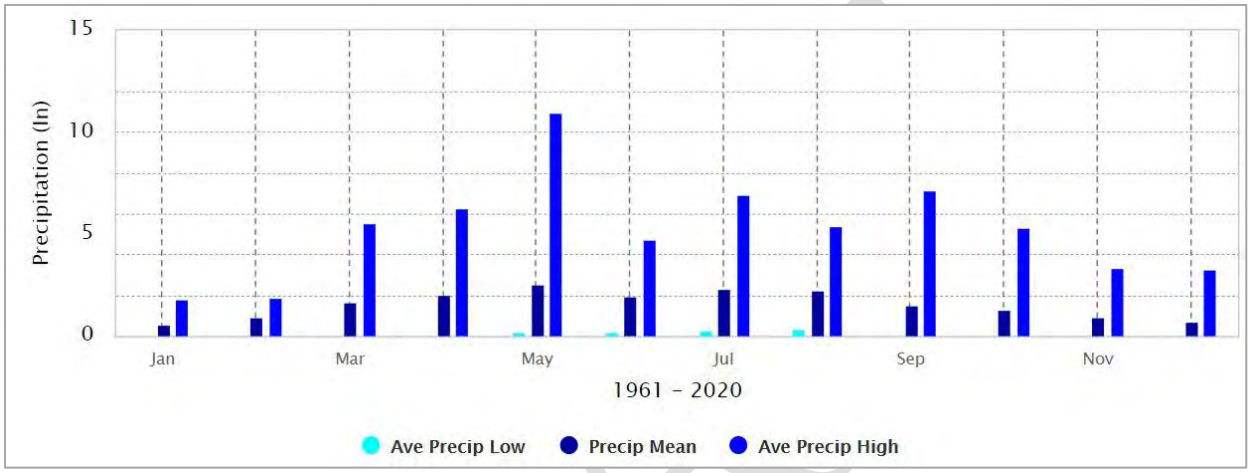
The Southwest Climate and Environmental Information Collaborative (SCENIC) reports precipitation data from weather stations in and around Jefferson County. The data reported here are from two of the stations: Lakewood and Evergreen. Table 4-19 contains precipitation summaries for the two stations, and Figure 4-9 through Figure 4-10 show monthly average total precipitation. These summaries include rainfall only. Drought in Colorado and Jefferson County is largely contingent upon winter snowpack, which is discussed in Section 4.2.13 Severe Winter Storms.

Table 4-19 Jefferson County Precipitation Summaries

Station	Average Annual Precipitation	Month with Most Precipitation/Average Precipitation	Highest Monthly Precipitation	Highest Annual Precipitation	Lowest Annual Precipitation
Evergreen (052790)[2]	18.88	May/2.55	10.94/May 1969	17.87/1992	12.55/1968
Lakewood (054762)[3]	16.67	May/2.55	6.87/Sept. 1976	19.66/1984	9.71/1968

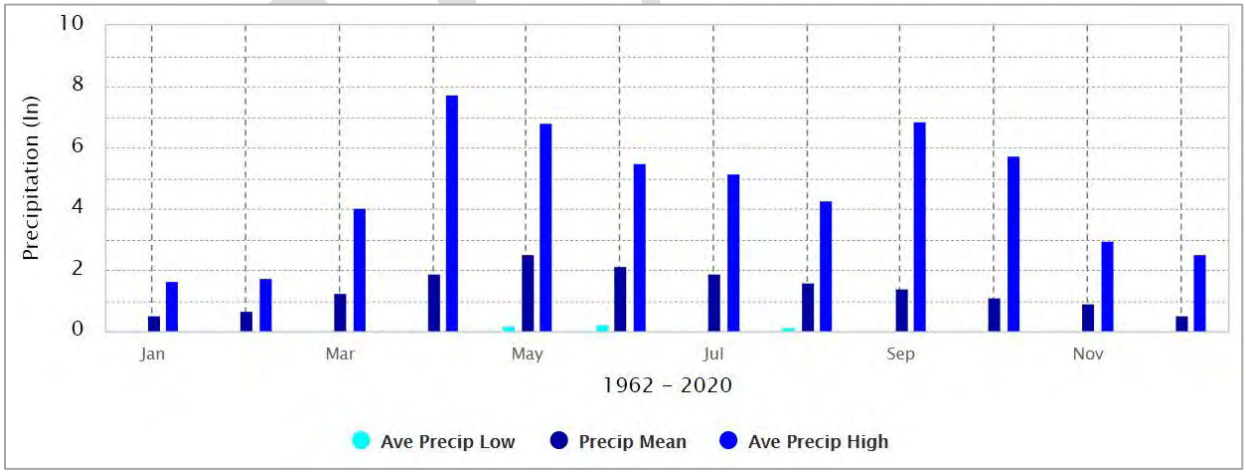
Source: SCENIC [1]All totals are reported inches; [2]Period of Record: 1961-2020 [3]Period of Record: 1962-2020

Figure 4-9 Evergreen Station (052790) Average Monthly Precipitation (In)



Source: SCENIC

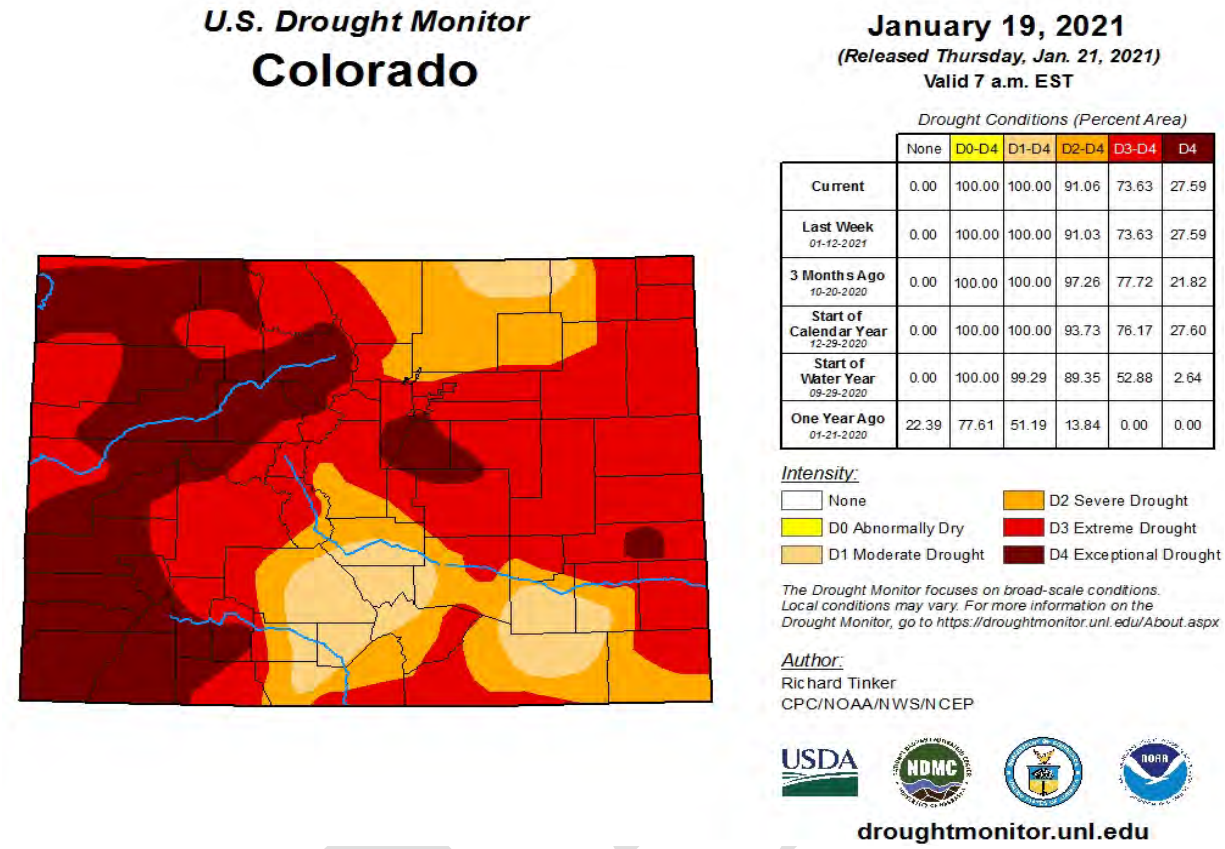
Figure 4-10 Lakewood Station (05472) Average Monthly Precipitation (In)



Source: SCENIC

Figure 4-11 shows the U.S. Drought Monitor for Colorado as of January 21, 2021, illustrating the regional nature of drought.

Figure 4-11 U.S. Drought Monitor, As of January 21, 2021



Previous Occurrences

Colorado has experienced multiple severe droughts over the years. The most significant of the instrumented period (which began in the late 1800s) are listed in Table 4-20. Although drought conditions can vary across the state, it is likely that Jefferson County was affected by most of these dry periods.

Table 4-20 Historical Dry and Wet Periods in Colorado

Date	Dry	Wet	Duration (years)
1893-1905	X		12
1905-1931		X	26
1931-1941	X		10
1941-1951		X	10
1951-1957	X		6
1957-1959		X	2
1963-1965	X		2
1965-1975		X	10
1975-1978	X		3
1979-1999*		X	20
2000-2006*	X		6
2007-2010		X	3

Date	Dry	Wet	Duration (years)
2011-2013	X		2
2018	X		1

Source: Source: McKee, et al. *Modified for the Colorado State Drought Plan in 2010 and Jefferson County Mitigation Plan 2021 based on input from the Colorado Climate Center and US Drought Monitor.

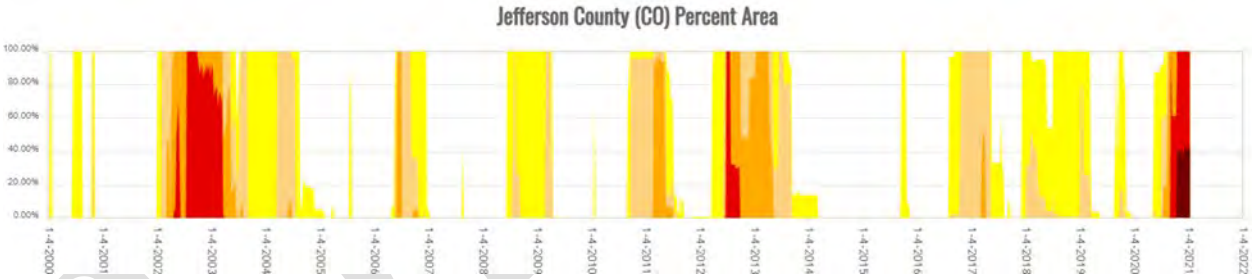
Drought is a regular and widespread occurrence in the State of Colorado. According to the U.S. Drought Monitor records for Jefferson County, in the 1,096-week period from 2000 through January 4, 2021, the county spent 645 weeks (60% of the time) in some level of drought, defined as Abnormally Dry (D0) or worse conditions. Approximately 36% of the time, or 393 weeks, was spent in Moderate Drought (D1) or worse conditions. Weeks in drought are summarized in Table 4-21 and shown in time series in Figure 4-12.

Table 4-21 Jefferson County Weeks in Drought by Intensity, 2000-Jan. 4, 2021

Category	Description	Palmer Drought Severity Index (PDSI)	Standardized Precipitation Index (SPI)	Jefferson County Weeks in Drought, 2000-Jan. 4, 2021
D0	Abnormally Dry	-1.0 to -1.9	-0.5 to -0.7	645
D1	Moderate Drought	-2.0 to -2.9	-0.8 to -1.2	393
D2	Severe Drought	-3.0 to -3.9	-1.3 to -1.5	194
D3	Extreme Drought	-4.0 to -4.9	-1.6 to -1.9	74
D4	Exceptional Drought	-5.0 or less	-2.0 or less	11

Source: U.S. Drought Monitor

Figure 4-12 Jefferson County Drought Intensity, 2000-Jan. 4, 2021



Source: U.S. Drought Monitor

Since 2012 there have been 8 drought declarations issued by the USDA's Secretary of Agriculture in Jefferson County, 7 of which were Fast Track Secretarial disaster designations (see Table 4-2 in Section 4.1.4). According to the Secretary of Agriculture, a Fast Track designation is for a severe drought and provides an automatic designation when, during the growing season, any portion of the county meets the severe drought intensity value for eight consecutive weeks or more.

April 2002: Statewide drought event. April, normally the third snowiest month of the year, ended up being the third driest April on record for Denver. Only a trace of snow was recorded for the month with .23 inches liquid precipitation. The snowpack in the North Platte River Basin was only 44 percent of normal by the end of the month. The snowpack was much lower across some of the other Colorado river basins. The very dry conditions prompted the Governor to request a statewide emergency drought declaration from the U.S. Agricultural Secretary, making farmers and ranchers eligible for federal assistance.

June 2002: Ongoing drought conditions, hot temperature, low relative humidity and strong winds caused the Hayman Fire to grow into, at the time, the largest wildfire in state's history. Located in the foothills

southwest of Denver the wildfire consumed a total of 137,760 acres of forest land, approximately 95,000 acres was burned in Park, Jefferson and Douglas Counties.

March 2011: The month of March 2011 was the eighth least snowiest March on record with 2.9 inches of snowfall at Denver International Airport. The seasonal snowfall of 20.6 inches, measured between July 1, 2010 and March 31, 2011 made it the third least snowiest season to date. The combination of above normal temperatures, windy conditions and sparse precipitation resulted in very dry conditions along the Front Range Foothills, Urban Corridor and Northeast Plains. Over two dozen wildfires occurred throughout the region in March alone. The Indian Gulch Wildfire occurred just west of Golden, between Clear Creek and Golden Gate Canyons from March 20-25th. Strong winds coupled with very rugged terrain hampered firefighting efforts and allowed the wildfire to consume another 1570 acres.

2012 Drought: Even though 2011 was very wet across northern Colorado, the extreme drought during this time in Texas, New Mexico, and Oklahoma was also felt in the Rio Grande and Arkansas Basins in Colorado. This trend continued in those basins as 2012 began, but also increased in breadth across the rest of Colorado. Based on the U.S. Drought Monitor, approximately 50% of Colorado was already under drought conditions at the beginning of 2012. Drought conditions and a period of extremely hot temperatures in June 2012 contributed to very dry forests, contributing to the conditions that led to the High Park fire in northern Colorado and the Waldo Canyon fire near Colorado Springs, two of Colorado's most destructive wildfires. Drought conditions also exacerbated the Lower North Fork fire in Jefferson County in March of 2012. Reservoir levels in many portions of the State helped abate some of the drought impacts seen in 2011-2013. Had the reservoir levels not been at levels sufficient for carryover storage into 2012 (due to record breaking high snowpack in 2011) in many river basins, many of the impacts discussed above may have been worse.

2018-2021 Drought: According to the HMPC, drought that begin in May 2018 and continuing into 2021 has caused inability to store snowmelt runoff on Beaver Brook due to junior water rights on Clear Creek. This has impacted the entire Lookout Mountain Water District although minimal revenue has been lost. The Water District considers a similar event is highly likely to occur in the future.

NOAA's National Centers for Environmental Information (NCEI) records 3 drought events between 1950 and 2020. Brief descriptions of each events are shown below, no damages or casualties were recorded for any of the events. Note, the June 9, 2002 and March 1, 2011 events were related to wildfire events which were both fueled by ongoing drought conditions.

Probability of Future Occurrences

According to information from the Colorado Drought Mitigation and Response Plan (2018), including recent drought conditions Colorado was in drought for 50 of the past 126 years (1893-2018). Thus, there is a 39.7% chance that a drought will happen in Colorado in any given year, and a drought can be expected somewhere in the state every 2.5 years. Similarly looking at the weekly U.S. Drought Monitor data cited above, Jefferson County was in moderate or worse drought conditions 36% of the time. Thus, the probability of drought conditions is **likely**.

Magnitude and Severity

The impacts drought can have on modern society are often underrated. Droughts cause obvious and severe impacts on agricultural areas by destroying existing crops and prolonging unsuitable growing conditions which hinders efforts to recover agricultural losses. This causes secondary financial impacts first on the farmers, who have no crops to sell, and then on the consumers, who must pay higher prices for scarce produce. Increased demand for a decreased water supply raises water costs, which also drives up the overall costs to both farm producers and consumers.

Urban areas are also impacted by rising water costs, which may impact personal property and personal water usage bills. Recreational uses which are water-dependent may increase significantly in price or decrease in availability, particularly those which are based in reservoirs or lakes, as the water levels may be too low to sustain safe recreation. Finally, the increased risk of wildfires impacts the planning region. While the hazard of fire itself is profiled separately, drought conditions increase the likelihood that wildfires will occur, either naturally or due to human causes.

To calculate a magnitude and severity rating for comparison with other hazards, and to assist in assessing the overall impact of the hazard on the planning area, information from the event of record is used. In some cases, the event of record represents an anticipated worst-case scenario, and in others, it reflects common occurrence. The event of record for Jefferson County occurred between 1999 and 2003. The event impacted the entire planning area, although the exact percent of directly-impacted property in the County is not available. Any damages inflicted on critical facilities and services (critical infrastructure) resulted in no loss or disruption of services. There were no directly attributable documented illnesses or injuries and the medical response capability of the County was not impacted. However, the drought seriously impacted water supply levels and water quality, and several severe wildfires, augmented by drought conditions, occurred in the planning area during this time. The impact on the costs of water resulted in significantly higher water billing rates, and some jurisdictions implemented water regulation measures which also extended beyond the drought period.

The U.S. Drought Monitor classifies droughts into different categories, from D0 (Abnormally Dry) to D4 (Exceptional Drought), as shown in Figure 4-13. Periods of dryness are classified in one of these categories as the drought's life cycle is tracked. The following table explains each of these categories.

Figure 4-13 U.S. Drought Monitor Drought Severity Classifications

			Ranges				
Category	Description	Possible Impacts	Palmer Drought Severity Index (PDSI)	CPC Soil Moisture Model (Percentiles)	USGS Weekly Streamflow (Percentiles)	Standardized Precipitation Index (SPI)	Objective Drought Indicator Blends (Percentiles)
D0	Abnormally Dry	Going into drought: • short-term dryness slowing planting, growth of crops or pastures Coming out of drought: • some lingering water deficits • pastures or crops not fully recovered	-1.0 to -1.9	21 to 30	21 to 30	-0.5 to -0.7	21 to 30
D1	Moderate Drought	• Some damage to crops, pastures • Streams, reservoirs, or wells low, some water shortages developing or imminent • Voluntary water-use restrictions requested	-2.0 to -2.9	11 to 20	11 to 20	-0.8 to -1.2	11 to 20
D2	Severe Drought	• Crop or pasture losses likely • Water shortages common • Water restrictions imposed	-3.0 to -3.9	6 to 10	6 to 10	-1.3 to -1.5	6 to 10
D3	Extreme Drought	• Major crop/pasture losses • Widespread water shortages or restrictions	-4.0 to -4.9	3 to 5	3 to 5	-1.6 to -1.9	3 to 5
D4	Exceptional Drought	• Exceptional and widespread crop/pasture losses • Shortages of water in reservoirs, streams, and wells creating water emergencies	-5.0 or less	0 to 2	0 to 2	-2.0 or less	0 to 2

Source: U.S. Drought Monitor

Drought impacts in Jefferson County can be wide-reaching: economic, environmental, and societal. The most significant impacts associated with drought are those related to water intensive activities such as wildfire protection, commerce, tourism/recreation, municipal usage, and wildlife preservation. Although the agricultural industry in the County is limited, it is expected to experience crop losses and livestock feeding expenses and deaths. Jefferson County will see an increase in dry fuels, beetle kill, associated wildfires, and some loss of tourism/recreation revenue. Water supply issues for municipal, industrial, and domestic needs will be a concern for the entire County. Lawn and tree impacts in suburban areas could result from water restrictions. Vulnerability increases with consecutive winters of below-average snowpack. Drought conditions can also cause soil to compact and not absorb water well, potentially making an area more susceptible to flooding. It also increases the wildfire hazard and even landslide hazard.

Based on these factors, the magnitude severity ratings for droughts are considered **critical**.

Climate Change Considerations

Climate change can have impacts both in terms of inter-annual droughts and intra-annual runoff patterns (State of Colorado Drought Mitigation and Response Plan Update, 2018). Temperatures increased and resulting changes in evaporation and soil moistures will also add to the trend of decreasing runoff in a majority of Colorado Basins. The following table shows the challenges water managers may face with the projected changes in climate.

Table 4-22 Future Drought Vulnerability Due to Climate Change and Challenges Faced by Colorado Water Managers

Challenge	Observed and/or Projected Change
Water demands for agriculture and outdoor watering	Increasing temperatures raise evapotranspiration by plants, lower soil moisture, alter growing seasons, and thus increase water demand.
Water supply infrastructure	Changes in snowpack, streamflow timing, and hydrograph evolution may affect reservoir operations including flood control and storage. Changes in the timing and magnitude of runoff may affect functioning of diversion, storage, and conveyance structures.
Legal water systems	Earlier runoff may complicate prior appropriation systems and interstate water compacts, affecting which rights holders receive water and operations plans for reservoirs
Water quality	Although other factors have a large impact, “water quality is sensitive both to increased water temperatures and changes in patterns of precipitation” (CCSP SAP 4.3, p. 149). For example, changes in the timing and hydrograph may affect sediment load and pollution, impacting human health.
Energy demand and operating costs	Warmer air temperatures may place higher demands on hydropower reservoirs for peaking power. Warmer lake and stream temperatures may affect water use by cooling power plants and other industries.
Mountain habitats	Increasing temperature and soil moisture changes may shift mountain habitats toward higher elevation.
Interplay among forests, hydrology, wildfires, and pests	Changes in air, water, and soil temperatures may affect the relationships between forests, surface and groundwater, wildfire, and insect pests. Water-stressed trees, for example, may be more vulnerable to pests.
Riparian habitats and fisheries	Stream temperatures are expected to increase as the climate warms, which could have direct and indirect effects on aquatic ecosystems (CCSP SAP 43.), including the spread of instream non-native species and diseases to higher elevation and the potential for nonnative plant species to invade riparian areas. Changes in streamflow intensity and timing may also affect riparian ecosystems.
Water – and snow – based recreation	Changes in reservoir storage affect lake and river recreation activities; changes in streamflow intensity and timing will continue to affect rafting directly and trout fishing indirectly. Changes in the character and timing of snowpack and the ratio of snowfall to rainfall will continue to influence winter recreational activities and tourism.
Groundwater resources	Changes in long-term precipitation and soil moisture can affect groundwater recharge rates; coupled with demand issues, this may mean greater pressure on groundwater resources.

Source: State of Colorado Drought Mitigation and Response Plan 2018, Reproduced from CWCB

Vulnerability Assessment

Based on Jefferson County’s recent multi-year droughts and Colorado’s drought history, it is evident that all of Jefferson County is vulnerable to drought. However, the impacts of future droughts will vary by region. The agricultural industry of the County, though limited, could experience hardships, including agricultural losses, and livestock feeding expenses and deaths. The County will see an increase in dry fuels, beetle kill, and associated wildfires and some loss of tourism/recreation revenue. Examples of

potential impacts to recreation include low water flows in the Golden Whitewater Park, fire bans and closures of campgrounds in the Pike National Forest, and water restrictions on golf courses.

The Colorado State Drought Mitigation Plan includes vulnerability to state owned buildings and critical infrastructure, state land board lands, state operated recreational activity, aquatic habitat and species, agriculture activities, protected environments, recreation, socioeconomics, and the municipal and industrial (M&I) sectors. Jefferson County generally ranked moderate in vulnerability across the sectors. The sector vulnerability scores for Jefferson County are shown in Table 4-23. A score of 3.0 or above means that sector is highly vulnerable to drought; Jefferson County doesn't reach the 3.0 score for any of the sectors.

Table 4-23 Jefferson County Drought Vulnerability Score by Sector

Sector	Score
Recreation	2.48
Energy	1.00
Agriculture	2.42
State Assets	2.59
Socioeconomic	2.0
Environment	2.27
Average Overall Vulnerability	2.13

Source: 2018 State of Colorado Drought Mitigation and Response Plan

The National Drought Mitigation Center (NDMC), located at the University of Nebraska in Lincoln, provides a clearinghouse for information on the effects of drought based on reports from media, observers, impact records, and other sources.

According to the NDMC's Drought Impact Reporter, during the 20-year period from 2000 through 2020, 924 drought impacts were recorded for the State of Colorado, of which 53 were reported to affect Jefferson County. Table 4-24 summarizes the number of impacts reported by category and the years impacts were reported for each category, where available. Note that the Drought Impact Reporter assigns multiple categories to each impact, so there is some duplication between categories.

Table 4-24 NDMC Drought Impact Reporter, 2000-2020

Impact Category	# of Impacts
Agriculture	8
Business & Industry	2
Fire	13
Plants & Wildlife	14
Relief, Response & Restrictions	20
Society & Public Health	6
Tourism & Recreation	4
Water Supply & Quality	16

Source: National Drought Mitigation Center Drought Impact Reporter (https://droughtreporter.unl.edu/map/)

General Property

Drought does not typically have a direct impact on buildings, although an increase in expanding or collapsing soils could affect building foundations. Developed areas may experience damages to landscaping if water use restrictions are put in place, however these losses are not considered significant.

People

The historical and potential impacts of drought on populations include agricultural and recreation/tourism sector job loss, secondary economic losses to local businesses and public recreational resources, increased cost to local and state government for large-scale water acquisition and delivery, and water rationing and water wells running dry for individuals and families. Other public health issues can include impaired drinking water quality, increased incidence of mosquito-borne illness, an increase in wildlife-human confrontations and respiratory complications as a result of declined air quality in times of drought.

Critical Facilities and Infrastructure

Water supply issues for municipal, industrial, and domestic needs will be a concern for the entire County during droughts. Water restrictions could lead to lawn and tree impacts in suburban areas. Much of Jefferson County's water comes from snow melt runoff in the high country of the western County that is captured in reservoir storage. Vulnerability increases with consecutive winters of below-average snowpack.

According to the State Drought Plan drought vulnerability within the Denver Metropolitan Area is relatively low when compared to other regions within the State. This is primarily attributed to the fact that Denver Water owns one of the most senior urban water rights portfolios along the Front Range. Denver Water has also taken additional drought mitigation actions since 2002 to further improve water supply reliability. Additional vulnerability and capability information on drought can be referenced in the Denver Water Annex.

Economy

Jefferson County's reliance on tourism and the recreation sector as the main economic base make it particularly vulnerable to the effects of drought. Wildlife viewing, hunting and fishing activities have been impacted in past drought events by lower production and requirement numbers and by animals moving away from traditional viewing and hunting areas due to lack of water, loss of vegetative cover, decreased streamflows, sedimentation and fish decline. Drought also has an impact on camping due to forced closures of campsites and surrounding forest due to wildfires and risk of wildfire and hazardous trees are all exacerbated by drought. Drought impacts on the County's natural environment and the cascading impacts to the recreation sector could lead to less people visiting and spending money in County which could have a negative impact on the entire local economy.

The Colorado Water Conservation Board (CWCB) maintains a Future Avoided Cost Explorer (FACE) tool, which estimates annual damages from drought. According to FACE analysis, Jefferson County could potentially experience an average annual loss of $210,000 due to drought conditions under current population and climate scenarios.

Historic, Cultural, and Natural Resources

Severe, prolonged drought can have a negative impact on the natural environment. Wildlife and natural habitats can be affected, including the shrinkage of habitat, dwindling food supplies and the migration of wildlife to more palatable areas. Prolonged drought can cause poor soil quality and increased soil erosion. One of the prevailing impacts of drought to the natural environment is the increased risk of pest infestations and wildfires that burn larger and more intensely during dry conditions. Drought conditions can also cause soil to compact and not absorb water well, potentially making an area more susceptible to flooding.

Future Development

Drought vulnerability will increase with future development as there will be increased demands for limited water resources. Future growth in the unincorporated areas will mean more wells and more demands on groundwater and surface water resources. Increased development also lends itself to the increased potential for impervious surface development, which reduces the amount of water absorbed into the ground from precipitation. State law (CRS 30-28-133(3)) requires that local governments "shall not approve an application for a development permit unless…the applicant has satisfactorily demonstrated that the proposed water supply will be adequate." The County implements this by requiring the Planning and Zoning Department to complete a Water Availability Analysis and Aquifer Test for all new

development. Section 21 Water Supply of the County's Land Development Regulations as well as policies in the Comprehensive Master Plan require new development to consider future water usage and water conservation. Refer to Section 2 Capabilities Assessment for further details on these water conservation and usage policies.

Lookout Mountain Water District noted that continuing residential development on Lookout Mountain has increased the need for more fire hydrants and better lateral pipelines to supply them water. Warming trends have increased the likelihood of early snowmelt runoff occurring before free river on Clear Creek, increasing the need for the District to acquire senior water rights on Clear Creek to enable Upper Beaver Brook reservoir to fill every year.

The Future Avoided Cost Explorer (FACE) developed by the Colorado Water Conservation Board (CWCB) provides an in-depth look at the potential economic impacts and expected annual damages from future flood, drought and wildfire events. The tool looks at three different climate scenarios (current climate conditions, 2050 future – moderately warmer climate and 2050 – severely warmer climate) as well as compares current population to low, medium and high growth population scenarios. The following table compares the estimated annual damages for Jefferson County due to drought events for each of the climate and population scenarios.

Table 4-25 Potential Future Economic Losses from Drought in Jefferson County

Climate Scenarios	Population Scenarios		
	Low Growth (~653,000)	Medium Growth (~695,000)	High Growth (~740,000)
Current Conditions	Total damages: $950,000	Total damages: $950,000	Total damages: $1M
	Total damages per person: less than $10	Total damages per person: less than $10	Total damages per person: less than $10
Moderately Warmer Climate by 2050	Total damages: $1.4M	Total damages: $1.5M	Total damages: $1.5M
	Total damages per person: less than $10	Total damages per person: less than $10	Total damages per person: less than $10
Severely Warmer Climate by 2050	Total damages: $1.7M	Total damages: $1.7M	Total damages: $1.8M
	Total damages per person: less than $10	Total damages per person: less than $10	Total damages per person: less than $10

Source: Colorado Water Conservation Board (CWCB) Future Avoided Cost Explorer: Hazards https://cwcb.colorado.gov/FACE

Overall Hazard Significance

Droughts in Jefferson County do have an impact on the planning area. While the impacts of the drought may be less severe than those inflicted on primarily agricultural counties, it is nevertheless a significant hazard to examine. As discussed earlier, the most profound impacts of drought on urbanized planning areas such as this are in the increased costs of water for general and recreational use and the heightened wildfire conditions. In fact, all of the drought periods recorded here culminated in a wildfire event, which is of particular concern for Jefferson County. The geographic extent of the hazard is considered **extensive**. The probability of future occurrences is considered **likely** and the magnitude/severity for the event of record is **critical**. This equates to an overall impact rating of **high.**

4.3.5 Earthquake

Description

An earthquake is caused by a sudden slip on a fault. Stresses in the earth's outer layer push the sides of the fault together. Stress builds up and the rocks slip suddenly, releasing energy in waves that travel through the earth's crust and cause the shaking that is felt during an earthquake. The amount of energy released during an earthquake is usually expressed as a Richter magnitude and is measured directly from the earthquake as recorded on seismographs. Another measure of earthquake severity is intensity. Intensity is an expression of the amount of shaking at any given location on the ground surface as felt by humans or resulting damage to structures and defined in the Modified Mercalli scale (see Table 4-26). Seismic shaking is typically the greatest cause of losses to structures during earthquakes.

Table 4-26 Modified Mercalli Intensity (MMI) Scale

Magnitude	Mercalli Intensity	Effects	Frequency
Less than 2.0	I	Micro-earthquakes, not felt or rarely felt; recorded by seismographs.	Continual
2.0-2.9	I to II	Felt slightly by some people; damages to buildings.	Over 1M per year
3.0-3.9	II to IV	Often felt by people; rarely causes damage; shaking of indoor objects noticeable.	Over 100,000 per year
4.0-4.9	IV to VI	Noticeable shaking of indoor objects and rattling noises; felt by most people in the affected area; slightly felt outside; generally, no to minimal damage.	10K to 15K per year
5.0-5.9	VI to VIII	Can cause damage of varying severity to poorly constructed buildings; at most, none to slight damage to all other buildings. Felt by everyone.	1K to 1,500 per year
6.0-6.9	VII to X	Damage to a moderate number of well-built structures in populated areas; earthquake-resistant structures survive with slight to moderate damage; poorly designed structures receive moderate to severe damage; felt in wider areas; up to hundreds of miles/kilometers from the epicenter; strong to violent shaking in epicentral area.	100 to 150 per year
7.0-7.9	VIII<	Causes damage to most buildings, some to partially or completely collapse or receive severe damage; well-designed structures are likely to receive damage; felt across great distances with major damage mostly limited to 250 km from epicenter.	10 to 20 per year
8.0-8.9	VIII<	Major damage to buildings, structures likely to be destroyed; will cause moderate to heavy damage to sturdy or earthquake-resistant buildings; damaging in large areas; felt in extremely large regions.	One per year
9.0 and Greater	VIII<	At or near total destruction - severe damage or collapse to all buildings; heavy damage and shaking extends to distant locations; permanent changes in ground topography.	One per 10-50 years

Source: USGS. http://earthquake.usgs.gov/learn/topics/mercalli.php

Earthquakes can cause structural damage, injury, and loss of life, as well as damage to infrastructure networks, such as water, power, communication, and transportation lines. Other damaging effects of earthquakes include surface rupture, fissuring, ground settlement, and permanent horizontal and vertical shifting of the ground. Secondary impacts can include landslides, seiches, liquefaction, fires, and dam failure. The combination of widespread primary and secondary affects from large earthquakes make this hazard potentially devastating.

Colorado's earthquake hazard is similar to other states in the intermountain west region. It is less than in states like California, Nevada, Washington, or Oregon, but greater than many states in the central and

eastern United States. There are many unknowns about the earthquake hazard in Colorado, but the potential for damaging earthquakes does exist.

Previous Occurrences

According to the U.S. Geological Survey (USGS), eastern Colorado is nearly aseismic, with just a few epicenters in the Arkansas and Platte river valleys. Most shocks in the history of Colorado have been centered west of the Rocky Mountain Front Range. The first seismographs in Colorado of sufficient quality to monitor earthquake activity were installed in 1962. Newspaper accounts are the primary source of published data for earthquake events before that time. Figure 4-14 illustrates historic earthquakes and Quaternary faults in Colorado.

More than 400 earthquake tremors of magnitude 2.5 or higher have been recorded in Colorado since 1867. More earthquakes of magnitude 2.5 to 3 probably occurred during that time, but were not recorded because of the sparse distribution of population and limited instrumental coverage in much of the state. For comparison, more than 20,500 similar-sized events have been recorded in California during the same period. Although many of Colorado's earthquakes occurred in mountainous regions of the state, some have been located east of the mountains. The best-known Colorado earthquakes were a series of events in the 1960s that were later shown to have been triggered by the injection of liquid waste into a deep borehole at the Rocky Mountain Arsenal northeast of Denver. These and other notable earthquakes affecting Jefferson County include:

November 7, 1882 - The first ever to cause damage at Denver, probably centered in the northern Front Range near Rocky Mountain National Park and is the largest historical earthquake in the state. The magnitude is estimated to be about 6.6 on the Richter scale. The quake was felt as far away as Salina, Kansas and Salt Lake City, Utah.

September 29, 1965 – A magnitude 4.7 earthquake epicentered near Arvada shook the northern metro area and cracked plaster and windows.

February 16, 1965 – A magnitude 4.6 located in northeastern Jefferson County – no further information.

November 14, 1966 – A strong shock rumbled through the Denver area, causing some damage at Commerce City and Eastlake. The magnitude of this event was between 4.1 and 4.4.

April 10, 1967 – This was one of the largest in a series of earthquakes that began in 1962; 118 windowpanes were broken in buildings at the Rocky Mountain Arsenal, a crack in an asphalt parking lot was noted in the Derby area, and schools were dismissed in Boulder, where walls sustained cracks. Legislators quickly moved from beneath chandeliers in the Denver Capitol Building, fearing they might fall. The Colorado School of Mines rated this shock a magnitude 5.0.

August 9, 1967 - The strongest and most widely felt shock in Denver's history struck at 6:25 in the morning. The magnitude 5.3 tremor caused the most serious damage at Northglenn, where a church's concrete pillar roof supports were weakened, and 20 windows were broken. An acoustical ceiling and light fixtures fell at one school. Many homeowners reported wall, ceiling, floor, patio, sidewalk, and foundation cracks. Several reported basement floors separated from walls. Extremely loud, explosive-like earth noises were heard. Damage on a lesser scale occurred throughout the area.

November 1967 - The Denver region was shaken by five moderate earthquakes. Two early morning shocks occurred November 14th. They awakened many residents but were not widely felt. A similar shock, magnitude 4.1, centered in the Denver area November 15th. Residents were generally shaken, but no damage was sustained. A local shock awakened a few persons in Commerce City November 25th. Houses creaked and objects rattled during this magnitude 2.1 earthquake.

November 26, 1967 - The magnitude 5.2 event caused widespread minor damage in the suburban areas of northeast Denver. Many residents reported it was the strongest earthquake they had ever experienced. It was felt at Laramie, Wyoming, to the northwest, east to Goodland, Kansas, and south to Pueblo, Colorado. At Commerce City merchandise fell in several supermarkets and walls cracked in larger buildings. Several persons scurried into the streets when buildings started shaking back and forth.

May 23, 1970 – A magnitude 4.1 earthquake struck northeastern Jefferson County on County line – no further information.

January 5, 1979 at 6:59 p.m. MST - A small but rare earthquake occurred in the central part of the State. The magnitude 2.9 tremor was centered about 30 miles northwest of Colorado Springs near Florissant and Lake George. Some minor damage (MM VI) was reported at Cripple Creek and Royal Gorge.

March, April, and November 1981 – On April 2nd a sharp earthquake, magnitude 4.1, occurred that was centered approximately 12 miles north of downtown Denver in the Thornton area. Some slight damage (MM VI) was observed at Commerce City and Thornton. The quake was felt in other parts of Adams County and in parts of Arapahoe, Boulder, Clear Creek, Denver, Douglas, Jefferson, Gilpin, and Weld Counties. This earthquake was preceded by a small tremor located in the same area on March 24 at 6:04 a.m. MST with magnitude 2.8. It was felt in the Commerce City and Northglenn-Thornton area. The north-central part of Colorado experienced a small earthquake on September 16, 1981 at 1:59 p.m. MDT. The magnitude 2.1 tremor was located in the Commerce City-Thornton area and was felt by a few people in that area.

November 1, 1981 - A minor but alarming earthquake occurred in Jefferson County on November 1, 1981, at 8:03 p.m. MST. The magnitude 3.1 tremor was centered in the Evergreen area about 22 miles southwest of Denver. The effects registered MM V, and were experienced in the Conifer, Evergreen, and Pine Junction areas. It was also felt in other parts of Jefferson County and in parts of Clear Creek and Park Counties.

March and September 1982 – On March 11, 1982 at 4:55 p.m. MST a very minor 2.8 magnitude earthquake occurred. It was located about 12 miles north of downtown Denver in the Thornton area. It was felt in the Commerce City, Northglenn, and Thornton areas. MM III effects were experienced in the Thornton area. On September 18 at 10:12 a.m. MDT, a small part of the north-central part of Colorado was shaken by a very minor earthquake. The magnitude 2.8 tremor was located about 12 miles north of downtown Denver in the Thornton area. MM III effects were noted at Thornton; it was also felt at Commerce City and Northglenn.

February 25, 1984 at 2:18 a.m. MDT - A very minor earthquake occurred in the Denver metropolitan area. This magnitude 2.5 tremor was located about 13 miles north of downtown Denver in the Thornton area where it was felt lightly.

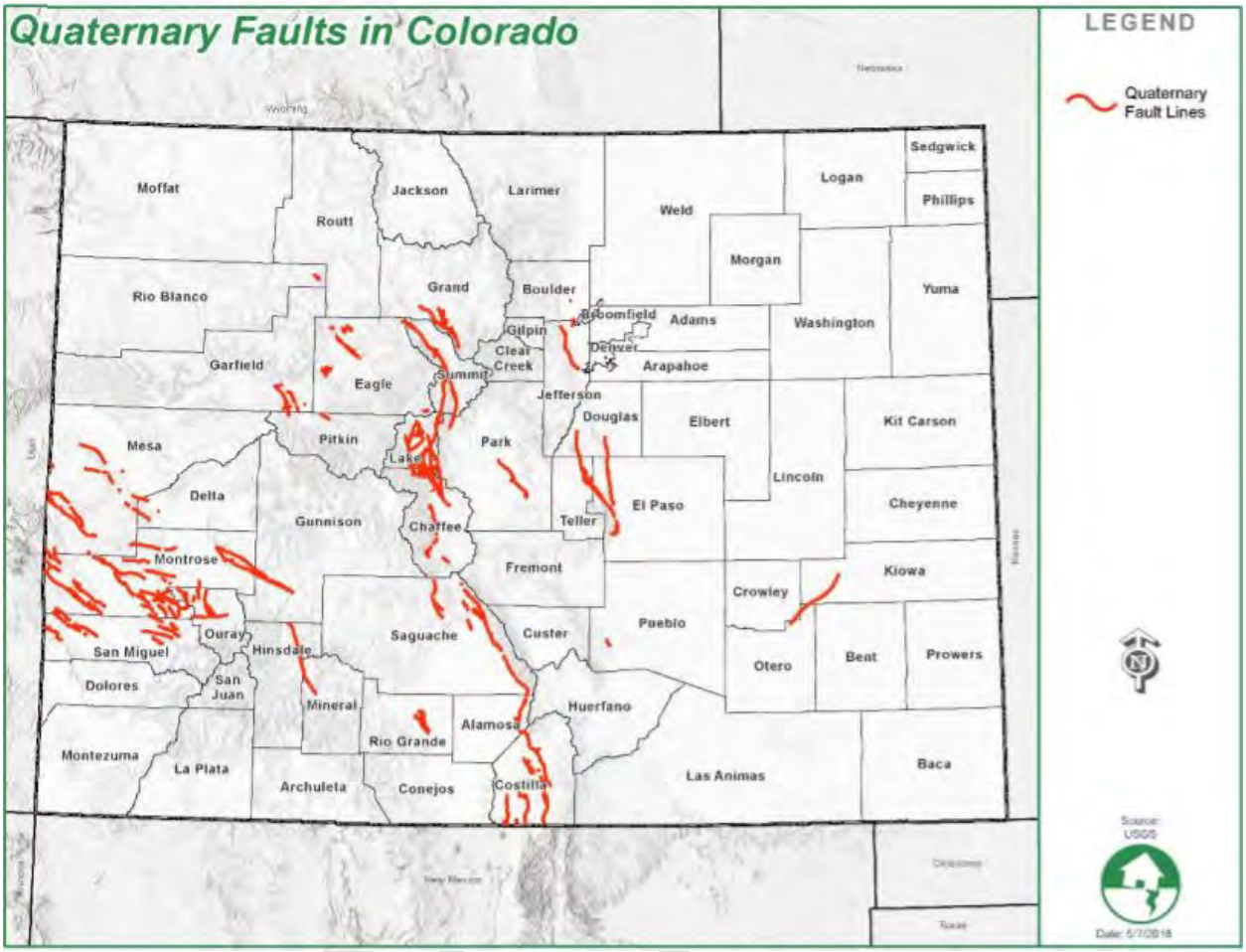
November 8, 1989 at 7:24 a.m. MDT - A minor earthquake with a magnitude of 2.5 was felt in the northern Denver metropolitan area. The shock was felt at different intensities in several location, MM IV at Thornton and MM III at Eastlake, Montbello, Northglenn and in parts of Denver. A small aftershock, ML 1.8, occurred about 90 seconds later.

December 25, 1994 12:06 p.m. MDT - A moderate earthquake with an epicenter approximately 6 miles southeast of Castle Rock struck the central front range. With a magnitude of 4.0 and a maximum Modified Mercalli intensity of V, the shock was felt from Colorado Springs to Denver. No further information available.

Geographic Extent

Geological research indicates there are about 100 potentially active faults in Colorado with documented movement within the last 2.6 million years (Quaternary). Figure 4-14 indicates that potentially active faults exist in the vicinity of Jefferson County that are capable of producing damaging earthquakes. There could be other faults in the state that may have potential for producing future earthquakes that are not known to be hazardous or do not rupture the ground surface.

Figure 4-14 Colorado Quaternary Fault Map



Source: State of Colorado Natural Hazard Mitigation Plan, 2018

Faults have been classified based on the geologic time frame of their latest suspected movement (in order of activity occurrence, most recent is listed first):

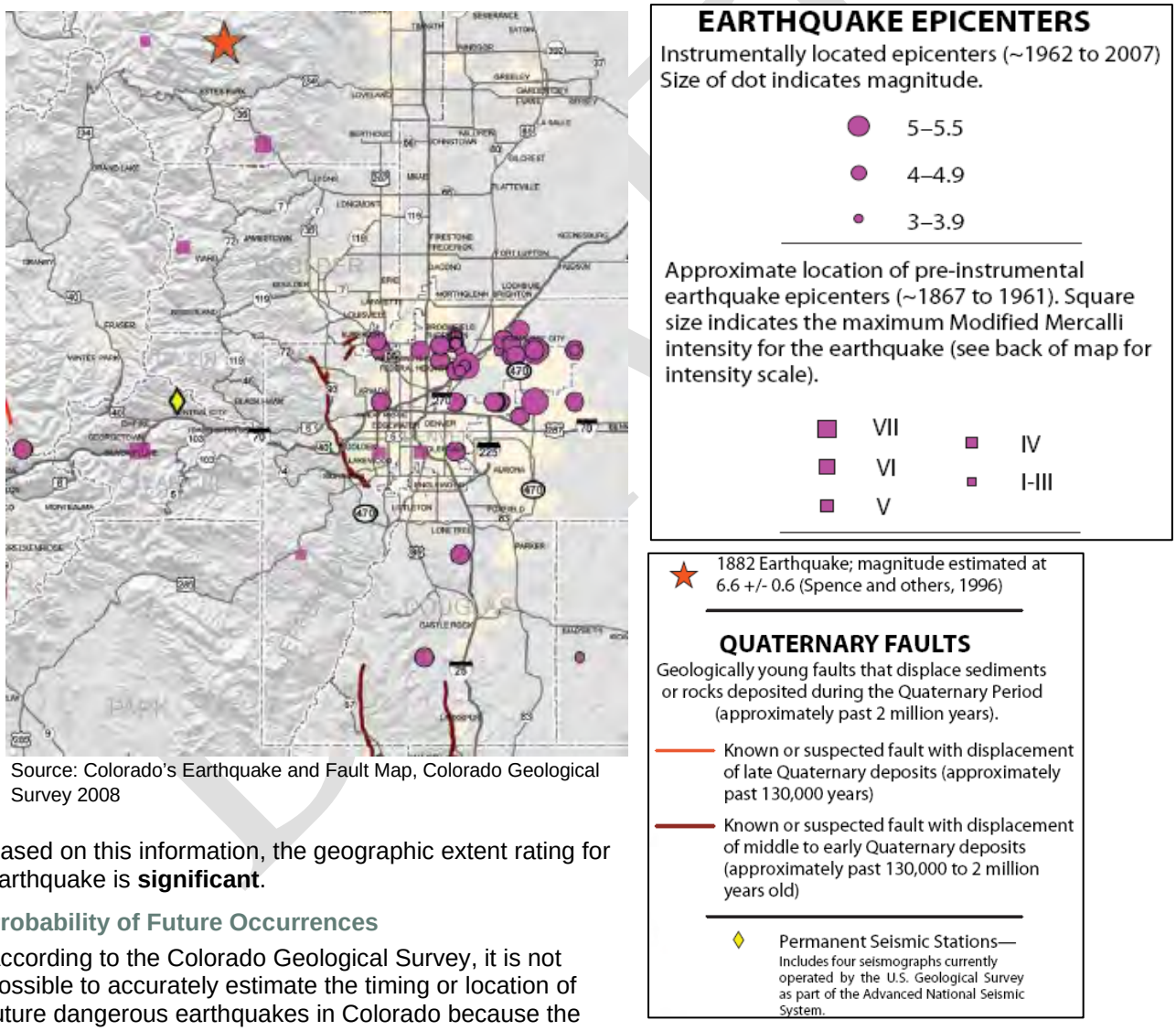
- H—Holocene (within past 15,000 years)
- LQ—Late Quaternary (15,000-130,000 years)
- MLQ—Middle to Late Quaternary (130,000 - 750,000 years)
- Q—Quaternary (approximately past 2.6 million years)

Faults with evidence of movement in the past 130,000 years (Late Quaternary) are considered active faults. Faults that last moved between 130,000 and 1.8 million years ago may be considered potentially active. These active and potentially active faults are thought to be the most likely source for future earthquakes (Source: 2018 Colorado State Hazard Mitigation Plan). The only known potentially active fault in Jefferson County is the Golden Fault, which is a Quaternary fault. This fault runs along the base of the foothills west of Golden, roughly paralleling Highway 93 from Highway 72 to the north down to Highway 285 near Morrison, and is shown on the map in Figure 4-14, which is taken from a statewide map of Colorado earthquake hazards developed by the Colorado Geological Survey. The fault runs through sparsely developed sections of western Arvada, Golden, western Lakewood, and just east of Morrison. According to the Colorado Earthquake Evaluation Report associated with the Colorado Hazard Mitigation Plan the fault is thought to be capable of producing a M6.5 earthquake. The Colorado Late Cenozoic Fault, Fold, and Earthquake Database considers this a “suspect feature” that has not shown evidence of movement in the past 500,000 years, and that definitive evidence of Quaternary movement is

lacking. Many of these faults and historic epicenters are also shown in Figure 4-15 below, which provides a focused view of Jefferson County.

In addition to the Golden Fault there are potentially active faults to the north (Walnut Creek (Q) and Valmont (MLQ), Rock Creek (Q) in Boulder County), east (Rocky Mountain Arsenal Fault (H) in Adams County), and south (Ute Pass (MLQ) in Douglas County) of the County. The Golden, Ute Pass, and Walnut Creek faults, all which could affect Jefferson County, are three of the state's five potentially most damaging faults, according to the Earthquake Evaluation Report. The Walnut Creek Fault is in unincorporated Jefferson and Boulder Counties near Rocky Flats. In addition to these faults there is a fault suspected to be located beneath the Rocky Mountain Arsenal, which has been the source of damaging earthquakes in the Denver metro area and is considered by the Colorado Geological Survey to have the potential of producing a magnitude 6.25 earthquake. This fault is not shown on the map because it is not evident on the earth's surface.

Figure 4-15 Colorado Earthquake Fault Map- Jefferson County Excerpt



Source: Colorado's Earthquake and Fault Map, Colorado Geological Survey 2008

Based on this information, the geographic extent rating for earthquake is **significant**.

Probability of Future Occurrences

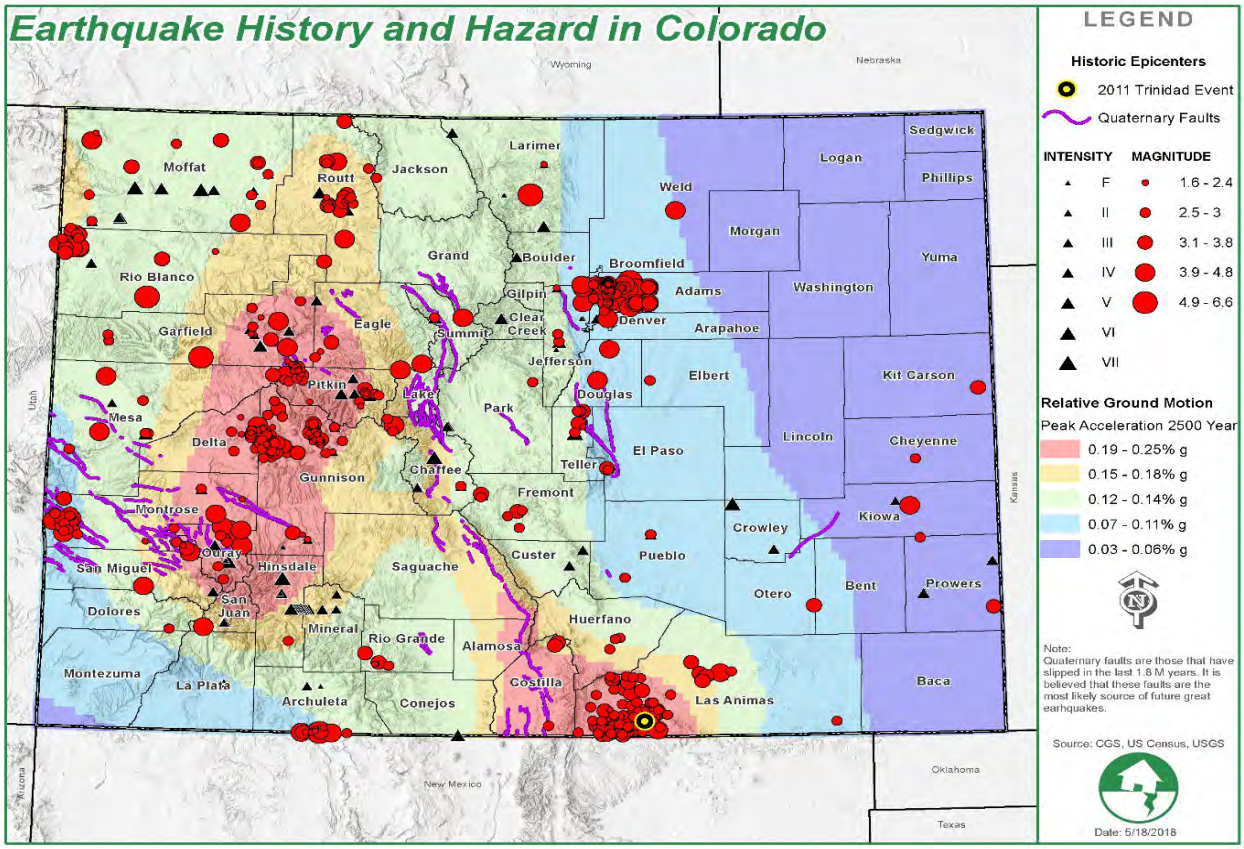
According to the Colorado Geological Survey, it is not possible to accurately estimate the timing or location of future dangerous earthquakes in Colorado because the occurrence of earthquakes is relatively infrequent in the state, and the historical earthquake record is relatively short (only about 145 years). It is prudent to expect future earthquakes as large as magnitude 6.6, the largest historical event in Colorado. Studies indicate earthquakes as large as 7.25 could occur

within the state, but scientists are unable to accurately predict when and where it will occur (Source: Colorado Earthquake Hazards – Colorado Earthquake Mitigation Council 2008.)

National seismic hazard zone maps indicate the probability of earthquakes in the United States, based on analyses of faults, soils, topography, and past events. Figure 4-16 is a probabilistic seismic hazard map of Colorado from the USGS that depicts the probability that ground motion will reach a certain level during an earthquake. The data show peak horizontal ground acceleration (the fastest measured change in speed for a particle at ground level that is moving horizontally because of an earthquake). Figure 4-16 represents the 2,500-year probability ground motion, which is more of a worst-case scenario, and depicts the shaking level that has a 2 percent chance of being exceeded over a period of 50 years. In this scenario, Jefferson County lies in the range of 10-14 and 14-20 percent peak acceleration. Ground motions become structurally damaging when average peak accelerations reach 10 to 15 percent of gravity, average peak velocities reach 8 to 12 centimeters per second, and when the Modified Mercalli Intensity Scale is about VII (18-34 percent peak ground acceleration), which is considered to be very strong (general alarm; walls crack; plaster falls).

Thus, probability for an earthquake producing minor shaking is considered **occasional**, and an earthquake causing significant damage is **unlikely**, with less than a 1 percent chance of occurrence over the next 100-year period.

Figure 4-16 Colorado Seismic Hazard Map—2% Probability of Exceedance in 50 Years



Source: Colorado State Hazard Mitigation Plan 2018

Magnitude and Severity

Earthquakes in or near Jefferson County are low probability but potentially high consequence events. The primary earthquake hazard in Jefferson County includes strong ground shaking, which could affect the entire County. It is prudent to expect future earthquakes as large as magnitude 6.6, the largest historical event in Colorado. Studies indicate earthquakes as large as 7.25 could occur within the state, but

scientists are unable to accurately predict when and where it will occur (Source: Colorado Earthquake Hazards – Colorado Earthquake Mitigation Council 2008.) While structural damage could result to buildings, damage to non-structural building elements and contents will account for the majority of damages. A 6.5 earthquake has the potential to cause multiple fatalities and injuries. The general perception is that earthquakes don't happen in Colorado, thus the populace is ill-prepared for what to do when one occurs. There is also potential for rupture of the ground surface, which could happen along a fault trace. Though a remote possibility, the potential for fault rupture would be most likely along the Golden Fault, in the vicinity of Golden along the base of the foothills. Fault rupture could impact homes and highways in west Golden. Secondary earthquake hazards that could occur in western Jefferson County and near Golden include landslides and rockfall, which could potentially damage transportation infrastructure, property, and cause death or injury. There is also the potential for damaging large waves called seiches that can form in lakes during earthquakes. This could impact reservoirs such as Chatfield, Strontia Springs, and Cheeseman, potentially causing damage to the marina and property at Chatfield.

During the development of this mitigation plan, HAZUS-MH was used to model the consequences of a large earthquake in Jefferson County. The results of this analysis are presented in the Vulnerability Assessment subsection below. This analysis complements HAZUS-MH studies performed by the Colorado Geological Survey on various faults statewide. According to those studies Jefferson County ranks 2nd in the state, behind El Paso County, as having the highest earthquake risk while comparing potential for economic loss and casualties. Considering a worst case scenario, the potential magnitude/severity rating of earthquakes is **catastrophic,** with widespread property damage, shutdown of facilities for more than two weeks and/or multiple fatalities.

Climate Change Considerations

According to the Colorado State Hazard Mitigation Plan, the best available data does not indicate that climate change is expected to influence future earthquake events in the planning area.

Vulnerability Assessment

As noted above, earthquakes strike with little to no warning and can have multiple impacts on an area. After-effects from an earthquake can include impacted roadways, downed power and communication lines, fires, and damages to structures (especially poorly built, or those already in disrepair).

The most appropriate risk assessment methodology for seismic hazards involves scenario modeling using FEMA's HAZUS loss estimation software. HAZUS is a regional earthquake loss estimation model developed by FEMA and the National Institute of Building Science. The primary purpose of HAZUS is to provide a methodology and software application to develop earthquake loss at a regional scale. HAZUS is a very useful planning tool because it provides a standard method for estimating earthquake damage, loss of function of infrastructure, and casualties, among many other factors. There are three levels of HAZUS analysis, from Level 1, which uses the default FEMA-derived datasets and damage functions, to Level 3, which uses independently compiled and accurately verified structure and infrastructure inventories and damage functions. A summary of the total loss estimations as a result of the HAZUS-MH analysis can be found below in Table 4-28.

Traditionally, earthquakes have not been considered a very likely hazard for Front Range communities and, as such, it is unlikely that many structures are built to be earthquake-resistant. All structures in the planning area are potentially exposed to damage from an event, with older or historic structures more at risk. Damage potential will vary by the size, extent, and severity of the earthquake and the location of the event's epicenter. The entire population of the planning area may also be considered at risk, and likely unprepared for earthquakes. The population at risk will vary based on the timing of a large earthquake.

Table 4-27 illustrates the potential earthquake losses in and around Jefferson County as compiled by the Colorado Geological Survey (CGS) Earthquake Reports, issued in 2013. The fatalities totals assume the quake occurs at 5:00pm. Economic impacts include both direct and indirect losses.

Table 4-27 Potential Earthquake Losses in Front Range by Fault

Fault/Magnitude	Casualties	Total Economic Loss
Inside Jefferson County		
Golden M6.5 Arbitrary	1,606	$45 Billion
Walnut Creek M6.5 CEUS	2,303	$60.5 Billion
Near Jefferson County/Front Range		
Chase Gulch M6.75	38	$4.4 Billion
Mosquito M7.0 Arbitrary	125	$8.04 Billion
Rampart M7.0 Arbitrary	743	$28 Billion
Rocky Mountain Arsenal M6.25	1,263	$39.9 Billion
Ute Pass M7.0 Arbitrary	594	$22.3 Billion
Valmont M5.0 Arbitrary	22	$2.9 Billion

Source: Earthquake Evaluation Reports, http://coloradogeologicalsurvey.org

According to the CGS reports, the Rocky Mountain Arsenal, Golden, Rampart Range, Ute Pass, and Walnut Creek faults are considered the top five potentially most damaging faults in the state (which includes damage to Jefferson as well as other counties in the Denver Metropolitan Area). Figure 4-14 shows the relative location of these faults.

A Level 1 HAZUS-MH earthquake loss analysis was conducted for this plan update, based on an inventory database compiled at a national level aggregated to Census Tracts. As with any model there are uncertainties, and the results should be considered approximate for planning purposes.

To evaluate potential losses associated with earthquake activity in the planning area, a HAZUS 2,500-year probabilistic scenario was run for the entire County. The methodology utilizes probabilistic seismic hazard contour maps developed by the U.S. Geological Survey (USGS).

During the update of this plan in 2021, a HAZUS-MH probabilistic earthquake scenario was run with the latest version of HAZUS-MH (Version 2.2). A driving Magnitude of 7.25 was input into the HAZUS scenario, but the results are primarily based on the USGS 2,500 year probabilistic ground shaking maps. The USGS maps provide estimates of potential ground acceleration and spectral acceleration at periods of 0.3 second and 1.0 second, respectively.

The 2,500-year return period analyzes ground shaking estimates with a 2 percent probability of being exceeded in 50 years, from the various seismic sources in the area. The International Building Code uses this level of ground shaking for building design in seismic areas. The CGS believes that the USGS probabilistic shaking maps likely underestimate the hazard, as there are limited studies of the earthquake hazard in the state to base the shaking maps on. Table 4-28 summarizes the results of the 2,500-year HAZUS-MH scenario. A 100-year return period scenario was also analyzed. This scenario did not produce any damage.

Table 4-28 HAZUS-MH Earthquake Loss Estimation 2,500-Year Scenario Results

Type of Impact	Impacts to County
Total Buildings Damaged	Slight: 25,355 Moderate: 10,355 Extensive: 2,004 Complete: 118

Type of Impact	Impacts to County
Building and Income Related Losses	$1.7 Billion 65% of damage related to residential structures 17% of loss due to business interruption
Total Economic Losses (includes building, income and lifeline losses)	$2.2 Billion Building: $1.41 Billion Income: $295.4 Million Transportation/Utility: $4.6 Million
Casualties (based on 2 a.m. time of occurrence)	Without requiring hospitalization: 177 Requiring hospitalization: 22 Life threatening: 2 Fatalities: 3
Casualties (based on 2 p.m. time of occurrence)	Without requiring hospitalization: 307 Requiring hospitalization: 46 Life threatening: 4 Fatalities: 8
Casualties (based on 5 p.m. time of occurrence)	Without requiring hospitalization: 223 Requiring hospitalization: 33 Life threatening: 3 Fatalities: 5
Damage to Transportation and Utility Systems and essential facilities	No transportation or pipeline damage, 0 essential facilities damaged
Fire Following Earthquake	0 Ignitions 0.00 sq. miles burnt
Debris Generation	416,000 million tons of debris generated 16,640 truckloads
Displaced Households	826
Shelter Requirements	437

Source: HAZUS-MH 2.2

Another HAZUS-MH earthquake scenario is included in this analysis. The Colorado Geologic Survey produced a report for a M6.5 event on the Golden Fault as it is presumed to be the most damaging to Jefferson County based on its proximity to the City of Golden and the Jefferson County governmental offices, including the Emergency Operations Center (EOC). The epicenter, or point on the ground surface where the earthquake originates, was chosen at an arbitrary location on the fault at -105.22 longitude and 39.75 latitude, just south of the community of Beverly Heights in Golden, along US Highway 6.

The model assumed the following fault rupture parameters: depth of 10km, rupture orientation of 157 degrees and a West US Extensional 2008 attenuation function. Table 4-29 summarizes the output from this 'worst case' scenario for Jefferson County.

Table 4-29 HAZUS-MH Earthquake Loss Estimation Golden Fault M 6.5 Scenario Results

Type of Impact	Impacts to County
Total Buildings Damaged	Slight: 48,908 Moderate: 35,760 Extensive: 17,176 Complete: 6,629

Type of Impact	Impacts to County
Building and Income Related Losses	Total: $11.5 Billion 60% of damage related to residential structures 20% of loss due to business interruption
Total Economic Losses (includes building, income and lifeline losses)	Total: $11.5 Billion Building: $8.3 Billion Income: $2.1Billion Lifeline: $1.2 Billion
Casualties (based on 2 a.m. time of occurrence)	Without requiring hospitalization: 2,218 Requiring hospitalization: 578 Life threatening: 88 Fatalities: 172
Casualties (based on 2 p.m. time of occurrence)	Without requiring hospitalization: 4,516 Requiring hospitalization: 1,297 Life threatening: 213 Fatalities: 415
Casualties (based on 5 p.m. time of occurrence)	Without requiring hospitalization: 3,191 Requiring hospitalization: 908 Life threatening: 169 Fatalities: 284
Damage to Transportation Facilities and essential facilities	Total Transportation Replacement Value: $3.5 Billion 34 essential facilities damaged with functionality > 50% on Day 1
Fire Following Earthquake (Monte Carlo Simulation)	0 ignitions 0.0 sq. miles burned
Debris Generation	3.73 million tons of debris generated 149,080 truckloads
Displaced Households	11,616
Shelter Requirements	6,086

Source: HAZUS-MH 2.2

General Property

There are an estimated 197,000 buildings in Jefferson County with a total building replacement value (excluding contents) of $66.7 Billion. Approximately 92% of these buildings (and 82% of the building value) are associated with residential housing. In terms of building construction types found in the region, wood frame construction makes up 70% of the building inventory. The remaining percentage is distributed between the other general building types.

The building losses are broken into two categories: direct building losses and business interruption losses. The direct building losses are the estimated costs to repair or replace the damage caused to the building and its contents.

The categories of damages defined by HAZUS are:

- **Slight** damage includes diagonal hairline fractures on most shear wall surfaces and hairline cracks on most infill walls.
- **Moderate** damage includes cracks on most walls and failure of some shear walls.
- **Extensive** damage means that most shear wall surfaces in the structure have reached or exceeded their capacity exhibited by large, through-the-wall diagonal cracks.
- **Complete** damage means that the structure has collapsed or is in danger of collapse.

In the probabilistic scenario, HAZUS estimates that about 12,477 buildings will be at least moderately damaged, of these an estimated 118 buildings will be damaged beyond repair. This leads to over 6% of the total number of buildings in the County being at least moderately damaged. Most of the damage modeled as extensive and complete is associated with unreinforced masonry buildings. Losses by type for this scenario, both in the type of loss (i.e. structural, wages, income, etc.) and occupancy type, are detailed further in Figure 4-17.

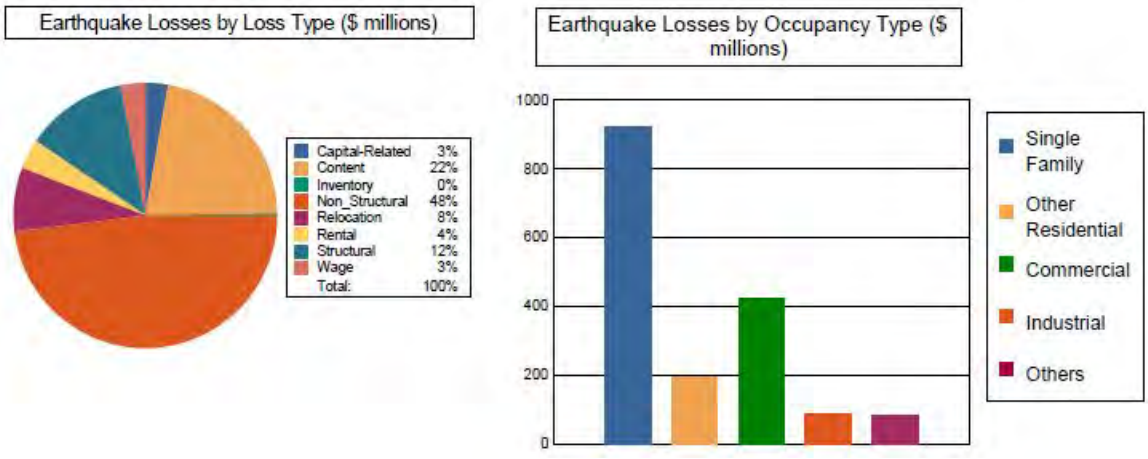
The total building-related losses in this scenario were $1.7 billion, with detail shown in Table 4-30. By far, the largest loss was sustained by the residential occupancies which made up over 65% of the total loss.

Table 4-30 Building-Related Economic Loss Estimates in Millions of Dollars – 2,500 Year Probabilistic Scenario

Category	Area	Single Family	Other Residential	Commercial	Industrial	Others	Total
Income Losses							
	Wage	0.0000	2.1614	45.5558	1.8342	3.5963	53.1477
	Capital-Related	0.0000	0.9199	43.5063	1.1226	0.6431	46.1919
	Rental	19.9095	10.9176	27.8553	0.7209	1.6131	61.0164
	Relocation	70.7959	8.5331	40.1474	4.5635	10.9656	135.0055
	Subtotal	**90.7054**	**22.5320**	**157.0648**	**8.2412**	**16.8181**	**295.3615**
Capital Stock Losses							
	Structural	122.0547	19.1404	47.5426	10.9099	11.3541	211.0017
	Non_Structural	495.4731	117.3821	135.3296	36.9199	31.3129	816.4176
	Content	212.2252	36.0274	81.5750	25.1596	20.1904	375.1776
	Inventory	0.0000	0.0000	1.7881	4.6542	0.3039	6.7462
	Subtotal	**829.7530**	**172.5499**	**266.2353**	**77.6436**	**63.1613**	**1409.3431**
	Total	**920.46**	**195.08**	**423.30**	**85.88**	**79.98**	**1704.70**

Source: HAZUS-MH Global Summary Report, Wood analysis

Figure 4-17 Earthquake Losses by Type – 2,500 Year Probabilistic Scenario



The business interruption losses are the losses associated with inability to operate a business because of the damage sustained during the earthquake. Business interruption losses also include the temporary living expenses for those people displaced from their homes because of the earthquake. 17% of the estimated losses were related to business interruption.

For the Golden Fault deterministic scenario, HAZUS estimates much more extensive damage with about 59,565 buildings at least moderately damaged and 6,629 of these buildings damaged beyond repair. This is over 30% of the total number of buildings in the County at least moderately damaged. Most of the

damage modeled as extensive and complete is associated with masonry buildings, both reinforced and unreinforced.

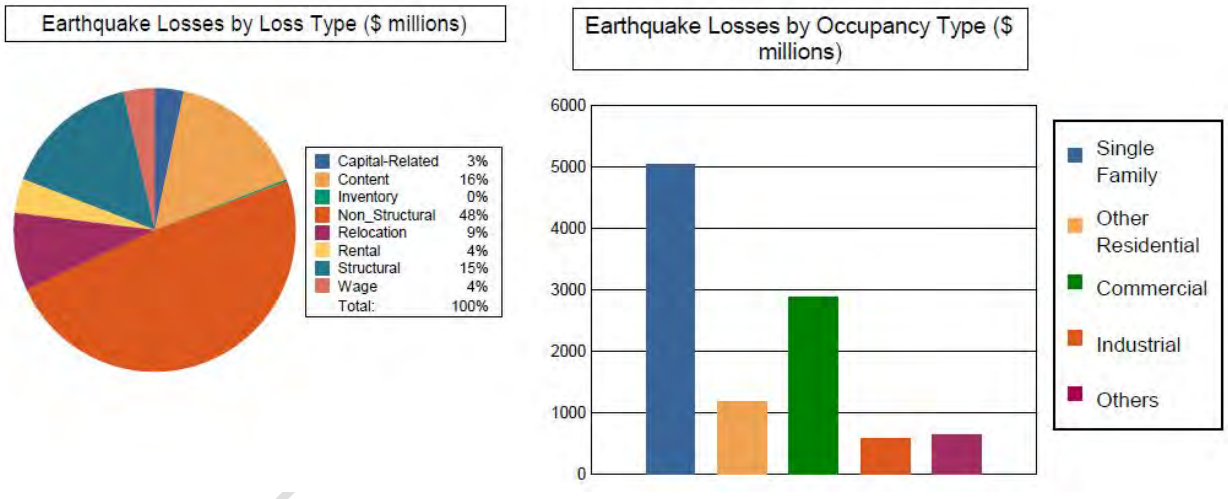
The total building-related losses in this scenario were $10.3 billion, with detail shown in Table 4-30. By far, the largest loss was sustained by the residential occupancies which made up over 65% of the total loss. Earthquake losses for the Golden Fault scenario by type, both in the type of loss (i.e. structural, wages, income, etc.) and occupancy type, are detailed further in Figure 4-18.

Table 4-31 Economic Loss Estimates in Millions of Dollars – M6.5 Golden Fault Scenario

Category	Area	Single Family	Other Residential	Commercial	Industrial	Others	Total
Income Losses							
	Wage	0.0000	18.8614	321.8556	13.1289	28.9066	382.7525
	Capital-Related	0.0000	8.0303	318.0109	8.1135	5.2837	339.4384
	Rental	143.7674	79.0565	170.5806	4.3559	14.1979	411.9583
	Relocation	500.7302	53.1115	252.0721	23.3202	90.8138	920.0478
	Subtotal	**644.4976**	**159.0597**	**1062.5192**	**48.9185**	**139.2020**	**2054.1970**
Capital Stock Losses							
	Structural	896.2019	144.3440	373.7022	84.0864	95.8819	1,594.2164
	Non_Structural	2758.7286	710.8701	1005.2295	260.7901	266.4793	5,002.0976
	Content	756.6651	161.3783	433.2579	159.2894	122.4645	1,633.0552
	Inventory	0.0000	0.0000	9.4733	28.8443	1.3308	39.6484
	Subtotal	**4411.5956**	**1016.5924**	**1821.6629**	**533.0102**	**486.1565**	**8269.0176**
	Total	**5056.09**	**1175.65**	**2884.18**	**581.93**	**625.36**	**10323.21**

Source: HAZUS-MH Global Summary Report, Wood analysis

Figure 4-18 Earthquake Losses by Type – M6.5 Golden Fault Scenario



People

Potential fatalities and injuries are described above in the HAZUS results. Ground movement during an earthquake is seldom the direct cause of death or injury. Most earthquake-related injuries result from collapsing walls, flying glass, and falling objects as a result of the ground shaking, or people trying to move more than a few feet during the shaking. HAZUS estimates the number of people that will be injured and killed by the earthquake. The casualties are broken down into four severity levels that describe the extent of the injuries. The levels are described as follows:

- **Severity Level 1**: Injuries will require medical attention, but hospitalization is not needed.

- **Severity Level 2**: Injuries will require hospitalization but are not considered life-threatening.
- **Severity Level 3**: Injuries will require hospitalization and can become life threatening if not promptly treated.
- **Severity Level 4**: Victims are killed by the earthquake.

The casualty estimates are provided for three times of day: 2:00 AM, 2:00 PM and 5:00 PM. These times represent the periods of the day that different sectors of the community are at their peak occupancy loads. The 2:00 AM estimate considers that the residential occupancy load is at its maximum. The 2:00 PM estimate considers that the educational, commercial, and industrial sector loads are at their maximum. The 5:00 PM represents peak commute time. The models show that for both scenarios the 2:00 PM event time would result in the most casualties. In the probabilistic scenario, most of these would be minor injuries (307 Level 1 and 46 Level 2), and 4 hospitalizations (Level 3) and 8 fatalities (Level 4) are estimated. In the M 6.5 Golden Fault event, the casualty numbers are estimated to be significantly higher, with 4,516 Level 1 and 1,297 Level 2 casualties, 213 hospitalizations, and 415 fatalities.

HAZUS estimates the number of households that are expected to be displaced from their homes due to the earthquake and the number of displaced people that will require accommodations in temporary public shelters. The model estimates that approximately 826 households will be displaced due to the earthquake, and 437 people will seek temporary shelter in public shelters. The Golden Fault scenario would result in an estimated 11,616 displaced households and 6,086 individuals seeking temporary shelter.

Critical Facilities and Infrastructure

HAZUS breaks critical facilities into two groups: essential facilities and high potential loss (HPL) facilities. Essential facilities include hospitals, medical clinics, schools, fire stations, police stations and emergency operations facilities. High potential loss facilities include dams, levees, military installations, nuclear power plants and hazardous material sites.

The model estimates the region has 6 hospitals with 780 hospital beds total. The probabilistic scenario estimates that on the day of the earthquake only 566 (73%) would be available for use. After one week 88% of the beds will be back in service. The model did not predict there would be any damage to schools, police, fire stations, or EOCs.

Within HAZUS, the lifeline inventory is divided between transportation and utility lifeline systems. There are 7 transportation systems that include highways, railways, light rail, bus, ports, ferry, and airports. The transportation systems inventory includes over 280.24 miles of highways and 447 bridges. The probabilistic scenario estimated approximately $4.6 million in damage to transportation systems, mostly to highways, bridges, and bus facilities.

There are 6 utility systems that include potable water, wastewater, natural gas, crude & refined oil, electric power, and communications. The inventory value of the utility lifeline systems combined is estimated to be $6.1 billion including 13,106 miles of pipes, and related economic losses to these systems in the probabilistic scenario would be around $486.6 million, with the largest losses to wastewater and electrical power systems.

The expected utility system facility damages in terms of Economic losses in millions of dollars are found in Table 4-32.

Table 4-32 Utility System Economic Losses in Millions of Dollars

System	Component	Inventory Value	Economic Loss	Loss Ratio (%)
Potable Water	Pipelines	0.0000	0.0000	0.00
	Facilities	161.5050	12.7520	7.90
	Distribution Lines	210.9119	0.8434	0.40
	Subtotal	**372.4169**	**13.5954**	
Waste Water	Pipelines	0.0000	0.0000	0.00
	Facilities	3783.9140	332.7814	8.79
	Distribution Lines	126.5471	0.4237	0.33
	Subtotal	**3910.4611**	**333.2051**	
Natural Gas	Pipelines	0.0000	0.0000	0.00
	Facilities	0.0000	0.0000	0.00
	Distribution Lines	84.3648	0.1452	0.17
	Subtotal	**84.3648**	**0.1452**	
Oil Systems	Pipelines	0.0000	0.0000	0.00
	Facilities	0.0970	0.0084	8.66
	Subtotal	**0.0970**	**0.0084**	
Electrical Power	Facilities	1697.0281	139.4595	8.22
	Subtotal	**1697.0281**	**139.4595**	
Communication	Facilities	2.4250	0.2037	8.40
	Subtotal	**2.4250**	**0.2037**	
	Total	**6,066.79**	**486.62**	

The Golden Fault scenario estimates that on the day of the earthquake only 240 hospital beds (31%) would be available for use. After one week 52% of the beds will be back in service. The model predicted that 3 hospitals, 126 schools, 5 EOCs, 14 police stations, and 20 fire stations would be at least moderately damaged but with > 50% functionality from the event. These figures make up 49% of the county's essential facilities. The model further estimates that 10 essential facilities would be completely damaged.

The model estimates the Golden Fault scenario would result in $50.55 million in economic losses to the transportation lifelines and $1.1 billion in losses to utility lifelines.

Economy

The 2,500 year probabilistic scenario estimates a total economic loss for the earthquake at $2.2 billion, which includes building and lifeline related losses based on the County's available inventory. $295.4 million is estimated to result from business interruption.

The M 6.5 Golden Fault scenario results in $11.5 billion in total economic losses for the county, including building and lifeline losses.

Historical, Cultural, and Natural Resources

Earthquake effects on the environment, natural resources, and historic and cultural assets would likely be minor. The biggest impact would likely be on the older historic properties constructed with unreinforced masonry.

Future Development

Without earthquake-resistant building considerations, future development will exhibit similar exposure and vulnerability to earthquakes as existing structures. As the region continues to expand, the overall estimated costs of a significant earthquake, both fiscally and in terms of casualty rates, may be expected to rise.

Overall Hazard Significance

Earthquakes in Jefferson County can impact the entire planning area. Within Colorado's relatively short historic record, earthquakes have been limited mainly and generally low in magnitude and/or intensity. The geographic extent of the hazard is considered **significant**. The probability of future large magnitude occurrences is considered **unlikely** (less than 1 percent probability of occurrence), though the magnitude/severity for a worst-case scenario is **catastrophic**. In addition, the HMPC considers the hazard to have a **high** overall impact on the County. While this lends itself to an overall ranking of high, the likelihood of an earthquake event that causes damages and significant impacts on the planning area is extremely low. Furthermore, mitigation activities for the planning area are very expensive and, according to stakeholder input, prohibitive in both timeframe for implementation and overall expense. As such the hazard is rated as **medium**.

4.3.6 Erosion and Deposition

Description

Erosion is the removal of solids (sediment, soil, rock and other particles) in the natural environment. It usually occurs due to transport by wind, water, or ice; by down-slope creep of soil and other material under the force of gravity; or in the case of bioerosion by living organisms such as burrowing animals. Erosion is distinct from weathering, which is the process of chemical or physical breakdown of the minerals in the rocks, although the two processes may occur concurrently.

The rate of erosion depends on many factors. Climatic factors include the amount and intensity of precipitation, freeze-thaw cycles, seasonality, the wind speed, and storm frequency. The geologic factors include the sediment or rock type, its porosity and permeability, the slope of the land, and whether the rocks are tilted, faulted, folded, or weathered. The biological factors include ground cover from vegetation or lack thereof, the type of organisms inhabiting the area, and the land use. Areas with high-intensity precipitation, more frequent rainfall, more wind, freeze-thaw cycles, or more storms are expected to have more erosion. Sediment with high sand or silt contents and areas with steep slopes erode more easily, as do areas with highly fractured or weathered rock. The porosity and permeability of the sediment or rock also affect how fast water can percolate into the ground. If the water moves underground, less runoff is generated, reducing the amount of surface erosion. Sediments containing more clay tend to erode less than those with sand or silt.

Grus soils form as a result of weathering of granites with abundant feldspar, such as the Pikes Peak Granite present in southwestern foothills of Jefferson County. The result is similar to ‘kitty litter’, which can easily be eroded and transported by wind and rain. Problems result from both erosion and deposition of these soils, particularly in areas burned by recent wildfires. Generally, land underlain by grus is gently rolling.

Changes in the kind of vegetation in an area can also affect erosion rates. Different kinds of vegetation lead to different infiltration rates of rain into the soil, and different surface runoff flow speeds. For example, forested areas have higher infiltration rates, so precipitation will result in less surface runoff, thus less erosion. If the trees are removed, for example by fire or logging, infiltration rates become high, but erosion can remain low to the degree that the forest floor remains intact. It is the removal of, or compromise to, the forest floor, not the removal of the canopy, which leads to increased erosion.

Poor land use practices can also lead to increased erosion. Some of those practices include deforestation, overgrazing, unmanaged construction activity and road-building. Land that is used for the production of agricultural crops generally experiences a significantly greater rate of erosion than that of land under natural vegetation. In the case of construction or road building, when the litter layer is removed or compacted, the susceptibility of the soil to erosion is greatly increased and the process, without proper engineering, can significantly change drainage patterns. There has been a marked increase in recreational land use that has left erosive remnants. The County Land Development Regulations, Section 17 addresses requirements for erosion and sediment control for new developments, refer to Section 2 Capabilities Assessment for further details. Large numbers of hikers use trails leaving furrowed foot traffic, or extensive use of off-road vehicles leave paths of beaten down vegetation and gouged terrain. There is a potential for the impacts of “beetle kill” to negatively affect soil stability and lead to erosion and watershed degradation as well. As discussed in Section 4.3.16 Wildfire, these predictions are difficult to quantify the impacts have not yet occurred, though the precedence is set. Future evaluation on the impacts of beetle kill on erosion may be merited in future planning efforts. While a certain amount of erosion is natural and, in fact, healthy for the ecosystem, wise land use practices are also necessary to keep it balanced.

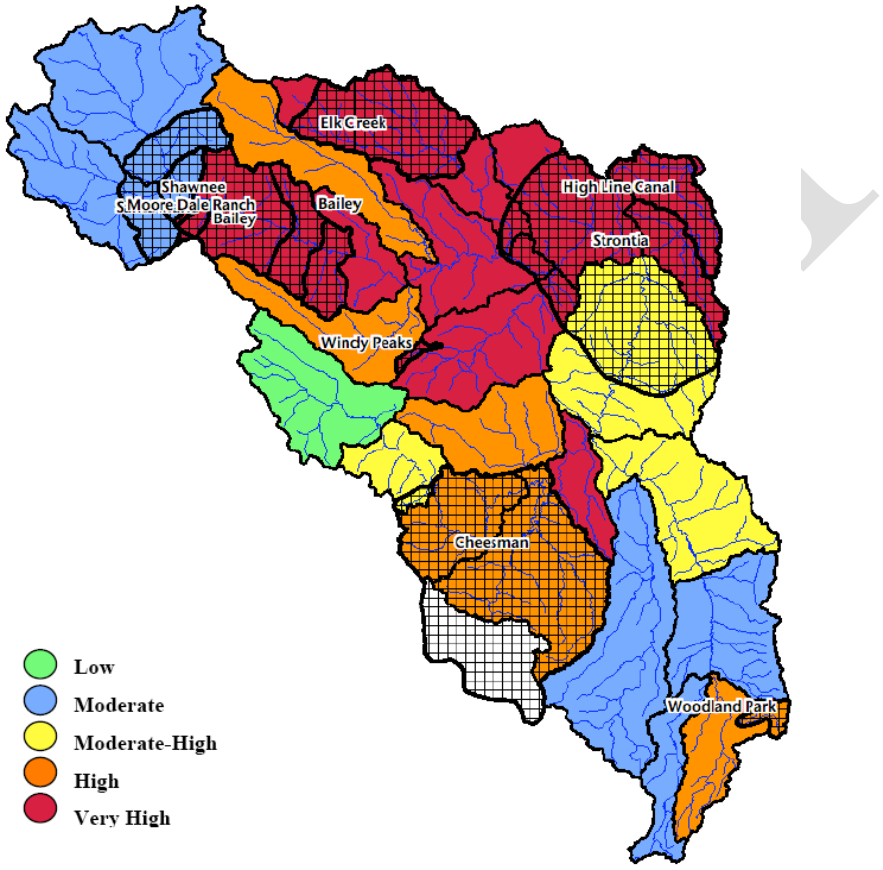
Geographic Extent

Determining erosion vulnerability for the planning area is difficult at best. Theoretically, areas of potential erosion due to human-exacerbated conditions, such as construction sites, are temporary and move around frequently as the County undergoes normal ebbs and flows in development.

Forested areas in the foothills of Jefferson County, which account for over 50% of the planning area, are potentially vulnerable to erosion problems after severe wildfires.

The Front Range Watershed Protection Data Refinement Work Group has developed a technical approach to protecting watersheds from post wildfire erosion. The purpose of this group is to identify and prioritize those watersheds that provided or convey water used by communities and municipalities. The data analysis is designed to identify and prioritize watersheds for hazard reduction treatments or other watershed protection measures. Through GIS analysis of soil erodibility, water uses, wildfire hazard, and flood or debris flow risk hazardous watersheds have been identified. Many of these are within Jefferson County are displayed on the following map. The source water area upstream from important surface water intakes, upstream diversion points, and classified drinking water supply reservoirs that have a higher potential for contributing significant sediment or debris is referred to as the Zone of Concern, and is mapped in Figure 4-19.

Figure 4-19 Upper South Platte Zones of Concern and Watershed Prioritization Map



Source: Front Range Watershed Protection Data Refinement Workgroup Executive Summary

Finally, the natural geologic formations found in the planning area, and specifically the sides of North and South Table Mountain, Green Mountain, and the hogback formations, may be vulnerable to erosion from natural causes. In general, however, the overall extent of erosion susceptibility is fairly small.

Based on this information, the geographic extent rating for erosion is **significant**.

Previous Occurrences

Erosion occurs frequently in Jefferson County and is, in fact, a natural part of the ecosystem. Concerns about erosion arise when large amounts of sedimentation are deposited into the water supply because of erosion (generally driven by human factors) or when significant erosion occurs in wildfire burn areas, which impacts both watershed quality and recovery efforts in the burn area.

Specific incidents of development-driven erosion, or the erosion that occurs when sites undergoing development and construction are not adequately protected against erosion, are too numerous to specifically quantify. Under state, local and federal regulation, however, construction sites are required to mitigate or minimize erosion and sedimentation as far as possible, which would reduce future occurrences.

The Buffalo Creek Fire in Jefferson County in May of 1996 was followed by substantial flooding and erosion two months later. The burned area is within the Pike National Forest, in the South Platte Watershed and foothills of Jefferson County. The flooding transported approximately 331,000 m^3 of coarse sediment into Strontia Springs Reservoir in three months after the fire. This reservoir supplies over 75% of the drinking water to the City of Denver. Studies indicate the sedimentation rate was nearly 30 times the annual rate of sediment input used in designing the reservoir. The reservoir also experienced a significant degradation in water quality as a result of the input of burned material and sediment. Denver Water, the agency responsible for distributing drinking water from the reservoir, estimates that it spent over $1 million in immediate clean-up efforts after the fire Denver Water is in the process of dredging excess sediment from the reservoir, at an estimated cost of $23 million.

The 2002 wildfire season, detailed in the wildfire hazard profile, was unusually severe in terms of both the number and extent of wildfires the state experienced, and the severity of the lasting impacts of those fires. Unlike the 1996 Buffalo Creek post-fire recovery time, localized extreme flooding and substantial erosion and deposition that pose significant hazards to the public have continued to 2009; the potential for more flooding and erosion and will likely continue for several more years, particularly in and near the community of West Creek and on Six Mile Creek near Deckers. In 2009, seven years after the fire, Vail Resorts, the U.S. Forest Service, and the National Forest Foundation announced plans to raise $4 million to undo damages caused by the Hayman fire, including watershed cleanup, restoration of burned lands, and rebuilding of recreational trails. This project was successfully completed over three years between 2011 and 2013. Based on the lessons learned from the Buffalo Creek Fire, Denver Water installed sediment traps on Turkey Creek to protect Cheesman reservoir from siltation, at a cost of $2 million. These sediment traps require periodic mucking out, which costs about $350,000 each time, but should mitigate more expensive dredging operations at the reservoir in addition to water quality impacts.

The Coal Creek Watershed suffered a heavy rainfall event on September 12, 2013 that caused large amounts of channel migration that resulted in erosion and deposition. Per the Upper Coal Creek Watershed Restoration Master Plan: The rainfall event on September 12, 2013, was unprecedented in the Coal Creek watershed. Damage throughout the corridor was widespread. In particular, downstream of Twin Spruce Gap Road, nearly every access culvert failed, was washed out, or was significantly damaged. The channel eroded significantly, leading to visible scour through the La Duwaik Estates and other central residential corridors. Highway culverts also plugged with debris, further exasperating flooding effects on the highway and downstream infrastructure. The culvert crossing at the Union Pacific Railroad (UPRR) did manage to pass the peak flows; however, a sedimentation zone was formed in the valley upstream of the culvert, where much of the eroded material was deposited. With the exception of the old Real Estate building at Twin Spruce Gap Road, no homes or buildings were destroyed in this area, although some were badly damaged. This building has since been demolished, and the land acquired by the Colorado Department of Transportation (CDOT).

The Coal Creek Canyon community center is located upstream of Twin Spruce Gap Road. Significant damage was also evident in this area, including structure inundation and culvert failures. Runoff from the Crescent Park Tributary eroded drainages and moved sediment through this corridor. Flood damage was widespread at both commercial and residential locations. A new channel was excavated at the intersection of Crescent Park Drive and Highway 72 to help direct discharges from the Crescent Park Tributary to Coal Creek.

Similar observations were made in the upper portions of Coal Creek and its tributaries, with damages along Twin Spruce Gap Road (Beaver Creek), Crescent Park Drive, and Ranch Elsie Road. Again, failure was noted at many driveway and access culverts, as well as damage to homes and other structures.

As with other historic flood events, highway and roadway access was limited during and after the flood event. Highway 72 reopened permanently approximately two months following the flood event. Access for

residents to and from the Front Range was very limited over this time period and required extensive detouring to otherwise nearby areas.

Following the flood event significant efforts were made (and are still ongoing) to repair the destruction. Much of the repair work, such as private culvert replacement, has been completed by individual landowners. The National Resources Conservation Services (NRCS) has also provided assistance to qualified landowners in need of immediate assistance through their Emergency Watershed Protection (EWP) program. Repair work to public infrastructure has been led by groups including Jefferson and Boulder Counties.

Along Highway 72, CDOT has been active in repairing and reopening the highway. This work has included debris removal, roadway reconstruction/resurfacing, and bank reinforcement in areas adjacent to the highway with high erosive susceptibility. Much of this initial work was an immediate response to the flood event and CDOT began flood repair and roadway improvement project along Coal Creek Canyon in April 2019 and completed in 2020. The repairs include road reconstruction of 12 miles of Highway 72, replacing culverts, stabilizing slopes and restoring channels, and adding a four-foot shoulder (CDOT 2020).

Probability of Future Occurrences

Erosion occurs daily as a natural process in both developed and undeveloped lands, and natural erosion is not considered a hazard.

Future incidents of erosion associated with wildfires are likely particularly in a mountainous area where the ground is sloping. As such, for this erosion and deposition, the probability of future occurrence mimics that of the wildfire hazard. Since 1980, there have been 23 fire incidents in Jefferson County that have burned 10 or more acres. The methodology for calculating the probability of future occurrences is described in Section 4.3.1. This formula evaluates that the probability of erosion occurring as a result of severe wildfire in any given year is 57.5%. This corresponds to a probability of future occurrences rating of **likely**.

Magnitude and Severity

According to the *Small Site Erosion and Sediment Control Manual* published by the Jefferson County Planning and Zoning Division, stormwater runoff polluted with sediment is the main cause of surface water pollution in the United States. Furthermore, construction activities may generate 400 times the amount of erosion compared to undisturbed land, or 400 years' worth of erosion over a period of one year of construction. Erosion issues with new development should be minimal if erosion control practices are utilized.

Post-fire erosion in the foothills of Jefferson County has and will continue to cause watershed health problems. Erosion rates due to wildfires varies based on the terrain, slope, severity of the burn, subsequent rainfall until groundcover can be re-established, and the overall erodibility of the soil in question. While a methodology is still under development, the impacts of erosion into watersheds is well documented. Erosion carries sediment, organic debris, and chemicals into the water supplies, which may damage aquatic habitats and impact the water quality utilized by populations. As water is a critical resource to Jefferson County's large population, the impacts may be widespread. Erosion, therefore, could pose significant indirect impacts on the planning area, even if it does not directly impact life quality and other critical services.

Information from the event of record is used to calculate a magnitude and severity rating for comparison with other hazards, and to assist in assessing the overall impact of the hazard on the planning area. In some cases, the event of record represents an anticipated worst-case scenario, and in others, it is a reflection of common occurrence. The event of record for this hazard is the resulting erosion caused by the Buffalo Creek Fire in 1996, but the impacts have been long-range. Response and recovery costs to address erosion problems have cost Denver Water alone over $27.7 million. Erosion may occur and damage the entire burn area, with damages inflicted on critical facilities from the loss or disruption of services, particularly if reservoirs, water treatment plants, roads, or communication lines are impacted or damaged. Erosion may cause illnesses to the watershed populations who are exposed to diminished water quality but the burden on the medical community is anticipated to be minimal. Knowledge of these

impacts is well addressed in local planning and mitigation efforts, however, which decreases the likely occurrence of these impacts.

Based on these factors, the magnitude severity rating for erosion is considered **critical,** mainly for watershed health and critical facility impacts.

Climate Change Considerations

Climate change projections show an increase of climate induced events related to in the intensity of heavy rain events which can result in increased erosion and sediment transport in local water bodies threatening to both water quality as well as the fish and aquatic vegetation the live in the streams and rivers. Higher river levels and faster stream velocity as a result of stronger, more intense storms can also increase erosion. According to the 2018 State of Colorado Hazard Mitigation Plan, the extent of erosion and deposition are expected to increase as the frequency of wildfires increase across the state. Overall, wildfire erosion is expected to increase across Colorado.

Dust-on-snow causes increased snowmelt because dust is darker than snow it absorbs more sunlight causing the snow underneath to heat up more rapidly. This is an emerging factor that could lead to substantial long-term reductions in Colorado's seasonal snow cover. The Center for Snow and Avalanche Studies (CSAS), located in Silverton, Colorado, operates the Colorado Dust-on-Snow (CODOS) program to study the effects of dust on Colorado's snowpack. The program has CSAS sensors at 11 mountain pass locations throughout the state to monitor the presence or absence of dust layers, including Grizzly Peak adjacent to Loveland Pass. As of April 30, 2019, the CODOS reported dust to be more evident and severe compared to the 10 other sites. The Rocky Mountains have been receiving dust since the ice age but the CODOS has seen evidence that the size and frequency of dust storms in the Colorado Mountains have been increasing since the 1990s.

Vulnerability Assessment

Two different areas of existing development are vulnerable to erosion. Erosion of soils due to slope grade, soil content and cover, and exposure to weather conditions is fairly limited and generally falls within underdeveloped areas. This is also due to the concurrence of erosion potential with other geologic hazard areas, such as dipping bedrock or subsidence regions, which are regulated for development by the County.

General Property

Buildings and infrastructure across the county may be vulnerable to the impacts of erosion and deposition. Although damage or losses to structures are typically minimal, there can be impacts with mitigation and maintenance costs, lost time, and minor structural damage. Areas susceptible to wildfire-driven erosion, which often result in debris flow (see below) or the erosion and deposition of soil into watersheds, also does not usually directly impact developed areas. There are some areas of variance, particularly in the wildland-urban interface, where debris flows may impact housing and commercial districts.

People

There are no reported injuries or deaths to these soil hazards in Jefferson County, and direct impacts on people are likely to be very minimal.

Critical Facilities and Infrastructure

In addition to the general areas of existing vulnerability, scour critical bridges are also vulnerable to the effects of erosion and deposition. These bridges are listed in Table 4-45. Erosion around bridges may compromise the construction of the structure, making them unsafe. Deposition may also press up against the structures, causing structural strain or sweeping out the structure by debris. In this instance, the vulnerability overlaps those identified in the debris flow section that follows.

Economy

Response and recovery costs to address erosion problems have cost Denver Water alone over $27.7 million. This can be used as an estimate of future losses but will vary depending on if fire and resulting erosion problems affect critical watersheds.

Historical, Cultural, and Natural Resources

The largest concern surrounding erosion centers on the pollution of the watersheds by soils, which impacts wildlife balances and degrades water quality for downstream habitats. Continued erosion and movement of soils in wildfire areas usually degrade watershed quality and thus exert a larger or disproportionate impact on the larger planning area. In addition, recovery for the washed-out areas may be prolonged or difficult, as demonstrated in the burn areas of the Hayman fire, due to the loss of nutrient-rich soil.

Future Development

Future development on steep slopes is not likely, and the areas at the base of the hogbacks are regulated by the County, therefore future development exposed to slope-driven erosion is unlikely. Unsuitable slopes are mapped in area plans (such as the Evergreen Area Community Plan) and are part of the County Comprehensive Plan. Future developments subjected to erosion and deposition as a result of wildfire, forest thinning, and clearcutting are vulnerable to the same extent as discussed in the landslide, debris flow, and rockslide hazard.

Overall Hazard Significance

Erosion events in Jefferson County have a potentially significant impact on the planning area, but the County has recognized and addressed these threats. As such, the geographic extent of the hazard is considered **significant**, the probability of future occurrences is considered **likely** and the magnitude/severity for the event of record is **critical**. In addition, the HMPC considers the hazard to have a low overall impact on the planning area. This equates to an overall impact rating of **medium**.

4.3.7 Expansive Soils

Description

Swelling soils and swelling bedrock contain clay which causes the material to increase in volume when exposed to moisture and shrink as it dries. They are also commonly known as expansive, shrinking and swelling, bentonitic, heaving, or unstable soils and bedrock. In general, the term refers to both soil and bedrock contents although the occurrence of the two materials may occur concurrently or separately. The difference between the materials is that swelling soil contains clay, while swelling bedrock contains claystone. In this profile, the term is used to refer to both materials, as they are both relevant to the planning area.

The clay materials in swelling soils are capable of absorbing large quantities of water and expanding 10 percent or more as the clay becomes wet. The force of expansion is capable of exerting pressures of 15,000 pounds per square foot or greater on foundations, slabs, and other confining structures. The amount of swelling (or potential volume of expansion) is linked to five main factors: the type of mineral content, the concentration of swelling clay, the density of the materials, moisture changes in the environment, and the restraining pressure exerted by materials on top of the swelling soil. Each of these factors impact how much swelling a particular area will experience, but may be modified, for better or worse, by development actions in the area.

In Colorado, swelling soils expand and contract naturally during seasonal wetting (winter and spring) and drying (summer and fall) conditions and in their natural, undeveloped state they cause little damage. However, exposure to additional water sources, such as lawn and garden irrigation or precipitation drainage from houses, and reduced evaporation properties caused by the development of roads, sidewalks, buildings and parking lots, may cause the swelling soils to expand more than they would if they remained undeveloped. In addition, the re-grading of development areas may expose more swelling soil to moisture than the natural state, causing a more widespread swelling event.

In Jefferson County, there are also areas of steeply dipping bedrock or heaving bedrock along the foothills. In these areas, sedimentary bedrock layers are steeply upturned and tilted to form the distinctive hogback features. This causes bedrock to swell unevenly in a linear pattern, instead of the uniform pattern more common to flatter areas of swelling soils, and subjects structures to extreme amounts of both vertical and lateral stress. In Jefferson County, areas of potential dipping and heaving bedrock are identified as a geologic hazard and construction in those areas is heavily restricted.

Swelling soils are one of the nation's most prevalent causes of damage to buildings. According to the 2018 State Hazard Mitigation Plan, annual losses nationwide are estimated in the range of $2 billion. In Colorado, the cost is estimated at $16 million annually. Potential damages include severe structural damage; cracked driveways, sidewalks, and basement floors; heaving of roads and highway structures; condemnation of buildings; and disruption of pipelines and other utilities. Destructive forces may be upward, horizontal, or both. Buildings designed with lightly loaded foundations and floor systems often incur the greatest damage and costly repairs from expansive soils. Building in and on swelling soils can be done successfully, although more expensively, as long as appropriate construction design and mitigation measures are followed. In some cases, avoidance may be the best mitigation policy.

Geographic Extent

The extent of swelling soils across Jefferson County is primarily contained in the developed portion of the County at the base of the foothills in the northeast portion of the planning area. In fact, the swelling soils neatly follow the rise of the Rocky Mountains along the western and southern portions of the County. The extent of dipping bedrock in the planning area neatly abuts the extent of the mostly horizontal plains of swelling soil on the east, and the fall of the hogback formations on the west. The figures below demonstrate the mapped geologic hazard layers utilized by the planning area for development.

Figure 4-20 Jefferson County Expansive Soils

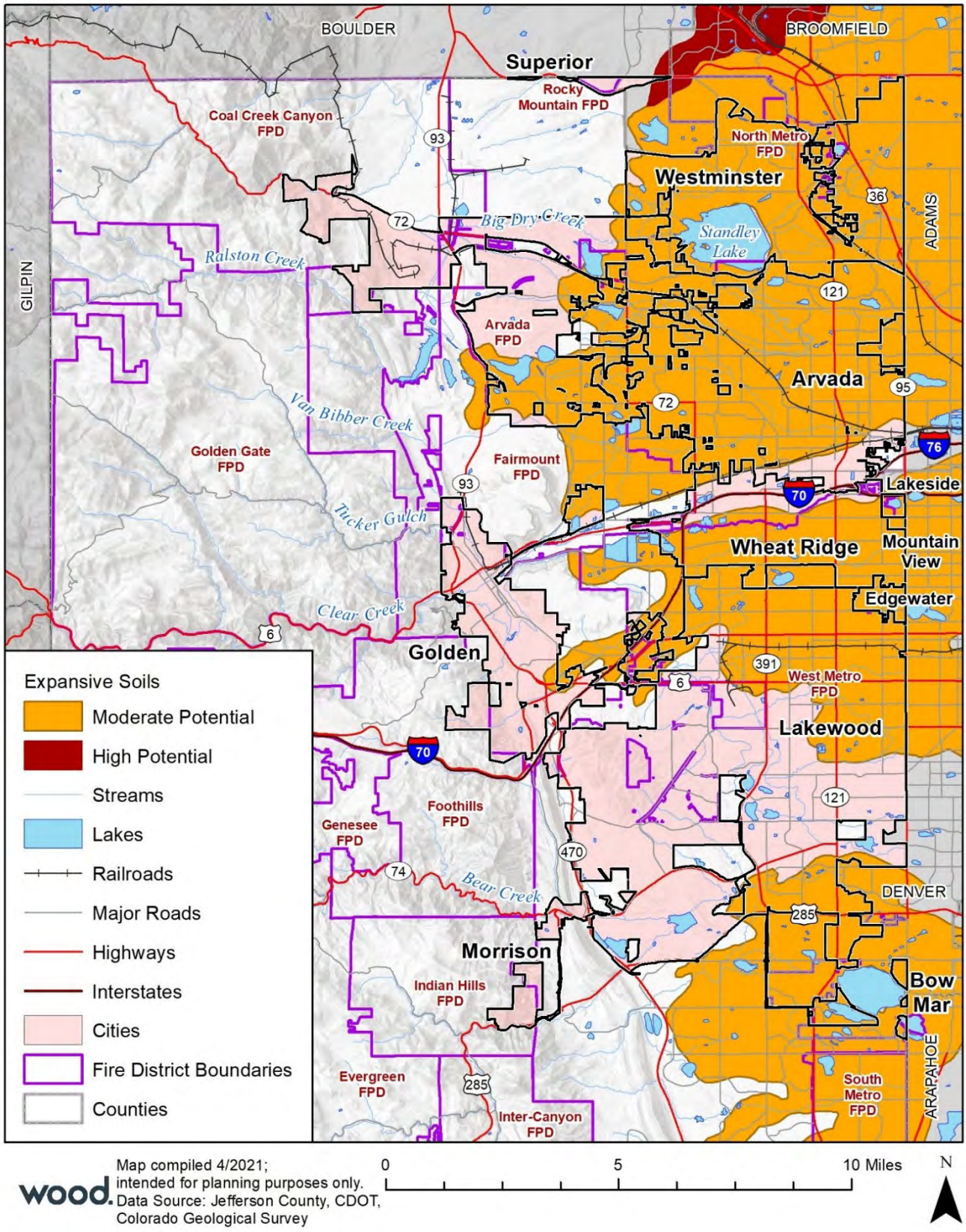
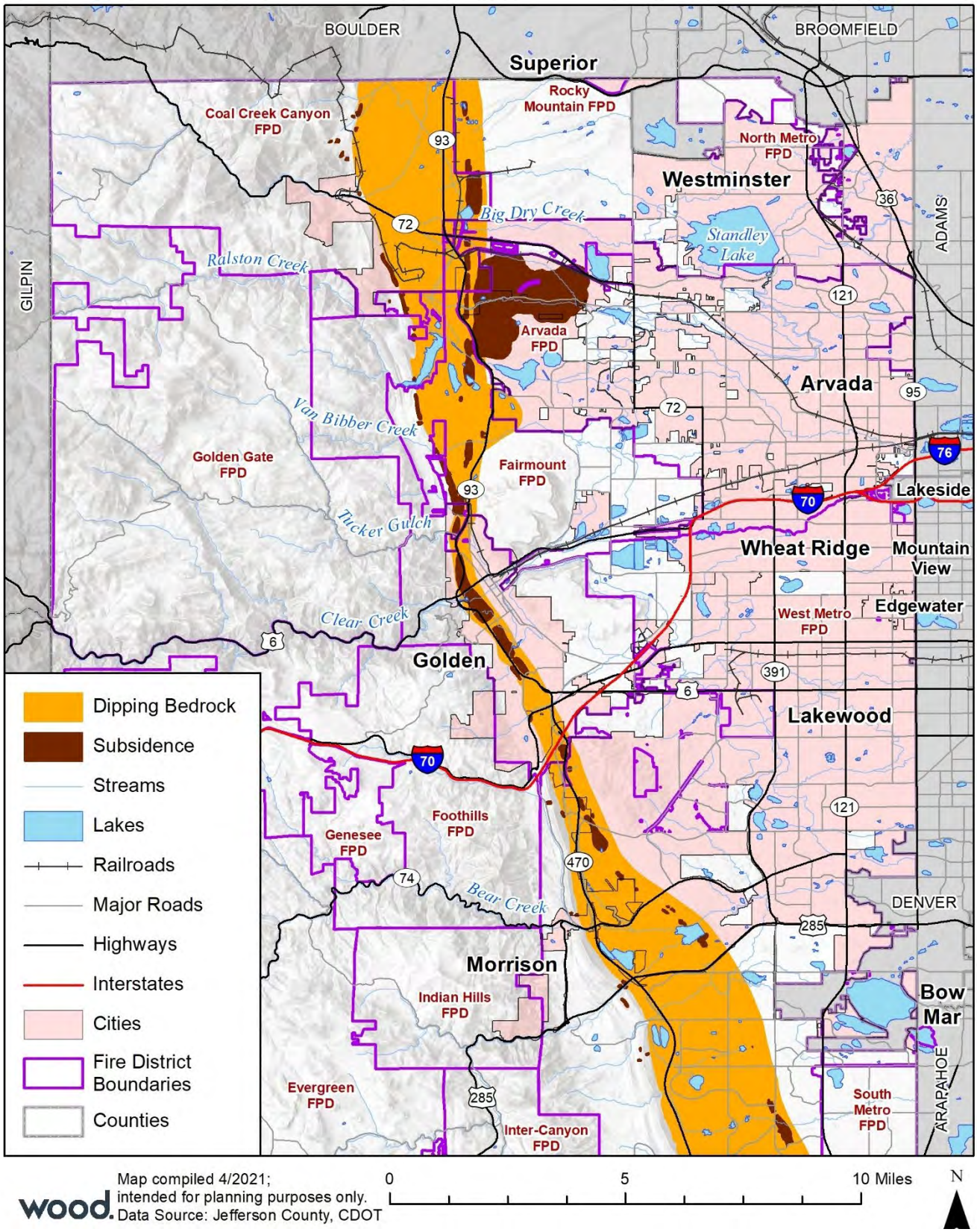


Figure 4-21 Jefferson County Dipping Bedrock and Subsidence



Previous Occurrences

Damage of varying degrees of severity occurs on an ongoing and seasonal basis. The frequency of damage from expansive soils is associated with the cycles of drought and heavy rainfall and also reflects changes in moisture content based on typical seasonal patterns. Building codes and structure ages also contribute to overall damages, as newer structures are usually built with more resistant techniques or as development restrictions in vulnerable areas minimize expansion and exposure. Published data summarizing damages specific to Jefferson County is not available, but it is acknowledged that a certain degree of damage to property and infrastructure occurs annually, as noted above.

Since the last plan update, the most significant areas that intersect Golden and Morrison remain largely undeveloped; however, growth in western Arvada, western Lakewood, and unincorporated areas along Highway 93 and CO-470 since the last update exposes new development to this hazard. It is important to note that recent development east of Highway 93 in West Arvada and north of Golden was not reflected in the 2015 plan. It is reflected in this plan and shows increased exposure for these areas.

The mapped extent of the hazards clearly impacts approximately 50% of the planning area. However, when considering the geographic impact on the planning area, it is important to note that the entire southern portion of the County is occupied by Pike National Forest, and therefore has a minimal impact on this hazard mitigation plan as development in the area is highly regulated outside of County authority. Of the actively developed and monitored lands in the County, more than 75% is subject to swelling soils or dipping bedrock hazards.

Based on this information, the geographic extent rating for swelling soils is **extensive**.

Probability of Future Occurrences

The planning area has extensive development regulations to minimize the damages incurred by dipping bedrock and other geologic hazards in the County. As such, while previous occurrences are certainly commonly known, it is reasonable to assume that damages and future occurrences should be decreasing.

Since records of specific occurrences are not available to the planning process, it is difficult to estimate the probability of future occurrences. The hazards occur seasonally and annually, which should theoretically equate to a highly likely rating. However, mitigation efforts in place in the County since 1995 should prevent the likelihood of the hazard having damaging impacts. Due to the extensiveness of swelling soils in the County the probability rating for this hazard is considered as **likely.**

Magnitude and Severity

Information from the event of record is used to calculate a magnitude and severity rating for comparison with other hazards, and to assist in assessing the overall impact of the hazard on the planning area. In some cases, the event of record represents an anticipated worst-case scenario, and in others, it is a reflection of common occurrence. For this hazard, there is no specific event of record, and the extensive mitigation efforts taken since the initial identification of the hazard nearly thirty years ago are taken into account with the magnitude and severity ratings. Therefore, this hazard will be evaluated for potential worst-case scenarios possible under current regulatory standards. Such an event could potentially damage entire neighborhoods, including roads, sidewalks, properties, and utility pipes. Even minor damages on such a scale would quickly incur enormous costs. While critical infrastructure services are not directly vulnerable to the hazard, structures experience the same risks identified for private and commercial properties: if they are built on swelling soil without adequate or appropriate building mitigation, they are vulnerable to damage. In worst case scenarios, this could include loss of communication lines or severe damages to structures rendering them uninhabitable. If this occurred to a hospital or jail, for instance, it could have significant social repercussions, in addition to the incurred costs. Injuries, illnesses and deaths associated with the hazard would be unique and minimal, and probably incurred as secondary hazards resulting from damages to infrastructure. Overall, though the fiscal damage may be extensive, the overall severity and impacts of the hazard are readily mitigated, reducing the overall impacts.

Based on these factors, the magnitude and severity rating for swelling soils is considered **limited**.

Climate Change Considerations

Changing climate conditions are expected to affect soil resources in many ways. During hot, dry years annual grasses that stabilize and protect topsoil often fail to germinate or do not grow well. This leaves soil surfaces highly vulnerable to erosion from wind and precipitation runoff. Without the availability of nutrient- rich topsoil, crops struggle to survive and flourish. As discussed previously, higher rates of erosion can have a profound effect on agricultural production and on the economies of rural areas of the county.

Many soils and rocks have the potential to swell or expand based on a combination of its mineralogy and water content. The actual swelling of expansive soils will be caused by a change in the environment (e.g. water content, stress, chemistry, or temperature) in which the material exists. Since the 1950s, snow precipitation and duration of snowpack have both decreased while rising temperatures have increase rate of water evaporating into the air and earlier runoff, creating drier soil conditions in Colorado (EPA 2016). More extremes in climate conditions (e.g. wet-dry conditions), could potentially exacerbate the swelling of expansive soil issues in the future.

Vulnerability Assessment

General Property

Similar to the subsidence hazard, the majority of the hazard's significance is drawn from the exposure of existing development to this hazard. As identified in the hazard profile and noted above, extensive areas of the planning region east of the foothills are characterized to some extent by swelling soils. Older construction may not be resistant to the swelling soil conditions and, therefore, may experience expensive and potentially extensive damages. This includes heaving sidewalks, structural damage to walls and basements, the need to replace windows and doors, or dangers and damages caused by ruptured pipelines. Newer construction may have included mitigation techniques to avoid most damage from the hazard, but the dangers continue if mitigation actions are not supported by homeowners. For example, the maintenance of grading away from foundations and the use of appropriate landscaping near structures must be continued to prevent an overabundance of water in vulnerable soils near structures. While continued public education efforts may help increase compliance for landscaping and interior finishing mitigation actions, physical reconstruction of foundations is probably not feasible in all but the most heavily impacted of existing development. Therefore, damages may be expected into the future for existing structures.

GIS was used to create a risk assessment for geological hazards in Jefferson County. Dipping bedrock (i.e. heaving bedrock) hazard data was overlaid on Jefferson County parcel and assessor's data. For the purposes of the analysis, if the hazard zone intersects an improved parcel center, its improved value is included and parcel is counted in Table 4-33. Results are sorted by occupancy type and by jurisdiction to demonstrate how the hazard's risk varies across the planning area.

This analysis outlines the potential exposure of improvements built on dipping bedrock for existing development in the planning area. This represents only a tiny portion of the swelling-soil related building exposure, as a swelling soils GIS layer was not available. However, the exposure to the dipping bedrock alone identifies that there could be potential for damage from this hazard. The table indicates that Golden, Lakewood, Morrison, Arvada and the unincorporated areas east of the foothills have the greatest exposure to this hazard. In this analysis, improved values (typically structures and buildings) are assumed to be potentially exposed, but not necessarily 'at risk.' This analysis does not take into account site-specific mitigation measures that may be in place, thus estimating losses for dipping bedrock is difficult.

Compared to 2016, in general exposure of buildings to dipping bedrock increased for all jurisdictions, likely due to development outward for all jurisdictions. Residential property exposure to dipping bedrock increased for parcels for Arvada, Golden, Lakewood, and Unincorporated. For example, residential property improved parcels exposed to dipping bedrock increased from 22 to 203, nearly a 10-fold increase.

Table 4-33 Exposure of Buildings to Dipping Bedrock

Jurisdiction	Property Type	Improved Parcels	Building Parcels	Total Value	Population
Arvada	Commercial	2	2	$3,589,478	
	Industrial	2	2	$8,225,885	
	Residential	203	205	$128,134,394	508
	Total	**207**	**209**	**$139,949,757**	**508**
Golden	Agriculture	1	1	$70,874	
	Commercial	78	99	$231,482,526	
	Exempt	15	31	$208,931,936	
	Industrial	86	89	$131,473,603	
	Mixed Use	9	17	$125,961,762	
	Residential	1,786	2,562	$1,247,910,033	5,739
	Total	**1,975**	**2,799**	**$1,945,830,734**	**5,739**
Lakewood	Commercial	2	15	$8,684,812	
	Exempt	2	3	$106,386	
	Industrial	1	4	$176,850	
	Residential	1,391	1,391	$975,570,386	3,158
	Total	**1,396**	**1,413**	**$984,538,434**	**3,158**
Morrison	Commercial	1	1	$1,681,678	
	Exempt	3	3	$17,958,698	
	Industrial	1	1	$181,443	
	Total	**5**	**5**	**$19,821,819**	**0**
Unincorporated	Agriculture	9	9	$1,131,166	
	Commercial	203	242	$584,914,140	
	Exempt	45	48	$358,498,400	
	Industrial	183	190	$286,860,023	
	Mixed Use	65	74	$118,221,706	
	Residential	20,393	20,696	$9,911,186,736	52,775
	Total	**20,898**	**21,259**	**$11,260,812,171**	**52,775**
	Grand Total	**24,481**	**25,685**	**$14,350,952,913**	**62,180**

Source: Jefferson County GIS and Assessor's Data

People

There are no reported injuries or deaths to these soil hazards in Jefferson County, and direct impacts on people are likely to be very minimal.

Critical Facilities and Infrastructure

Existing critical facilities impacted by dipping bedrock and other swelling soil hazards are of particular concern, as the damages caused to these structures may impact the ability of the planning area to provide critical services to the population. Schools built on the area may pose a danger to occupants if the buildings are severely damaged in an event. If building integrity is compromised, it may also reduce the sheltering capacity or public health distribution capacity of the County, as schools are often used for these functions.

Table 4-34 includes the results of a GIS overlay of critical facilities on the dipping bedrock areas. Critical facilities exposed to dipping bedrock increased in number for all jurisdictions compared to the 2016 plan. The unincorporated jurisdiction has the most critical facilities at risk and a majority of those are communication and transportation FEMA lifelines. A number of schools and fire stations in the planning area are potentially exposed. This analysis does not take into account site-specific mitigation measures that may be in place.

Table 4-34 Critical Facilities in Dipping Bedrock Zones in Jefferson County

Jurisdiction	FEMA Lifeline	Critical Facility Type	Count
Arvada	Communications	Land Mobile Private Towers	1
	Communications	Microwave Service Towers	2
	Energy	Electric Substation	2
	Energy	Power Plant	2
	Hazardous Material	Tier II	1
	Transportation	Bridge	2
		Total	**10**
Golden	Communications	Land Mobile Private Towers	9
	Communications	Microwave Service Towers	9
	Food, Water, Shelter	Water Facility	1
	Hazardous Material	Household Hazardous Waste	1
	Hazardous Material	Tier II	1
	Health and Medical	Nursing Home	2
	Safety and Security	EOC	1
	Safety and Security	Government Facility	6
	Safety and Security	Law Enforcement	1
	Safety and Security	School	2
	Transportation	Bridge	6
		Total	**39**
Lakewood	Communications	Land Mobile Private Towers	1
	Energy	Electric Substation	2
	Food, Water, Shelter	Wastewater Plant	1
	Transportation	Bridge	7
		Total	**11**
Morrison	Communications	Land Mobile Private Towers	1
	Safety and Security	Fire Station	1
	Transportation	Bridge	2
		Total	**4**
Unincorporated	Communications	Land Mobile Private Towers	31
	Communications	Microwave Service Towers	29
	Energy	Electric Substation	6
	Energy	Power Plant	1
	Hazardous Material	Tier II	13
	Health and Medical	Nursing Home	9
	Safety and Security	Fire Station	2

Jurisdiction	FEMA Lifeline	Critical Facility Type	Count
	Safety and Security	Government Facility	1
	Safety and Security	Law Enforcement	1
	Safety and Security	School	17
	Transportation	Bridge	45
	Transportation	Government Facility	4
		Total	**159**

Source: HIFLD and CERC

Economy

The economic cost of this hazard is typically minor in the short term, although over time they can add up to significant impacts.

Historical, Cultural, and Natural Resources

Collapsible and expansive soils are a natural environmental process. Nonetheless they have the potential to alter the landscape and can cause damages to historic and cultural resources.

Future Development

The most effective mitigation actions for expansive soil are complete avoidance or non-conflicting use, or correct engineering design (which includes foundation design, adequate drainage, landscaping, and appropriate interior finishing.) While some areas are devoted to non-conflicting use permits, in particular the areas which are included in the dipping bedrock zones, so much of the Colorado basin is covered in swelling soils that complete avoidance is not possible.

Land use planning regulations in place should temper the risk of swelling soil impacts on future development. Continued efforts to regulate building in areas of high or moderate swelling potential increase the number of structures and infrastructure built with swelling-adaptive methods, which in turn reduces the amount of damage incurred each year on the property. Continued education on the hazard, particularly with landscaping and maintenance concerns, will be needed to reduce the impacts of the hazard on development. As existing development deteriorates and requires either renovation or reconstruction, mitigation methods should be implemented to bring the developments up to contemporary mitigation standards.

Since the last plan update, the most significant areas that intersect Golden and Morrison remain largely undeveloped; however, growth in western Arvada, unincorporated areas along Highway 93, and in Lakewood exposes new development to this hazard. It is important to note that recent development east of Highway 93 in West Arvada and north of Golden was not reflected in the 2015 parcel and associated databases. It is reflected in this plan and shows increased exposure for these areas.

Overall Hazard Significance

Swelling soil in Jefferson County has, historically, exerted significant impacts on the County, particularly during the large growth expansion experienced between 1970 and 1995. In response to the growing hazard, Jefferson County formed and convened an Expansive Soils Task Force in the spring of 1994 and implemented development regulations by 1995. As a result, the impacts of the hazards in the planning area have been extensively mitigated, either by restricting where development is permitted or by heavily regulating the type of construction permitted in certain areas to adequately address the hazard. The geographic extent of the hazard is considered **extensive**. The probability of future occurrences is considered **likely** and the magnitude/severity for the event of record is **limited**. In addition, the HMPC considers the hazard to have a low overall impact on the jurisdiction. This equates to an overall impact rating of **medium**. In many ways, the swelling soils hazard is an excellent example for demonstrating the effectiveness of how mitigation efforts may reduce the vulnerabilities and risks of a previously high-concern hazard. Sound planning and engineering practices should keep the impact to future development low, however the potential for damages exist in older residential areas.

4.3.8 Extreme Temperatures

Description

Extreme Heat

The Colorado State Hazard Mitigation Plan defines extreme heat as "temperatures over 90 degrees for an extended period of time, or that hover 10 degrees or more above the average high temperature for the region and last for multiple consecutive days." In a normal year, about 175 Americans succumb to the demands of summer heat. According to the National Weather Service (NWS), among natural hazards, only the cold of winter—not lightning, hurricanes, tornadoes, floods, or earthquakes—takes a greater toll. In the 40-year period from 1936 through 1975, nearly 20,000 people were killed in the United States by the effects of heat and solar radiation. In the heat wave of 1980, more than 1,250 people died.

Heat disorders generally have to do with a reduction or collapse of the body's ability to shed heat by circulatory changes and sweating or a chemical (salt) imbalance caused by too much sweating. When heat gain exceeds the level the body can remove, or when the body cannot compensate for fluids and salt lost through perspiration, the temperature of the body's inner core begins to rise, and heat-related illness may develop. Elderly persons, small children, those with chronic illnesses, those on certain medications or drugs, and persons with weight and alcohol problems are particularly susceptible to heat reactions, especially during heat waves in areas where moderate climate usually prevails.

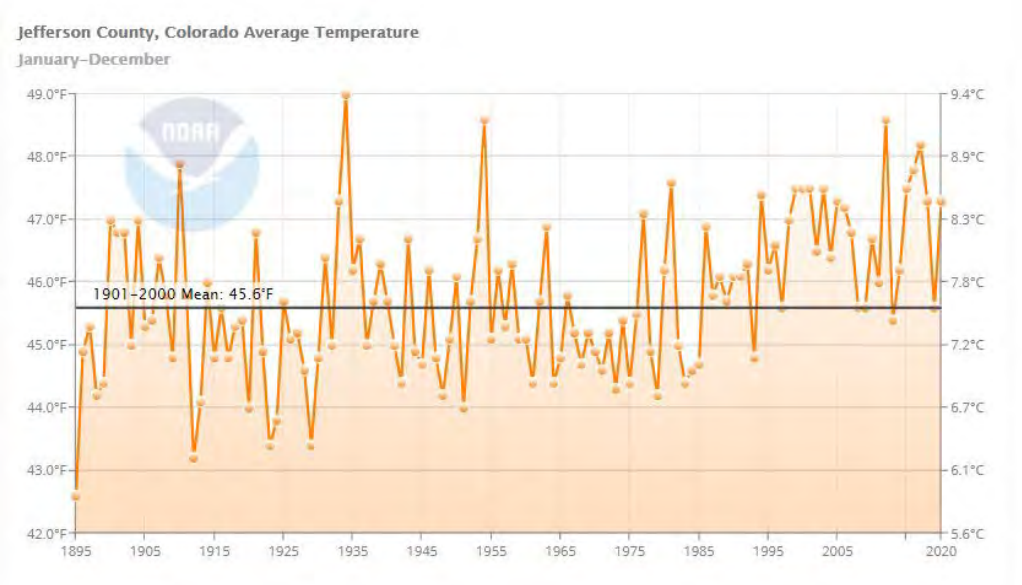
Extreme Cold

Extreme cold often accompanies a winter storm or is left in its wake. It is most likely to occur in the winter months of December, January, and February. Prolonged exposure to the cold can cause frostbite or hypothermia and can become life-threatening. Infants and the elderly are most susceptible. Pipes may freeze and burst in homes or buildings that are poorly insulated or without heat. Extreme cold can disrupt or impair communications facilities.

Previous Occurrences

According to the National Weather Service Forecast Office for Denver/Boulder, there have been 82 streaks with temperatures of 90 degrees or greater since 1895, which accounts for more than 150 days of extremely hot temperatures in the metro area (NWS). During 2008, Denver's 87-year-old record for the number of consecutive days above 90 degrees Fahrenheit was broken. The new record of 24 consecutive days surpassed the previous record by almost a week. On August 1st, it reached 104 degrees, breaking a record set in 1938 and on August 2nd, it reached 103 degrees, breaking a record set in 1878. In addition, as of August 2008, the area documented 68 days with temperatures above 100°F and 29 days with temperatures below -20°F between February 2008 and 1872 (NWS), as shown in Figure 4-22.

Figure 4-22 Jefferson County Average Annual Temperature, 1895 – 2020



Source: NOAA

By contrast, the Denver Metro area averages 156 days a year with a minimum temperature of 32°F or less. The highest recorded temperature for Jefferson County is 104°F, and the lowest is -41°F. The Southwest Climate and Environmental Information Collaborative (SCENIC) reports data summaries from a station in the City of Lakewood and a station in the Town of Evergreen. Table 4-35 contains temperature summaries related to extreme heat for the station.

Table 4-35 Temperature Data from Lakewood and Evergreen Stations

Station	Average Annual Maximum Temperature	Average Annual Minimum Temperature	Extreme Maximum Temperature	Extreme Maximum Temperature	Avg Annual Days Max. >90	Avg Annual Days Max. <32	Avg Annual Days Min. <32	Avg Annual Days Min. <0
Lakewood1 (054762)	64	37	104 6/27/1994	-26 1/12/1963	8.7	6.5	49.2	2
Evergreen2 (052790)	61	27	97 6/236/2012	-38 1/12/1963	1.5	6.7	74.3	6

Source: SCENIC [1]Period of Record: 1962-2020 [2]Period of Record: 1961-2020

Since temperature variations are a regional hazard, many of the previous occurrences are documented at a regional level as well. For example, between 1996 and 2020 the NCEI database reflects one incident of extreme temperatures for Jefferson County (extreme cold/wind chill in 2011), but documents eight incidents in neighboring Denver County. Therefore, the incidents below impact more than just the planning region.

1983 – A cold spell impacted the entire Metro area with readings dipping to -21°F, marking the coldest recorded temperature in 20 years.

1989 – Periods of extreme cold and high winds combined with snow created a severe storm scenario. Stapleton Airport was closed, and a 46-car pileup occurred on Interstate 25. More details on this storm are captured in Section 4.3.13.

April 11, 1995 – Extreme cold was reported across the region with temperatures recorded at 13°F. Damages to wheat crops in Arapahoe County were estimated at $1 million ($1.4 million in 2008 dollars).

December 16-18, 1996 – Extreme wind chills impacted the entire Front Range and plains regions. Lows in the Denver area were reported at -9°F. A homeless man found in his car, with a body temperature of only 85°F at the time, died a few hours later.

October 24-25, 1997 – A blizzard left snow up to 4′ deep in the foothills and wind gusts were documented at 70 mph. With wind chill, temperatures dropped to between -25°F and -40°F. A State of Emergency was declared, with five recorded deaths and 15 injuries.

December 18-24, 1998 – An arctic air mass settled in over northeastern Colorado dropping overnight temperatures well below zero for 6 consecutive days. Overnight temperatures bottomed out at -19°F on the morning of the 22nd. At least 15 people, mostly homeless, were treated for hypothermia at area hospitals. The bitter cold weather was responsible, either directly or indirectly, for at least 5 fatalities. Three of the victims died directly from exposure. The cold weather also caused intermittent power outages. Following the cold snap, thawing water pipes cracked and burst in several homes and businesses causing extensive damage. Damage estimates were unavailable.

June and July 2000 – June 29th marked the beginning of a near record hot streak for the Denver area. The maximum high temperature at Denver International Airport equaled or exceeded the 90°F mark for 17 consecutive days, from June 29th-July 15th; one day short of tying the all-time record. The record of 18 consecutive days was set in two different years, July 1st-18th, 1874 and July 6th-23rd, 1901.

February 1-4, 2011 – A frigid Arctic air mass settled into the Front Range Urban Corridor to start out the month. At Denver International Airport, overnight low temperatures on the 1st through the 3rd were 13 and 17 below zero and zero respectively. The icy temperatures caused pipes to crack and burst following the freeze. At the Jefferson County Courts administration building, a steady stream of water from a crack on the 5th floor went unnoticed and flooded all floors of the administration wing overnight, damaging much of the office equipment, furniture and carpet. The icy temperatures also forced the closure of several school districts.

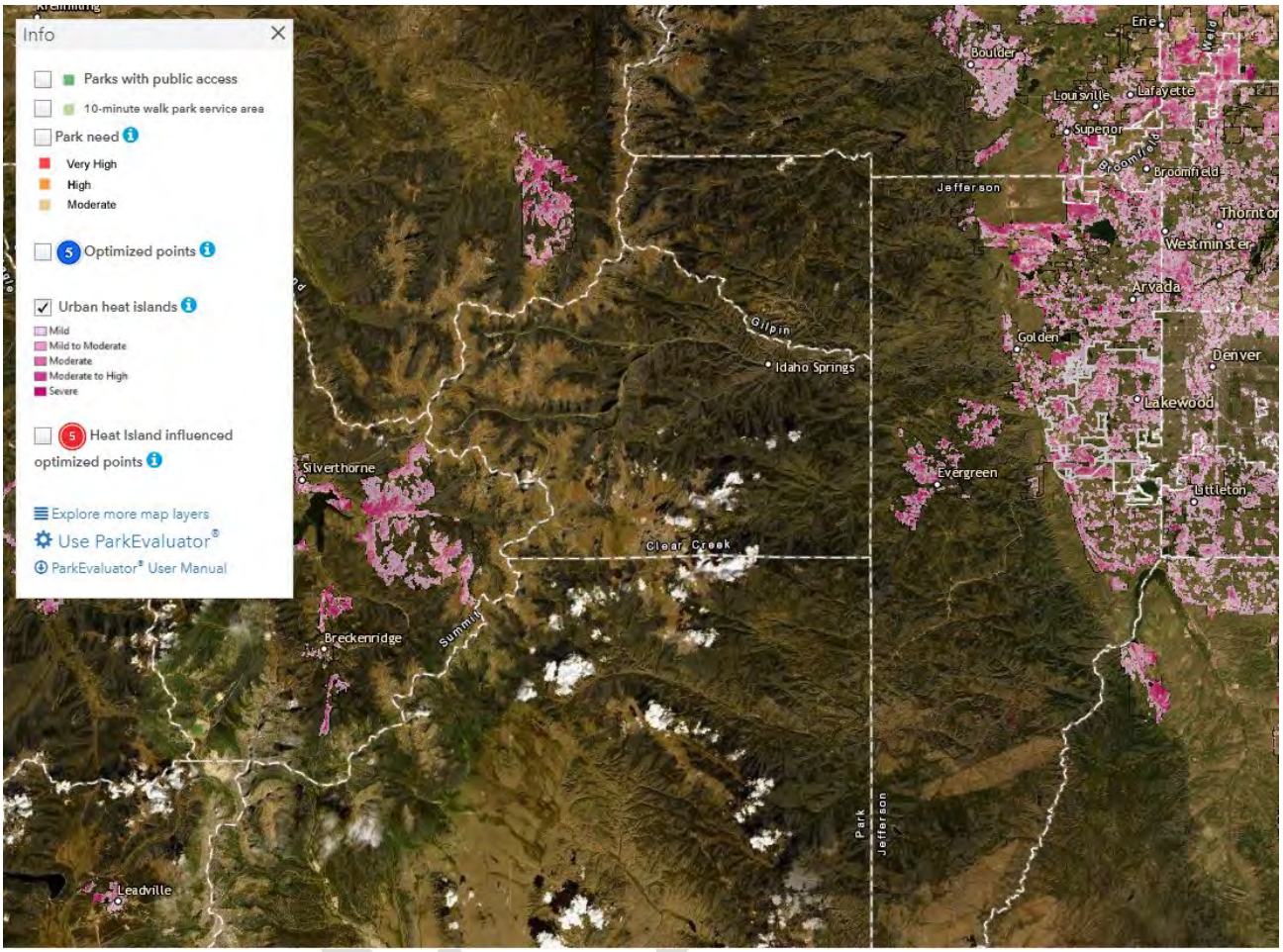
Geographic Extent

The inherent nature of temperature hazards makes them a regional threat, impacting most or all of the planning area simultaneously although the impacts will vary by location. The County being located along the foothills of the Rocky Mountains and encompasses the West Denver Metro area municipalities of Arvada, Golden, Lakewood, Lakeside, Morrison, Mountain View, Westminster and Wheat Ridge. These areas experience similar temperate climate to the remaining Denver Metropolitan Area and are more susceptible to extreme heat events compared to the higher elevations of the County due to the more urbanized areas. The areas of higher elevations like Kittredge, Evergreen, Idledale, and the unincorporated rural mountain areas are more susceptible to extreme variations in general, which can pose a danger to those citizens that may be more vulnerable and certainly so if those extremes temperatures are extended. This is reflected in the previous occurrence record, which consistently discusses the Denver Metro Area, rather than singling out particular counties or communities.

Urbanized areas, in the Denver Metro Area can experience pockets of heightened temperatures where surfaces such as pavement and roofs become hotter than the air temperatures, a phenomenon known as the urban heat island effect. These hot surfaces also retain heat, causing high temperatures to persist even when air temperature drops. Per the EPA, “the annual mean air temperature of a city with 1 million people or more can be 1.8–5.4°F (1–3°C) warmer than its surroundings. On a clear, calm night, however, the temperature difference can be as much as 22°F” (US EPA). Colorado’s climate tends to experience large day and night temperature changes. This nighttime cooling will help alleviate heat conditions and is thought to benefit and reduce risk of extreme heat.

The Trust for Public Land, ParkServe online mapping tool allows users to find areas that are impacted by urban heat islands as well as the availability of parks with public access. Figure 4-23 shows the urban heat island areas within Jefferson County and the level of severity, from mild to severe impact.

Figure 4-23 Urban Heat Island Areas within Jefferson County



Source: The Trust for Public Lands, ParkServe https://parkserve.tpl.org/mapping/ The geographic extent rating for extreme temperatures is extensive.

Probability of Future Occurrences

Temperature extremes occur on a regular basis, with an annual average of 4.6 days in the mountain areas and 25.7 in the metro area where the maximum temperatures exceed 90°F. The temperatures dip below freezing (32°F) an annual average of 19 days. Severe incidents or prolonged exposures to a temperature extreme are a higher threat to the community than isolated, seasonal occurrences.

There have been 23 incidents of extreme temperatures in Jefferson County since 1961. The methodology for calculating the probability of future occurrences is described in Section 4.3.1. This formula evaluates that the probability of a severe temperature extreme occurring in any given year is 39%. This corresponds to a probability of future occurrences rating of **likely**.

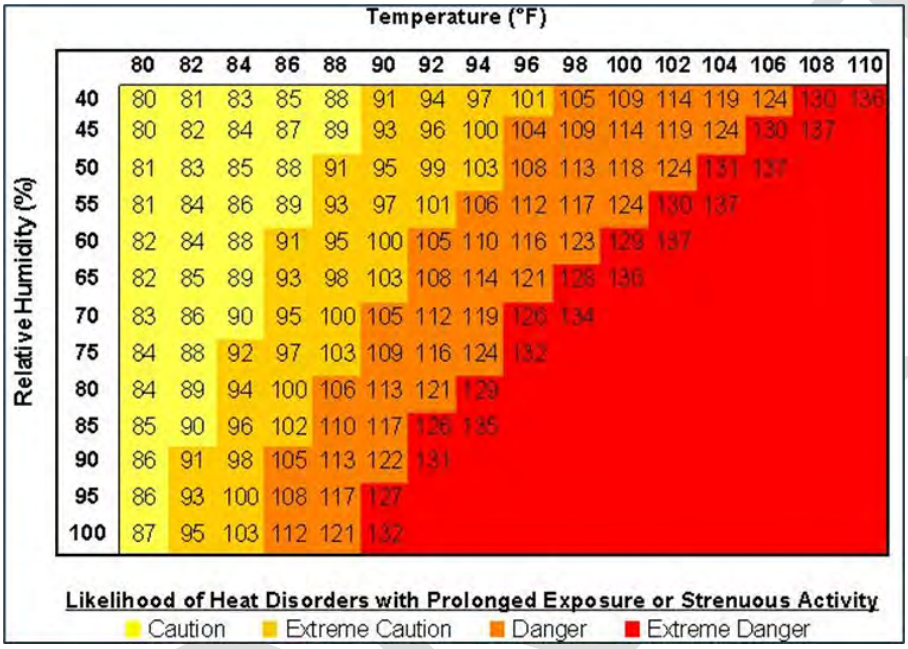
Magnitude and Severity

Information from the event of record is used to calculate a magnitude and severity rating for comparison with other hazards, and to assist in assessing the overall impact of the hazard on the planning area. In some cases, the event of record represents an anticipated worst-case scenario, and in others, it is a reflection of common occurrence. Since temperature extremes refer to both extreme heat and extreme cold, there is not a single event of record. The event of record for extreme heat in Jefferson County occurred in the summer of 2000. While specific property damages are not available, the event coincided with a severe drought period, which caused extensive damages to crops and personal property, impacted overall water supplies, and caused economic damages due to both conditions. The event of record for

extended periods of severe cold in Jefferson County occurred during December 18-24 in 1998. Damages caused by ruptured water pipes were considered extensive in both the private and public sectors. Power outages increased damages to property and impacted human lives. Hospitals documented a small surge in casualties either directly or indirectly attributed to the cold, and at least 15 injuries were reported. Five deaths were attributed to the cold weather as well, with three of them due directly to exposure. Nationwide, extreme temperatures remain the leading cause of weather-related deaths.

The National Weather Service Heat Index Program provides a measure of the extent of typical health impacts of exposure to heat, as shown in Figure 4-24 and Table 4-36. During these conditions, the human body has difficulties cooling through the normal method of the evaporation of perspiration, and health risks rise. The chart below illustrates the relationship of temperature and humidity to heat disorders.

Figure 4-24 Heat Index Chart



Source: National Weather Service

Note that Heat Index (HI) values were devised for shady, light wind conditions. Exposure to full sunshine can increase HI values by up to 15°F. Also, strong winds, particularly with very hot, dry air, can be extremely hazardous.

Table 4-36 Typical Health Impacts of Extreme Heat by Heat Index

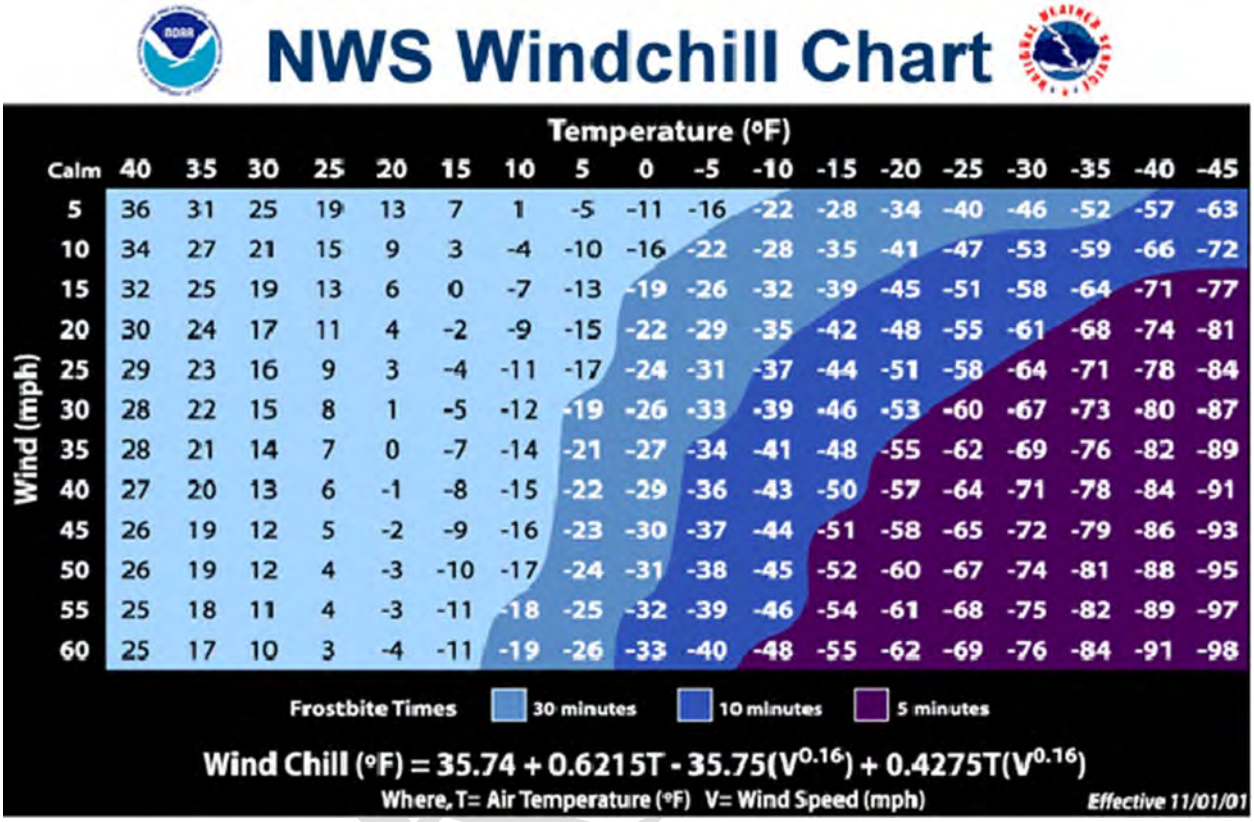
Heat Index	Disorder
80-90° F	Fatigue possible with prolonged exposure and/or physical activity
90-105° F	Sunstroke, heat cramps, and heat exhaustion possible with prolonged exposure and/or physical activity
105-130° F	Heatstroke/sunstroke highly likely with continued exposure

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

The NWS has in place a system to initiate alert procedures (advisories or warnings) when the Heat Index is expected to have a significant impact on public safety. The expected severity of the heat determines whether advisories or warnings are issued. A common guideline for the issuance of excessive heat alerts is when the maximum daytime high is expected to equal or exceed 105°F and a nighttime minimum high of 80°F or above is expected for two or more consecutive days.

In 2001, the NWS implemented an updated Wind Chill Temperature index (see Figure 4-25). This index was developed to describe the relative discomfort/danger resulting from the combination of wind and temperature. Wind chill is based on the rate of heat loss from exposed skin caused by wind and cold. As the wind increases, it draws heat from the body, driving down skin temperature and eventually the internal body temperature.

Figure 4-25 National Weather Service Wind Chill Chart



Source: National Weather Service

The National Weather Service Denver/Boulder Forecast Office issues warnings and advisories for cold temperatures. The following is a breakdown on the various NWS defined watches, warnings and advisories that could be issued:

- Wind Chill Watch is issued when wind chill warning criteria are possible in the next 12 to 35 hours.
- Wind Chill Warning is issued for wind chills of at least -25°F on the plains and -35°F in the mountains and foothills.
- Wind Chill advisory is issues on the plains when wind and temperature combine to produce wind chill values of -18°F to -25°F and -25°F for the mountains and foothills.
- Freeze Watch is issued when freeze conditions are possible in the next 12 to 36 hours.
- Freeze Warning is issued during the growing season when widespread temperatures are expected to drop to below 32°F.
- A frost advisory is issued during the growing season when temperatures are expected to drop to between 32°F and 35°F on clear calm nights.

The Jefferson County Emergency Preparedness Guide addresses both of these temperature extremes, and notes that people living in urban areas may experience a greater risk from the effects of a prolonged heat wave than those living in rural areas, due to the impacts of heat on the atmosphere, air quality and temperature. In some cases, extreme heat incidents may lead to emergency water shortages, which are shorter in duration than a drought, but exhibit similar impacts and secondary hazardous situations.

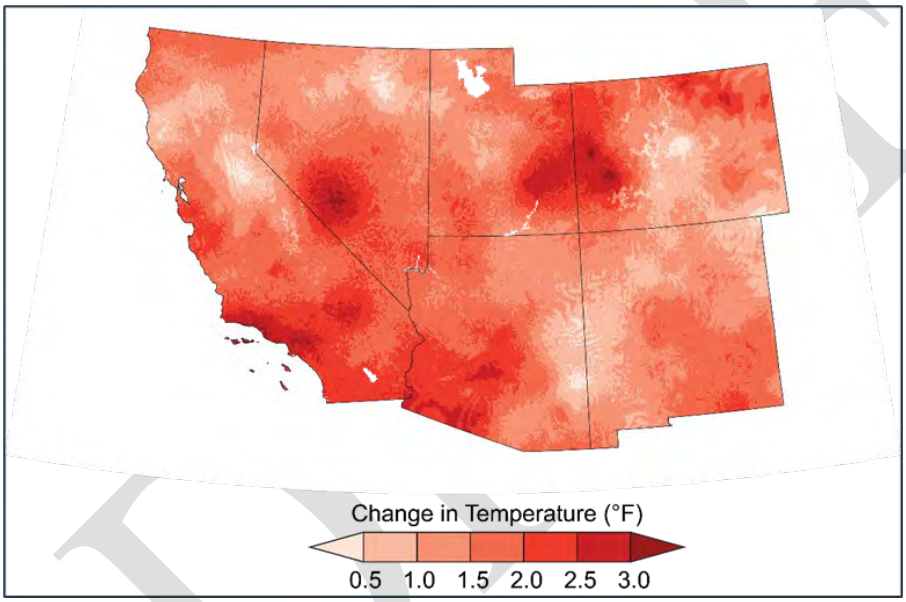
Based on these factors, the magnitude and severity rating for temperature extremes is considered **limited**.

Climate Change Considerations

Climate change is projected to increase the uncertainty of weather patterns and produce more extreme climate induced events. Scientists have suggested that warming in the Artic has been linked changes in the jet stream which may lead to increased polar vortex events in Colorado. The polar vortex is well documented and is described as large areas of low pressure and cold air surrounding the North and South poles. Increased temperatures in the polar regions has weakened and destabilized the jet stream leading to polar air to dip into lower latitudes, bringing it farther south than typical (UC Davis).

Research cited in the Fourth National Climate Assessment indicates that average temperatures have already increased across the Southwest and will likely continue to rise. Figure 4-26 shows the difference between the 1986-2016 average temperature and the 1901-1960 average temperature. This trend toward higher temperatures is expected to continue and would cause more frequent and severe droughts in the Southwest as well as drier future conditions and an increased risk of megadroughts—dry periods lasting 10 years or more). Additionally, current models project decreases in snowpack, less snow and more rain, shorter snowfall seasons, and earlier runoff, all of which may increase the probability of future water shortages (Gonzalez et al., 2018).

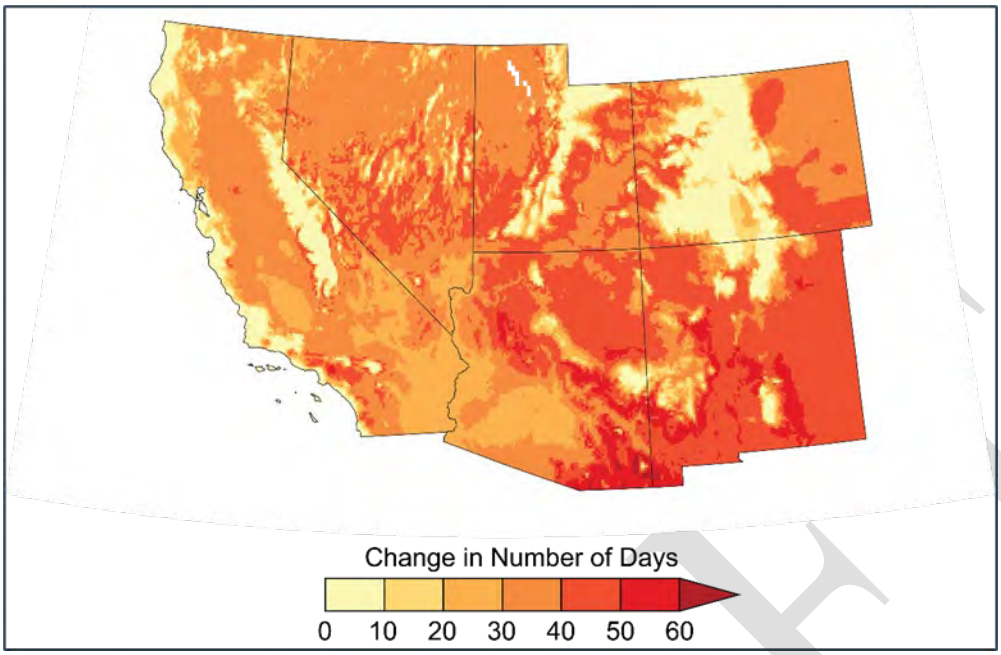
Figure 4-26 Change in Average Temperature Across the Southwest, 1901-1960 to 1986-2016



Source: Fourth National Climate Assessment

Extreme heat is also expected to increase in frequency. Figure 4-27 shows projected increases in extreme heat as an increase in the number of days per year when the temperature exceeds 90°F by the period 2036-2065 compared to the period 1976-2005. Under the higher emissions scenario (RCP8.5), the number of days of extreme heat would increase in Jefferson County by 30 to 50 days based on the figure below.

Figure 4-27 Projected Increases in Extreme Heat



Source: Fourth National Climate Assessment *Based on higher emission scenario RCP8.5

Vulnerability Assessment

General Property

Recent research indicates that the impact of extreme temperatures, particularly on populations, has been historically under-represented. The risks of extreme temperatures are often profiled as part of larger hazards, such as severe winter storms or drought. However, as temperature variances may occur outside of larger hazards or outside of the expected seasons but still incur large costs, it is important to examine them as stand-alone hazards. Extreme heat may overload demands for electricity to run air conditioners in homes and businesses during prolonged periods of exposure and presents health concerns to individuals outside in the temperatures. Extreme heat may also be a secondary effect of droughts or may cause temporary drought-like conditions. For example, several weeks of extreme heat increases evapotranspiration and reduces moisture content in vegetation, leading to higher wildfire vulnerability for that time period even if the rest of the season is relatively moist.

Extreme cold impacts structures when pipes or water mains freeze and burst, causing damage. Cold can also, in the most extreme of circumstances, make materials more fragile and breakable, although the Front Range rarely gets this cold. Extreme cold may also lead to higher electricity and natural gas demands to maintain appropriate indoor heating levels combined with damages caused to the delivery infrastructure such as frozen lines and pipes. Cold may impact transportation as well. Exposed populations may be at risk while waiting for public transportation, particularly when combined with wind-chill, and some vehicles may not start which impacts the commute of the workforce and, in worst case scenarios, the movement of emergency services personnel.

People

The impacts of cold and extreme heat on health are also a consideration. Traditionally, the very young and very old are considered at higher risk to the effects of extreme temperatures, but any populations outdoors in the weather are exposed, including otherwise young and healthy adults and homeless populations. Arguably, the young-and-otherwise-healthy demographic may be more exposed and experience a higher vulnerability because of the increased likelihood that they will be out in the extreme temperature deviation, whether due to commuting for work or school, conducting property maintenance such as snow removal or lawn care, or for recreational reasons.

Critical Facilities and Infrastructure

Prolonged heat exposure can have significant impacts on infrastructure. Prolonged high heat exposure increases the potential of pavement deterioration, as well as railroad warping or buckling. High heat also puts a strain on energy systems and consumption, as air conditioners are run at a higher rate and for longer. Extreme heat can also reduce transmission capacity over electric systems.

Secondary impacts of extreme cold can affect the supporting mechanisms or systems of a community's infrastructure. For example, when extreme cold is coupled with high winds or ice storms, power lines may be downed, resulting in an interruption in the transmission of that power shutting down electric furnaces, which may lead to frozen pipes in homes and businesses.

The impact of severe temperature deviation on power delivery is a significant factor when assessing current development exposure. Xcel Energy, the utility provider for Jefferson County, estimates that service outages due to extreme temperatures cost the utility an average of $50,000 to fix for every 20,000 people affected. This includes repair and replacements costs, equipment usage and crew overtime.

Economy

Extreme temperatures can lead to potential loss of facilities or infrastructure function or accessibility and uninsured damages. Impact to transportation sector and movement of goods. Historic events in Colorado have impacted community business districts where a majority of businesses are lost (CO SHMP 2018).

Historical, Cultural, and Natural Resources

Jefferson County has hundreds of square miles of parks and open space which provide habitat for various species that are valuable to residents and visitors to the County, and which are vulnerable to extreme temperatures. (Jefferson County 2018). Extreme temperatures can have significant impacts to these natural ecosystems. Increasing temperatures may cause species to shift habitats in elevation and latitude and extended periods of extreme heat can stress both flora and fauna species. According to Colorado Parks and Wildlife, warmer temperatures can also lead to earlier snowmelt affecting insect and wildlife life cycles as well as seed production and germination.

Future Development

Since structures are not usually directly impacted by severe temperature fluctuations, continued development is less impacted by this hazard than others in the plan. However, new development can add stress to the electric grid, potentially increasing the possibility of brownouts or blackouts.

Pre-emptive cautions such as construction of green buildings that require less energy to heat and cool, use of good insulation on pipes and electric wirings, and smart construction of walkways, parking structures, and pedestrian zones that minimize exposures to severe temperatures may help increase the overall durability of the buildings and the community to the variations. Continued development also implies continued population growth, which raises the number of individuals potentially exposed to variations. Public education efforts should continue to help the population understand the risks and vulnerabilities of outdoor activities, property maintenance, and regular exposures during periods of extreme heat and cold.

Overall Hazard Significance

Extreme temperatures in Jefferson County have a particular impact on the planning area. The risk to the population is the greatest, with exposure posing a significant threat to life and safety of residents. In addition, potential damages to property as an indirect impact of the temperature, particularly during cold weather, are costly. Temperature extremes often accompany other, more obvious hazards such as droughts and blizzards or other winter storms and may have undocumented impacts in the community as well. The geographic extent of the hazard is considered **extensive**. The probability of future occurrences is considered **likely** and the magnitude/severity for the events of record is **limited**. The HMPC considers the hazard to have an overall impact rating of **low** on the County. Collectively, the data indicates that the overall impact rating for extreme temperatures is **low**.

4.3.9 Flood

Description

A flood is an overflow or accumulation of an expanse of water that submerges land. Flooding may result from the volume of water within a river or lake which escapes its normal boundaries. While the size of a lake or river will vary with seasonal changes in precipitation and snow melt, it is not a significant flood unless such escapes of water endanger lives and property of inhabited areas along the waterway, which is referred to as the floodplain.

River (or stream) flooding is normally due to excessive high flows and the strength of the water-force that pushes it out of the river channel, particularly at bends or meanders. Businesses and homes along such rivers usually sustain significant damages. While flood damage can be virtually eliminated by moving away from rivers and other bodies of water, people continue to inhabit areas that are threatened by the flood hazard. Communities are strengthening their floodplain building regulations, acquiring property along floodplains to turn into open space recreational areas, and designing flood control projects that better protect large populations.

Floods can be among the most frequent and costly natural disaster in terms of human hardship and economic loss. They are caused by a number of different weather events. Floods can cause injuries and deaths and substantial damage to structures, landscapes, and critical infrastructure and services. Certain health hazards are also common to flood events. Standing water and wet materials in structures can become a breeding ground for microorganisms such as bacteria, mold, and viruses. This can cause disease, trigger allergic reactions, and damage materials long after the flooding event is over.

Direct impacts such as drowning can be limited with adequate warning and public education about what to do during floods. Where flooding occurs in populated areas, warning and evacuation will be critical to reduce life and safety impacts.

Although heavy rainfall, especially in the form of cloudbursts, is alone capable of causing flash flooding, snowmelt combined with heavy rainfall can certainly increase the chance of flash flooding. Floods caused by rainstorms can peak within a few hours of the onset, and in less than an hour on smaller streams, leaving little time for evacuation.

Communities in Jefferson County are susceptible to various types of flood events as described below.

Riverine or Overbank Flooding

Riverine or overbank flooding is defined as *a watercourse that exceeds its "bank-full" capacity* and is usually the most common type of flood event. Riverine flooding generally occurs as a result of prolonged rainfall, or rainfall that occurs when soils are already saturated, or drainage systems overloaded from previous rain events. The duration of riverine floods may vary from a few hours to several days and may exhibit a seasonal pattern over a course of years.

Factors that directly affect the amount of flood runoff include: 1) precipitation amount, precipitation intensity, frequency of precipitation, and its spatial and temporal distribution; 2) the saturation levels of the soils, variation in vegetation, erosion and/or bank stability, and the amount of impervious surfaces due to urbanization; and 3) snow-pack depth at higher elevations, rate of snow melt versus snow evaporation and transpiration, and the ratio or pattern of sunny hot days to cooler cloudy days. The weather pattern during peak runoff can be a major factor in whether a watercourse exceeds its capacity or not. Another critical consideration, though secondary to the flood event, is the presence of debris blocking a waterway, channel, bridge, or culverts. The debris can be recent build-up from current runoff or an accumulation long overdue for removal. In any case, debris can further aggravate a flood event.

Development can alter the natural environment, changing and interrupting natural drainage-ways. As a result, drainage systems can become overloaded more frequently intensifying the effects of flooding.

Figure 4-28 and Figure 4-29 show examples of recent riverine flooding in the County. In Figure 4-28, the Cottonwood trees in Bear Lake Park dramatically show the high water line from the September 2013 flooding. The leaves below the high-water line were destroyed, leaving the tops of the trees untouched and still able to display their fall colors. During the height of the fall floods, the park's water level rose

roughly 55 feet above normal. The park, more than 2,500 acres in size, suffered substantial damage due to the high water level, but functioned as it was designed and protected many people and properties downstream.

Figure 4-28 High Water Mark from September 2013 Flooding in Bear Lake Park

Source: CASFM and Lakewood resident Carole Kaune

Figure 4-29 South Platte River at Trumbull Bridge Hwy 67 June 17, 2015

Source: Jefferson County Emergency Management

The most serious overbank flooding occurs during flash floods. They result from intense rainstorms or following a dam or levee failure. The term flash flood describes localized flooding as an incident of sizable peak flow and magnitude, in conjunction with quick onset and short duration. Flash floods usually results from a heavy rainfall on a relatively small drainage areas can occur very quickly with little or no warning; locally, these are known as cloudburst storms. In contrast, frontal-type rainstorms or snowmelt runoff are more regional in nature, result from moderate rainfall or snowmelt over large areas. Though rain-on-snow flooding can occur, it is fairly infrequent in the Colorado Front Range (and Colorado in general) and does not produce maximum flooding. Flash flooding usually results from a heavy rainfall on a relatively small drainage area occurring very quickly with little or no warning. With residential and businesses development along these small drainages combined with the quickness of an overbank-type flash flooding, evacuation can be difficult. Early warning systems that include automated detection of heavy rainfall and stream level changes are imperative for the public's safety in these types of developed drainage-ways.

Gulches/Irrigation Ditch/Canal Flooding

Jefferson County has numerous valleys, gulches and creeks, canyons and draws, irrigation ditches, and canals used to convey water collected in the mountain reservoirs to downstream users. Ditches convey irrigation water along hillsides, following contours and, as a result, cut across the natural drainage pattern of stormwater runoff flowing down hillsides. Although efforts are made to separate stormwater runoff and irrigation water, excessive runoff can flow into an irrigation ditch causing overbank flooding or a collapse of the ditch itself. Similar to flash floods, there is often little warning for these types of events.

Urban or Street Flood Events

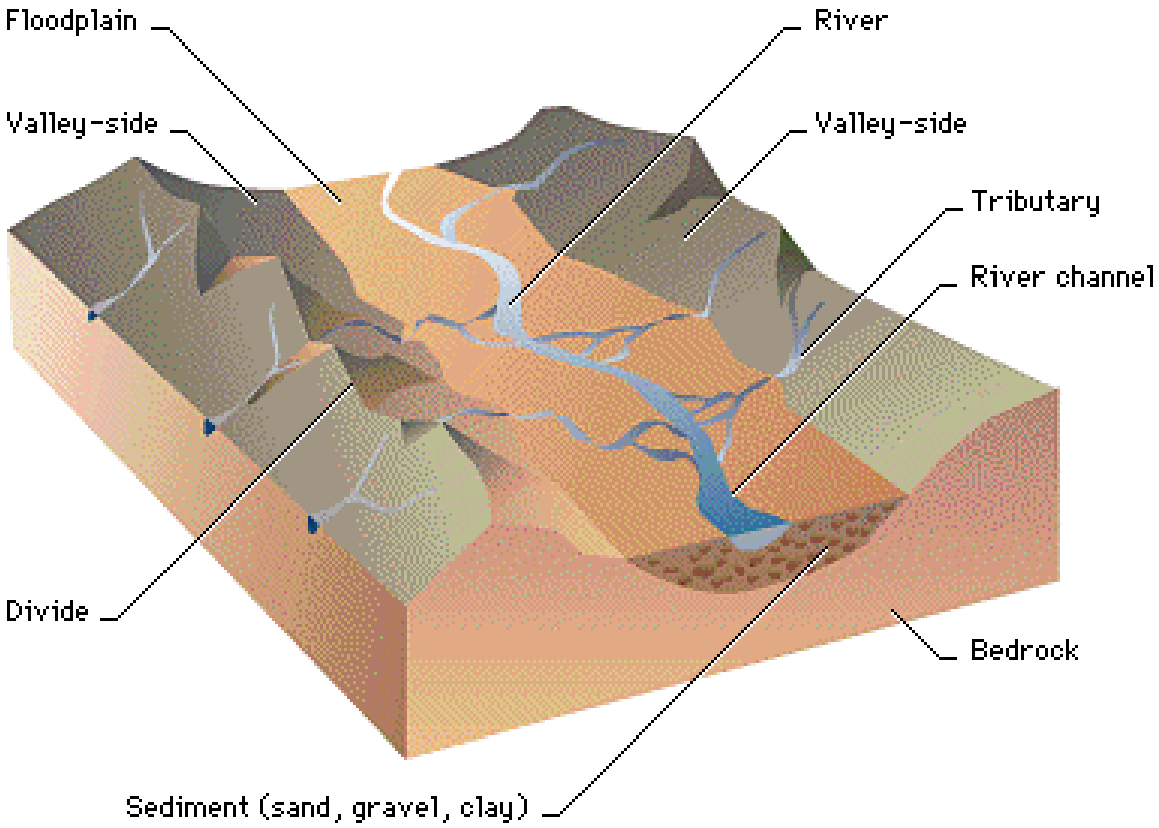
Urban or street flood events occur due to the conversion of land from undeveloped areas to surfaces appropriate for roads, parking lots, and other types of site development needs. This is called urbanization, which is the reason that a soil's ability to absorb water is reduced. When soil is subjected to an excessive

amount of water in an accelerated timeframe, it cannot balance the rate of absorption. Urbanization increases runoff two to six times over what would occur on natural terrain. Underpasses, street flooding and yard ponding usually do not exceed more than a foot or two and are often viewed more as a nuisance than a major hazard. However, in some localized urban areas, larger flood velocities and depths, which can develop as rapidly as flash floods, can produce extremely hazardous conditions to the public and block vehicular traffic. Stormwater drainage systems may or may not be adequate enough to handle the incoming flow. Impervious surface studies can be conducted to assess runoff levels, which can identify areas of increased risk or threat as well as the need for improved capture of stormwater runoff.

Floodplain

As shown in Figure 4-30, a floodplain is flat or nearly flat land adjacent to a stream or river that experiences occasional or periodic flooding. It includes the floodway, which consists of the stream channel and adjacent areas that carry flood flows, and the flood fringe, which are areas covered by the flood, but which do not experience a strong current.

Figure 4-30 Floodplain Topography



Floodplains are made when floodwaters exceed the capacity of the main channel or escape the channel by eroding its banks. When this occurs sediments (including rocks and debris) are deposited that gradually build up over time to create the floor of the floodplain. Floodplains generally contain unconsolidated sediments, often extending below the bed of the stream.

Regulated floodplains are illustrated on inundation maps called Flood Insurance Rate Maps (FIRM). FIRM maps are currently being replaced with Digital Flood Insurance Rate Maps (DFIRM) as part of FEMA's map modernization project. The Jefferson County DFIRM is current as February 5, 2014. It is the official

map of a community on which the Federal Emergency Management Agency (FEMA) has delineated both the special flood hazard areas and the risk premium zones applicable to the community. Private citizens and insurance agents use FIRM's to determine whether or not specific properties are located within the FEMA defined flood hazard zones.

Each of the flood zones that begins with the letter 'A' depict the Special Flood Hazard Area, or the 1% annual chance flood event (commonly referred to as the 100-year flood). Table 4-37 explains the difference between mapped flood zones.

Table 4-37 Flood Hazard Zones

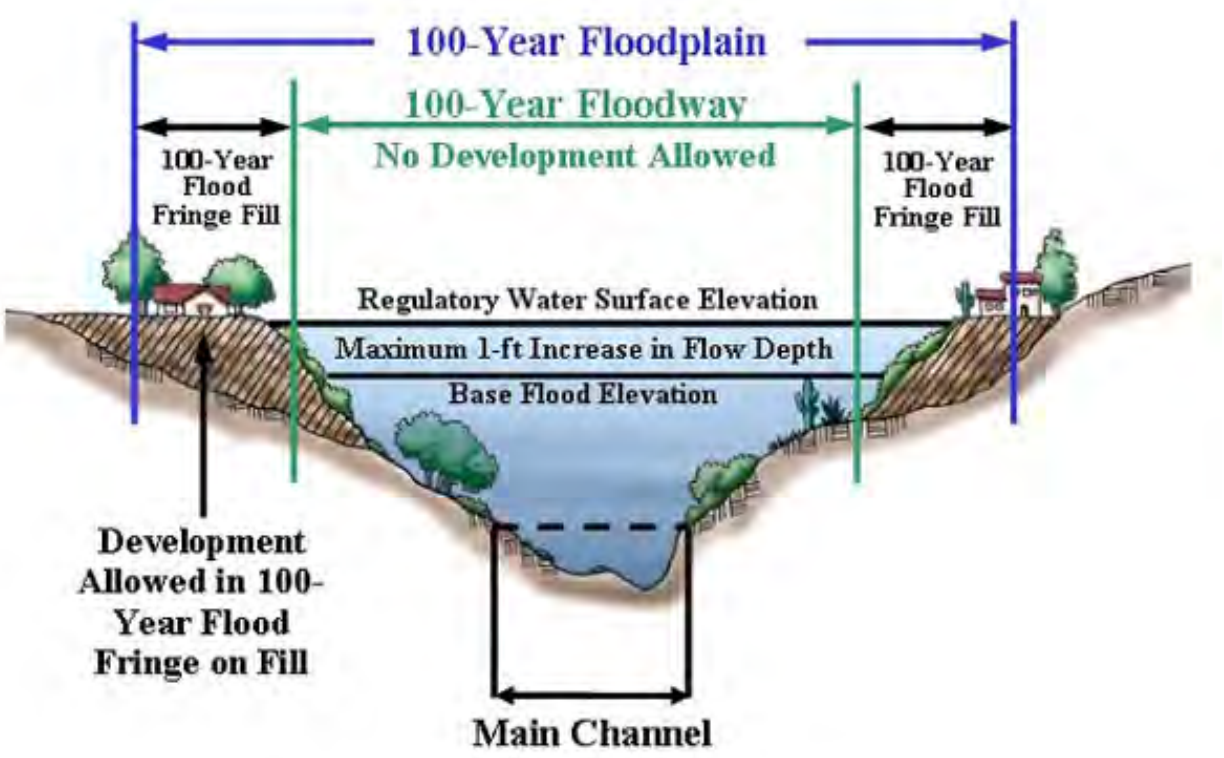
Flood Zone	Description
1% Annual Chance	100-year Flood: Also known as the base flood, is the flood that has a 1% chance of being equaled or exceeded in any given year.
Zone A	100-year Flood: No base flood elevations provided
Zone AE	100-year Flood: Base flood elevations provided
Zone AO	100-year Flood: Sheet flow areas, base flood depths provided
0.2% Annual Chance or Shaded Zone X	Areas of 0.2% annual chance flood; areas of 1% annual chance flood with average depth of less than 1 foot or with drainage areas less than 1 square mile; and areas protect by levees from 1% annual chance flood
Zone D	Areas in which flood hazards are undetermined, but possible
Zone X	Areas determined to be outside the 0.2% annual chance floodplain

Source: FEMA

Community officials use DFIRM's to administer floodplain management regulations and to mitigate flood damage. Lending institutions and federal agencies use FIRM's to locate properties and buildings in relation to mapped flood hazards, and to determine whether flood insurance is required when making loans or providing grants following a disaster for the purchase or construction of a building.

The floodplain most often refers to that area that is inundated by the 100-year flood. The term 100-year flood is misleading. It is not the flood that will occur once every 100 years. Rather, it is the flood elevation (or depth) that has a 1- percent chance of being equaled or exceeded each year. Thus, the 100-year flood could occur more than once in a relatively short period of time. The 100-year flood, which is the minimum standard used by most Federal and state agencies, is used by the National Flood Insurance Program (NFIP) as the standard for floodplain management and to determine the need for flood insurance. Over a 30-year period (the term of a typical home mortgage), a structure located within a special flood hazard area has a one-in-four chance of experiencing the flood depicted on the NFIP map. The chance is even more likely that a damaging flood of lesser magnitude will occur, while the possibility of a much larger flood is also quite real. Extreme events have been measured at many locations that exceed the magnitude of the 100-year flood by three times or more. Figure 4-31 illustrates a 100-year floodplain. Figure 4-32 shows the 100-year floodplains in Jefferson County. Only major streams are highlighted; however, flooding can occur in any channel or drainage in the County.

Figure 4-31 100-year Floodplain



Geographic Extent

Jefferson County has multiple creeks, tributaries, and associated floodplains that comprise the geographic extent of flooding throughout the planning area. It is a region heavily influenced by snow and rain patterns in the mountains that flow downstream to a heavily urbanized area in the foothills and plains. Abbreviated snow melts can cause flooding along these creeks and tributaries and they can swell to many times their size after large amounts of rainfall in a short period of time. This overwhelms the smaller channels quickly, which in turn impacts downstream populated areas with little or no warning. As mentioned above, the Buffalo Creek and Hayman burn areas were stripped of vital vegetation ground cover, which is imperative for natural flood mitigation. With soils scorched and stripped of their nutrients and cohesiveness, the areas became more susceptible to flash flooding immediately after the wildfire devastation. It has continued to be a secondary impact issue ten years after the initial incident. In fact, two deaths occurred in the North Fork fire district (Pine Junction area) from secondary flash flooding within weeks after the fire, which caused massive debris flows where innocent people were caught in their paths. Debris flows of this magnitude are attributed to the inability of depleted soils and lack of ground vegetation to hold back the runoff, and thereby normal rainfall precipitation can become a wall of moving earthen debris. See more description of debris flows in the landslide, debris flow and rockfall hazard profile.

The geographic extent rating for flooding is limited as it is within 10% to 25% of the County's area. Refer to Figure 4-32 through Figure 4-34 for the location of the FEMA and local floodplains. Figure 4-34 depicts areas Jefferson County regulates that are within Zone D, and are within 50 feet of the thalweg of a major drainage tributary area of 130 acres or greater. The section following these figures details the extent and history of flood hazards by the major watersheds in the County including Bear Creek, Clear Creek, South Platte River, Turkey Creek, and Ralston Creek.

Figure 4-32 Jefferson County Flood Hazard Map

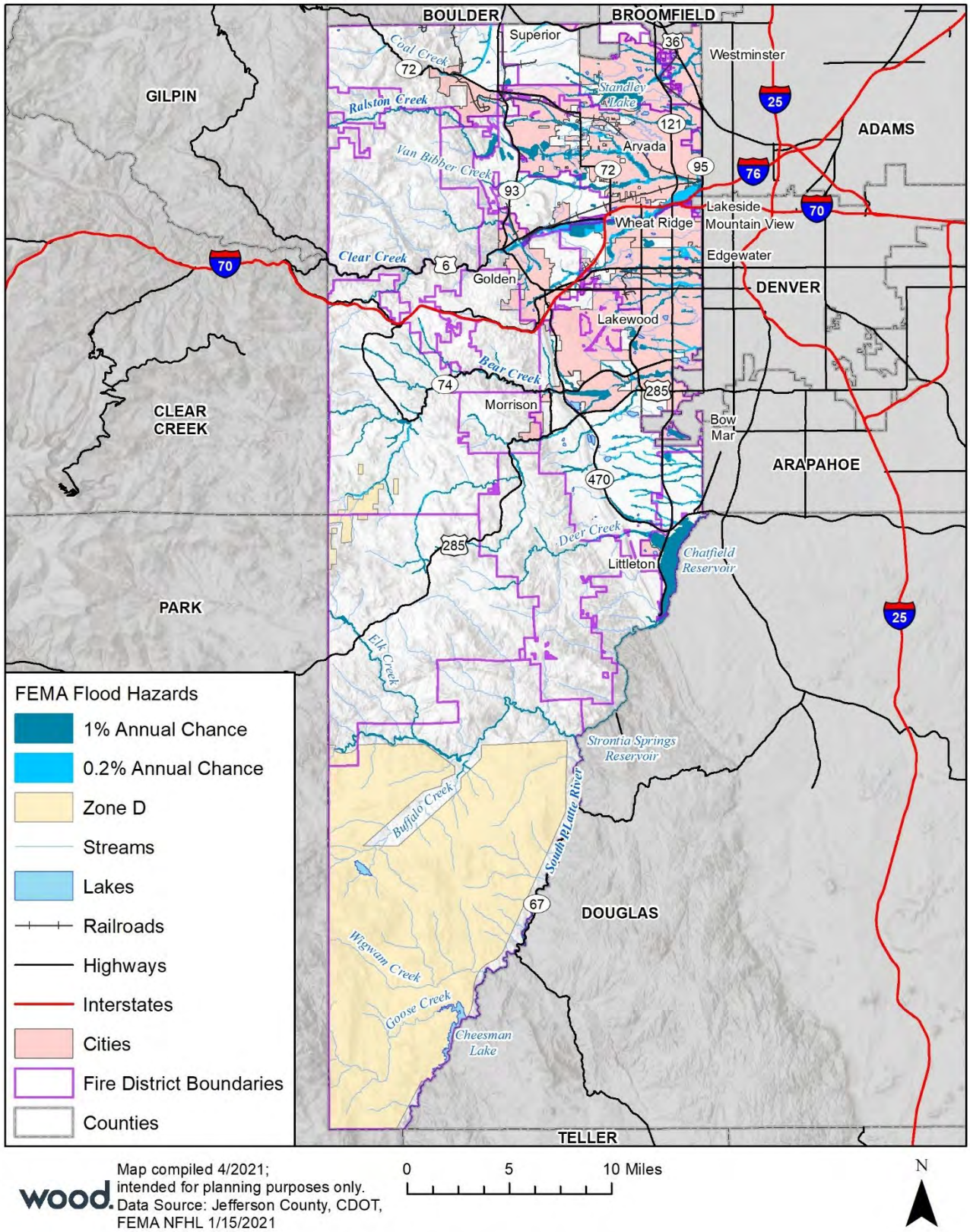


Figure 4-33 Jefferson County Flood Hazard Map (North Half)

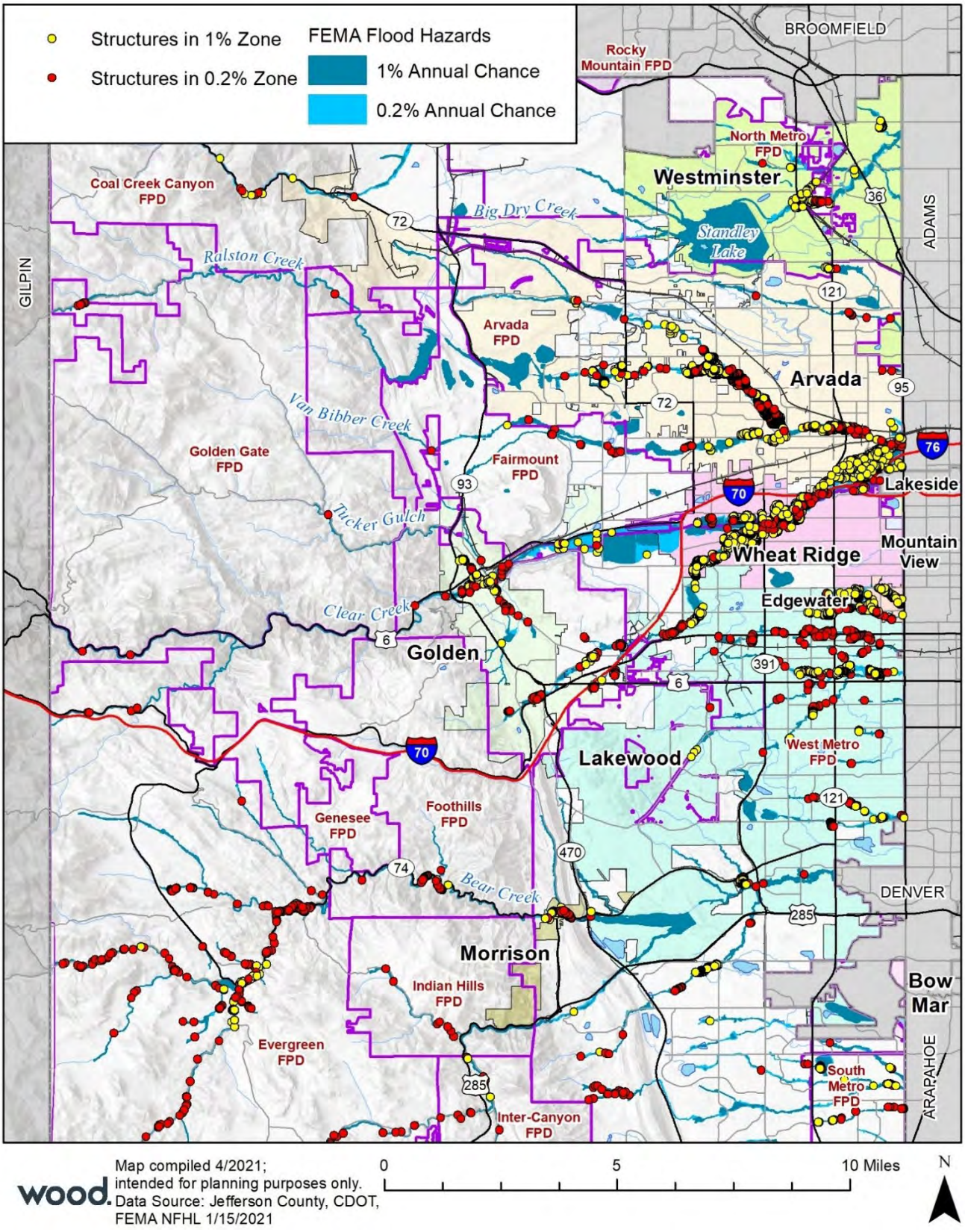
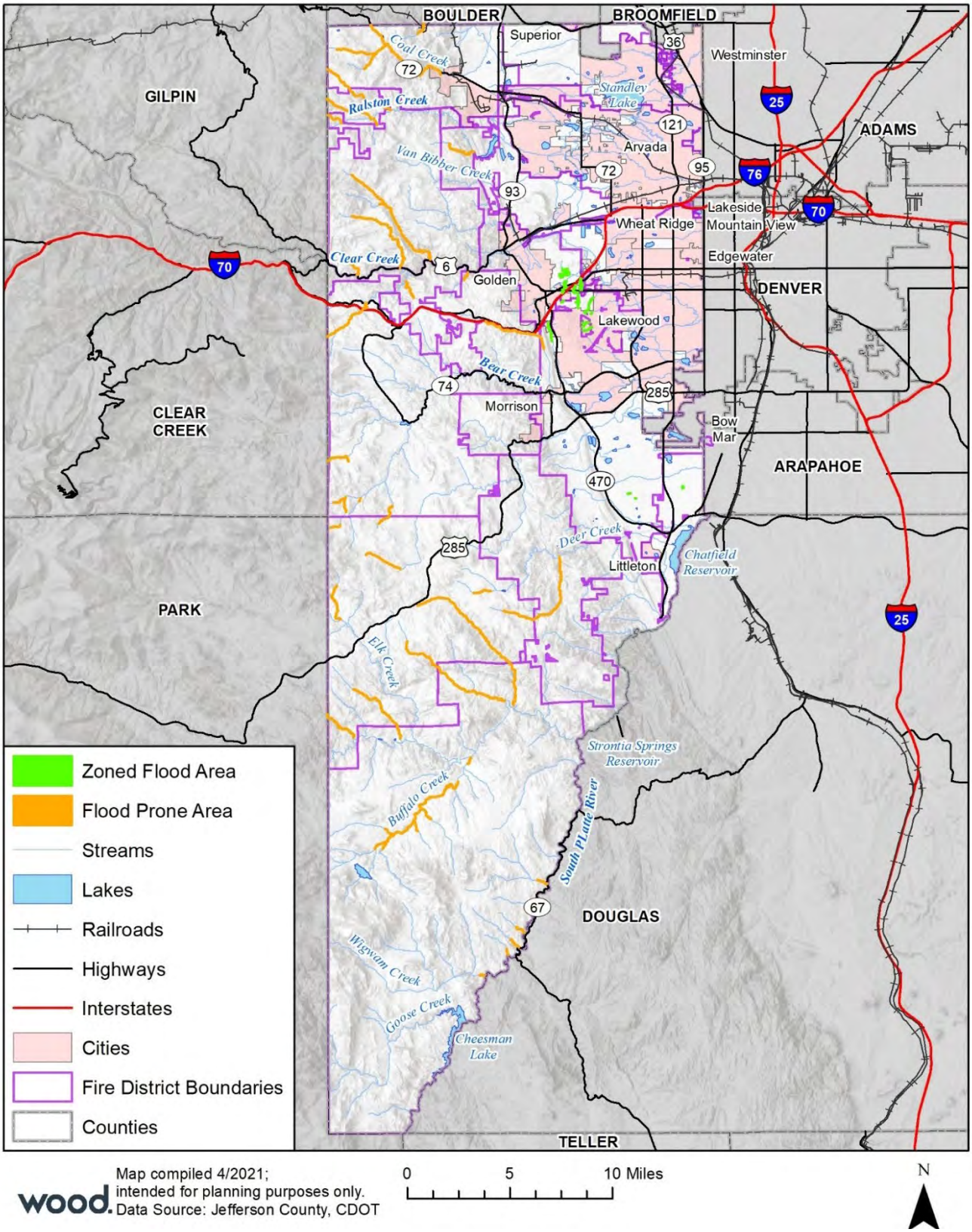


Figure 4-34 Jefferson County Local Flood Hazards



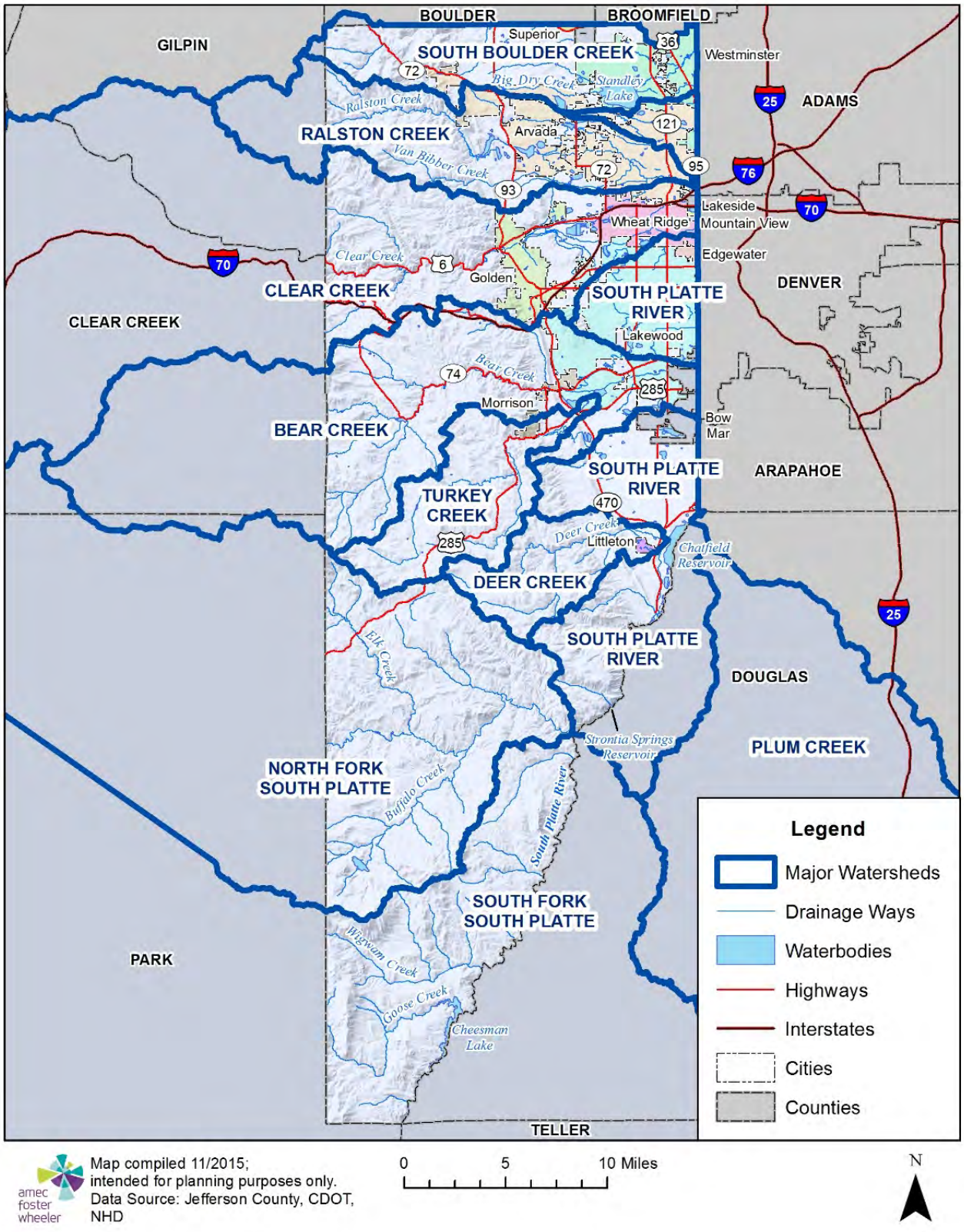
Watershed Drainage Systems

A watershed is an area of land that gets drained by a river and its tributaries. While there are many definitions, scientist and geographer John Wesley Powell put it succinctly when he said that a watershed is: *"…that area of land, a bounded hydrologic system, within which all living things are inextricably linked by their common water course and where, as humans settled, simple logic demanded that they become part of a community."*

A watershed's boundaries are defined by areas of higher elevation, such as a ridge or mountain range, from which rain and snow melt runoff flows toward a common low point. In this hazard profile, since the planning area includes unincorporated Jefferson County and its municipalities, the flood history or occurrences are identified by watershed or areas impacted to indicate locations with a higher flood hazard risk. The association between wildfire impacted areas and floods as secondary impacts are also discussed.

Figure 4-35 illustrates the watersheds in Jefferson County.

Figure 4-35 Watershed Map



South Platte River Watershed

The South Platte River Watershed begins high up in the Rocky Mountains at the origin of the South Platte River, and encompasses 28,068 square miles in Colorado, of which the Denver metro area sits squarely in the middle. Jefferson County is located west of Denver and makes up the west metro area Denver suburbs of Lakewood, Golden, Wheat Ridge, Edgewater, Mountain View, Lakeside, Arvada, Westminster, parts of Littleton, and Bow Mar. The foothills communities include the town of Morrison, unincorporated Evergreen, and various urban interface communities along I-70.

The Denver region covers about 535 square miles, all of which are in the South Platte River Watershed. The South Platte River is the main artery of the watershed, and is fed by the many creeks, lakes and minor tributaries that come down from the mountains and hills that surround Denver. Some of these tributaries include South Fork, Middle Fork, North Fork, Clear Creek, Bear Creek, Cherry Creek, and Sand Creek. Clear Creek and Bear Creek run through Jefferson County as they descend from the mountains to the plains. The water that fills Denver's lakes also eventually makes its way into the streams. In addition, drainage ditches, intermittent streams and, most critically, storm sewers, empty into the watershed. Figure 4-36 illustrates the South Platte River Basin Watershed.

Figure 4-36 South Platte River Basin Watersheds

Source: United States Geological Survey

South Platte River

Description

The South Platte River is one of the two principal tributaries of the Platte River and itself a major river of the American West located in Colorado and Nebraska. It drains much of the eastern flank of the Rocky Mountains in Colorado, as well as much of the populated region known as the Colorado Front Range and Eastern Plains. The South Platte forms the Platte at its confluence with the North Platte River in western Nebraska. The river serves as the principal source of water for eastern Colorado. Its valley along the foothills in Colorado has provided for agriculture in an area of the Colorado Piedmont and Great Plains that is otherwise arid. Its drainage basin also includes a portion of southeastern Wyoming in the vicinity of the city of Cheyenne.

The river is formed in Park County, Colorado southwest of Denver in the South Park grassland basin by the confluence of the South Fork and Middle Fork, approximately 15 miles southeast of Fairplay. Both forks rise along the eastern flank of the Mosquito Range, on the western side of South Park, which is drained by the tributaries at the headwaters of the river. From South Park, it passes through Platte Canyon, which is a deep narrow scenic gorge. The canyon is southwest of Denver on the border between Jefferson and Douglas counties. The canyon, approximately 50 miles in length, also receives the North Fork through the Rampart Range before it emerges on the Eastern Plains where it is impounded to form Chatfield Reservoir, a source of drinking water for the Denver Metropolitan Area.

The river flows north through central Denver, which was founded along its banks at its confluence with Cherry Creek. The valley through Denver is highly industrialized, serving generally as the route for both the railroad lines, as well as Interstate 25. On the north side of Denver, it is joined somewhat inconspicuously by Clear Creek, which descends from the Continental Divide through Clear Creek County following Interstate 70 and Hwy 6 through Clear Creek Canyon entering Jefferson County west of the City of Golden flowing past the Coors Brewing Company. North of Denver the South Platte River flows through the agricultural heartland of the Eastern Plains or Piedmont region (rock formations of sandstone, shale, and limestone that was formed by ocean deposited sediments through erosion of the ancestral Rockies). It flows directly past the communities of Brighton and Fort Lupton, and is joined in succession by Saint Vrain Creek, the Little Thompson River, the Big Thompson River, and the Cache la Poudre River, which it receives just east of Greeley.

East of Greeley it turns eastward, flowing across the Colorado Eastern Plains, past the towns of Fort Morgan and Brush, where it turns northeastward, flowing past the town of Sterling and into Nebraska near the town of Julesburg. In Nebraska, it passes south of the town of Ogallala and joins the North Platte near the town of North Platte, Nebraska.

In an urban area where millions of people live and work, the cumulative actions of a watershed's residents can have a powerful impact on the health of the watershed. On the other hand, in sparsely populated areas of wildland urban interface, careless human-caused wildfires can devastate a watershed leaving it vulnerable to the ravaging effects of post-wildfire flooding. The following flood history is a more recent schedule of events that have occurred post Buffalo Creek, Hi Meadow, and Hayman wildfire burns.

South Platte Watershed Flood History

June 16, 1965 – In mid-June of 1965, heavy spring storms stalled over the Front Range, overwhelming the basins of the Arkansas and South Platte rivers. The magnitude of the rain, floodwaters and subsequent damage defied belief to those who did not witness the storms firsthand. Over three hours, 14 inches of rain fell at Castle Rock. The water was too much for the creeks and arroyos, picking up debris and scraping gouges in the western flank of Dawson Butte that are still visible today. At the juncture of Plum Creek and the South Platte, it was estimated that the river was 200 feet wide and 20 feet deep, moving at ten miles per hour and carrying 40 times its normal flow. In the *Report to the Colorado General Assembly*, total damages from the 1965 floods were estimated at $397 million with 11 lives lost. Jefferson County emerged relatively unscathed with no officially reported monetary damage or lives lost. This was due to the limited length of the flooded river along the southern county border. Only about one mile of the South Platte River between Plum Creek and Wolhurst was flooded. At the time, this area was rural and sparsely populated (Jefferson County 2014).

July 12, 1996 – On May 18, 1996, a human induced wildfire burned nearly 12,000 acres of the Pike National Forest and surrounding private lands, destroying 10 dwellings and costing millions in suppression costs and property damage. Less than two months later, on July 12, 1996, a high intensity thunderstorm dumped approximately 2.5 inches of rain on the fire ravaged terrain causing severe flooding, which resulted in the washout of Jefferson County Highway 126 and the destruction of the Buffalo Creek community's potable water system and telephone facilities. Major flood flows occurred along Sand Draw, Buffalo Creek, the North Fork of the South Platte River (North Fork) below its confluence with Buffalo Creek, Spring Creek (a tributary to the South Platte River just upstream from the North Fork South Platte River), and several other tributary streams in the area. The storm also resulted in the deposition of hundreds of thousands of tons of sediment into Strontia Springs Reservoir (15-year sediment load), the loss of miles of pristine riparian habitat along Buffalo Creek and Spring Creek drainages. Two lives were lost as a direct result of the flooding. Although the geographic area affected was smaller than in some other floods, the Buffalo Creek flash flood event was truly a disaster. Given the magnitude and quick onslaught of the flood flows, it is nothing short of a miracle that more people weren't killed or injured. The flooding hazards and increased sediment loading potential associated with barren watersheds was dramatically evident at Buffalo Creek after July 12, 1996. Total damages were more than $4.6 million.

September 14, 1996 – Thunderstorms over southern Jefferson County brought more heavy rain to the Buffalo Creek area. Some minor roads were washed out by flash flooding but no other damage was reported.

July 28, 1997 – Some culverts in the Pine and Conifer areas were washed out due to heavy rainfall.

July 31, 1998 – Heavy rain, up to 3 inches in an hour, caused a flash flood along Buffalo Creek, Portions of County Road 126, just south of the town of Buffalo Creek, were washed out. The floodwaters nearly washed away the bridge as mud and debris slammed into the structure. It was 2 years earlier that a deadly flash flood rushed through the small town killing 2 residents. There was no loss of life or structures, however, large debris accumulations, and disrupting electric, phone and water service for the night. Debris flows were a problem for a number of other mountain towns that evening.

August 4, 1999 - Flooding and flash flooding problems developed over portions of the Urban Corridor as slow moving thunderstorms dumped anywhere from 2 to 3.5 inches of rainfall in approximately 3 hours. Numerous outages were reported with widespread blackouts in Thornton and Littleton. Along Massey Draw in Jefferson County, near Carr Street and Chatfield Reservoir, four homes were flood damaged and portions of their backyards washed out.

July 12, 2000 – Heavy rain fell across a portion of the Hi Meadow burn area near Buffalo Creek, causing localized flash flooding. Approximately three quarters of an inch (0.75) of rain fell in 30 minutes across Miller Gulch. Some culverts became plugged by debris from the fire. As a result, small sections of a forest service road along Miller Gulch were washed out.

July 17, 2000 – An estimated 2 inches of rain reportedly fell in less than an hour in Pine. As a result, two secondary roads in Buck and Miller gulches, in the Hi Meadows burn area, washed out. Water also covered County Road 68 which connects to Bailey. Homeowners in Pine Valley Estates attempted to divert some of the runoff by piling stacks of hay above their homes.

June 19, 2002 - July 21, 2002 – Six flash floods were reported over this 33 day period in the southern portion of the County. Locally heavy rainfall in the Hayman burn area washed out a secondary road. Debris associated with the runoff, blocked a culvert, forcing the water to wash out the road. Gulch Road, which connects to Forest Service Road 211 was washed out. Runoff from heavy rainfall in the Hayman burn area flooded Lost Creek Ranch with up to 18 inches of water, just off of State Highway 126. Floodwaters ruined a very expensive rug in the lodge. Also, a driveway to another local residence was washed out.

May 30, 2003 – Flash flooding was reported in the Hayman burn area in Jefferson County and in southwestern sections of Douglas County, as up to 1 inch of rain reportedly fell in 30 minutes. In Jefferson County, several access roads were washed out.

June 8, 2004 – Locally heavy rain caused flash flooding in the Hayman burn area. Up to a foot of water damaged sections of Trumbull Road and a maintenance road near Lazy Gulch.

August 29, 2007 – Heavy rain caused localized flash flooding in the Hayman burn area, in Southern Jefferson County. The flash flooding forced the closure of County Road 126 and Wigwam Road. Brush and Wigwam Creeks jumped their banks, leaving debris atop the roadway.

July 21, 2009 – Heavy rain produced mudslides in the Hayman burn area. Trees, stumps, sticks, debris, and decomposed granite came down with the mudslides. Most of the damage occurred from Six Mile Creek to Forest Service Road 211 above the Wigwam Fishing Club. Road crews had to totally restore shoulders and slopes and cleaned out ditches downstream of draws and ravines. The mudslides washed out a 250-ft stretch of one shoulder of State Highway 126, near the turnoff to Cheesman Reservoir, and a large section of guard rail was washed out.

September 2013 – Between September 11th and 14th, Colorado's Front Range experienced major flooding and flash flooding. Storms began on September 9, when power was knocked out at the Jefferson County Administration and Courts Facility and in southern Golden, and west Colfax Avenue had to be closed due to torrential rain. Two days later, Highway 72 in Coal Creek Canyon was closed, as was Highway 93 a few days later. Many major roadways were closed by Friday, September 13th; voluntary and involuntary evacuations were in effect in Upper Bear Creek, below Leyden Dam, and from Morrison to Evergreen. Jefferson County's Fairgrounds accepted more than 100 horses, five goats, and two llamas. Rockslides were a major concern in canyons, and prevention efforts occupied emergency crews throughout the foothills.

Bear Creek stood at 8.8 feet above normal flows by Friday night. All the water pouring down from its 164 sq. mile upper watershed was captured in Bear Creek Lake until Monday, September 16, when the Army Corps of Engineers finally began releasing some of the water into the lower drainage systems. By then, floodwaters had raised water elevations in the lake 53 feet, to a new record high of more than 5,600 feet. The previous record, set in 1995, was six feet lower. On September 17th, the Jefferson County Sheriff's Office estimated damage to infrastructure countywide at a "preliminary" $6,000,000, with 14 residences destroyed, 215 damaged, and 5,805 threatened. Two dozen commercial properties were damaged and another 24 threatened; 200 more "minor" structures were also affected or threatened.

Jefferson County, however, escaped the worst effects, which struck with full force in the northern Front Range. Across the 17 counties affected, eight people died, an estimated 1,500 homes were destroyed, thousands more damaged, and more than $2 billion in costs incurred, largely by homeowners. Within the county, Coal Creek Canyon, Clear Creek, and Bear Creek were the hardest hit, as the effects of the storms dwindled southward. Clear Creek and Bear Creek remained torrential well into October, but service gradually began to be restored across the county. Most roads and parks hit by flooding reopened within weeks, although repair efforts continued in some places for months after (Jefferson County 2014).

July 7, 2014 – Severe thunderstorms large hail and damaging winds across Arapahoe, Boulder, Elbert and Jefferson County. Heavy rainfall, nearly two inches in one hour, flooded several residences in Evergreen. In addition, several bridges along Forest Estate Road were washed out.

May 9, 2015 – Heavy rain and rising levels of South Turkey Creek washed out many driveways in Indian Hills.

June 14, 2015 – The combination of heavy rain and snowmelt caused minor flooding in southern Jefferson County. Road closures included West Platte River Rd from Buffalo Creek, and sections of South West River Rd and West Pine Creek Rd.

Watershed Health

Watershed health is of utmost importance after a devastating wildfire. There is evidence that a scorched area from wildfire can even attract atmospheric systems, which then dump its moisture on the same soils stripped of its natural defenses. The chances increase for secondary impacts of flooding, erosion, and sedimentation when an area has been burnt from wildfire. There are Federal and State program dollars used to focus on expediting the re-vegetation of wildfire impacted areas to help reduce the devastation of the secondary impacts of flooding.

Bear Creek Drainage Basin

Bear Creek, which rises in the mountains southwest of Denver, is a left bank tributary of the South Platte River. The total drainage area at the mouth is 261 square miles of which 164 square miles are upstream of Morrison. The basin, shown in Figure 4-35 includes parts of Jefferson, Clear Creek and Park Counties, and ranges in elevation from 5,780 feet at Morrison to 14,264 feet at Mt. Evans. Idledale, Kittredge, and Evergreen are towns located in Jefferson County along Bear Creek upstream of Morrison. Major tributaries entering Bear Creek below Evergreen Lake to Morrison include: Cub Creek, Troublesome Creek, Swede Gulch, Cold Spring Gulch, Sawmill Gulch at Idledale and Mount Vernon Creek at Morrison. Bear Creek flows into Bear Creek Lake just east (downstream) of the Dakota Hogback geologic formation at Morrison. This facility is a major flood control reservoir constructed and operated by the U. S. Army Corps of Engineers. East of the hogback, Rooney Gulch enters Bear Creek Lake from the north and Turkey Creek enters the lake from the south. The City of Lakewood Parks Department is responsible for public safety in the park area surrounding Bear Creek Lake. Upstream, the Evergreen Dam is a 380′ long, 34′ high structure located on the main stem of Bear Creek above Cub Creek at the town of Evergreen, forming a 40-acre lake known as Evergreen Lake. This reservoir is not a flood control facility, but it does impound 670 acre-feet of water.

Turkey Creek Watershed (Part of the Bear Creek Drainage Basin)

The Turkey Creek Watershed is a main drainage basin located along the southeast border of the Bear Creek Drainage Basin.

Turkey Creek Watershed Study

The USGS Mountain Ground Water Resources Study (MGWRS) on the Turkey Creek Watershed was conducted in 1999-2000. The purpose of the study was to better understand water resources, including surface and ground water quantity and quality, in the 47 square mile Turkey Creek Watershed. This study was considered a first step in developing scientifically sound management strategies and for the development of methods to assess ground water availability within different hydrologic settings, evapotranspiration (a term used to describe the sum of evaporation and plant transpiration from the land surface to the atmosphere) and ground water vulnerability to various land uses. Today there is an aggressive Turkey Creek Watershed monitoring program in force. The Precipitation Runoff Modeling System (PMRS) is used to evaluate the amount of precipitation received that is potentially available for ground water storage. The three most important components of runoff are surface runoff, sub-surface flow, and ground water flow. The PMRS results include the percent of precipitation that is returned to the atmosphere by evapotranspiration, the percent that leaves the watershed through surface runoff and subsurface flow, or becomes part of the long-term ground water storage system.

Bear Creek Drainage Basin Flood History

From 1866 to 1973 there have been 24 known floods in the Bear Creek basin; and from 1974 to 2007 there have been 23, which will be discussed later. Most of the floods from 1866 to 1973 were caused by runoff from intense rainstorms during the summer months. However, early season floods were caused from rainfall runoff in conjunction with snowmelt flows. The UDFCD monitors rainfall and streamflow from the Bear Creek basin as part of their early flood warning program, which runs from mid-April through mid-September. The peak discharge measurement at the stream gage on Bear Creek at Morrison in 1896 was 8,600 cubic feet per second (cfs) and the peak discharge on Bear Creek downstream of the gage below the confluence of Mount Vernon Creek during the 1938 flood was estimated to be considerably more than 10,000 cfs. The peak flow rate for Mount Vernon Creek alone was estimated at 9,230 cfs, which is more than twice the magnitude of the 100-year flood.

Mount Vernon Creek enters Bear Creek downstream of the Morrison Stream gage and has a drainage area of only 9.4 square miles. The headwaters of Mount Vernon Creek are at Genesee where I-70 begins its climb into the mountains along Mount Vernon Canyon. The south side of Lookout Mountain also drains into Mount Vernon Creek. At the Dakota Hogback the creek turns south, passing through Red Rocks Park and continuing to its mouth at Morrison, where a very narrow, confined stream channel exists.

A stream gage located east of Bear Creek Lake at Lowell Blvd and Sheridan has continuously measured Bear Creek flows since 1927. The Morrison gage has partial records dating back to 1888 and continuous records since 1922. When comparing the gage records it can reveal variances in peak discharges for

each flood event. This indicates the majority of flood drainage came from two different locations. For example, in the 1933, 1934 and 1938 floods, the storms were concentrated in the foothills and mountains of Bear Creek, and the resulting flood peaks attenuated between Morrison and Sheridan. For the 1957, 1965, 1969, and 1973 floods, the majority of runoff occurred from watershed areas downstream of Morrison or from Turkey Creek.

Bear Creek floods are characterized as rapid concentrations of runoff, sharp peak discharges, and rapid flood recession. Peaking time for floods on Bear Creek at Morrison is about 3 to 5 hours after the causing rainfall, while floods on Mount Vernon Creek peak between 1 and 3 hours.

Turkey Creek was the known principal contributor for the 1957, 1965, 1969 and 1973 flood events.

May 21-23, 1876 – Reported by the Denver Tribune on June 5 of that year; "... informs us that one resident had never seen such destruction in the region… He spent some days in the valleys of Soda and Bear Creeks and their tributaries and found new gullies worn to the depth of 20 feet in the action of the raging torrents."

May 29-June 1, 1894 – In the vicinity of Morrison, a flood that caused the loss of bridges, railroad tracks, houses, and destroyed the highway in the canyon.

July 24, 1896 – Intense rainfall centered on Cub Creek, a tributary of Bear Creek near Evergreen. "Without a moment's warning the largest flood that ever came down Bear Creek struck Morrison about 8 o'clock tonight (July 24), sweeping everything in its path ... although the water came down through the town nearly 3 feet deep in the main street, the buildings in the business section all withstood it."" Twenty-seven lives were lost in the flood (available records do not indicate where the deaths occurred) and severe damages were reported from Evergreen to the mouth of Bear Creek. No rainfall records of this flood are available. The peak flow on Bear Creek at the Morrison gauging station was estimated at 8,600 cfs, which is the flood of record for the gage. The most recent hydrologic studies indicate that this flood would have a one in 40 chance of occurring in any year. It is not known to what extent Mount Vernon Creek contributed to the Morrison flooding. The Flood of 1896 was the most catastrophic flash flood to hit Bear Creek Canyon. Farms along Cub Creek were obliterated. "The water descended about Evergreen like a huge, moving wall carrying houses, sheds, barns and livestock with it", according to the news. It was determined after the news account that 29 lives were actually lost.

July 7-8, 1933 – "Five persons known dead ... property damage of un-estimated degree and nearly all the highways between Mt. Morrison and Idledale ruined, is the toll up to date of one of the most devastating floods last Friday afternoon (July 7) ever to visit the Bear Creek Watershed. A cloudburst at about 1 o'clock in the neighborhood of Idledale sent a wall of water down Saw Mill Gulch leading to Bear Creek, and another raging torrent down Vernon Creek. ... The Vernon Creek waters reached a height of 15 feet ... in the narrow passage between the business houses. The highway up beautiful Bear Creek Canyon between Mt. Morrison and Idledale is practically ruined." The peak discharge at Morrison was 8,000 cfs on Bear Creek and estimated as 1,500 cfs on Mount Vernon Creek.

August 9, 1934 – The flood of August 9, 1934 in the Bear Creek basin was caused by cloudburst-type rainfall near Kittredge and at the head of Mount Vernon Creek. Six lives were lost and much property damage resulted. It was reported that Mount Vernon Creek ran higher than the previous year and much of the canyon roadway was destroyed. Damage to Morrison was reduced because the Bear Creek peak flow passed through the town before the Mount Vernon Creek high water arrived.

September 2-3, 1938 – A widespread thunderstorm that began over the eastern slope of the Front Range on 30 August became most intense in the Morrison area on 2 September. An unofficial report stated that 7.9 inches fell just north of Morrison in six hours. The heaviest rainfall centered on the divide between Bear Creek and Mount Vernon Creek. The peak discharge on Bear Creek at Morrison above Mount Vernon Creek was 6,200 cfs. From post flood measurements the Mount Vernon Creek peak discharge was estimated at 9,230 cfs at a point 1/2 mile upstream from Morrison. From statements by local residents, it appears that the peak discharge on Mount Vernon Creek reached Morrison at about 7 p.m., preceding that on Bear Creek by 1/2 hour. Six persons drowned when trapped in their automobile between Morrison and Kittredge. Damages in the basin were estimated at $450,000. If Morrison had not

been warned, or if the flood had occurred late at night, the number of deaths would likely have been considerably higher.

August 24, 1946 – A heavy rain near Idledale caused Bear Creek to overflow. A Morrison woman was swept from her stranded car and drowned.

August 21, 1957 – Thunderstorms occurred over the Bear Creek basin with heavy rain and hail beginning about 1 p.m. east of Squaw Pass and northwest of Evergreen. At most locations the rain stopped within an hour. The Mount Vernon Creek peak discharge at Morrison was estimated at 1,000 cfs at 2:30 p.m., and 1,640 cfs on Bear Creek at about 3 p.m. While most damages from Bear Creek occurred downstream of Morrison, which is a drainage from Turkey Creek. Mount Vernon Creek left debris on the grounds of six or seven residences in Morrison, flooded a garage and a used car lot, and broke a water main. State Highway 8 at Morrison was closed upon warning of the flood. Later, portions of the highway were flooded by both streams.

July 25, 1965 – On 23-24 July 1965, heavy rains over the headwaters of Bear Creek caused minor flooding throughout its length. Most damages occurred downstream of Morrison. A peak discharge of 1,030 cfs was measured for Bear Creek at Morrison on July 25, 1965.

May 7, 1969 – Heavy rains from May 4-8, 1969 resulted in flooding in the Bear Creek basin with most damages occurring downstream from Morrison. A weather station at Morrison reported a total storm rainfall of 11.27 inches, with a maximum daily amount of 5.77 inches. Unofficial rainfall amounts in the basin varied from 6.7 inches to 11.8 inches during the five-day storm period. The peak flow for Bear Creek at Morrison was 2,340 cfs on May 7, 1969.

May 6, 1973 – The last significant flood to cause damages in the Bear Creek Basin. According to the National Weather Service, damages from the flood were estimated at around $120 million. The following damage estimates were printed in the Denver Post on May 13, 1973. Damages estimates in Weld County, hardest hit by the flood, were $20 million. In Adams County, the estimate was $8 million. In Denver, the estimate had climbed to well over $6 million and in Jefferson County, officials reported over $500,000 damage to roads, culverts, and other County property. Two deaths were attributed to this event.

“The 1973 flood was the last big flood in Denver” (Brian Schat, Denver Public Works, personal communication 8/22/03). Rainfall was widespread along the Front Range with totals ranging from one to five inches. A sustained downpour dropped more than three inches in the Denver metropolitan area on Sunday, May 6. In the foothills, heavy snow fell.

Most of the damage was a result of river flooding. The South Platte was four feet above flood level at its crest when it measured 10.85 feet at the 19th Street Bridge early on the morning of May 7. The flood stage of the South Platte at W. Evans Ave. equaled that during the 1965 disaster. However, this flood was more of “a steady overflowing of water” as opposed to the “one surge” Denver experienced during the flood of 1965.

The South Platte flooding was compounded when normally dry gulches and tributaries from the mountains west of Denver became turbulent flows that emptied into the river. When Bear Creek reached southwest Denver, it had grown to be 150 yards wide in spots. Plum Creek and Indian Creek, other South Platte tributaries, also poured out of their banks, virtually isolating the town of Louviers. In Englewood, the Highline Canal and the normally dry Little Dry Creek both overflowed.

Before evacuations were ordered in Denver, water began rising in Turkey, Bear, and Clear Creek Canyons because of the heavy snow runoff on May 5. By May 6, several Jefferson County roads in those areas had been washed out and residents had to be evacuated. In addition, several rockfalls and debris flows forced road closures.

Flooding in the Bear Creek watershed has killed 45 people and caused extensive property damage since the area was settled. It is idyllic for tourists and recreation seekers, unfortunately, under the right conditions Bear Creek Canyon and its tributaries can become death traps in a short amount of time. It doesn’t take much rain to create a devastating flash flood. Retired Captain from the Jefferson County Sheriff’s Office and historian, Dennis Potter, has documented 15 major floods that have taken place

between 1864 and 1938. Of the 15, two occurred in May, one in June, eight in July, two in August, and two in September.

September 2013 – The damage associated with the widespread Front Range flood event was largely north of the Bear Creek Watershed, but damage

Clear Creek Watershed Drainage Basin

Located west of Denver, the Clear Creek Watershed spans 575-square miles from the 14,000-ft. mountain peaks along its southwestern edge on the basing and part of the Continental Divide, to the urbanized plains at its confluence to the South Platte River just north of Denver. The Clear Creek Watershed is the source of drinking water for more than 300,000 people. Clear Creek also provides water for irrigation, recreation and industry. Four hundred square miles of the watershed are located in the mountains west of Golden, and fully one-third of the Clear Creek Watershed lies within the Arapahoe & Roosevelt National Forests.

Clear Creek's headwaters begin in an area rimmed by four 14-ers (mountains that are 14,000 feet in elevation or higher) – Grays and Torreys Peaks, Mt. Evans, and Mt. Bierstadt. Major tributaries that feed into Clear Creek include the North, South and West Forks; Leavenworth, Lion, Trail, Chicago, Soda and Ralston Creeks; Fall River; Tucker Gulch; Kenneys Run; Lena Gulch; Little Dry Creek (confluence in Adams County); and Beaver Brook. The main-stem flows eastward along the Interstate 70 (I-70) corridor, through several communities, along approximately 12 miles of Highway 6 corridor through the Clear Creek Canyon and then back along the I-70 corridor through several Denver Front Range Communities.

Clear Creek

Clear Creek is a tributary of the South Platte River, approximately 40 miles long, in north central Colorado in the United States. The creek drains a canyon, called Clear Creek Canyon in the Rocky Mountains directly west of Denver, descending through a long gorge to emerge on the Colorado Eastern Plains where it joins the South Platte. The creek is famous as the location of the most intense early mining activity during the Colorado Gold Rush of 1859. The creek provided the route of the Colorado Central Railroad and later for the United States Highway 6 and Interstate 70 as they ascend to the Continental Divide west of Denver.

The creek begins near the continental divide in the Front Range, northwest of Grays Peak in western Clear Creek County. It descends eastward through Clear Creek Canyon past the towns of Silver Plume, Georgetown, and Idaho Springs, all of which were founded as mining camps in the 1859 gold rush. Within the canyon it receives numerous smaller tributary creeks that descend from the rugged mountains on either side.

At the mouth of the canyon, in Jefferson County, the creek passes through the town of Golden, past the Coors brewery. East of the foothills, it flows through the northwest part of the Denver Metropolitan Area, passing through Wheat Ridge, southeastern Arvada, then roughly along the route of Interstate 76 (I-76). Along this section it is largely an undeveloped urban stream, with an undeveloped floodplain. Part of the creek path forms a wooded park with bicycle/foot path. It passes under Interstate 25 (I-25) between its junction with Interstate -70 (I-70) and U.S. Highway 36 (Hwy 36 - the Boulder-Denver Turnpike). It joins the South Platte from the west in southeast Thornton, near the junction of Interstate 76 (I-76) and State Highway 224 (Hwy 224).

Clear Creek Watershed Flood History

The Mile High Flood District (MHFD), formally known as the Urban Drainage and Flood Control District (UDFCD), under joint sponsorship with the City and County of Denver, City of Wheat Ridge, City of Golden, Adams County, Jefferson County and ICON Engineering, Inc. conducted a study, *Planning and Flood Hazard Delineation Area for Clear Creek Drainageway,* which extends from Sheridan Boulevard at the downstream study limit to the City of Golden in Jefferson County, at the upstream study limit. The drainage area at the location of the Golden gage near the bluff line is approximately 400 square miles. From Golden, Clear Creek flows in a northeasterly direction, through the Denver Metropolitan Area to its confluence with the South Platte River, near Derby. At the Derby gage, located approximately 0.6 miles upstream from the mouth, Clear Creek has a drainage area of approximately 575 square miles.

Elevations within the Clear Creek basin range from approximately 5,100 feet above mean sea level at the mouth to over 14,000 feet above mean sea level in the Rocky Mountains.

The intent of the report is to evaluate and document the existing floodplain along Clear Creek so that project stakeholders, and other users, can implement floodplain zoning ordinances, floodplain regulations, and other land-use controls, as needed, to reduce potential damages and adverse development in the floodplain. This report provides information on past flooding events and defines the nature and extent of probable future floods along an 11.6 mile reach of Clear Creek, from Sheridan Boulevard to approximately 2,200 feet upstream of Highway 6 in the City of Golden. Discharge information along Clear Creek was originally computed by the U.S. Army Corps of Engineers (COE) and incorporated into previous Flood Hazard Area Delineation (FHAD) and Master Planning documents. Historically, flooding in the Clear Creek basin has been relatively infrequent. Since 1864, twelve floods have been reported on Clear Creek and its tributaries. The following descriptions include the floods of August 1888, July 1890, June 1956, and July 1965 (Gingery 1979).

Flood of August 1888 – This flood resulted from cloudbursts on the eastern slope of the Front Range of the Rocky Mountains. A discharge of 8,700 cubic feet per second (cfs) was reported at the mouth of Clear Creek canyon. This is the largest estimated peak discharge in the history of this gauging station, which is located 1.5 miles upstream from Golden.

July 19, 1890 – A severe rainstorm began after a long dry spell, causing Clear Creek to flood. Flood waters reached Golden at 4:00 p.m. on the 20th. The deaths of two women and an 18-month-old baby were attributed to the flood.

July 26, 1923 – Cloudbursts in the foothills above Golden caused floods in all the gulches that enter Clear Creek from the north within 2 miles of Golden. At the mouth of Magpie Gulch the rainfall was moderate, but half a mile above it was a cloudburst. The rain began about 12:45 p.m. and the flood reached its crest by 1 p.m. and then fell so rapidly that by 1:40 p.m. the flow in the gulch was again normal. This flood deposited a gravel and boulder dam 10 feet high entirely across Clear Creek, a distance of about 70 feet. Some of the boulders moved by the flood weighed as much as 5 tons.

June 6, 1948 – there was a flash flood in Tucker Gulch, a left bank tributary to Clear Creek in Golden. The peak discharge in Golden was 11,600 cfs and there were substantial flood damages. This flood from the 11.2 mi2 basin is nearly twice the largest flood in Clear Creek (~400 mi2). This is one of the largest, if not the largest, flood for this size watershed in Colorado.

Flood of June 1956 – Unusually heavy snowmelt runoff resulted in the failure of the Georgetown Dam located about 1 mile downstream from Georgetown. The peak discharge passing the gage above Golden was 5,250 cfs. By the time the crest reached the gauging station near the mouth of Clear Creek, it was reduced to 2,880 cfs.

Flood of July 23-26, 1965 - On July 23 and 24, during severe storms over the headwaters of Clear Creek and Tucker Gulch, 4.5 inches of rain was reported to have fallen in Tucker Gulch in an hour, which caused flash flooding in Golden, however, flooding extended only a short distance downstream. In Golden, flood waters from Tucker Gulch spread over about 17 blocks and caused an estimated $112,000 damage to 69 residences, three commercial enterprises, three railroad bridges, four street bridges, and utility lines. At Georgetown, debris blocked the channel and diverted the waters down a street, thereby causing extensive washing of the surface and the flooding of several basements.

July 29, 2003 – Heavy rainfall caused flooding and flash flooding problems in north central Jefferson County. Officials were forced to briefly close State Highway 93, north of Golden, which was flooded by runoff and littered with debris. In Golden, flash floods left several backyards and basements full of standing water. At least one car was submerged in a garage. Radar estimated 1 to 1.5 inches of rain had fallen in the area in approximately 30 minutes.

June 8, 2004 – In Golden, heavy rains triggered a small debris flow on U.S. Highway 6, near the intersection of Colorado Highway 119. Automated gages in the area registered 2 to 3 inches of rain in one hour. Near the Colorado Mills Mall in the Lena Gulch drainage basin, numerous intersections were inundated from 1 to 3 feet of water and hail, stranding several vehicles, including a fire engine. Approximately 30 basements were flooded in Golden and Lakewood and many windows, to both cars and

homes, were broken by large hail. June 8th was the first of five days in which flash flood warnings were issued for the UDFCD area. Seven other days warranted flash flood watches, making 2004 one of the most active flood seasons in the 26-year history of the District's flash flood prediction program. Fortunately, no lives were lost and the flooding that did occur was localized with total damages not reaching disaster proportions. An early morning cold front set the stage for 2004's first outbreak of flood producing storms. Around 8 p.m. storms began developing along the urban foothills of Jefferson County. Over the next two hours, Golden, Lakewood, Wheat Ridge, and nearby areas were pounded by heavy rain and hail. The Colorado Mills shopping mall was hit especially hard with over 3 inches of rain in 90 minutes. Homes were flooded and streets were closed in the vicinity of W. 32nd Ave. and I-70 where an unconfirmed precipitation measurement of 5" was reported. A Golden firefighter stated that flood fighting at the intersection of 20th Street and Washington was like working a swift water rescue. Hail depths up to 18 inches were reported in some areas and motorists in Lakewood were rescued from cars.

June 27, 2004 – A deluge of very heavy rain from nearly stationary thunderstorms caused flooding and flash flooding problems over parts of Jefferson County. In Jefferson County, an automated rain gauge north of Golden measure 3.6 inches of rain in one hour. Numerous homes were flooded in Golden, including one that was 146 years old. The home was listed as a complete loss. In addition, State Highway 93 had to be closed from the Pine Ridge subdivision (near 6th Ave and Hwy 93) to Golden Gate Canyon Road. At the height of the storm, about 4 feet of water covered Colorado 93 through Golden, forcing its temporary closure. Rockfall and debris flows were also reported in Golden Gate Canyon. Several intersections were also flooded and impassable. The worst flooding in Golden occurred along a small drainage known as Arapahoe Gulch, which runs along the west side of Washington Street. Affected residents there may have a similar predicament with regard to flood insurance since the hazard area associated with Arapahoe Gulch is not shown on the Flood Insurance Rate Map. The storm that caused this flooding produced between 3.5 and 4 inches of rain over the watershed. Based on surveyed high water marks and debris lines, peak flow rates in Arapahoe Gulch during the June 27 event were approximately 400 cfs. The peak flow estimate was nearly a 200-year event and greatly exceeded the capacity of the Arapahoe Gulch drainage system downstream of 2nd Street.

August 3, 2006 – Heavy rain caused flash flooding along Leyden Creek in unincorporated Jefferson County, northwest of Arvada. An automated rain gauge in upper Leyden Creek, 6 miles northwest of Arvada, measured 2.68 inches of rain in less than two hours. Two to three feet of water covered the roadway at 82nd and Quaker. Leyden Creek is a tributary to Ralston Creek.

September 2013 – See the dam failure section for a description of flooding during 2013.

May 2015 – Sustained rainfall in the month of May caused many creeks and drainages to be bank full and causing minor overbank flooding including along Leyden Creek in Arvada.

Coal Creek Watershed

The Coal Creek Watershed drains almost 80 square miles in southern Boulder County and northern Jefferson County and is part of the South Boulder Creek Watershed. The watershed is approximately 28 miles long and an average of 3 miles wide, with an elevation drop of about 5,500 feet. The drainage begins in the foothills east of the Rocky Mountains, and flows through Superior, Louisville, Lafayette, Erie, and the City and County of Broomfield until it reaches Boulder Creek. The existing land use within the watershed is about 61 percent open space and parks. Rural residential development makes up approximately 16 percent of the existing land use, while residential, commercial, industrial and roadways comprise another 16 percent of the watershed. Public facilities, such as schools, comprise about 7 percent. Approximately 45 percent of the watershed is considered developed, with the lower end still developing.

The Coal Creek Watershed suffered a heavy rainfall event on September 12, 2013 that caused large amounts of channel migration that resulted in erosion and deposition. More information on this can be found in the Erosion and Deposition section of this document.

Ralston Creek Watershed

Ralston Creek is a tributary of Clear Creek, approximately 15 miles long. It drains a suburban and urban area of the northwestern Denver Metropolitan Area. It rises in the foothills in northeastern Gilpin County,

in southern Golden Gate Canyon State Park. It descends through a valley eastward into Jefferson County following Drew Hill Road (County Road 57), emerging from the mountains approximately 3 miles north of Golden, where it is impounded to form Ralston Reservoir west of State Highway 93 and the Arvada/Blunn Reservoir on both sides downstream of State Highway 93. It flows eastward through Arvada and joins Clear Creek from the north in southeast Arvada, near the intersection of Sheridan Avenue and Interstate 76. The U.S. Army Corps of Engineers funded a flood and erosion control stream improvement project to the 100-year floodplain along Ralston Creek at the location of the Garrison Street Bridge in 2005.

Deer Creek Watershed

Deer Creek created Deer Creek Canyon. It is an important riparian corridor between the hogback and Wetlands Conservation Areas. It is a rich butterfly habitat and a large portion of it is protected by the Deer Creek Canyon Park, which encompasses diverse, natural environments. Perhaps most striking is the scrub oak habitat, uncommon in Jefferson County. Although small in stature, the scrub oak provides important food and cover for wildlife including grouse, turkey, mule deer, elk, mountain lion, and black bear. Deer Creek discharges directly into Chatfield Reservoir.

Significant Jefferson County Gulches

As mentioned above there are over 90 gulches, canyons and draws in Jefferson County. Some gulches, where there is a high vulnerability to larger numbers of populations, are discussed in further detail below.

Lena Gulch

Lena Gulch is a tributary of Clear Creek with a confluence near 41st Avenue and Kipling Street. The total drainage area for the basin is 13.3 square miles. Lena Gulch is predominantly in the City of Wheat Ridge, but also through Golden, the Pleasant View area, Lakewood, Wheat Ridge and parts of unincorporated Jefferson County. The lower reach of Lena Gulch begins at Maple Grove Reservoir, which is a water storage reservoir operated by the Consolidated Mutual Water District Company. The drainage basin entering Maple Grove Reservoir is 10.5 square miles. Typically, low flows from the upper basin pass through the reservoir and are released downstream. The lower basin has a drainage area of 2.8 square miles. Lena Gulch is unusual for a small foothills stream in that it has a constant base flow. This makes for an attractive stream setting with riparian zones and aquatic flora and fauna along the corridor. There are several areas of concern along Lena Gulch. Discussions for flood control projects are currently under way across several jurisdictions. Lena Gulch will be further discussed in the jurisdictional annex for the City of Wheat Ridge. A complete study of the Flood Hazard Area Delineation for Lena Gulch has been created.

Lena Gulch Flood History

July 27, 1997 – Heavy rain caused Lena Gulch to surge 2 feet over its banks. The fire department had to rescue a man when his van stalled in the high water.

August 10, 1998 – Heavy rain caused flooding and flash flooding problems over southwest portions of Metropolitan Denver. An observer in Lakewood recorded 3.26 inches of rainfall in one hour. Several streets were flooded in central Lakewood. In addition, a trailer park along Lena Gulch in Wheat Ridge was evacuated due to the high waters.

June 8, 2004 – Heavy rain and large hail caused flooding and flash flooding across northeast Jefferson County. Automated gages in the area registered 2 to 3 inches of rain in one hour.

Lakewood Gulch

Lakewood Gulch is a well-defined drainageway. It originates on the northwest slopes of Green Mountain in Lakewood, flows east through Sixth Avenue West Park, and continues east through Lakewood into Denver, where it joins the South Platte River southwest of the intersection of I-25 and Colfax Avenue. A small portion of the studied length of Lakewood Gulch is in unincorporated Jefferson County, while the predominant length lies in Lakewood. Lakewood Gulch will be further discussed in the jurisdiction annex for the City of Lakewood. A complete study of the Flood Hazard Area Delineation for Lakewood Gulch has been created.

Lakewood Gulch Flood History

August 21, 1998 – While no flash flood warning was issued for the August 10th storm, extensive urban flooding did occur in Lakewood and Denver. Between 4:45 and 5:45 P.M., 3.26 inches of rain was measured in Lakewood near the intersection West 1st Ave. and Balsam Street. Rush-hour traffic was at a crawl while many homes had their basements flooded. Vehicles were floating in the Wal-Mart parking lot where the floodwater was 3 to 4 feet deep. This parking lot is located in the floodplain of South Lakewood Gulch near West 2nd Ave. and Wadsworth Blvd. East of Kipling Street, McIntyre Gulch was out of its banks at a number of locations. Lakewood Gulch in Denver overtopped Wolff Street by at least 3 feet. This event contributed directly to a Lakewood City County action exactly 2 weeks later endorsing a plan to form a stormwater utility and establish a fee of $0.88 a month for each 1,000 square feet of impervious surface area, costing the average homeowner $1.98 per month.

May 14, 2007 – a mother and her toddler got trapped in a flash flood on Lakewood Gulch in Denver. They were taking a walk along the gulch trail when it started to hail. They attempted to escape the hail from the storm by going further down into a small box culvert underneath Decatur Street adjoining the creek as it travels under Decatur Street in Denver. The mother lost the grip of her toddler's stroller and the child was swept downstream. He was found dead a few days later a few miles away on the banks of the South Platte River. After the incident, the bike path adjoining the creek was permanently closed.

July 20, 2019 – A thunderstorm produced a flash flood in southern Jefferson and southwest Denver counties. Rescue crews searched Lakewood Gulch, after the report of a person in the water near West 12th Avenue and Miller Street. Her body was found in 10 ft of water the following day along Lakewood Gulch near West 12th Avenue and Lee Street. There were reports of West Colfax Avenue in Lakewood being inundated with water. There was up to 3 feet of water on other streets in Lakewood. One woman was rescued by a passerby in Lakewood when floodwaters began pouring into her car near the iconic Casa Bonita restaurant.

Past Occurrences

A discussion on previous occurrences of flood events is organized under each major watershed above.

Probability of Future Occurrences

There have been 48 floods in Jefferson County recorded since 1876; however, 38 of them (35 recorded by the NCEI, 3 recorded by NWS and a number of others by MHFD) have occurred since 1950, or a span of 70 years. The methodology for calculating the probability of future occurrences using the number of incidents from 1950 is described in Section 4.3.1. This formula evaluates that the probability of a flood occurring in any given year is 69%. This corresponds to a probability of future occurrences rating of **likely.**

If the total number of flood incidents is used (48) over a period of 144 years, the probability of a flood occurring in any given year is 33%. This still corresponds to a probability of future occurrences rating of **likely.** A 100-year flood has an annual probability of 1%. A 500-year flood has a 0.2% chance of occurring in any given year.

Magnitude and Severity

Magnitude and severity can be described or evaluated in terms of a combination of the different levels of impact that a community sustains from a hazard event. Several factors contribute to the relative vulnerabilities of certain areas in the floodplain. Development, or the presence of people and property in the hazardous areas, is a critical factor in determining vulnerability to flooding. Additional factors that contribute to flood vulnerability range from specific characteristics of the floodplain to characteristics of the structures located within the floodplain. The following is a brief discussion of some of these flood factors which pose risk.

- **Elevation**: The lowest possible point where floodwaters may enter a structure is the most significant factor contributing to its vulnerability to damage, due to the higher likelihood that it will come into contact with water for a prolonged amount of time.
- **Flood depth:** The greater the depth of flooding, the higher the potential for significant damages due to larger availability of flooding waters.

- **Flood duration**: The longer duration of time that floodwaters are in contact with building components, such as structural members, interior finishes, and mechanical equipment, the greater the potential for damage.
- **Velocity:** Flowing water exerts forces on the structural members of a building, increasing the likelihood of significant damage (e.g. such as scouring).
- **Construction type**: Certain types of construction and materials are more resistant to the effects of floodwaters than others. Typically, masonry buildings, constructed of brick or concrete blocks, are the most resistant to damages simply because masonry materials can be in contact with limited depths of flooding without sustaining significant damage. Wood frame structures are more susceptible to damage because the construction materials used are easily damaged when inundated with water.

Specific examples of negative impacts from flooding on Jefferson County span a comprehensive range and are summarized as follows:

- Floods cause damage to private property that often creates financial hardship for individuals and families;
- Floods cause damage to public infrastructure resulting in increased public expenditures and demand for tax dollars;
- Floods cause loss of personal income for agricultural producers that experience flood damages;
- Floods cause loss of income to businesses relying on recreational uses of County waterways;
- Floods cause emotional distress on individuals and families; and
- Floods can cause injury and death.

Note that the terms 1% annual chance flood and 0.2% change annual flood, described above as measures of frequency, are also used as a shorthand to describe magnitude, particularly in terms of flood depth.

Jefferson County is uniquely located covering very populated urban areas as well as wildland urban interface foothills. Areas burned by wildfire tend to have a high runoff, resulting in flash flooding in those areas. Hilly terrain, coupled with brief, heavy summer downpours can result in flash flooding in many areas in the County. Fast-moving water is extremely powerful. The result can be deadly to anyone in the water's path. The force of flash flood waters can be extremely dangerous to motorists who unwittingly or unknowingly drive over water-covered roads - only two feet of running water are needed to sweep away a car. Risks to life and property can be very high during periods of flash flooding.

The magnitude and severity of the flood hazard is usually determined by not only the extent of impact it has on the overall geographic area, but also by identifying the most catastrophic event in the previous flood history. Sometimes it is referred to as the "event of record." There are differences in how the various natural hazard events are recorded and therefore do not apply across the hazards equally. For this reason additional data was taken into consideration to define the term "flood of record." Normally a flood of record relates to official stream-flow information available from the USGS and other sources, which include the National Weather Service and Urban Drainage and Flood Control District. The "flood of record" is almost always correlated to a peak discharge at a gage, but that event may not have caused the worst historic flood impact in terms of property damage, deaths, etc.

The 1938 flood illustrates this point well. It was likely the most devastating flood that Morrison has ever experienced; however, the '38 flood was not the largest historic stream-flow measurement for the Bear Creek at Morrison gage. The 1896 Black Friday Flood peak discharge was 8,600 cfs versus 6,200 cfs for the 1938 flood. In 1933 the Bear Creek gage recorded a peak discharge of 8,110 cfs and deaths occurred, but the 1938 flood caused far more damage to the town.

With this said, it is important to evaluate all the variables when attempting to identify a "flood of record." The 1965 flood received much media attention along Plum Creek in Douglas County and along the South Platte River through Denver, but Jefferson County sustained its share of damages as well. When major floods happen, lesser impact areas from the same event are given less attention by the media. To get a handle on the flood year that caused the most damage, additional research was necessary. NFIP claims statistics for the past 30 years were considered, however, the two worst flood damage years predated the NFIP. Inflation adjustments were also calculated. The accumulated data pointed to the 1896 Black Friday

Flood to be the "flood of record." There were 29 lives lost and devastation from Evergreen to the mouth of Bear Creek wiping out everything in its path. Farms were destroyed along with the livelihoods of most of those who lived in the area. The City of Golden was under siege by floodwaters coming in from two directions taking out all bridges and shutting down the electric plant. Miles of railroad tracks were twisted like pretzels up Clear Creek, and the town of Morrison was a mass of wreckage and ruin. Enormous amounts of debris were strewn from the mountains to the plains of Denver. It was considered an economic catastrophe of its time where reconstruction took years. A future event of this magnitude could have similar devastation to Morrison and Golden. Based on these factors, the magnitude severity ratings for flood are considered **critical**.

Climate Change Considerations

According to the National Oceanic and Atmospheric Administration, there is generally more rain and snow falling in the Northern Hemisphere and precipitation has increased by about 5% over the last century. An increase in precipitation alone is not immediately alarming, but "factors such as precipitation intensity, soil moisture and snow conditions, and basin topography are also important in determining the occurrence and severity of flooding." As with temperature, it is the extremes that matter most with regard to rainfall. According to Robert Hanson, author of The Thinking Person's Guide to Climate Change, "Data shows a clear ramp up in precipitation intensity for the United States, Europe, and several other areas over the last century, especially since the 1970s. When it rains or snows in these places, it now tends to rain or snow harder, over periods ranging from a few hours to several days." Additionally, with wildfires already being a problem in many parts of Colorado, increasing periods of drought and lack of precipitation are expected to exacerbate conditions for fires to occur, and in turn worsen the potential for runoff and flooding associated with burned areas.

These events can lead to increased infrastructure damage, injury, illness, and death. Additionally, warmer temperatures in the winters may cause increased precipitation to fall as rain instead of snow in mountain regions of Colorado. This may lead to elevated stream flows and increased flood risk across the state. As climate science and data evolves it will be important for communities in and around Jefferson County to address how our changing climate will affect how water moves through local streams and regional landscapes.

Vulnerability Assessment

General Property

Floods pose a significant risk to existing development in the planning area. In addition to the enormous economic loss potential associated with flood hazards, floods have historically been a source of significant loss of life in the planning area.

A flood vulnerability assessment was performed for Jefferson County using GIS. The county's address point layer and associated assessor's building improvement valuation data were provided by the county and were used as the basis for the inventory. The latest FEMA NFHL data along with the Jefferson County parcel layer provided by the Assessor's Office. FEMA's NFHL data depicts the 1% annual chance (100-year) and the 0.2% annual chance (500-year) flood events. Flood zones A, AE, AH and AO are variations of the 1% annual chance event and were included in the analysis. The Shaded Zone X along with the subtype 0.2% annual chance hazard zone were used to represent the 500-year flood event.

GIS was used to create a centroid, or point, representing the center of each parcel polygon. Only parcels with improvement values greater than zero were used in the analysis (with the exception of Exempt parcels, which were included regardless of improvement values); this assumes that improved parcels have a structure of some type. The FEMA flood zones were overlaid in GIS on the parcel centroid data to identify structures that would likely be inundated during a 1% annual chance or 0.2% annual chance flood event. Property improvement values for the points were based on the assessor's parcel data and summed by parcel type and jurisdiction across the county.

Results of the overlay analysis are summarized in Table 4-38 and Table 4-39; further details are shown in Table 4-40 and Table 4-41 by property type. Contents values were estimated as a percentage of property improvement values based on their occupancy type, using FEMA HAZUS guidance as follows: a) Commercial parcels received content values worth 100% of their improvements; b) Residential parcels

received content values worth 50% of their improvements; and c) Exempt and Vacant parcels received content values worth 0% of their improvements. Property improvements and content values were then totaled, and a 25% loss estimation factor was applied based on those totals, per the FEMA depth damage functions.

There are approximately 2,228 buildings in the 1% annual chance flood zone based on the analysis. The total property exposure (actual building value plus content value estimate) in that flood zone is $1,417,453,541, with a loss estimate of $354,363,385. In the 0.2% annual chance flood there are 3,003 buildings, with a total exposure value of $1,952,814,238 and a loss estimate of $488,203,559 million additional for that zone. Morrison and Edgewater have the greatest percentage of improved parcels (10% and 14%) at risk of the 0.2% annual flood.

Based on this analysis, the greatest potential losses from 500-year flooding, based on combining the 1% and 0.2% building counts, would occur in Arvada (with roughly total 1,353 buildings) and Wheat Ridge (with 1,441 buildings), unincorporated Jefferson County (with 1,052 buildings), and Lakewood (with 578 buildings). Overall, there are a total of 4,405 parcels at risk or 2% of total improved parcels, with a total value of $3,370,267,779 million and a loss estimate of $842,566,945 countywide.

Table 4-38 1% Annual Chance Flood Vulnerability by Jurisdiction

Jurisdiction	Improved Parcels	Building Count	Improved Value	Content Value	Total Value	Estimated Loss	Population
Arvada	631	692	$206,855,552	$114,802,322	$320,406,861	$80,101,715	1,622
Edgewater	23	33	$11,012,162	$5,506,081	$16,518,243	$4,129,561	76
Golden	78	124	$55,642,393	$38,348,992	$93,991,385	$23,497,846	188
Lakewood	212	269	$183,062,710	$114,867,152	$297,929,862	$74,482,466	338
Morrison	37	60	$11,257,465	$9,528,695	$20,786,160	$5,196,540	43
Wheat Ridge	333	414	$107,158,293	$61,743,602	$168,901,895	$42,225,474	772
Unincorporated	561	636	$289,319,650	$209,599,486	$498,919,136	$124,729,784	1,385
Total	**1,875**	**2,228**	**$864,338,225**	**$554,396,329**	**$1,417,453,541**	**$354,363,385**	**4,424**

Source: Wood analysis with Jefferson County Assessor's Data,

Table 4-39 0.2% Annual Chance Flood Vulnerability by Jurisdiction

Jurisdiction	Improved Parcels	Building Count	Improved Value	Content Value	Total Value	Estimated Loss	Population
Arvada	722	804	$364,374,198	$281,578,730	$645,952,928	$161,488,232	1,696
Edgewater	152	166	$30,133,979	$15,979,212	$46,113,191	$11,528,298	368
Golden	245	256	$144,999,142	$91,462,889	$236,462,031	$59,115,508	491
Lakewood	297	309	$104,593,776	$58,388,391	$162,982,167	$40,745,542	686
Morrison	21	25	$5,413,965	$3,025,722	$8,439,687	$2,109,922	39
Wheat Ridge	778	1,027	$287,950,652	$162,587,474	$450,538,126	$112,634,531	2,067
Unincorporated	315	416	$212,552,121	$189,773,989	$402,326,110	$100,581,527	1,061
Total							

Source: Wood analysis with Jefferson County Assessor's Data

Table 4-40 Improved Properties at Risk of 1% Annual Chance Flood Hazard by Jurisdiction

Jurisdiction	Property Type	Improved Parcels	Building Counts	Improved Value	Content Value	Total Value	Estimated Loss (25%)	% of Total Parcels
Arvada	Commercial	10	20	$11,938,573	$11,938,573	$23,877,146	$5,969,287	
	Exempt	3	4	$479,778	$479,778	$959,556	$239,889	
	Industrial	4	5	$5,550,988	$8,326,482	$13,877,470	$3,469,368	
	Mixed Use	1	9	$1,760,791	$479,778	$959,556	$239,889	
	Residential	613	654	$187,155,422	$93,577,711	$280,733,133	$70,183,283	
	Total	**631**	**692**	**$206,885,552**	**$114,802,322**	**$320,406,861**	**$80,101,715**	**2%**
Edgewater	Residential	23	33	$11,012,162	$5,506,081	$16,518,243	$4,129,561	
	Total	**23**	**33**	**$11,012,162**	**$5,506,081**	**$16,518,243**	**$4,129,561**	**2%**
Golden	Commercial	16	26	$10,064,295	$10,064,295	$20,128,590	$5,032,148	
	Exempt	3	3	$5,775,725	$5,775,725	$11,551,450	$2,887,863	
	Industrial	7	8	$1,990,530	$2,985,795	$4,976,325	$1,244,081	
	Mixed Use	3	3	$1,234,510	$1,234,510	$2,469,020	$617,255	
	Residential	49	84	$36,577,333	$18,288,667	$54,866,000	$13,716,500	
	Total	**78**	**124**	**$55,642,393**	**$38,348,992**	**$93,991,385**	**$23,497,846**	**1%**
Lakewood	Commercial	52	85	$27,573,709	$27,573,709	$55,147,418	$13,786,855	
	Exempt	4	4	$2,942,409	$2,942,409	$5,884,818	$1,471,205	
	Industrial	13	25	$7,039,789	$10,559,684	$17,599,473	$4,399,868	
	Mixed Use	5	6	$2,075,898	$2,075,898	$4,151,796	$1,037,949	
	Residential	138	149	$143,430,905	$71,715,453	$215,146,358	$53,786,589	
	Total	**212**	**269**	**$183,062,710**	**$114,867,152**	**$297,929,862**	**$74,482,466**	**0.4%**
Morrison	Commercial	18	31	$5,632,583	$5,632,583	$11,265,166	$2,816,292	
	Mixed Use	7	8	$2,167,342	$2,167,342	$4,334,684	$1,083,671	
	Residential	12	21	$3,457,540	$1,728,770	$5,186,310	$1,296,578	
	Total	**37**	**60**	**$11,257,465**	**$9,528,695**	**$20,786,160**	**$5,196,540**	**24%**
Wheat Ridge	Commercial	8	12	$2,593,423	$2,593,423	$5,186,846	$1,296,712	
	Exempt	4	6	$497,426	$497,426	$994,852	$248,713	
	Industrial	11	32	$6,619,031	$9,928,547	$16,547,578	$4,136,894	
	Residential	310	364	$97,448,413	$48,724,207	$146,172,620	$36,543,155	

Jurisdiction	Property Type	Improved Parcels	Building Counts	Improved Value	Content Value	Total Value	Estimated Loss (25%)	% of Total Parcels
	Total	**333**	**414**	**$107,158,293**	**$61,743,602**	**$168,901,895**	**$42,225,474**	**3%**
Unincorporated	Agriculture	4	4	$83,279	$83,279	$166,558	$41,640	
	Commercial	49	63	$110,506,915	$110,506,915	$221,013,830	$55,253,458	
	Exempt	6	7	$415,435	$415,435	$830,870	$207,718	
	Industrial	9	12	$8,938,011	$13,407,017	$22,345,028	$5,586,257	
	Mixed Use	6	7	$997,670	$997,670	$1,995,340	$498,835	
	Residential	487	543	$168,378,340	$84,189,170	$252,567,510	$63,141,878	
	Total	**561**	**636**	**$289,319,650**	**$209,599,486**	**$498,919,136**	**$124,729,784**	**1%**
Grand Total		**1,875**	**2,228**	**$864,338,225**	**$554,396,329**	**$1,417,453,541**	**$354,363,385**	**1%**

Source: Wood analysis with Jefferson County Assessor's Data,

Table 4-41 Improved Properties at Risk of 0.2% Annual Chance Flood by Jurisdiction

Jurisdiction	Property Type	Improved Parcels	Building Counts	Improved Value	Content Value	Total Value	Estimated Loss (25%)	% of Total Parcels
Arvada	Agriculture	3	3	$265,224	$265,224	$530,448	$132,612	
	Commercial	44	63	$68,906,209	$68,906,209	$137,812,418	$34,453,105	
	Exempt	2	2	$2,159,510	$2,159,510	$4,319,020	$1,079,755	
	Industrial	35	42	$54,539,458	$81,809,187	$136,348,645	$34,087,161	
	Mixed Use	6	10	$18,373,402	$18,373,402	$36,746,804	$9,186,701	
	Residential	632	684	$220,130,395	$110,065,198	$330,195,593	$82,548,898	
	Total	**722**	**804**	**$364,374,198**	**$281,578,730**	**$645,952,928**	**$161,488,232**	**2%**
Edgewater	Commercial	2	2	$908,775	$908,775	$1,817,550	$454,388	
	Exempt	1	1	$28,499	$28,499	$56,998	$14,250	
	Mixed Use	1	3	$887,171	$887,171	$1,774,342	$443,586	
	Residential	148	160	$28,309,534	$14,154,767	$42,464,301	$10,616,075	
	Total	**152**	**166**	**$30,133,979**	**$15,979,212**	**$46,113,191**	**$11,528,298**	**10%**
Golden	Commercial	19	19	$29,186,056	$29,186,056	$58,372,112	$14,593,028	
	Exempt	2	2	$4,019,419	$4,019,419	$8,038,838	$2,009,710	
	Industrial	1	1	$167,454	$251,181	$418,635	$104,659	

Jurisdiction	Property Type	Improved Parcels	Building Counts	Improved Value	Content Value	Total Value	Estimated Loss (25%)	% of Total Parcels
	Mixed Use	15	15	$4,386,252	$4,386,252	$8,772,504	$2,193,126	
	Residential	208	219	$107,239,961	$53,619,981	$160,859,942	$40,214,985	
	Total	**245**	**256**	**$144,999,142**	**$91,462,889**	**$236,462,031**	**$59,115,508**	**4%**
Lakewood	Commercial	7	7	$12,183,005	$12,183,005	$24,366,010	$6,091,503	
	Residential	290	302	$92,410,771	$46,205,386	$138,616,157	$34,654,039	
	Total	**297**	**309**	**$104,593,776**	**$58,388,391**	**$162,982,167**	**$40,745,542**	**1%**
Morrison	Commercial	1	3	$467,746	$467,746	$935,492	$233,873	
	Exempt	2	2	$139,723	$139,723	$279,446	$69,862	
	Mixed Use	1	1	$30,010	$30,010	$60,020	$15,005	
	Residential	17	19	$4,776,486	$2,388,243	$7,164,729	$1,791,182	
	Total	**21**	**25**	**$5,413,965**	**$3,025,722**	**$8,439,687**	**$2,109,922**	**14%**
Wheat Ridge	Agriculture	1	1	$11,380	$11,380	$22,760	$5,690	
	Commercial	30	38	$29,597,739	$29,597,739	$59,195,478	$14,798,870	
	Exempt	2	2	$333,766	$333,766	$667,532	$166,883	
	Industrial	4	7	$3,171,115	$4,756,673	$7,927,788	$1,981,947	
	Mixed Use	4	4	$939,180	$939,180	$1,878,360	$469,590	
	Residential	737	975	$253,897,472	$126,948,736	$380,846,208	$95,211,552	
	Total	**778**	**1,027**	**$287,950,652**	**$162,587,474**	**$450,538,126**	**$112,634,531**	**7%**
Unincorporated	Commercial	33	48	$107,855,057	$107,855,057	$215,710,114	$53,927,529	
	Exempt	2	2	$1,253,533	$1,253,533	$2,507,066	$626,767	
	Industrial	31	110	$28,252,214	$42,378,321	$70,630,535	$17,657,634	
	Mixed Use	6	7	$1,382,838	$1,382,838	$2,765,676	$691,419	
	Residential	243	249	$73,808,479	$36,904,240	$110,712,719	$27,678,180	
	Total	**315**	**416**	**$212,552,121**	**$189,773,989**	**$402,326,110**	**$100,581,527**	**0.4%**
Grand Total		**2,530**	**3,003**	**$1,150,017,833**	**$802,796,405**	**$1,952,814,238**	**$488,203,559**	**1%**

Source: Wood analysis with Jefferson County Assessor's Data

Based on this analysis, Arvada, Wheat Ridge and unincorporated parts of the County have the most total vulnerable buildings to the 1% annual chance flood (631, 333 and 561 structures, respectively). Additionally, these same jurisdictions have the most total vulnerable buildings to the 0.2% annual chance flood (722, 778 and 315 structures, respectively).

It is also evident that the jurisdictions of Arvada, Lakewood and the unincorporated parts of the county have the highest total dollar exposure to potential losses from the 1% annual chance flood. The analysis shows potential losses for Arvada at $80M, Lakewood at $74M and $124M for the unincorporated County. In the 0.2% annual chance scenario Arvada, Wheat Ridge and the unincorporated County show the greatest losses at $161M, $112M and $100M, respectively.

Not included in the tables above is analysis of locally regulated floodplains and FEMA Zone D, which are mostly in the southern portion of the County where development is limited (Refer to Figure 4-32 and Figure 4-34). Jefferson County regulates areas in Zone D that are within 50 feet of the thalweg (aka deepest part of a stream channel) of a major drainage tributary area of 130 acres or greater. There are 121 buildings with a total value of $45,451,637 within Golden, Lakewood and unincorporated areas of the county at risk to flooding in this area. A majority (109) are located within unincorporated Jefferson County including 104 residential properties. The follow table shows the results of the analysis using the county's local flood layers.

Table 4-42 Properties within Local Flood Areas (Zone D)

Jurisdiction	Property Type	Improved Parcels	Building Count	Improved Value	Content Value	Total Value	Estimated Loss	Population
Golden	Commercial	1	1	$6,917	$6,917	$13,834	$3,459	
	Total	**1**	**1**	**$6,917**	**$6,917**	**$13,834**	**$3,459**	
Lakewood	Commercial	1	1	$299,234	$299,234	$598,468	$149,617	
	Residential	2	2	$601,432	$300,716	$902,148	$225,537	5
	Total	**3**	**3**	**$900,666**	**$599,950**	**$1,500,616**	**$375,154**	**5**
Unincorporated	Commercial	4	4	$124,899	$124,899	$249,798	$62,450	
	Exempt	1	1	$34,143	$34,143	$68,286	$17,072	
	Residential	104	112	$29,371,455	$14,685,728	$44,057,183	$11,014,296	286
	Total	**109**	**117**	**$29,530,497**	**$14,844,770**	**$44,375,267**	**$11,093,817**	**286**
Grand Total		**113**	**121**	**$30,438,080**	**$15,451,637**	**$45,889,717**	**$11,472,429**	**290**

Source: Jefferson County Floodplain Administrator, Wood Analysis

People

Table 4-40 and Table 4-41 show estimates of population affected by both the 1% annual chance and the 0.2% annual chance flood scenarios. Consistent with the building and value vulnerabilities, Arvada, Wheat Ridge and the unincorporated County are most at-risk, although Wheat Ridge has a far greater number (2,067 persons) potentially vulnerable to the 0.2% annual chance compared to the building and value vulnerabilities. The numbers are based on multiplying the counts of residential structures within the flood hazard areas by the average household size for the County based on data from the State of Colorado Office of Demography.

Critical Facilities and Infrastructure

To estimate the potential impact of floods on critical facilities, a GIS overlay was performed of the flood hazard layer for critical facility point locations Critical facilities at-risk to the 1% annual chance flood are listed in Table 4-43. Critical facilities at-risk to the 0.2% annual chance flood are shown in Table 4-44.

Replacement values were not available with the data thus an estimate of potential monetary loss could not be performed. Impacts to any of these facilities could have wide ranging ramifications, in addition to property damage. As expected, most bridges and other critical facilities are located in the urbanized northeastern part of the county where the majority of the population is located. Nevertheless, the critical

facilities in the southern part of the County are extremely important as failure of one of these could require assistance and emergency services to be brought in from distant locations. Bridges and road infrastructure in Coal Creek Canyon and the canyons of Boulder and Larimer County were severely impacted in the 2013 floods. The bridge maps indicate concentrations of bridges along Highway 74 west of Morrison.

Table 4-43 Critical Facilities in 1% Annual Chance Flood Hazard Areas

FEMA Lifeline	Critical Facility Type	Count
Communications	Land Mobile Private Towers	38
	Microwave Service Towers	7
	Total	**45**
Energy	Electric Substation	2
	Power Plant	2
	Total	**4**
Food, Water, Shelter	Wastewater Plant	3
	Water Facility	1
	Total	**4**
Hazardous Material	RMP Facility	1
	Tier II	6
	Total	**7**
Safety and Security	Fire Station	2
	Government Facility	2
	Total	**4**
Transportation	Bridge	138
	Total	**138**
Grand Total		**202**

Source: HIFLD and CERC

Table 4-44 Critical Facilities in 0.2% Annual Chance Flood Hazard Areas

FEMA Lifeline	Critical Facility Type	Count
Communications	Land Mobile Private Towers	15
	Paging Transmission	1
	Total	**16**
Food, Water, Shelter	Water Facility	1
	Total	**1**
Hazardous Material	Tier II	7
	Total	**7**
Health and Medical	Nursing Home	2
	Total	2
Safety and Security	EOC	1
	Fire Station	2
	Government Facility	3
	Law Enforcement	2

FEMA Lifeline	Critical Facility Type	Count
	School	2
	Total	**10**
Transportation	Bridge	45
	Total	**45**
	Grand Total	**81**

Source: HIFLD and CERC

Bridges

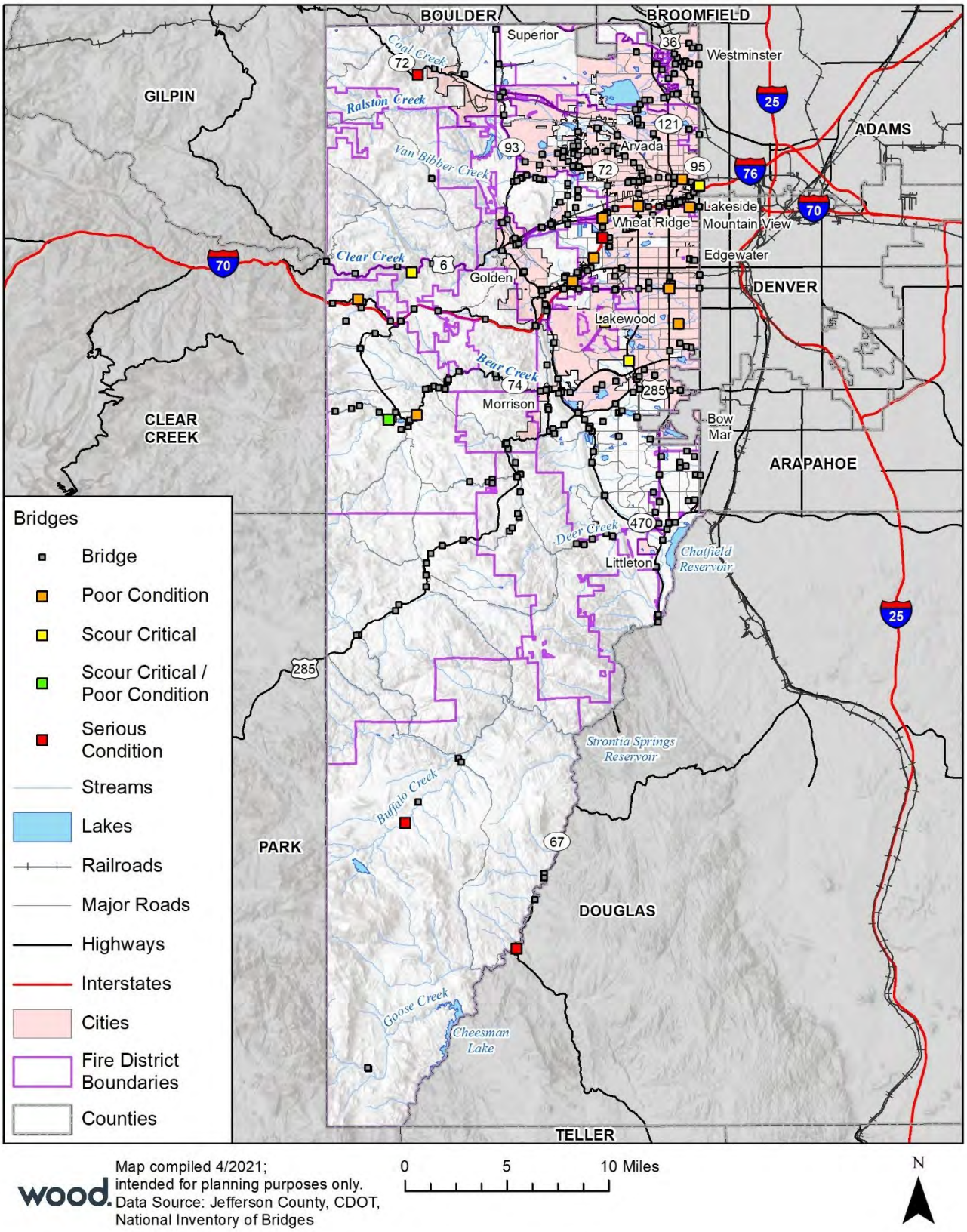
Jefferson County does have a number of bridges of concern, including scour critical (a bridge with a foundation element determined to be unstable for the observed or evaluated scour condition) structurally deficient (when key components like the superstructure are inspected and rated 'poor' or worse by a bridge engineer) and functionally obsolete (when design components are outdated) facilities. Based on a search of the National Bridge inventory there are 9 bridges that fall within these categories, 3 of which are located across Clear Creek. Table 4-45 and Figure 4-37 show the counts and locations for each critical factor listed above.

Table 4-45 Jefferson County Bridges of Concern

Critical Factor	Waterway
Structurally Deficient	Buffalo Creek
Scour Critical/Structurally Deficient	Bear Creek
Scour Critical	Clear Creek
Scour Critical	Clear Creek
Scour Critical	Iliff Gulch
Functionally Obsolete	Coal Creek
Functionally Obsolete	Clear Creek
Functionally Obsolete	I 70 ML
Functionally Obsolete	Bear Creek

Source: National Bridge Inventory

Figure 4-37 Jefferson County Bridges



Economy

Flooding can have a major economic impact on the economy, including indirect losses such as business interruption, lost wages, reduced tourism and visitation, and other downtime costs. Flooding often coincides with the summer tourism months and may hence impact, directly or indirectly (such as from the negative perception of potential danger to his hazard), the revenues of tourist agencies, hotel bookings, outdoor activity companies, and other such businesses in the commercial and industrial sectors.

The Colorado Water Conservation Board (CWCB), Future Avoided Cost Explorer (FACE) tool which estimates annual damages from flooding, Jefferson County could potentially experience an average annual loss of $12 million in total damages and $20 total damages per person due to flooding under current population and climate scenarios.

Historical, Cultural, and Natural Resources

There are significant historic, cultural, and natural resources and assets located throughout the County (e.g. trails and natural spaces, lakes). Natural areas within the floodplain often benefit from periodic flooding as a naturally recurring phenomenon. These natural areas often reduce flood impacts by allowing absorption and infiltration of floodwaters. Natural resources are generally resistant to flooding except where natural landscapes and soil compositions have been altered for human development or after periods of previous disasters such as drought and fire. Wetlands, for example, exist because of natural flooding incidents. Areas that are no longer wetlands may suffer from oversaturation of water, as will areas that are particularly impacted by drought. Areas which may have recently suffered from wildfire damage may erode because of flooding, which can permanently alter an ecological system.

National Flood Insurance Program/Community Rating System

The National Flood Insurance Program (NFIP) is a federal program enabling property owners in participating communities to purchase insurance as a protection against flood losses. A jurisdiction's eligibility to participate is premised on their adoption and enforcement of state and community floodplain management regulations intended to prevent unsafe development in the floodplain, thereby reducing future flood damages. Thus, participation in the NFIP is based on an agreement between communities and the federal government. If a community adopts and enforces a floodplain management ordinance to reduce future flood risk to new construction in floodplains, the federal government will make flood insurance available within the community as a financial protection against flood losses. Table 4-46 shows the dates the jurisdictions in Jefferson County joined the NFIP, the date of the most recent FIRM maps, total number of claims since joining and total dollar value of claims. The data shows that the unincorporated parts of the county have the highest dollar value of claims, with Lakewood the highest number of claims.

Table 4-46 NFIP Data, Jefferson County

Jurisdiction	Date Joined	Effective FIRM Date	Number of Claims	Claims Totals
Arvada, City of	6/23/1972	1/15/2021	71	$66,412
Edgewater, City of	8/15/1989	2/5/2014	27	$51,637
Golden, City of	5/15/1985	12/20/2019	14	$48,938
Lakewood, City of	7/21/1972	2/5/2014	157	$649,522
Morrison, Town of	12/1/1982	2/5/2014	8	$1,231
Westminster, City of	9/30/1988	12/20/2019	39	$260,098
Wheat Ridge, City of	5/26/1972	2/5/2014	45	$97,251
Unincorporated	8/5/1986	1/15/2021	138	$1,407,172

Source: FEMA Community Information Systems, Accessed: January 2021

Table 4-47 shows the trends of policies in force from 2015 to 2020; with the exception of Golden all jurisdictions in Jefferson County have decreased numbers of policies in force. Reductions in some cases,

notably Arvada, also reflect flood reduction projects that were implemented in recent years (e.g. along Ralston Creek near Independence St) that have reduced the SFHA and the requirement for flood insurance.

Table 4-47 NFIP Policies in Force, 2015 to 2020

Jurisdiction	Policies in Force		Change 2015 to 2020
	2015	2020	
Arvada	484	360	-124
Edgewater	42	35	-7
Golden	93	94	1
Lakewood	412	371	-41
Morrison	12	8	-4
Westminster	121	97	-24
Wheat Ridge	254	222	-32
Unincorporated	597	415	-182

Source: FEMA Community Information Systems, Accessed: January 2021

Table 4-48 shows the same data, in terms of total dollar amounts insured. This analysis shows most jurisdictions in the County have decreased net dollar amounts insured, reflecting reduced flood vulnerability.

Table 4-48 NFIP Insurance in Force, 2015 to 2020 (Non-Adjusted US Dollars)

Jurisdiction	Insurance in Force		Change 2015 to 2020
	2015	2020	
Arvada	$114,839,400	$95,962,300	-$18,877,100
Edgewater	$8,859,200	$9,177,800	$318,600
Golden	$25,629,000	$26,368,500	$739,500
Lakewood	$113,461,100	$107,586,600	-$5,874,500
Morrison	$2,590,000	$2,756,300	$166,300
Westminster	$33,447,400	$27,283,700	-$6,163,700
Wheat Ridge	$58,590,100	$55,482,200	-$3,107,900
Unincorporated	$150,687,200	$113,566,400	-$37,120,800

Source: FEMA Community Information Systems, Accessed: January 2021

The Community Rating System (CRS) was created in 1990 to recognize communities whose floodplain management activities go above and beyond the NFIP's minimum requirements. Under the CRS, if a community implements certain program activities, such as public information, mapping, regulatory, loss reduction, and/or flood preparedness activities, then its residents can qualify for a flood insurance premium rate reduction.

Table 4-49 shows how jurisdictions in Jefferson County have progressed in the CRS system since 2010.

Table 4-49 Jefferson County Jurisdictions, CRS Rating Trends 2010 - 2020

Jurisdiction	CRS Rating			Change in Class 2015 to 2020
	2010	2015	2020	
Arvada	6	5	5	0
Golden	9	7	7	0
Lakewood	6	6	6	0
Morrison	9	9	8	+1
Westminster	6	6	6	0
Wheat Ridge	7	6	5	+1
Unincorporated	9	6	5	+1

Source: FEMA Community Information Systems, Accessed: January 2021

All jurisdictions in Jefferson County maintained status quo or achieved an improved CRS rating since 2015, suggesting progress in the floodplain management and flood mitigation efforts.

A repetitive loss property is one that has received two or more flood insurance claim payments for at least $1,000 each in any 10-year period since 1978. A repetitive loss property may or may not be currently insured by the NFIP. According to NFIP data from the Colorado Water Conservation Board (CWCB), accessed January 2021, there are a total of 15 repetitive loss buildings and have been 41 total losses in Jefferson County. Of the claims, 31 losses were associated with the City of Lakewood, 5 with unincorporated county and 5 with the City Arvada. In total there have been $794,936 repetitive loss payments, $687,717 is related to buildings and $107,219 are payments for contents. Table 4-50 shows these repetitive loss buildings by occupancy type.

Table 4-50 Repetitive Loss Properties

Community	Building Type (Occupancy)	# of Losses	NFIP Insured (y/n)
Arvada	Single Family	3	Yes
	Single Family	2	No
Evergreen	Other Non-residential	2	No
Lakewood	Other Residential	1	No
	Other Non-residential	2	No
	Other Non-residential	2	No
	Single Family	6	No
	Single Family	4	No
	Single Family	4	No
	Single Family	4	No
	Single Family	3	No
	Single Family	2	No
	Single Family	2	Yes
	Single Family	2	No
Littleton	Single Family	2	No
Total	**15**	**41**	

Source: CWCB

Severe repetitive loss properties (SRL) are those for which the program has either made at least four payments for buildings and/or contents of more than $5,000 or at least two building- only payments that

exceeded the value of the property. As of January 2021, there were no severe repetitive loss (SRL) structures located within Jefferson County.

Future Development

An analysis of the Year Built field in County Assessor's Office data shows that from 2015 through 2020, 21 new structures have been built in the 1% floodplain and 71 structures were built in the 0.2% floodplain. While not a large number compared to the total structures at risk described above, it does show that new development is continuing in flood prone areas. New development in the 1% floodplain is mitigated per local floodplain regulations. In general development in the 0.2% floodplain is not regulated; based on this trend and the analysis shown in the vulnerability assessment a 0.2% flood, while less likely, has potential to do extensive damage.

Jefferson County's continued population, housing, and employment growth creates pressure for land use change and the supporting infrastructure improvements. Floodplain management practices implemented through local floodplain management ordinances should mitigate the flood risk to new development in floodplains. Urbanization and increasing impervious surface areas tend to increase both the rate and the volume of stormwater runoff. Thus, the largest issue with future development trends is urbanization and stormwater drainage issues that add to the peak discharge and volume of floodwaters in floodplains.

The Colorado Water Conservation Board (CWCB), Future Avoided Cost Explorer (FACE) provides an in-depth look at the potential economic impacts and expected annual damages from future flood, drought and wildfire events. The tool looks at three different climate scenarios (current climate conditions, 2050 future – moderately warmer climate and 2050 – severely warmer climate) as well as compares current population to low, medium and high growth population scenarios. The following table compares the estimated annual damages for Jefferson County due to drought events for each of the climate and population scenarios.

Table 4-51 Potential Future Economic Losses from Flooding in Jefferson County

Climate Scenarios	Population Scenarios		
	Low Growth (~653,000)	Medium Growth (~695,000)	High Growth (~740,000)
Current Conditions	Total damages: $12M	Total damages: $12M	Total damages: $13M
	Total damages per person: $20	Total damages per person: $20	Total damages per person: $20
Moderate or More Severe Climate	Total damages: $20M	Total damages: $20M	Total damages: $20M
	Total damages per person: $30	Total damages per person: $30	Total damages per person: $30

Source: Colorado Water Conservation Board (CWCB) Future Avoided Cost Explorer: Hazards https://cwcb.colorado.gov/FACE

Overall Hazard Significance

Floods in Jefferson County can have a particular impact on the planning area. Widespread flooding is less frequent, but the 2013 flood demonstrated that these events happen. Flash floods and flooding in small pockets of the County happens with regularity. The geographic extent of the hazard is considered **limited**. The probability of future occurrences is considered **likely** and the magnitude/severity for the event of record is **critical**. In addition, the HMPC considers the hazard to have a **high** overall impact rating on the County. This equates to an overall impact rating of **high**.

4.3.10 Hailstorms

Description

Hailstorms are any storm events where hailstones fall. Hail forms when updrafts carry raindrops into extremely cold areas of the atmosphere where the drops freeze into ice. Hail falls when it becomes heavy enough to overcome the strength of the updraft and is pulled by gravity towards the earth. The process of falling, thawing, moving up into the updraft and refreezing before falling again may repeat many times, increasing the size of the hailstone. Hailstones are usually less than two-inches in diameter, but have been reported much larger and may fall at speeds of up to 120 mph. Hailstorms occur throughout the spring, summer, and fall in the region, but are more frequent in late spring and early summer. These events are often associated with thunderstorms that may also cause high winds and tornadoes. Hail causes nearly $1 billion in damage to crops and property each year in the United States. Hail is also one of the requirements which the National Weather Service uses to classify thunderstorms as severe. If hail more than ¾ of an inch is produced in a thunderstorm, it qualifies as severe.

The National Weather Service classifies hail by diameter size, and corresponding everyday objects to help relay scope and severity to the population. The table below indicates the hailstone measurements utilized by the National Weather Service.

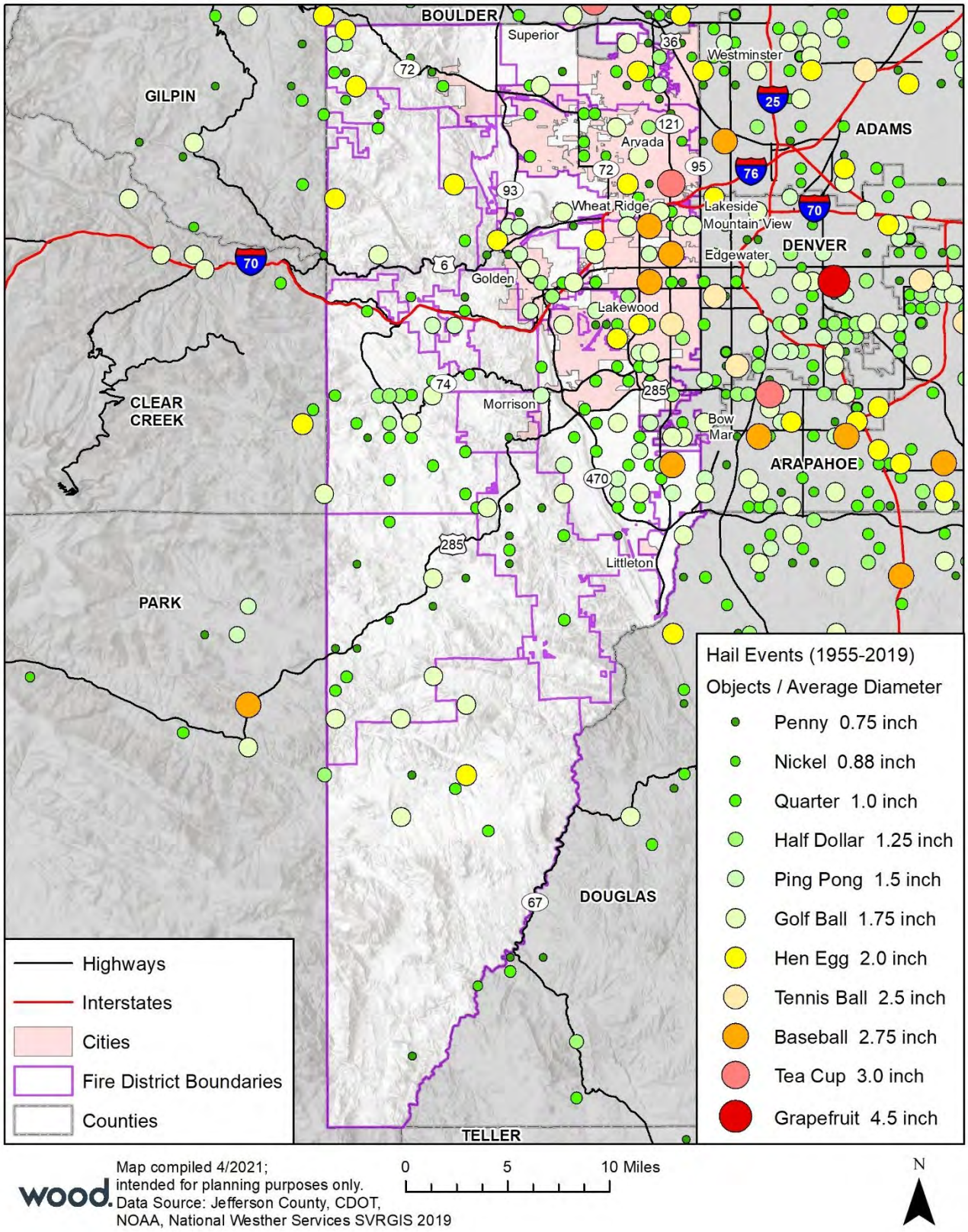
Table 4-52 Hailstone Measurements

Average Diameter	Corresponding Household Object
.25 inch	Pea
.5 inch	Marble/Mothball
.75 inch	Dime/Penny
.875 inch	Nickel
1.0 inch	Quarter
1.5 inch	Ping-pong ball
1.75 inch	Golf-Ball
2.0 inch	Hen Egg
2.5 inch	Tennis Ball
2.75 inch	Baseball
3.00 inch	Teacup
4.00 inch	Grapefruit
4.5 inch	Softball

Source: National Weather Service

In Colorado, hail is one of the most damaging of natural hazards. In fact, the 1996 July hailstorm set a record for most damaging hailstorm on a national level at that time. According to the 2018 State Hazard Mitigation Plan, the damaging hail season in Colorado ranges from mid-April to mid-August. Colorado's Front Range, including the entire planning area, is located in the heart of Hail Alley, which receives the highest frequency of large hail in North America and most of the world. According to an April 2020 report from the National Insurance Crime Bureau (NICB), Colorado had the second highest number of insurance claims involving hail from 2017-2019. The Rocky Mountain Insurance Information Association (RMIIA) also reports that hailstorms have caused upwards of $5 billion over the last 10 years.

Figure 4-38 Jefferson County Hail Events



Geographic Extent

Hailstorms occur during severe storms, which are regional in nature. However, just as the amount of precipitation in the form of snow or rain may vary significantly within a single storm, so may the amount, size, and duration of hail within a severe storm. In general, hail can fall anywhere in Colorado. The areas where hail is most frequently reported with damaging effects are in the eastern plains, where hail damages crops and livestock, and in the Denver metro area, where hailstorms damage buildings, cars and trees, and may cause driving conditions to deteriorate. The extent of impact ranges from limited, where a single community within the planning area is affected, to significant, where more than 50% of the County was impacted. There are no known incidents where a single hailstorm impacted more than 75% of the County; however, so while hail is *possible* anywhere in the planning area, it is not likely to affect the entire area simultaneously. Figure 4-38 below illustrates the location and magnitude of hail events within and adjacent to the planning area from 1955-2019.

Based on this information, the geographic extent rating for hailstorms is **significant**.

Previous Occurrences

Since hailstorms are so prevalent in Colorado, the most useful previous occurrences to examine are those which caused a particularly high amount of damage or incurred some other unique cost or impact. The NCEI database records 422 hail events in the planning area between January 1, 1950 and December 31, 2020. Nineteen of those storms reported hailstones at least two inches in diameter; however, some of these individual storm records reflect the different size hailstones for the same storm event, so the data is somewhat skewed. Several selected incidents, including some not captured in the NCEI database, are profiled below. These selections illustrate the severity of the hail hazard for the jurisdiction and are representative of the range and risk but are not comprehensive.

June 13, 1984 – A mega rain/hailstorm occurred on June 13, 1984. Severe thunderstorms crossed northern Jefferson County and western Adams County dropping 2 to 4" rain and 1" to 3.5" diameter hail. There was serious flooding in Arvada, Westminster, Wheat Ridge and Lakewood. Damage was estimated at $350-$400 million ($723-$825 million in 2008 dollars) damage in Jefferson County.

July 11, 1990 – A storm with hailstones of up to 2.75" in diameter incurred 13 injuries in the planning area. A companion entry for the same date indicated the hail size was 1.75" but that 47 injuries were reported, which were mostly documented in Elitch Gardens (then located in Denver County). The RMIIA placed the total insured hail damages for the affected area at $625 million ($1.03 billion in 2009 dollars). The storm impacted Adams, Arapahoe, Boulder, Denver, Elbert, Jefferson and Larimer counties, with the heaviest damages reported in Jefferson County. Additional accounts indicate that this was the costliest hailstorm in U.S. history, as hail ranged along the entire Front Range. Jefferson County also suffered severe damages to aircraft at the Jefferson County Airport, power and utilities were disrupted to thousands of residents, and storm drains clogged with hail flooded roads three to six feet deep in Arvada.

June 1, 1991 – Intense thunderstorms formed in northern Jefferson County on June 1, 1991. These storms flooded streets and urban streams from Columbine County Club through Lakewood into Golden with 0.75" to 1.5" diameter hail and 1.5" to 3.5" rainfall in less than 1 hour. I didn't have information on the estimated damage for this event.

October 1, 1994 – An afternoon hailstorm, lasting for nearly three hours as it crossed the Denver metro area, produced hail ranging from pea to golf ball sizes. Damages and incidents reported in the planning area include Arvada, Edgewater, and Wheat Ridge. Other impacted areas included Denver, Boulder, Last Chance, Bennett, Strasburg, Wiggins, Penrose, and the Buckley Air National Guard Base near Aurora. Overall insured estimates, sourced by RMIIA, totaled at $225 million ($326 million in 2009 dollars).

May 22, 1996 – A severe thunderstorm producing large hail ranging in size from 3/4 to two inches in diameter rumbled across the northwest and northern portions of the Denver metropolitan area. The thunderstorm apparently developed from an outflow boundary generated from the supercell thunderstorm that moved across extreme northeastern Colorado earlier in the evening. The storm developed near the foothills and moved east northeast across northern portions of the metro area. The hardest hit areas were cities of Arvada and Westminster, northwest of Denver. The insurance industry estimated $60 million in damage to homes and personal property and $62 million in damage to automobiles for a total of $122

million in insured losses ($166.8 million in 2009 dollars). This estimate also included the cities of Golden, Thornton, and Wheat Ridge.

June 8, 2004 – A series of hailstorms stretching along the Front Range from Colorado Springs to Larimer County and out to the eastern border of the state dropped hailstones ranging from dime to golf ball sized. The hail in Jefferson County fell mostly between 7:00 and 8:00 pm across Evergreen and Golden. The next afternoon, Morrison, Conifer, and Lakewood were all impacted by large hailstorms as well. Statewide, insurance damages were reported at $146.5 million ($166.4 million in 2009 dollars). This storm was classified as the eighth most costly hailstorm event in Colorado history as of July 2009.

May 24, 2007 – Several fast-moving storms dropped substantial amounts of hail in the foothills southwest of Denver. One hailstorm impacted U.S. Highway 285 near Aspen Park, where state patrol reported two inches of pea-sized hail fell on the highway, causing it to become snow packed and slick. Four associated accidents were reported shortly thereafter, including three roll-overs in a 10-minute period of time. No injuries were reported, and damages were estimated at $20,000 ($20,700 in 2009 dollars (most recent data available)).

July 20, 2009 – In an unusual overnight storm, rain, winds and golf-ball sized hail battered roofs, uprooted trees, damaged homes, and pounded vehicles in Wheat Ridge, Lakewood, Arvada and Englewood. Most of the damage in this storm are attributed to property losses, with 32,900 homeowner claims and 19,500 automobile claims filed as of July 27, 2009, which amounts to $350 million in insurance claims based on preliminary estimates. While the entire Denver metro area was impacted by the storm, the most significant damages were reported in Jefferson County. This storm is projected to be the second costliest natural disaster in Colorado, in terms of insured losses.

May 8, 2017 – A severe afternoon thunderstorm produced what would become the most expensive insured catastrophe in Colorado state history, and the second costliest hailstorm in US history. Hailstones recorded in the event ranged in size from 0.75 inches to 2.75 inches in diameter depending on the location and impacted a large highly populated area of Jefferson County including the cities of Lakewood, Arvada, and Wheat Ridge. According to NCEI, an estimated 150,000 auto insurance claims and 50,000 homeowner insurance claims were filed. The event severely damaged and forced a six month closure of the Colorado Mills Mall in Lakewood, resulting in an estimated monthly loss of $350,000 in lost sales tax revenue in addition to lost business revenue. The total damage cost of the event totaled around $2.3 billion.

Probability of Future Occurrences

The record of previous occurrences, as discussed earlier, is incomplete as well, but provides a useful reference for hailstorms which produced significant size stones and/or caused damage. Calculating that Jefferson County experiences six hail events per year is less useful than determining how frequently the planning area may experience a severe event. According to RMIIA, there have been eight severe hailstorms which caused more than $100 million in damages that impacted Jefferson County in some way since 1990. Since the last plan update, the NCEI records have been updated to include the 2017 event and an event in Columbine that caused over $350 million in damage to property. This data will be used to determine the probability of a severe hailstorm in Jefferson County.

There have been 87 severe incidents, defined as hailstones 1 inch or greater in diameter in the 2018 Colorado State Hazard Mitigation Plan, involving Jefferson County since 1990. The methodology for calculating the probability of future occurrences is described in Section 4.3.1. This formula evaluates that the probability of a severe hailstorm occurring in any given year is 290%. If the same methodology is applied to all hailstorms (including those that cause minimal damage), then there have been 422 events since 1950, for a span of 70 years. This indicates that Jefferson County can expect an average of 6 hailstorms per year.

This corresponds to a probability of future occurrences rating of **highly likely**.

Magnitude and Severity

Information from the event of record is used to calculate a magnitude and severity rating for comparison with other hazards, and to assist in assessing the overall impact of the hazard on the planning area. In some cases, the event of record represents an anticipated worst-case scenario, and in others, it is a

reflection of common occurrence. The event of record for Jefferson County occurred on May 8, 2017. According to the RMIAA, the event caused $2.3 billion in damages to property in the jurisdiction. This storm was the costliest in Colorado history and the second costliest storm in US history.

Also of note are the July 20, 2009 and July 11, 1990 hail events. The former of these events resulted in $767.6 million in insured damages according to the RMIAA. The latter resulted in 60 direct injuries in the duration of the event, and damages inflicted on critical facilities and services (critical infrastructure) resulted in a loss or disruption of serves for a minimal amount of time. Documented injuries were considered critical, though the medical response of the jurisdiction was considered minimally impacted.

According to the RMIAA, eight of the top ten hazard events in Colorado by the amount of insured loss were either entirely hail-related or involved hail as a hazard. RMIAA also ranks Colorado 2nd in the U.S. for hail insurance claims.

Based on these factors, the magnitude severity rating for hailstorms is considered **critical**.

Climate Change Considerations

According to the 2018 Colorado State Hazard Mitigation Plan, the future impacts of climate change are expected to influence future hail events. Ongoing efforts to reduce Colorado's greenhouse gas emissions and adapt to a changing climate, such as the Colorado Climate Plan and the Climate Change in Colorado Report, will help to reduce the impacts of climate induced hazard such as hail.

Vulnerability Assessment

All assets located in Jefferson County can be considered at risk from severe hail events. This includes 100% of the County's population, and all buildings and infrastructure within the County.

General Property

Research into the damages inflicted by this hazard indicates the hazard has a high impact on the entire planning area, and perhaps the greatest economic impacts. Hail impacts anything exposed to the event, including structures, infrastructure, landscaping, personal property and vehicles, people, agriculture, and livestock. Jefferson County has the highest number of reported injuries due to hail in the state. Hail is also the costliest insured-losses natural disaster to impact the state of Colorado, with nine separate incidents falling within the top ten disasters list for the state. Existing development remains exposed to hail with minimal mitigation opportunities. Individuals can mitigate exposure by remaining indoors and away from windows during hailstorm events. Vehicles can be parked under shelters to help minimize damage costs incurred in that arena. However, in many cases it is impossible to move existing development away from the impact areas. For example, hail heavily impacts the economic contributors who house merchandize outdoors, such as car retailers, home improvement stores and gardening stores. Damage to landscape and agriculture is also almost impossible to prevent, as the plants cannot be transported indoors for the storm.

People

Exposure is the greatest danger to people from hail, for those caught outside in the open without shelter. Large hail has the potential to cause significant bruising, concussions, the potential for broken bones, and even death. The impacts of hail on vulnerable populations can be more severe. Low income families are more likely to live in poorly constructed homes that are more likely to be damaged, and are more likely to be uninsured or underinsured, making it more difficult for them to recover from hail events. Individuals with disabilities may need more assistance after a major event, especially if transportation or utility services are disrupted. Severe weather warnings must use methods that reach vision or hearing-impaired people and those with limited English proficiency.

Critical Facilities and Infrastructure

Hail can lead to the temporary incapacitation of roads when small hail stones build up so deep, they block roads. Hail has also been observed to block storm drains and prevent proper runoff, potentially resulting in flooding as a secondary hazard. Most structures, including the County's critical facilities, should be able to provide adequate protection from hail but the structures could suffer broken windows and dented exteriors. Those facilities with back-up generators are better equipped to handle a severe weather situation should the power go out.

Economy

The economic impact from hail can be severe on impacted areas, and potentially long lasting. As mentioned throughout this section, hail is the costliest hazard experienced in the planning area. Direct damages have totaled $5 billion over the last 10 years (averaging to $500,000,000 per year), but severe indirect economic impacts can also be felt through businesses forced to close for repairs. For example, the 2017 event led to the city of Lakewood losing an estimated $350,000 in monthly sales tax revenue due to a several month closure of the Colorado Mills mall. Impacts such as these can result in lost revenue and employment, adding to the impact of direct damage costs. Insurance helps to offset some, but not all, of these losses.

Historical, Cultural, and Natural Resources

While hail is a natural environmental process, it can cause significant environmental damage, breaking tree limbs, damaging trees and other plants in bloom, and destroying crops. Some cultural and historic properties may also potentially be at risk of damage from hail.

Future Development

Consideration for future development may include the use of resilient landscaping or the construction of covered parking to minimize those losses. The increased availability of accurate, real-time weather forecasting and alerts the most some protection to both residents and visitors. In some cases, the costs of future mitigation efforts, even in new future development, may outweigh the potential insurance losses; for example, Jefferson County does not generally consider shelters a cost effective mitigation effort in built environments.

Overall Hazard Significance

Hailstorms in Jefferson County have a significant impact on the planning area. The costs of hailstorms are higher than any other natural disaster currently documented for the planning area. In addition, Jefferson County reports the highest number of hail-related injuries in the state at 60. The geographic extent of the hazard is considered **significant**. The probability of future occurrences is considered **highly likely** and the magnitude/severity for the event of record is **critical**. The HMPC considers the hazard to have an overall impact rating of low on the County. The data indicates, however, that an overall impact rating of **high** is most appropriate.

While hailstorms are not as high profile as other natural disasters such as tornadoes, blizzards, or floods, the amount of damage they inflict on the planning area is hugely significant. The hazard is frequent enough in occurrence to pose a significant financial risk to the planning area, and though mitigation measures are limited, the hazard deserves due consideration in the overall profile effort.

4.3.11 Landslides, Debris Flows, and Rockfalls

Description

Landslide

Landslides are a serious geologic hazard common to almost every state in the United States. It is estimated that nationally they cause up to $2 billion in damages and from 25 to 50 deaths annually. Some landslides move slowly and cause damage gradually, whereas others move so rapidly that they can destroy property and take lives suddenly and unexpectedly. Gravity is the force driving landslide movement. Factors that allow the force of gravity to overcome the resistance of earth material to landslide include saturation by water, erosion or construction, alternate freezing or thawing, earthquake shaking, and volcanic eruptions.

Landslides are typically associated with periods of heavy rainfall or rapid snow melt and tend to worsen the effects of flooding that often accompanies these events. In areas burned by forest and brush fires, a lower threshold of precipitation may initiate landslides. Generally significant landslides follow periods of above-average precipitation over an extended period, followed by several days of intense rainfall. It is on these days of intense rainfall that slides are most likely.

Areas that are generally prone to landslide hazards include existing old landslides; the bases of steep slopes; the bases of drainage channels; and developed hillsides where leach-field septic systems are used. The most vulnerable areas are the mountain corridors and the urbanized areas along the Rocky Mountain Front Range. Landslides are often a secondary hazard related to other natural disasters. Landslide triggering rainstorms often produce damaging floods. Earthquakes often induce landslides that can cause additional damage.

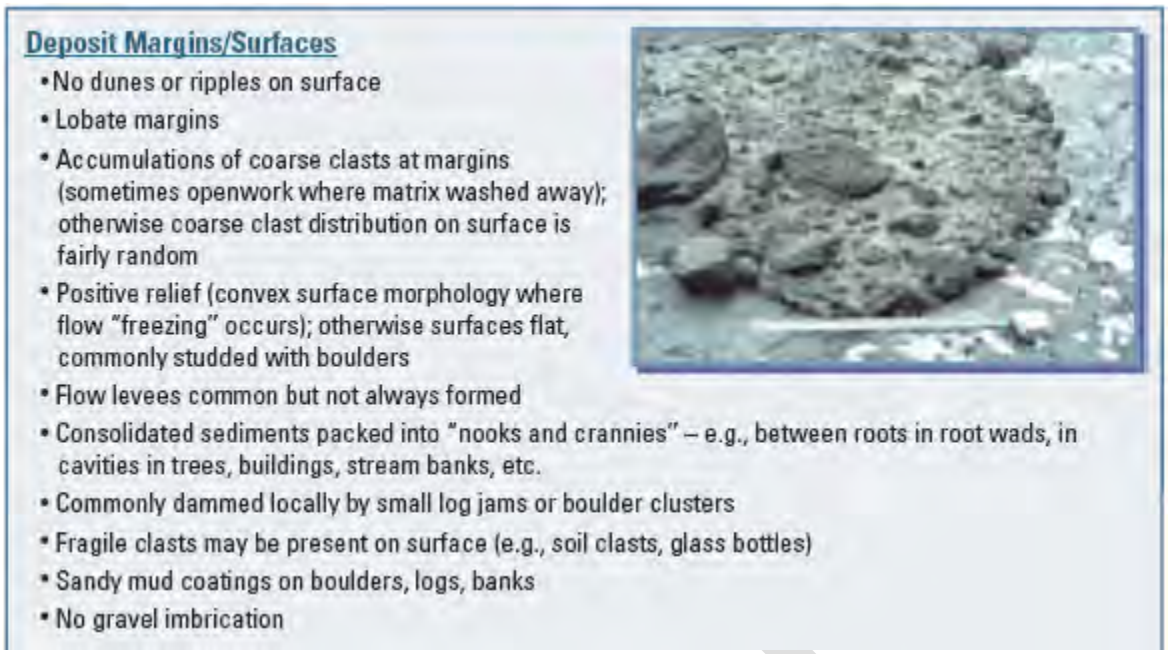
Slope failures typically damage or destroy portions of roads and railroads, sewer and water lines, homes and public buildings, and other utility lines. Even small-scale landslides are expensive due to clean up costs that may include debris clearance from streets, drains, streams and reservoirs; new or renewed support for road and rail embankments and slopes; minor vehicle and building damage; personal injury; and livestock, timber, crop and fencing losses and damaged utility systems.

The identification of areas susceptible to landslides is necessary to support grading, building, foundation design, housing density, and other land development regulations in reducing the risk of property damage and personal injury. Some work has been done to prevent development on top of or below slopes subject to sliding. More needs to be done to educate the public and to prevent development in vulnerable areas. Jefferson County has developed a dipping bedrock overlay zone that is designed to mitigate development in these areas that could be damaged by landslides (FEMA, Colorado Geological Survey).

Debris Flow

Debris flows, sometimes referred to as mudslides, mudflows, lahars, or debris avalanches, are common types of fast-moving landslides. They are a combination of fast-moving water and a great volume of sediment and debris that surges down slope with tremendous force. These flows generally occur during periods of intense rainfall or rapid snowmelt and may occur with little onset warning, similar to a flash flood. They usually start on steep hillsides as shallow landslides that liquefy and accelerate to speeds that are typically about 10 miles per hour but can exceed 35 miles per hour. The consistency of debris flow ranges from watery mud to thick, rocky mud that can carry large items such as boulders, trees, and cars. Debris flows from many different sources can combine in channels, and their destructive power may be greatly increased. When the flows reach flatter ground, the debris spreads over a broad area, sometimes accumulating in thick deposits that can wreak havoc in developed areas. Mudflows are covered under the National Flood Insurance Program; however, landslides are not. Figure 4-39 gives a description of debris flows, characteristics, and provides a picture of the leading edge of a debris flow.

Figure 4-39 Field Evidence of Debris Flow



Source: USGS publication "Distinguishing between Debris Flows and Floods from Field Evidence in Small Watersheds"

A drainage may have several debris flows a year, or none for several years or decades. They are common events in the steep terrain of Colorado and vary widely in size and destructiveness. Cloudbursts provide the usual source of water for a debris flow in Colorado.

Debris flows ruin substantial improvements with the force of the flow itself and the burying or erosion of them by mud and debris. The heavy mass pushes in walls, removes buildings from foundations, fills in basements and excavations and sweeps away cars, trucks heavy equipment and other substantial objects. Boulders and trees swept along by the muddy mass demolish buildings and flatten fences and utility poles. In mountain areas, portions of valleys have been eroded to a depth of several feet by the flow process.

Removal of vegetation on steep slopes, dumping debris and fill in a mud flow path, and improper road building or earth moving can contribute to a debris flow. The failure of a dam, irrigation ditch or other water management structure can initiate debris flows if the escaping water can swiftly accumulate a large volume of soil materials. Similarly, a landslide that temporarily blocks a stream may cause or contribute to a debris flow.

Rockfall

Rockfalls are the fastest type of landslide and occur most frequently in mountains or other steep areas during early spring when there is abundant moisture and repeated freezing and thawing. The rocks may freefall or carom down in an erratic sequence of tumbling, rolling, and sliding. When a large number of rocks plummet downward at high velocity, it is called a rock avalanche.

Rockfall can be a continuous process over a considerable period of time or a single or series of single, intermittent events. Simultaneous activation of a large mass of rock can result in a rockfall avalanche or very rapid down slope and spreading movement of a large quantity of rock material.

Rockfalls are caused by the loss of support from underneath or detachment from a larger rock mass. Ice wedging, root growth, or ground shaking, as well as a loss of support through erosion or chemical weathering may start the fall.

Rockfalls can demolish structures and kill people. Rocks falling on highways may strike vehicles, block traffic, cause accidents, and sometimes damage the road. Minor but costly consequences are the work of

clearing highways and borrow ditches in rockfall areas. Any structure in the path of a large rockfall is subject to damage or destruction.

Geographic Extent

This hazard is most prevalent in the foothills of western Jefferson County, particularly in the canyons that dissect the region, most of which have County roads or State highways running through them, and some residential development.

US Highway 6 in Clear Creek Canyon is prone to rockfall hazards. North and South Table Mountain in Golden can also produce rockfalls from the namesake basalt cliffs that formed them. The base of the foothills in Golden on the northwest side of the intersection of highways 6 and 93 has also been prone to landslides. This landslide sits directly on top of the Golden Fault. Homes were developed just to the north of this landslide area shortly after the landslide was mitigated. The north side of Green Mountain in Lakewood has also had landslide problems.

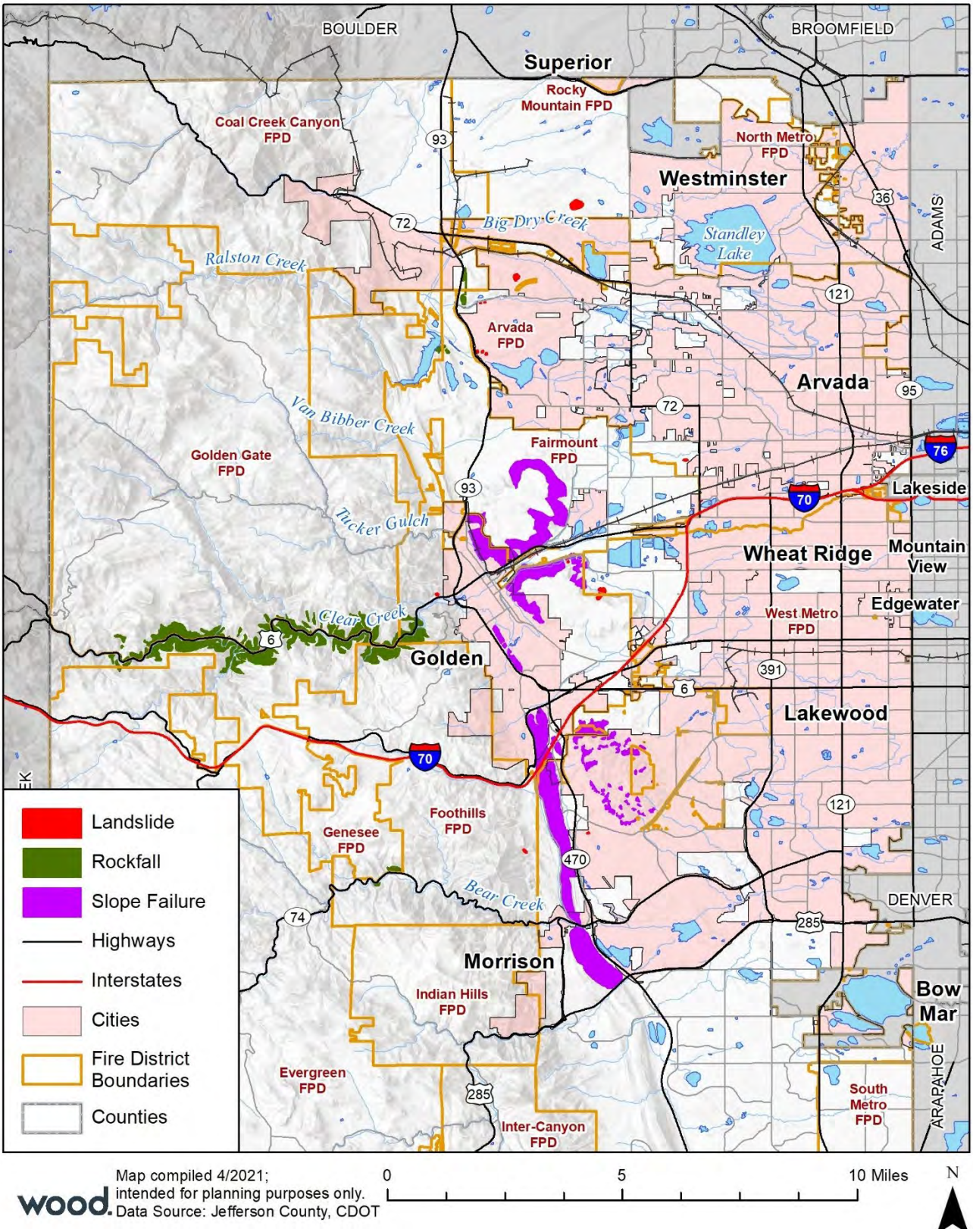
The Colorado Landslide Hazard Mitigation Plan, developed in 1988 and updated in 2002, identified 49 areas in Colorado where landslides could have the “most serious or immediate potential impact on communities, transportation corridors, lifelines, or the economy.” A Year 2002 Review and Priority List was done as part of an update of the 1988 Colorado Landslide Mitigation Plan. The update is a status report on 49 locations believed to pose the most serious landslide risk in Colorado that were identified in the 1988 plan. The hazard areas (landslide/rockfall or debris flow) are categorized into three tiers. Tier One listings are serious cases needing immediate or ongoing action or attention because of the severity of potential impacts. Tier Two listings are very significant but less severe; or where adequate information and/or some mitigation is in place, or where current development pressures are less extreme. Tier Three listings are similar to Tier Two but with less severe consequences or primarily local impact.

Rockfall areas along US HWY 6 in Clear Creek Canyon are considered Tier One rockfall areas. This area is considered a state priority due to the increased traffic and vulnerability of the traveling public to the gambling destinations of Blackhawk and Central City.

Two areas were identified as Tier One debris flow areas including the foothills of Jefferson County burned by the Hi Meadows wildfire in 2000 and the Schoonover wildfire in 2002. In addition, the burn area of the Hayman Fire must be considered a particularly vulnerable area. These wildfires leave the potential for debris flows, rockfalls, and extreme erosion in the area around the fire. Minor landslides will likely continue in susceptible areas because of post-fire conditions or when heavy precipitation occurs.

Two Tier Three landslide areas are identified: Golden to Boulder along CO Hwy 93 and the Morrison Town water plant. The report noted that impacts to Hwy 93 have lessened with roadway improvements and sound engineering practices. The Morrison Town water plant landslide has been mitigated but it is recommended that good drainage be maintained, and that no construction or expansion of the facility be done without thorough geological evaluation and engineering design.

Figure 4-40 Landslide, Rockfall, and Slope Failure Hazards in Jefferson County



As demonstrated in Figure 4-40, a minimal portion of the planning area is prone to occurrences of landslide and rockfall hazards, and of that, only areas with development (such as highways, roads, and subdivisions) are particularly vulnerable to the direct impacts. It should be noted, however, that when this hazard causes road closures, the overall area affected indirectly can be much larger than the slide area itself, with impacts extending into multiple counties on both ends of the incident.

Based on this information, the geographic extent rating for landslide, debris flow, and rockfall is considered **limited**.

Previous Occurrences

Since landslides, debris flows, and rockfalls have a high level of prevalence in Colorado, and a moderate level of prevalence in Jefferson County, the most useful previous occurrences to examine are those which caused a particular high amount of damage or incurred some other cost or impact. Several selected incidents are profiled below. There is no public database or information clearinghouse for this hazard. Information regarding these incidents was sourced from multiple sources. This is not an exhaustive list, but it does illustrate the severity of impacts that landslides, debris flows, and rockfalls exert on Jefferson County.

March 1974 – A boulder the size of a small car hurtled down the steep west side of the hogbacks in Jefferson County. It bounced into a new subdivision and stopped after penetrating a wall in the back of an expensive home. No one was injured. Property damage was about $10,000, including the cost of measures to prevent similar incidents at that site in the immediate future. The incident could have been prevented easily in the subdivision development stage, but it was not recognized.

1985 – A landslide directly upslope from the Morrison's water treatment plan became active in the spring of 1985. The problem was mitigated by removing most of the landslide-prone material and has not had problems since (CO Landslide Mitigation Plan 2002 update).

1993-1994 – The Highway 93 Golden bypass at the base of the foothills in Golden on the northwest side of the intersection of Highways 6 and 93 was affected by a landslide shortly after its construction. CDOT spent $3 million in 1994 to mitigate the problem.

August 31, 1997 – Rock and debris were deposited on the southbound lanes of Highway 285 at the base of the south and north flanks of the slide. Two cars on highway 285 were damaged due to the slide; one drove into rocks and debris on the highway and a second then ran into the first. North and south bound lanes of Highway 285, a major commuter route to and from Denver, were closed and traffic was diverted through Tiny Town along Turkey Creek Road. The southbound lane was closed for over one month. Movement was believed to have been triggered by the cumulative effect of above average rainfall in August.

1998 – Renewed movement of an older landslide deposit on the north side of Green Mountain resulted in three homes being damaged beyond repair and two other homes severely damaged. Earth anchors and drainage improvements have been installed to mitigate future movement.

2000 – On U.S. 6 in Clear Creek Canyon, a vehicle crashed into a 2-ton rock on the highway. There were no serious injuries reported. In a separate incident, a motorist was injured when a basketball sized rock crashed through the windshield and hit him in leg.

2003 – Heavy rains in June of 2003 resulted in flash floods that moved substantial amounts of sediment, causing road obstructions, flooding, and extreme siltation of the South Platte River near Deckers, Colorado. This was a result of the burned out area caused by the Schoonover fire in 2002.

2005 – On U.S. 6 in Clear Creek Canyon 1,400 tons of rock fell during a rockfall. Two truck drivers and a motorist escaped injury. One boulder was measured to be the size of a minivan.

2006 – On U.S. 6 in Clear Creek Canyon, a car (unoccupied at the time) was flattened under a slab of rock.

2006 – In West Creek and Deckers, there were boulders and debris flows during rainstorms over areas previously affected by a wildfire burn.

2007 – On US 6, a rock crashed through the roof of an SUV. The driver of the SUV sustained minor injuries. The rock was measured and reported to be the size of a beach ball.

July 21, 2009 – Highway 126 north of Deckers near Cheesman Reservoir was washed out due to a severe rainstorm, placing trees and debris on the road. Jefferson County closed the highway down to Deckers. No one was killed or injured. The road was severely undercut and washed away in several places. Jefferson County Road and Bridge performed maintenance on the area periodically for two to three weeks to repair the damage done to the roadway.

September 2013 – Rainfall on September 9-13th triggered at least 1,138 debris flows along the Colorado Front Range. According to the HMPC there were debris flows blocking US 6 in Clear Creek Canyon, Golden Gate Canyon, Coal Creek Canyon, and Upper Bear Creek above Evergreen Dam all at the same time on September 12th.

February 24, 2015 – US 6 was closed in both directions between Golden and Colorado 119 as a number of rocks slid off Clear Creek Canyon approximately 6 miles west of Golden. One car was severely damaged; a passenger in the car was transported to the hospital in good condition.

2020 – Landslide in Leyden Rock in an open space area in Arvada (City of Arvada 2020).

Probability of Future Occurrences

Mitigation efforts have been taken to decrease probability of future occurrences. A rockfall mitigation project has been underway in Bear Creek Canyon between Idledale and Morrison since September 2020. The mitigation project will enhance safety for motorists and cyclists along Highway 74 with a goal of preventing roadway damage or unexpected closures due to a landslide or rockfall (CDOT 2020).

Based on the history of landslides, debris flow incidents, and rockfalls in Jefferson County (15 incidents over 46 years events) since 1974 a damaging event occurs on average every three years. Rockfalls in the canyons typically occur annually and usually in the winter and spring during freeze-thaw cycles. Since the hazards are profiled together due to common onset and impacts, the probability of future occurrence is established collectively. The methodology for calculating the probability of future occurrences is described in Section 4.3.1. This formula evaluates that the probability of a landslide-type event occurring in any given year is 33%. This corresponds to a probability of future occurrences rating of **likely**.

Magnitude and Severity

The overall magnitude and severity rating is a reflection of the common occurrence of this hazard. Property damages from these hazards has been in the millions of dollars, but generally limited in extent and periodic, typically during wet cycles. The damages inflicted on critical facilities and services (critical infrastructure) are primarily highways in the planning region. This has resulted in a loss or disruption of services periodically in the Clear Creek Canyon HWY 6 corridor. By a combination of mitigation efforts and luck there has not been documented deaths from rockfall in Clear Creek Canyon, but the potential remains. Based on these factors, the magnitude severity ratings for landslide, debris flow, and rockfall are considered **limited**.

Climate Change Considerations

Increased temperatures are projected to contribute to more water evaporation making drought more common, which would increase the probability of wildfire, reducing the vegetation that helps to support steep slopes. Wildfires and earthquakes destabilize soil on steep slopes increasing landslide and debris flow risk. Erosion caused by development on steep hillsides increases risk of landslides. Since the 1950s, snow precipitation and duration of snowpack have both decreased while rising temperatures have increase rate of water evaporating into the air, creating drier soil conditions in Colorado (EPA 2016).

Vulnerability Assessment

Research in the hazard profile for landslide, debris flow, and rockfall events revealed sporadic impacts, particularly in the canyons that dissect the region, most of which have County roads or State highways running through them, and repetitive debris flow issues in areas that have had recent wildfire burns. Future property losses to existing developments would likely be minor, based on patterns of previous events, and impact mostly infrastructure.

General Property

GIS was used to create a risk assessment for geological hazards in Jefferson County. Landslide, rockfall, slope failure and subsidence hazard data were overlaid on Jefferson County parcel and assessor's data.

For the purposes of this analysis, and address point layer in GIS was used to approximate the center of buildings. Geologic hazard data was then overlaid on the address points. For the purposes of this analysis, the hazard zone that intersected an address point was assigned the hazard for the entire parcel. The model assumes that every parcel with a structure value greater than zero is improved in some way. Specifically, an improved parcel assumes there is a building.

These counts are listed in Table 4-53. Critical facilities at risk to slope failure are listed in Table 4-54. The model did not identify any buildings at risk to rockfall hazards.

These tables show the value of developed parcels identified as being exposed to the landslide or slope failure hazard. No parcels were exposed to the rockfall hazard. Results are sorted by occupancy type and by jurisdiction to demonstrate how the hazard's risk varies across the planning area. Maps that display the parcels affected by these hazards can be referenced in the applicable jurisdictional annexes. Overall, the total value exposed to landslide or slope failure increased from approximately $354 million in 2016 to nearly $427 million in 2020. The jurisdiction with the greatest exposure to landslide or slope failure is Golden with nearly $349 million of total value exposed. A more site-specific analysis would need to be done to further determine if exposure equates to vulnerability, as this analysis does not take into account mitigation or strategic building siting that might have occurred during development.

Table 4-53 Building Exposure to Landslides or Slope Failure

Jurisdiction	Property Type	Improved Parcels	Building Counts	Total Value	Population
Golden	Exempt	1	1	$95,600	
	Industrial	1	1	$1,289,075	
	Mixed Use	1	2	$103,992,458	
	Residential	292	292	$243,596,070	654
	Total	**295**	**296**	**$348,973,203**	**654**
Lakewood	Exempt	1	1	$95,600	
	Industrial	1	1	$176,850	
	Residential	16	16	$8,135,145	36
	Total	**18**	**18**	**$8,407,595**	**36**
Morrison	Exempt	1	1	$50,528	
	Mixed Use	3	3	$1,039,080	
	Residential	4	4	$1,086,720	8
	Total	**8**	**8**	**$2,176,328**	**8**
Unincorporated	Commercial	4	5	$14,402,494	
	Exempt	1	1	$88,334	
	Residential	60	60	$52,631,627	153
	Total	**65**	**66**	**$67,122,455**	**153**
	Grand Total	**386**	**388**	**$426,679,581**	**852**

Source: Based on analysis of Jefferson County GIS and Assessor's Data

People

Past landslides in Jefferson County have not caused loss of life or major injuries to date, although the potential for both exists. As shown in Table 4-53, 852 people live in areas at risk of landslide or slope failure. Exposure is the greatest danger to people in remote locations in areas of steep slopes and higher precipitation areas in the western to central portion of the county. People who travel along these

roadways or highways that are susceptible to landslides and rockslides are also exposed. Landslides have closed down highways for hours to days, which can affect essential services for rural populations. As population, tourism, and development increases in landslide prone areas, landslide occurrence interacting with people and development will also increase.

Critical Facilities and Infrastructure

Critical facilities exposed to landslides or slope failure increased from three in Golden in 2016 to six in 2020. And the unincorporated jurisdiction now has four critical facilities exposed.

Table 4-54 Critical Facilities At-Risk to Landslides or Slope Failure

Jurisdiction	FEMA Lifeline	Critical Facility Type	Count
Golden	Communications	Microwave Service Towers	3
	Hazardous Material	Household Hazardous Waste	1
	Safety and Security	Government Facility	2
Unincorporated	Communications	Land Mobile Private Towers	3
	Hazardous Material	Tier II	1

Source: HIFLD and CERC

Economy

Rockfall impacts on Jefferson County foothill highways and County roads have the potential to cause significant indirect economic loss. The most significant road that could be impacted by rockfall and related road closures is Highway 6 in Jefferson County in Clear Creek Canyon. Economic losses from this road closure and resulting detours could be estimated with traffic counts and detour mileage.

Historical, Cultural, and Natural Resources

Landslides/rockslides are a natural environmental process. Environmental impacts include the removal of vegetation, soil, and rock.

Future Development

Steep slope regulations limit problems from these hazards for future development, thus the exposure of infrastructure to these hazards is not anticipated to grow. As expansion of the gambling communities grows in nearby Gilpin County, the amount of traffic along the Clear Creek Canyon Highway 6 corridor will increase, and thus the amount of people exposed to danger from rockfall hazards may increase. While mitigation projects are in place to reduce dangers to drivers from falling rock along this corridor, more may be necessary in the future.

Overall Hazard Significance

Landslides, debris flow, and rockfall in Jefferson County periodically impact on the planning area. The geographic extent of the hazard is considered **limited**. The probability of future occurrences is considered **likely** and the magnitude/severity for the event of record is **limited**. This equates to an overall impact rating of **medium**. While landslides, debris flow, and rockfall do occur with some regularity in Jefferson County, the direct effect on the populace is low, but the potential for severe injury or death remains from rockfall. Singular individuals or small groups may be affected by the direct effects of landslides, debris flow, and rockfall. The secondary effect of closed roads is a greater threat to the larger populace, especially if the closed roads cut off emergency personnel from those who need assistance.

4.3.12 Lightning

Description

Lightning is an electrical discharge between positive and negative regions of a thunderstorm. A lightning flash is composed of a series of strokes with an average of about four. The length and duration of each lightning stroke vary, but typically average about 30 microseconds. Typically, thunderstorms include rain, hail, or other forms of precipitation. However, it is possible for a thunderstorm to produce lightning with no delivery of precipitation. These events are called 'dry thunderstorms.'

Intra-cloud lightning is the most common type of discharge. This occurs between oppositely charged centers within the same cloud. Usually it takes place inside the cloud and looks from the outside of the cloud like a diffuse brightening that flickers. However, the flash may exit the boundary of the cloud, and a bright channel, similar to a cloud-to-ground flash, can be visible for many miles.

Cloud-to-ground lightning is the most damaging and dangerous form of lightning, though it is less common than intra-cloud occurrences. Most flashes originate near the lower-negative charge center and deliver negative charge to earth. However, some flashes carry positive charge to earth. These positive flashes often occur during the dissipating stage of a thunderstorm's life. Positive flashes are also more common as a percentage of total ground strikes during the winter months. This type of lightning is particularly dangerous for several reasons. It frequently strikes away from the rain core, either ahead or behind the thunderstorm, and can strike as far as 5 or 10 miles from the storm and occur in areas where common observers may not recognize the danger. Positive lightning also has a longer duration, so fires are more easily ignited. Positive lightning strikes usually carry a high peak electrical current, which may potentially result in greater damage.

The ratio of cloud-to-ground and intra-cloud lightning varies significantly between storms. Depending upon cloud height above ground and changes in electric field strength between cloud and earth, the discharge either stays within the cloud or makes direct contact with the earth. If the field strength is highest in the lower regions of the cloud, a downward flash may occur from cloud to earth. Using a network of lightning detection systems, the United States monitors an average of 22 million strokes of lightning from the cloud-to-ground every year.

According to the Colorado Division of Homeland Security and Emergency Management, lightning is the number one life threatening weather hazard. Each year, lightning is responsible for deaths, injuries, and millions of dollars in property damage, including damage to buildings, communications systems, power lines, and electrical systems. Lightning also causes forest and brush fires, and deaths and injuries to livestock and other animals. According to the National Lightning Safety Institute, lightning causes more than 24,600 fires in the United States each year. The Institute estimates annual damages from lightning to be approximately $4-5 billion in the US. Lightning is so significant in Colorado that the Governor declares an annual Lightning and Wildfire Awareness Week each summer. According to NOAA, Colorado ranks 5th out of all states in total lightning caused fatalities from 1959 to 2016. Additionally, NOAA ranks Colorado 19th in the nation in the number of cloud-to-ground lightning flashes and 32nd in the nation in overall flash density with 4.8 flashes per square kilometer.

Previous Occurrences

There are approximately 2,000 thunderstorms occurring globally at any one time, with 75-100 cloud-to-ground lightning strikes per second. The NCEI storm events database lists 33 significant lightning strike events since 1995 in Jefferson County. Impacts of these strikes generally can be drawn into two categories:

- Strikes that are notable because of human injury or fatality (7 strikes). These primarily occur when the victim is unsheltered during a lightning storm.
- Strikes that are notable because of property damage (12 strikes). Most damages occurred to single properties.

The selections below demonstrate some events which caused notable injury, death, or property damage, and those events which triggered wildfires. (See Section 4.3.17 for more information on wildfire risk.) These records, drawn from the NCEI database, illustrate the wide variety of impacts that lightning poses to the planning area.

May 29, 1995 – Lightning struck a soccer goal post and injured six adults viewing a soccer game. Although no one received a direct hit, one woman was hospitalized.

September 4, 1995 – Two people were injured when lightning struck their home. The lightning entered in the attic where it sparked a small fire. It then travelled through the walls exploding a mirror that sprayed glass on the residents. Damages were estimated at $4,500.

July 3 - 5, 1996 – Lightning from a fast moving thunderstorm blasted a large hole in the side of a house in Lakewood, southwest of Denver. Lightning sparked a small fire near Buffalo Creek. Only one acre was burned before the fire was contained.

September 2, 1996 – Lightning sparked a brush fire in the south buffer zone of the Rocky Flats Environmental Test Facility. No structures were damaged but the fire burned approximately 100 acres of grassland before it was contained.

July 29, 1997 – A woman received minor injuries when lightning struck her when it passed through the office window. She suffered temporary blindness for approximately 15 minutes.

August 13, 2000 – Lightning sparked three separate grassfires near Golden. The fires were quickly contained, however.

May 30, 2001 – Lightning ignited a fire which destroyed a luxury home on Bear Mountain near Evergreen, resulting in a recorded $1 million in property damage.

May 27, 2002 – Lightning sparked a wildfire near Deckers. Extremely dry conditions and very strong winds the following day allowed the fire to consume 3,860 acres before it could be contained. Thirteen structures were destroyed, including 4 homes. This incident is discussed further in the wildfire hazard profile.

June 19, 2002 – Lightning damaged the Evergreen Fire Protection District (EFPD) repeater. One microwave transmitter, the main fire channel transmitter and two solar panel controllers were ruined. Damage costs were estimated at $5,000.

August 1, 2001 – Lightning coupled with strong thunderstorm winds knocked out power to approximately 10,000 Xcel Energy customers in Golden**.**

May 29, 2004 – A father and son practicing on the driving range at the Meadows Golf Club were struck by lightning. The father was killed and the teenage boy was seriously injured. Three other people standing nearby only received minor injuries.

July 23, 2004 – Lightning caused a power outage in Arvada, leaving approximately 9,800 customers without power for 90 minutes.

July 27, 2007 – A man was struck and killed by lightning while jogging at Matthews Winters Park in Morrison. The thunderstorm produced numerous lightning strikes and caused a power outage at Red Rocks Amphitheatre, which forced the cancellation of a concert later in the evening. Damages were reported at $5,000.

August 4, 2008 – Lightning sparked a grassfire that consumed 300 acres on the northern edge of Green Mountain. Gusty winds and very dry conditions allowed the fire to spread quickly and threaten several homes. Only minor damage was reported, caused by smoke and melted siding. Damages were estimated at $100,000.

August 16, 2010 – Lightning struck a tree in Morrison; separately, a lightning strike sparked a small grass fire near Quaker Street and Golden Road in Golden. It was quickly extinguished by emergency responders.

May 23, 2011 – Lightning struck a park ranger's office in Evergreen and destroyed a nearby gasoline storage tank. Damages were estimated at $1,000.

June 6, 2012 – Lightning struck a home in Lakewood, causing extensive electrical damage. Damages were estimated at $20,000.

July 7, 2014 – A man in Arvada was injured by a nearby lightning strike while he recorded a video of a thunderstorm with his cell phone. He was standing in his garage, when a nearby lightning bolt knocked him out. He suffered overall body aches and had a ringing sensation in one of his ears.

August 8, 2014 – A man in Evergreen suffered minor injuries when he was struck by lightning, which entered through his finger, traveled down his body, and exited his foot.

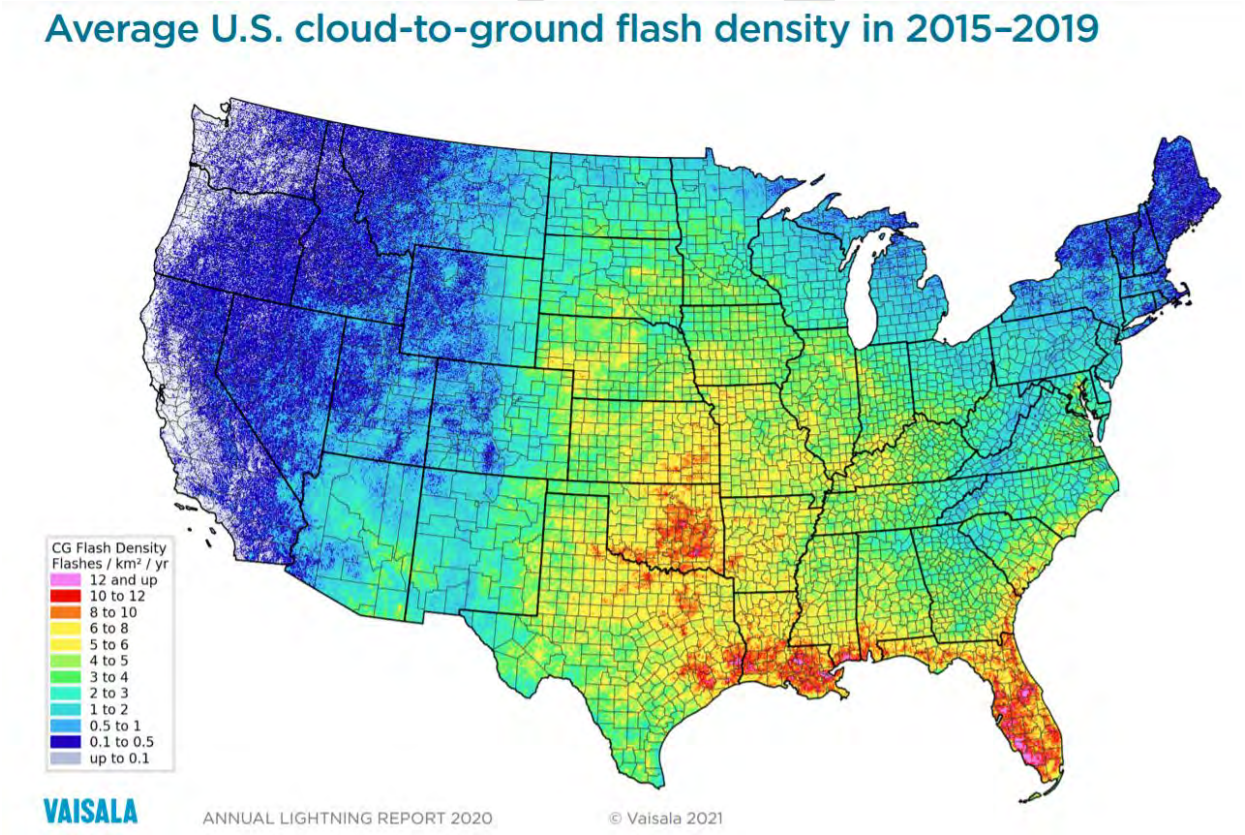
July 19, 2016 – Two men at the Indian Tree Golf Course in Arvada were struck by lightning when they sought shelter beneath a tree during a rapidly developing thunderstorm. One man suffered minor injuries, while the other died from his injuries.

Geographic Extent

The geographic extent for lightning may be examined in two ways. In one regard, 'lightning' is a regional hazard measured by the possible places of occurrence. In the other, 'lightning incidents' refer to single-point occurrences and are measured according to density. Examining the density of the lightning flashes may yield more useful information, particularly when the impacts of the hazard are examined. According to the NOAA, Jefferson County averages 7,000 lightning strikes per year. This results in approximately 8.9 lightning strikes per square mile per year (7000/785 mi^2). Figure 4-41 indicates that, for the most part, Colorado's Front Range experiences an average density rating that is higher than the rest of the state and much of the country. Therefore, while 100% of the planning area is vulnerable to lightning strikes, the density of these single-point occurrences is fairly limited.

Based on this information, the geographic extent rating for lightning is **limited**.

Figure 4-41 Cloud-to-Ground Lightning Density



Source: Vaisala 2020 Annual Lightning Report, **https://www.vaisala.com/sites/default/files/documents/WEA-MET-Annual-Lightning-Report-2020-B212260EN-A.pdf**

Probability of Future Occurrences

As identified earlier, lightning occurs thousands of times a year in Colorado alone. According to information retrieved from NOAA, the planning area receives an average of 8.9 lightning strikes per square mile. This means the planning area, which is 785 square miles in size, experiences an average of 6,987 cloud-to-ground strikes of lightning a year. Knowing that the probability of any lightning event occurring in the future is highly likely helps underscore the importance of increased public education about the hazard. In order to fairly compare the lightning hazard to other hazards in the planning area, the probability of future occurrences for a lightning event that causes damage should also be computed.

The NCEI database is the only available dataset for county-specific lightning incidents that includes property and fire damages. Although this dataset is probably incomplete, it will be used as the source for the probability of occurrence calculation below. If additional lightning data becomes available for Jefferson County, then this section may need to be revisited. However, as all other data sets available reflect information that is consistent with the NCEI effort, the information calculated below is expected to remain fairly consistent with the application of a more comprehensive dataset. There have been 33 NCEI-recorded lightning strikes in Jefferson County since 1995; of these, there were 10 damaging incidents reported in Jefferson County between 1995 and 2020. The methodology for calculating the probability of future occurrences is described in Section 4.3.1. Based on this formula the probability of a damaging lighting strike occurring in any given year is 40%. This corresponds to a probability of future occurrences rating of **highly likely**.

Magnitude and Severity

Impacts for lightning are both direct and indirect. People or objects are directly impacted when struck, or indirectly damaged when the current of the bolt passes through or near the person or object. Other impacts include the ignition of wildfires. The Colorado Division of Homeland Security and Emergency Management estimates that more than half of all forest fires in Colorado are ignited by lightning, in addition to the rangeland and wheat-field fires that lightning causes. Lightning is most likely to cause wildfires during dry conditions or during dry thunderstorms. Records of previous incidents in the NCEI database indicates that most events damage only personal property, and do not significantly impact the availability of critical services or infrastructure, corresponding to negligible severity ratings in both categories. Isolated cases, usually those which trigger large wildfires, have a more significant impact on property damages, but the ratings are still classified as limited.

The National Weather Service Pueblo Lightning Page indicates that between 1980 and 2016, nine people have been killed and 38 people have been injured by lightning strikes in Jefferson County. This equates to 9.1% of all killed and 7.8% of all injured reports for the state. The majority of lightning strikes with casualties for Colorado occurred between the hours of noon and 5:00 pm, peaking between 2:00 and 4:00 pm. This correlates to the times when the population are most exposed, as well: during the temperate summer months, on days where people are most likely to be outside, during peak times of day where outdoor activities are expected to occur. The injury and fatality rates associated with lightning are the greatest indicators of magnitude and severity. It is particularly telling when the flash density of the State is considered. As discussed in the geographic extent section, Colorado experiences an average number of cloud-to-ground strikes when compared to the nation. However, Colorado's injury and fatality ratings are consistently in the top five, or top three when adjusted for population. Therefore, the magnitude and severity of lighting on the population is critical.

Information from the event of record is used to calculate a magnitude and severity rating for comparison with other hazards, and to assist in assessing the overall impact of the hazard on the planning area. In some cases, the event of record represents an anticipated worst-case scenario, and in others, it is a reflection of common occurrence. For lightning, there is no outstanding event of record, so the overall magnitude and severity rating for the County is determined based on the comprehensive discussion of severity contained above. Lightning events typically damage less than 10% of the property in the County. The damages inflicted on critical facilities and services (critical infrastructure) typically result in a loss or disruption of serves for less than 24 hours. While direct impacts may be negligible, the indirect impacts listed above, particularly the link to wildfire ignition, raises the magnitude severity ratings for lightning strikes to **limited**.

Climate Change Considerations

According to the 2018 Colorado State Hazard Mitigation Plan, the future impacts of climate induced lightning in Colorado are still unclear. No clear projected trend in the frequency or intensity of warm-season convective storms has been identified for Colorado. Therefore, the intensity and extent of thunderstorm and lightning events is not projected to change. However, according to studies referenced by the National Lightning Safety Institute, it could be possible globally to see an increase of 10-20% in the incidence of lightning with each degree Celsius of global temperature increase. This could potentially lead to higher frequency of occurrence in Colorado.

Vulnerability Assessment

General Property

It is difficult to quantify where specific losses will occur due to the random nature of this hazard. Given the lightning statistics for Colorado and Jefferson County, the County remains at risk and is vulnerable to the effects of lightning. According to NCEI data, $1.44 million dollars in property damage and $12,000 in crop damage was reported in Jefferson County over a 20 year period.

People

Persons recreating or working outdoors during the months of April through September will be most at risk to lightning strikes. It is difficult to quantify future deaths and injuries due to lightning, other than to note that future occurrences are likely without increased public education.

Critical Facilities and Infrastructure

Critical facilities and infrastructure will have the greatest consequences if damaged by a lightning strike. The effect of wind, combined with lightning, rain and hail, on power delivery is a significant factor when assessing current development exposure. An analysis of this impact is described in the hail vulnerability section. According to the 2018 Colorado State Hazard Mitigation Plan, statewide between 2008 and 2017, the Office of Risk Management (ORM) reported that 48 severe thunderstorm and lightning events damaged state assets. In this timeframe, these events resulted in $1,041,989 in losses, some of which occurred to critical facilities such as within the state correctional system. Forty-five of the 48 events were due to lightning strikes, equating to $1,010,944 of the $1,041,989 in losses. These lightning strikes resulted in damages to building contents such as electric and power equipment connected to the electrical system more than causing structural damage.

Economy

Economic impact of a severe thunderstorm is typically short term. Lightning and high wind events can cause power outages and fires. Generally, long-term economic impacts center more around hazards that cascade from a severe thunderstorm, including wildfires ignited by lightning. Similarly with the previous section, lightning can cause structural damage or damage to electrical systems to private buildings as well as critical infrastructure.

Historical, Cultural, and Natural Resources

According to NCEI data, the average significant lightning strike in Jefferson County occurs every 1.5 years. The strike most likely occurs in the summer, between 12 PM and 5 PM. Thirty-eight percent of damaging lightning strikes cause damage to either property or crops. The greatest losses from lightning result from the secondary hazard of wildfire, which can have cascading impacts on natural resources.

Future Development

New critical facilities such as communications towers should be built with lightning protection measures. As the population continues to increase and the number of people exposed to the hazard increases, it is reasonable to assume that injuries and deaths will also increase proportionately. Construction of lightning shelters at outdoor venues and increased public awareness campaigns may help minimize increased effects of lightning on growing populations.

Overall Hazard Significance

Lightning strikes in Jefferson County have a range of impacts on the planning area. The most serious impacts are the potential for injuries and deaths, with the most serious indirect impact associated with wildfire caused by lightning. The geographic extent of the hazard is considered **limited**. The probability of future occurrences is considered **highly likely** and the magnitude/severity for the event of record is **limited**. The HMPC considers the hazard to have a **low** overall impact on the County. Together, this equates to an overall impact rating of **medium**. This rating recognizes that other hazards may be a higher priority for the County or may possess more actionable mitigation solutions, while still addressing the significant threat that lightning poses to personal life safety for the jurisdiction's citizens. This is also consistent with the efforts of the Colorado Division of Homeland Security and Emergency Management to increase lightning safety and awareness.

4.3.13 Severe Winter Storms

Description

The National Weather Service defines a storm as "any disturbed state of the atmosphere, especially affecting the Earth's surface, and strongly implying destructive and otherwise unpleasant weather." Winter storms, then, are storms that occur during the winter months and produce snow, ice, freezing rain, sleet, etc. Winter storms are a yearly occurrence in climates where precipitation may freeze and are not always considered a disaster or hazard. For the purposes of this plan, severe winter storms are those which produce heavy snow, significant ice accumulation, or prolonged blizzard conditions. Disasters occur when the severe storms impact the operations of the affected community by damaging property, stalling the delivery of critical services, or causing injuries or deaths among the population.

Winter storm watches and warnings may be helpful for determining the difference between a seasonal winter storm and a severe winter storm. Warnings are issued if the storm is producing or suspected of producing heavy snow or significant ice accumulations. Watches are usually issued 24 to 36 hours in advance for storms capable of producing those conditions, though criteria may vary between locations. Winter Weather Advisories are issued when a low pressure system produces a combination of winter weather that presents a hazard but does not meet warning criteria. A blizzard warning is issued when conditions are expected to prevail for a period of three hours or longer: sustained wind or frequent gusts to 35 miles an hour or greater; and considerable falling and/or blowing snow (i.e., reducing visibility frequently to less than a ¼ mile).

Heavy snow can immobilize a region, stranding commuters, stopping the flow of supplies, and disrupting emergency and medical services. Accumulations of snow can collapse roofs and knock down trees and power lines. In rural areas, homes and farms may be isolated for days, and unprotected livestock may be lost. The cost of snow removal, damage repair, and business losses can have a tremendous impact on cities and towns. Heavy accumulations of ice can bring down trees, electrical wires, telephone poles and lines, and communication towers. Communications and power can be disrupted for days until damages are repaired. Even small accumulations of ice may cause extreme hazards to motorists and pedestrians.

Some winter storms are accompanied by strong winds, creating blizzard conditions with blinding wind-driven snow, severe drifting, and dangerous wind chills. Strong winds with these intense storms and cold fronts can knock down trees, utility poles, and power lines. Blowing snow can reduce visibilities to only a few feet in areas where there are no trees or buildings. Serious vehicle accidents can result with injuries and deaths.

Winter storms in Jefferson County, including strong winds and blizzard conditions, may cause localized power and phone outages, closures of streets, highways, schools, businesses, and non-essential government operations, and increase the likelihood of winter-weather related injury or death. People may be stranded in vehicles or other locations not suited to sheltering operations or isolated from essential services. A winter storm can escalate, creating life threatening situations when emergency response is limited by severe winter conditions. Other issues associated with severe winter storms include the threat of physical overexertion that may lead to heart attacks or strokes. Snow removal costs can pose significant budget impacts, as can repairing the associated damages caused by downed power lines, trees, structural damages, etc. Heavy snowfall during winter can also lead to flooding or landslides during the spring if the area snowpack saturates soils and melts too quickly.

Geographic Extent

Winter storms are a yearly feature of the Colorado climate and may occur anywhere in Jefferson County. Generally, severe winter storm events are considered regional, which implies the storms impact multiple counties simultaneously, often for extended time periods. It is possible for the geographic extent of the hazard to vary significantly within a single county- a regional storm may directly impact only a small portion of the planning area while still extending over a large portion of the surrounding area. However, even in these instances, the impacts and effects of a regional hazard are still felt within the planning area. Therefore, while the percent of the planning area directly affected ranges from less than 10% to 100% depending on the specific circumstances, if any portion of the planning area is impacted by the storm, then the entire planning area suffers indirect impacts.

Based on this information, the geographic extent rating for severe winter storms is **extensive**.

Previous Occurrences

According to the National Centers for Environmental Information (NCEI) database, there were 274 events reported as impacting Jefferson County over the 20-year period between 2000 and 2020. Events included anything categorized as Blizzard (4 events), Heavy Snow (64 events), or Winter Storm (206). Many of these events impacted multiple counties and spanned several days. Several notable events for the planning area are summarized below.

March 6, 1990 – Winds gusting up to 58 mph and heavy snow whipped into drifts 3 to 4 feet deep pummeled the Metro Denver Area. Streets and highways became impassable as many stores and schools closed. Police and National Guard rescued hundreds of stranded motorists, including the Governor who was stranded on Highway 36. An airliner with 82 passengers aboard skidded off a runway at Stapleton International Airport. Snowfall totaled 18 to 50″ in the foothills and between 9 to 24″ west of Interstate 25, including most of urbanized Jefferson County.

March 8 - 9, 1992 – A springtime blizzard struck the Metro Denver Area with snowfall amounts of up to a foot and a half blown in on north winds at speeds of 30 to 40 mph with gusts as high as 52mph. Many roads were closed including Interstate 70 east of Denver and Interstate 25 north and south of Denver. Many homes and businesses lost power.

October 24-25, 1997 – One of the worst blizzards of the 1990s dumped 14 to 31 inches of snow across the Metro Denver Area. The heaviest snow occurred in the foothills west and southwest of Denver, including in Jefferson County, where 2′ to 4′ of snow were measured. Sustained winds of 40 mph with gusts as high as 60 mph reduced visibilities to zero and produced extremely cold wind chill temperatures of -25°F to -40°F. The strong winds also piled snow into drifts ranging from 4′ to 10′ deep. Several major roads and highways were closed as travel became impossible and Red Cross shelters were set up for hundreds of stranded travelers forced to abandon their vehicles. Two people were severely injured and five people were killed as a direct result of the event. At Denver International Airport, 4,000 travelers were stranded when the airport was forced to close, and air carriers estimated losses at $20 million ($26.7 million 2009 dollars). Snowfall totaled 21.9″, setting a new 24-hour snowfall record of 19.1″ for the month.

March 17 - 20, 2003 – A major snowstorm dumped more than 2′ of snow in the Rocky Mountain Region, which closed highways in Colorado and wide sections of Wyoming. Wind gusts of 30 mph reduced visibility across Denver, including the main boulevard leading to Denver International Airport, stranding travelers at the airport and along the roadways. Avalanche warnings were issued for Colorado mountainous areas where up to 29″ of snow fell. Upwards of 8′ of snow were reported in the Evergreen and Conifer areas of Jefferson County by members of the HMPC. This late season snowstorm stranded hundreds of people and resulted in a Presidential Emergency Declaration to help ease the burden of clean-up costs, which amounted to more than $8 million. The insurance industry estimates this blizzard to be the most costly winter storm in Colorado history, reporting at least $93.3 million ($131.2 million in 2020 dollars) in claims. Jefferson County was designated for emergency public assistance from this event. Figure 4-42 shows the distribution and snow totals in inches for the storm for the County and surrounding areas.

December 2006 – Back-to-back major storms occurred the third and fourth weeks of the month of December across the Front Range and Eastern Colorado. Heavy snow accumulated over three feet deep in some areas. Strong wind drifted the snow into 12′ to 20′ drifts and thousands of animals in the eastern plain were stranded from shelter and food by the snow. Travel was hampered for days in the hardest hit areas, including the Denver International Airport. Combined, these events qualified for a Presidential Emergency Declaration to assist communities with costs in the aftermath. Jefferson County was designated for public assistance after the first storm.

April 16, 2008 – Storm totals ranged from 9″ to 13″. A storm system brought heavy snow to parts of the North-Central Mountains, Front Range Foothills and Palmer Divide. The heaviest snow fell mainly south of the Interstate 70 corridor. Storm totals in the mountains and foothills ranged from 8″ to nearly 15″.

January 12, 2009 – A fast moving storm system brought heavy snow to the foothills of Boulder and Jefferson Counties as well as the western and southern suburbs of the metropolitan Denver. The storm

resulted in multiple accidents along the Urban Corridor. In the foothills storm totals ranged from 6 to 8″. In the suburbs, Lakewood reported 8″, with variances across the area ranging from 4.5 to 11″.

March 26, 2009 – At Denver International Airport, hundreds of flights were canceled. In addition, schools throughout the region were shut down and many roads closed due to multiple accidents. Dozens of vehicles slid off Interstate 25 and an accident between Fort Collins and Cheyenne, Wyoming involved up to 75 vehicles. Portions of U.S. Highway 36, between Denver and Boulder, were also closed during the day. The Red Cross opened six shelters for stranded motorists. Snow totals in and near Jefferson County averaged 11.5 inches.

May 11-12, 2014 – A strong storm system moved from southwest Colorado and produced heavy snow over the Front Range and adjacent plains. The snow was heaviest over the Front Range foothills where up to 2-1/2 feet of snow was observed. In the mountains and foothills, storm totals included: 12 inches at Arapahoe Ridge and Columbine; 11 inches at Evergreen and Fremont Pass. Along the urban corridor and Palmer Divide, storm totals included: 10 inches at Ken Caryl; 9 inches at Superior; 8 inches near Morrison; 7 inches in Denver, near Franktown, Golden, Lakewood and Highlands Ranch; 6 inches, 5 miles northeast of Westminster, 7 miles south of Lyons, near Parker and Shaw.

April 15-17, 2016 – A powerful spring snowstorm brought heavy, wet snow to areas in and near the Front Range Foothills and Palmer Divide. Storm totals generally ranged from 2 to 4 feet in the Foothills with 1 to 2 feet across the Mountains and Palmer Divide. Front Range Urban Corridor had amounts ranging from 6 to 20 inches with the highest totals across the western and southern suburbs. Numerous but mostly temporary road closures from 1 to 5 hours occurred throughout the storm, including major routes like I-70 and Highway 103 throughout Jefferson County. Snow accumulations totaled 46 inches in Conifer, 42 inches in Genesee, and 29.5 inches near Evergreen. Several hundred flights were reported cancelled at Denver International Airport in this event.

March 13, 2019 – A rare “bomb cyclone” blizzard brought record low barometric conditions to the Denver Metro area, creating widespread blizzard conditions and heavy snow, leading to significant road, school, and business closures.

March 13-14, 2021 – The 4th largest snowstorm in Denver’s recorded history dropped 27.1” of snow in the Denver Metro area, making March 2021 the second snowiest March on record. Overall impacts in Jefferson County were relatively minor, but it took several days to fully clear the roads.

Often, total snowfall is one of the major considerations in tallying a ‘severe’ winter storm. The top ten snowfall storms for the Denver Metro region since 1946, according to the National Weather Association, are listed in Table 4-55. It is helpful to remember that the official reckoning for snowfall in Denver is at the airport (Stapleton Airport until February 1995 and currently at Denver International Airport) and that snowfall totals may actually be higher for Jefferson County, particularly in the western communities.

Table 4-55 Top Ten Snowfall Storms in the Denver Metro Area since 1946

Date	Snowfall in Inches
March 18, 2003	31.8”
November 3, 1946	30.4”
March 13-14, 2021	27.1”
December 24, 1982	23.8”
October 25, 1997	21.9”
November 27, 1983	21.5”
November 19, 1991	21.2”
December 20, 2006	20.7”
March 5, 1983	18.7”
November 19, 1979	17.7”

Source: National Weather Service Weather Forecast Office: Denver/Boulder area

Probability of Future Occurrences

Winter storms are a yearly feature in Colorado, often occurring multiple times each winter, and thus are considered a seasonal feature. In that regard, these hazards are considered a highly likely occurrence. When an event is seasonal and an anticipated element in a given climate, it is also important to examine the probability of future *severe* occurrences of the hazard.

According to the NCEI database, there have been 274 catalogued events over a 20-year period, or approximately 14 events per year. There have been at least 10 incidents of severe winter storms that have resulted in severe impacts to Jefferson County since 1990. The methodology for calculating the probability of future occurrences is described in Section 4.3.1. This formula evaluates that the probability of a severe winter storm occurring in any given is almost certain. This corresponds to a probability of future occurrences rating of **highly likely**.

Magnitude and Severity

The damages caused by severe winter storms and blizzards vary and are dependent on several factors: the duration of the storm; the geographic extent; the time of year; meteorological factors such as wind, moisture content of the snow, ground and air temperatures; and the advance warning of the storm. Impacts from the storm dictate the magnitude of the event, emphasizing that how much snow falls may not always directly correlate to how bad the storm is. Damaged power lines and dangerous or impassable roadways may forestall the delivery of critical services such as medical and emergency assistance, the delivery of food supplies and medications, or even the provision of basic utilities such as heat and running water. When events happen with a long warning time, it is possible to pre-mitigate the effects of insufficient supply levels or to pre-test emergency generators, which may prevent some of the previously described impacts from occurring. Unanticipated storms increase the number of people stranded, both in cars and at public locations, which may increase the number of injuries and deaths attributed to the event (often caused by exposure) and place uneven and unanticipated strains on public sheltering capacities. The weight of the snow, driven by the water content of the fall, increases the potential for damages caused to structures and trees. Lighter snow caused by extreme cold increases the damages caused to livestock, agriculture, and landscaping due to freezing conditions. Winter storms which go through periods of thaw and freeze prolong dangerous icy conditions, increasing the likelihood of frozen and damaged water pipes, impassable or dangerous roadways, damaged communication lines, or more extensive damages to infrastructure and structures caused by seeping water freezing under roofs, porches, patios, inside sidings, or causing damage to vehicles.

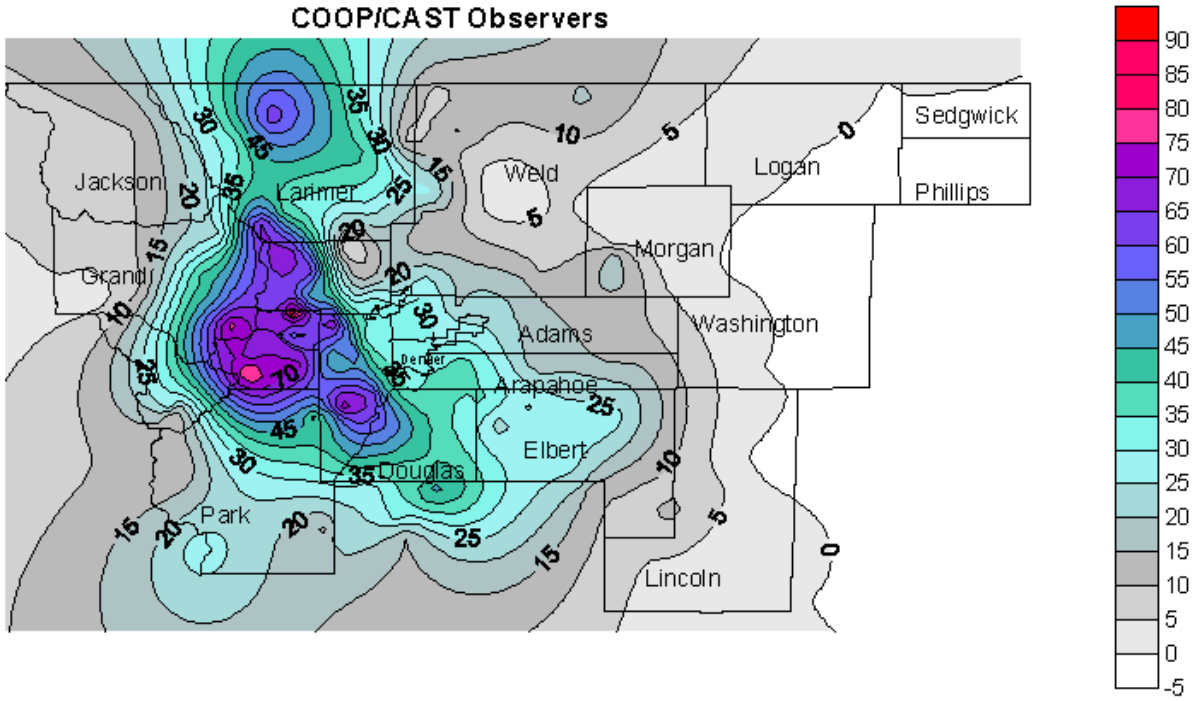
Information from the event of record is used to calculate a magnitude and severity rating for comparison with other hazards, and to assist in assessing the overall impact of the hazard on the planning area. In some cases, the event of record represents an anticipated worst-case scenario, and in others it is a reflection of common occurrence. The most damaging event of record for Jefferson County occurred between March 17 and March 20, 2003. This is distinct from the snowstorm with the greatest amount of snowfall, which occurred from December 1-6, 1913, and officially documented 45.7 inches of snow. In order to reflect the significance of each, both events are considered in developing the severity and magnitude ratings.

As noted, the December 1913 storm snow totals in the metro area were officially recorded at 45.7 inches. Snow totals were even deeper in the mountains, where Georgetown reported 86 inches total. The high winds caused significant drifting which completely blocked all transportation. The Rocky Mountain News reported that one rescue party and eight miners were lost in the storm and thousands more moved into hotels for shelter. The city opened the auditorium and other public buildings to shelter the homeless during the event. Of interesting note, the snow removal costs were considered an economic advantage, citing that over 780 men found employment and at least $700 ($18,300 in 2020) was spent in snow removal costs. The paper also reported that “(m)illions of dollars [in] additional wealth to Colorado were brought yesterday by the snowfall…it rang up the curtain on the 1914 crop outlook, revealing visions of unprecedented prosperity to every line of industry and bountiful harvest to the farmers.”

The March 17-20, 2003 snowfall in the metro area was officially tabulated at 31.8 inches, though up to eight feet of snow was reported in the Evergreen and Conifer areas. Detailed snowfall totals across the

region from this event are depicted in Figure 4-42. The event damaged huge amounts of infrastructure and property, with insurance losses alone estimated at more than $93.3 million ($131.3 million in 2020 dollars). Insurance losses note that more than 90% of those damages were based on homeowner's insurance claims, and that of the auto insurance claims, most were a result of the vehicle being crushed by the weight of the snow rather than weather-related accidents. The event also resulted in a Presidential Emergency Declaration. The damages inflicted on critical facilities and services (critical infrastructure) resulted in a loss or disruption of services for several days, including power, telephone, and in some cases, heat. Emergency response personnel were hindered from response due to impassible roadways. Documented illnesses and injuries were considered critical, with two serious reported injuries and five directly attributed deaths. The medical response of the region was considered impaired to a limited extent.

Figure 4-42 March 17-20, 2003 Snowfall Totals



Source: National Weather Service Forecast Office: Denver/Boulder CO

Based on these factors, the magnitude severity potential for severe winter storms which may impact Jefferson County are considered **critical**.

Climate Change Considerations

Climate change has the potential to exacerbate the severity and intensity of winter storms, including potential heavy amounts of snow. A warming climate may also result in warmer winters, the benefits of which may include lower winter heating demand, less cold stress on humans and animals, and a longer growing season. However, these benefits are expected to be offset by the negative consequences of warmer summer temperatures.

Vulnerability Assessment

All assets located in Jefferson County can be considered at risk from severe winter storms, although based on historic records they are a higher risk for areas between 6,000 and 9,000 feet and areas higher in the mountain above 9,000 feet. Severe winter storms affect the entire planning area and its jurisdictions including all above-ground structures and infrastructure. Although losses to structures are typically minimal and covered by insurance, there can be impacts with lost time, maintenance costs, and contents

within structures. A timely forecast may not be able to mitigate the property loss but could reduce the casualties and associated injury.

General Property

High snow loads can cause damage to buildings and roofs. Most property damages with winter storms are related to the heavy snow loads and vehicle accidents. Older buildings are more at risk, as are buildings with large flat rooftops (often found in public buildings such as schools). Vulnerability is influenced both by architecture and type of construction material and should be assessed on a building-by-building basis.

People

The threat to public safety is typically the greatest concern when it comes to impacts of winter storms. The highest risk will be to travelers that attempt to drive during adverse conditions. People can also become isolated from essential services in their homes and vehicles. While virtually all aspects of the population are vulnerable to the potential indirect impacts of a winter storm, others may be more vulnerable, such as individuals with access and functional needs, who may become isolated to essential services.

The weight of heavy snowfall and/or ice accumulating on power lines often brings them to the ground, causing service disruptions for thousands of customers. According to data from the U.S. Department of Health and Human Services' emPOWER mapping site, 12,629 of the 115,998 Medicare Beneficiaries in the county rely on electricity-dependent medical equipment such as ventilators to live independent in their homes. In addition, prolonged power outages can also have economic impacts if there is a loss of food in grocery stores and other businesses.

Cold and extreme cold temperatures have been the main cause of winter weather related causalities in the County. Infants, elderly, and the homeless population are most vulnerable to the impacts of extreme cold. Exposure to extreme cold can cause frostbite or hypothermia and, in some cases, even death.

The region can experience high winds and drifting snow during winter storms that can occasionally isolate individuals and entire communities and lead to serious damage to infrastructure. Travelers on I-70 and Highway 285 in the mountainous portions of the planning area, can become isolated and visitors can become stranded, requiring search and rescue assistance and shelter provisions.

Critical Facilities and Infrastructure

Roads are especially susceptible to the effects of a severe winter storm, which can temporarily hinder transportation and require resources for snow removal. As noted under the people section, heavy snow accumulation may also lead to downed power lines not only causing disruption to customers but also have potentially negative impacts on critical facilities in the county which may have cascading impacts on the local governments' ability to operate.

Economy

Closure of major transportation routes during severe winter storms could temporarily isolate communities in Jefferson County and further isolate the more remote areas of the County. Depending on the length of the closure it could also hinder the local economy by disrupting tourism and out of county visitors, and as well as the potential impacts to shipping delays from a closure of I-70. Snow removal costs can also impact budgets significantly.

Power outages may lead to business closures as was seen in the 2019 Bomb Cyclone event with impacts lasting for multiple days in some areas.

Xcel Energy provided data for the number customers within their service area who experienced loss of power supply caused by snow and ice. As with extreme temperatures and wind/hail, Xcel estimates that outages cost the utility approximately $50,000 per 20,000 people affected.

In a typical year (based on historic Xcel data from 2006-2009) utility customers in Jefferson County experience 2 days of service interruption due to snow and ice per year impacting (on average) 48,809 people per outage. FEMA standard values for loss of service for utilities estimate that a power supply

interruption costs the average person $126 per day of service outage. This equates to an average annual loss of $12,299,868 based on power outages due to snow and ice.

Historical, Cultural, and Natural Resources

Natural resources may be damaged by the severe winter weather, including broken trees and death of wildlife. Unseasonable storms may damage or kill plants and wildlife, which may impact natural food chains until the next growing seasons. Most of these impacts would be short-term. As noted previously, older, historic buildings could potentially be more vulnerable to roof and structural damage from heavy snow.

Future Development

Future residential or commercial buildings built to code should be able to withstand snow loads from severe winter storms. Population and commercial growth in the County will increase the potential for complications with traffic and commerce interruptions associated winter storms, as well as increased exposed populations vulnerable to the impacts of a severe winter storm such as power outages or delays in vital services. Future power outages or delays in power delivery to future developments may be mitigated by construction considerations such as buried power lines. Future development will also require future considerations for snow removal capacity including equipment, personnel, logistical support, and planning for snow storage areas. Adequate planning will help establish the cost-effective balance.

Public education efforts may help minimize the risks to future populations by increasing knowledge of appropriate mitigation behaviors, clothing, sheltering capacities, and decision making regarding snow totals, icy roads, driving conditions, and outdoor activities (all of which are contributors to decreased public safety during severe winter storms.) New establishments or increased populations who are particularly vulnerable to severe winter storms (such as those with health concerns or those who live in communities that may be isolated for extended periods of time due to the hazard) should be encouraged to maintain at least a 72-hour self-sufficiency as recommended by FEMA. Encouraging contingency planning for businesses may help alleviate future economic losses caused by such hazards while simultaneously limiting the population exposed to the hazards during commuting or commerce-driven activities.

Overall Hazard Significance

Severe winter storms in Jefferson County have a significant impact on and presence in the planning area. Damages from winter storms are the second highest cause of insurance-related costs and claims for the County. The planning area is subjected to damaged trees and structures, icy and dangerous roadways, and the large costs associated with snow removal and cleanup after severe events. In addition, the hazard is regional in nature, indicating that if the planning area is impacted, it is likely that the planning area's immediate neighbors will also be impacted, reducing the available resources and aid capacities for response and recovery from the event.

The geographic extent of the hazard is considered **extensive**. The probability of future occurrences is considered **likely** and the magnitude/severity for the event of record is **critical**. In addition, the HMPC considers the hazard to have **high** impact on the County. This equates to an overall impact rating of **high**.

4.3.14 Subsidence

Description

The Colorado Geological Survey defines land subsidence as the sinking of the land over manmade or natural underground voids. Subsidence occurs naturally and also through man-driven or technologically exacerbated circumstances. Natural causes of subsidence occur when water in the ground dissolves minerals and other materials in the earth, creating pockets or voids. When the void can no longer support the weight of the earth above it, it collapses, causing a sinkhole depression in the landscape. Often, natural subsidence is associated with limestone erosion, but may also occur with other water-soluble minerals. Man-driven or technology-exacerbated subsidence conditions are associated with the lowering of water tables, extraction of natural gas, or subsurface mining activities. As the underground voids caused by these activities settle or collapse, subsidence occurs on the surface. In Jefferson County, past coal and clay mining activities have created surface subsidence in some areas and created the potential for subsidence in other areas. Any area where past sub-surface mining was documented has some risk of subsidence; however, tracking these areas is difficult. In some cases, coal was “poached” or more coal was removed from an area than would be noted on the mine map. Also, many mines were incorrectly located relative to surface features due to surveying errors. As such, maps of past mine workings and extents may be incorrect, but rough estimates are available.

Extraction of coal and clay from mines in Jefferson County varied based on the location of the material beds and the available technology. Prior to World War II, nearly all mines in the County were worked using the room and pillar mining pattern. In the room and pillar technique, an opening was followed by a shaft that was driven or dug to the layer of coal or clay. Passageways were excavated in the material seam, and rooms were created when the materials were dug out along the original tunnel. The materials were then worked in the direction that correlated to the bed. Between the rooms, pillars of the material were left in place to support the roof of the mine, although sometimes the pillars were replaced with timbers. Subsidence occurs when the stopes collapse, either due to overhead pressure or when the support structures collapse. Other subsidence incidents may occur over air shafts and man shafts. This subsidence forms pits, which may range in diameters of 5′ to 20′ and range in depth from a few feet to 20′, depending on the amount of in-filling which has occurred since the mine was abandoned. Because subsidence incidents are often incomplete, an event may occur multiple times over the same area, increasing the risk and danger of this particular type of subsidence.

Troughs, or long lengths of subsidence, tend to occur over tunnels and slope entries, and may range in length from 10′ to 80′ and in depth from 5′ to 15′ or more. Once they collapse, they present a reduced additional risk, as the subsidence is generally complete along the entire length of the tunnel. Another common form on subsidence in Jefferson County occurs when pits and trenches open over stopes that were extended to, or very close to, the surface during the mining process. These features are particularly evident along the east side of the Dakota Hogback from I-70 north to Coal Creek Canyon and range in length from 10′ to 100′ and in widths of 5′ to 40′. This form of subsidence forms a minimal risk in the planning area, as it occurs in areas where development is highly regulated, but additional risks from these features are documented below. Subsidence over reclaimed land occurs when open pit mines are cosmetically back-filled, but the fill is not as compacted as the enclosing bedrock. When construction on the fill material occurs, the weight causes the fill material to compress more than the bedrock, creating a stress or bending movement in the structure, which can result in significant damage to the structures.

Subsidence may result in serious structural damage to buildings, roads, irrigation ditches, underground utilities, and pipelines. It can disrupt and alter the flow of surface or underground water. Weight, including surface developments such as roads, reservoirs, and buildings and manmade vibrations from such activities as blasting or heavy truck or train traffic can accelerate natural processes of subsidence, or incur subsidence over manmade voids. Fluctuations in the level of underground water caused by pumping or by injecting fluids into the earth can initiate sinking to fill the empty space previously occupied by water or soluble minerals. The consequences of improper use of land subject to ground subsidence can be excessive economic losses, including the high costs of repair and maintenance for buildings, irrigation works, highways, utilities, and other structures. This results in direct economic losses to citizens as well as indirect economic losses through increased taxes and decreased property values.

Geographic Extent

Areas of Jefferson County at risk for subsidence are shown in Figure 4-21on the map of dipping bedrock and subsidence. Coal deposits in Jefferson County were located mostly along the northeastern borders shared with Boulder, Adams, Denver and Arapahoe counties. Known coal mines in the County were confined along a narrow strip of land along Highway 93 from Arvada to approximately the junction with C-470, and then along the C-470 corridor, without known extent into the northeastern portion of the coal field. As such, the location of inactive coal mines in the County is limited compared to other counties (see Figure 4-43.

Previous Occurrences

Most known areas of potential subsidence in the planning area occur in rural, undeveloped areas and, therefore, have caused no damage. However, there are few records on subsidence. In addition, the planning area exercises specific planning and zoning regulations to minimize the structures permitted on vulnerable lands, as demonstrated in Table 4-57.

While actual events of subsidence are visible throughout the County, extensive research on the hazard produced only one reportable incident. A family housing section built on the Colorado School of Mines campus, located in Golden, suffered damage when subsidence occurred over a reclaimed open-pit clay mine. Though the structures were built with mitigation techniques, differential compaction still occurred. Streets and sidewalks suffered damage, as did the structural integrity of several buildings. This report is contained in a County profile issued in 1978 and additional confirmation of the event, along the fate of the structures and associated damage estimates, are not currently available.

Figure 4-43 Locations of Inactive Coal Mines, State of Colorado

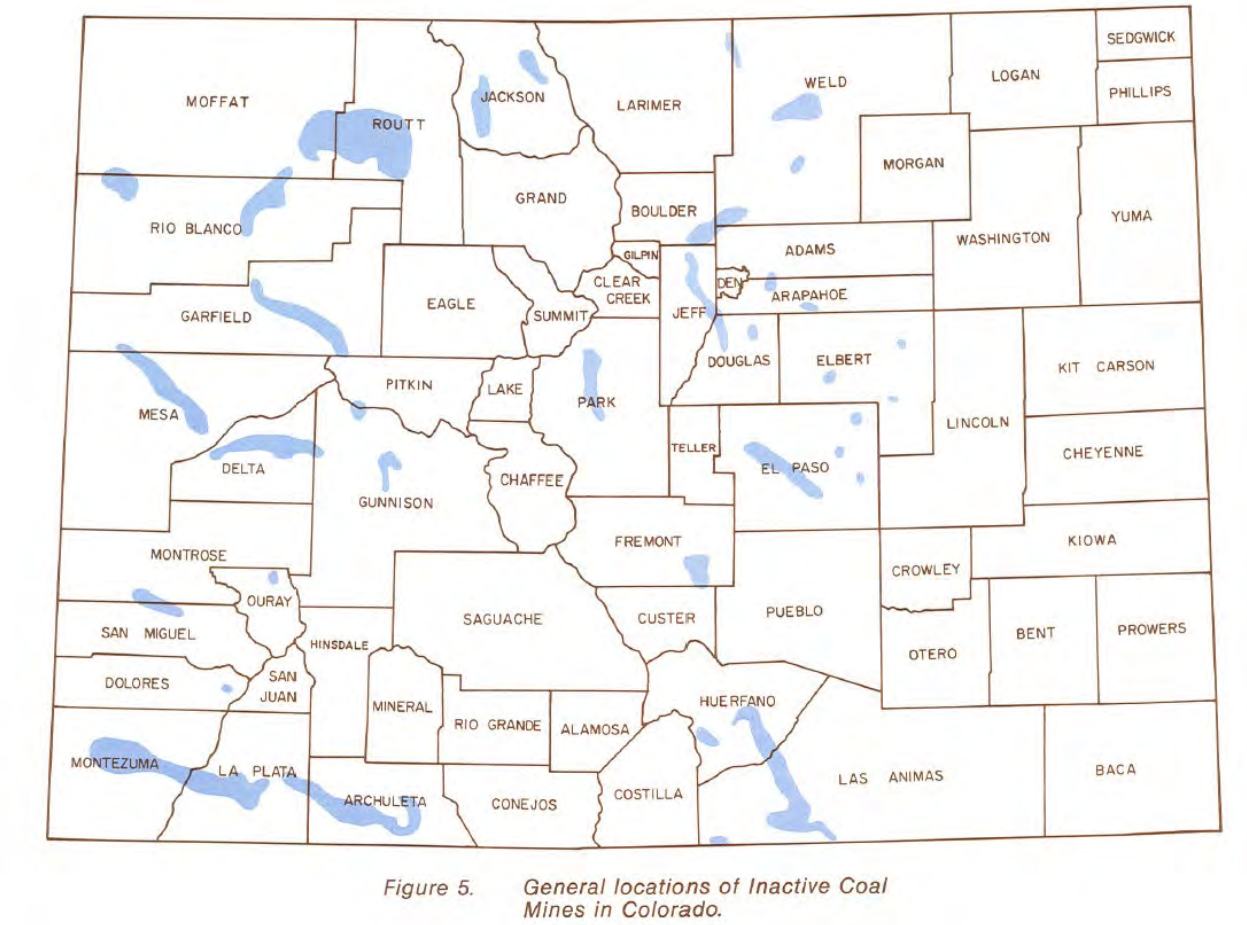


Figure 5. General locations of Inactive Coal Mines in Colorado.

Source: Subsidence above Inactive Coal Mines

According to the State Hazard Mitigation Plan, Jefferson County hosts 48 abandoned coal mines and 100 other types of abandoned mines. According to the Colorado Division of Reclamation and Safety, as of February 2021 there are 111 mine permits in the County and 17 of those permits are active. The majority of the mines permitted, inactive and active, are for sand and gravel, followed by clay, and then aggregate. There is one permitted, but inactive, coal mine in the County in Township 6S 69W.

Figure 4-21 illustrates the areas of suspected or known subsidence for Jefferson County, as determined by the County Geological Hazards data layer. The area, marked brown, only minimally corresponds to the areas of inactive coal mines in the County, and accounts for some subsidence vulnerabilities due to clay mining. Of note is the large area of vulnerability in unincorporated Jefferson County and portions of the City of Arvada, which is located south of Rocky Flats Lake and north of Arvada Reservoir, which extends east from Highway 93. While some of this area is open space, there is residential housing development that has occurred within the suspected area. In Golden, developments along Highway 93 are exposed to the risk as well from the northern edge of the city down until just north of the junction of Highway 93 and Highway 6. In the areas east and north of C-470, subsidence hazard areas are located along several developments along Kipling in Lakewood and the unincorporated County. Other potential subsidence areas are in western Lakewood on the south side of Green Mountain, near the recent Solterra development. This amounts to only a small portion of the total developed landmass in the County - somewhere between 10% and 25%.

Based on this information, the geographic extent rating for subsidence is **limited**.

Probability of Future Occurrences

This assessment was conducted to maintain consistency with other hazards profiled in this planning effort but represents some significant problems. As the data of previous occurrence is skewed, the accuracy of future probability predictions is heavily impeded. In addition, the existing mitigation efforts in the planning area heavily restrict development in subsidence-prone areas, which reduces the number of occurrences that cause damages, and therefore, reduces the number of occurrences that are reported.

There has only been 1 reported incident in Jefferson County that caused property damage since 1978. The methodology for calculating the probability of future occurrences is described in Section 4.3.1. This formula evaluates that the probability of subsidence occurring in any given year is 2.4%. This corresponds to a probability of future occurrences rating of **occasional**.

Magnitude and Severity

The greatest dangers associated with subsidence are related to property damages incurred by the hazard. There are minimal risks to injury and death from unexpected subsidence or accidental exposure to it, but the risk is possible. No injuries or deaths related to subsidence have been reported in the planning area, but the State Hazard Mitigation plan documented two injuries related to subsidence in the state.

Information from the event of record is used to calculate a magnitude and severity rating for comparison with other hazards, and to assist in assessing the overall impact of the hazard on the planning area. In some cases, the event of record represents an anticipated worst-case scenario, and in others, it reflects common occurrence. In this case, there is no event of record for the County related to subsidence. Instead, estimates based on predicted areas of vulnerability are used to complete the assessment for comparison purposes to other hazards profiled in this plan. The developed areas with the greatest vulnerability to known subsidence areas is in the neighborhoods just north and just south of the C-470 corridor on the western border of the urbanized planning area in Lakewood. Widespread subsidence in the area could damage houses, retail facilities, roads, sidewalks, utilities infrastructure, and critical infrastructure facilities located in the area. Such an event would not be expected to impact overall delivery of essential services and functions to the planning area, though the affected community may be affected for weeks as water, gas, power lines, roads, and houses are repaired. If events are severe enough, structures may be deemed unsafe for continued occupancy, forcing residents to relocate. Injuries or deaths are possible, but not expected, in such an event.

Based on these factors, the magnitude severity ratings for subsidence are considered **limited**, based on the dollar amount of property damage incurred.

Climate Change Considerations

Changing climate conditions are not anticipated to affect subsidence.

Vulnerability Assessment

Existing Development

Existing development makes up almost all of the risk to subsidence in the planning area; the hazard rating for subsidence was elevated based on the existing development vulnerabilities and losses. The areas of subsidence vulnerability, as identified earlier in this section, make up a fairly limited area of the County. However, there are areas of Golden, Arvada, Lakewood, and the unincorporated County that are already developed, which means there is exposure to the hazard. Once the land is developed, subsidence mitigation becomes extremely expensive. In addition, poor or inaccurate mapping of former mining efforts may lead to unknown areas of vulnerability which are only discovered after the land is developed, when pre-emptive techniques are unavailable. Vulnerable construction includes roads, homes, business, and landscaped recreational areas. Dangers include damage caused to structures or roads and the secondary impacts such as injuries to occupants or passers-by, the rapid development of deep holes under people or cars which results in injury, death and/or property damage, and the fiscal cost of the damages.

Methodology

GIS was used to create a risk assessment for geological hazards in Jefferson County. Subsidence hazard data was overlaid on Jefferson County parcel and assessor's data. For the purposes of this analysis, a GIS layer of address points was used to identify potential structures exposed to the hazard, combined with parcel-based information. Subsidence hazard data was then overlaid on the address points. If the address point intersects the hazard layer, the hazard is assigned for the entire parcel. The model assumes that every parcel with a structure value greater than zero is improved in some way. Specifically, an improved parcel assumes there is a building. The parcel, its improvement value and estimated content value are listed in Table 4-56 and Table 4-57.

Results are sorted by occupancy type and by jurisdiction to demonstrate how the hazard's risk varies for all property types across the planning area. According to this analysis, all jurisdictions have seen an extremely large increase of exposed properties to subsidence since 2016. Over $38 billion of total structure value is exposed to subsidence. This is a 50-fold increase from $750 million of total value of exposed properties in the 2016 plan. It is difficult to estimate potential losses beyond this exposure analysis, however these values are included as a reference. Unincorporated jurisdictions have the greatest exposure to the hazard, with a total of nearly $17 billion of exposed structure total value and over 67,000 persons. Arvada also surpassed Golden with greater total value exposure to subsidence since the 2016 plan. This analysis does not account for site investigations or mitigation that may have occurred during subdivision development.

Table 4-56 Improved Properties Exposed to Subsidence in Jefferson County

Jurisdiction	Improved Parcels	Building Count	Improved Value	Content Value	Total Value	Population
Arvada	11,116	11,411	$4,468,492,106	$2,401,836,700	$6,870,328,806	27,850
Golden	5,134	6,221	$3,272,708,675	$2,320,286,196	$5,592,994,871	12,277
Lakewood	14,172	14,987	$5,559,542,300	$3,055,937,501	$8,615,479,801	33,231
Littleton	730	730	$323,311,784	$161,655,892	$484,967,676	2,206
Morrison	155	188	$65,397,995	$42,503,428	$107,901,423	279
Unincorporated	26,264	27,162	$10,899,622,635	$6,010,852,181	$16,910,474,816	67,445
Total	**57,571**	**60,699**	**$24,589,075,495**	**$13,993,071,898**	**$38,582,147,393**	**143,289**

Source: Jefferson County GIS

Table 4-57 Improved Properties Exposed to Subsidence in Jefferson County by Building Type

Jurisdiction	Property Type	Improved Parcels	Building Parcels	Total Value	Population
Arvada	Agriculture	1	1	$3,146,514	
	Commercial	75	120	$299,008,526	
	Exempt	16	20	$135,097,064	
	Industrial	26	28	$107,768,630	
	Mixed Use	9	12	$60,680,674	
	Residential	10,989	11,230	$6,264,627,398	27,850
	Total	**11,116**	**11,411**	**$6,870,328,806**	**27,850**
Golden	Agriculture	1	1	$70,874	
	Commercial	261	360	$1,034,458,800	
	Exempt	59	124	$652,011,360	
	Industrial	159	176	$515,077,410	
	Mixed Use	62	79	$225,062,544	
	Residential	4,592	5,481	$3,166,313,883	12,277
	Total	**5,134**	**6,221**	**$5,592,994,871**	**12,277**
Lakewood	Commercial	141	259	$719,468,156	
	Exempt	39	49	$312,706,774	
	Industrial	6	9	$19,943,388	
	Mixed Use	27	31	$40,581,054	
	Residential	13,959	14,639	$7,522,780,430	33,231
	Total	**14,172**	**14,987**	**$8,615,479,801**	**33,231**
Littleton	Commercial	1	1	$1,524,450	
	Exempt	1	1	$3,131,988	
	Residential	728	728	$480,311,238	2,206
	Total	**730**	**730**	**$484,967,676**	**2,206**
Morrison	Commercial	20	36	$13,052,412	
	Exempt	6	6	$19,840,302	
	Industrial	2	2	$1,206,440	
	Mixed Use	8	9	$4,394,704	
	Residential	119	135	$69,407,565	279
	Total	**155**	**188**	**$107,901,423**	**279**
Unincorporated	Agriculture	21	23	$6,921,186	
	Commercial	282	448	$1,256,358,358	
	Exempt	76	99	$431,633,214	
	Industrial	49	110	$230,856,088	
	Mixed Use	27	33	$179,880,956	
	Residential	25,809	26,449	$14,804,825,015	67,445
	Total	**26,264**	**27,162**	**$16,910,474,816**	**67,445**
	Grand Total	**57,571**	**60,699**	**$38,582,147,393**	**143,289**

Source: Jefferson County GIS

*The Assessor's Office values buildings for the specific purpose of valuation for ad valorem tax purposes and values represented do not reflect actual building replacement values.
**The Assessor does not have data about the contents of structures and the contents values shown in the table are not derived from Assessor data but are estimates based upon the structure value using FEMA recommended values.

Table 4-58 displays the critical facilities at risk to subsidence in the planning area. Golden contains the most critical facilities exposed to subsidence with 15, an increase from seven in 2016. Arvada and unincorporated jurisdictions have seven and five critical facilities exposed to subsidence, respectively.

Table 4-58 Critical Facility Exposure to Subsidence

Jurisdiction	FEMA Lifeline	Critical Facility Type	Count
Arvada	Communications	Land Mobile Private Towers	2
	Communications	Microwave Service Towers	2
	Energy	Electric Substation	2
	Energy	Power Plant	1
		Total	**7**
Golden	Communications	Land Mobile Private Towers	4
	Communications	Microwave Service Towers	5
	Food, Water, Shelter	Water Facility	1
	Safety and Security	Government Facility	2
	Safety and Security	School	1
	Transportation	Bridge	2
		Total	**15**
Unincorporated	Communications	Land Mobile Private Towers	3
	Hazardous Material	Tier II	2
		Total	**5**

Source: HIFLD and CERC

Future Development

As noted in the hazard profile section there are areas of western Arvada, Lakewood and unincorporated areas along the highway 93 and 470 corridors that are experiencing growth in and near potential subsidence hazard areas. Subsidence-resistant construction and mitigation efforts during construction are more cost effective than retroactive mitigation efforts and helps prevent damage from occurring. As such, vulnerability to this hazard is not anticipated to increase with new development, provided that land use planning and engineering regulations and practices are followed. Increased efforts to monitor mining operations, increased accuracy of mapping of former mining works, and emphasis on appropriate grading and ground compaction during development will help alleviate vulnerability for future development in unknown areas of risk. In many ways, the efforts of Jefferson County to pre-empt the subsidence hazard (along with the erosion and swelling soils hazards) is a best-practices example for successful mitigation efforts and projects.

Other development that could occur in or near potential subsidence areas include the proposed Northwest Parkway, a segment of a toll road that has been studied and planned for several years to connect E470 and C470 north of Golden and through western Arvada.

Overall Hazard Significance

Subsidence events in Jefferson County have had minimal impacts on the planning area, due in large part to careful land use planning. The geographic extent of the hazard is considered **limited**. The probability of future occurrences is considered **occasional** and the magnitude/severity for the event of record is **limited**. In addition, the HMPC considers the hazard to have a **low** overall impact on the jurisdiction. This equates to an overall impact rating of **medium**.

This rating is based on the current development policies in place in the County, which limit construction in vulnerable areas. If previously unknown areas of subsidence are discovered, particularly in already-developed areas, this assessment may change. In addition, as development continues out and below the areas of mines worked in steep-slope conditions, those properties may experience a higher vulnerability to landslides caused by subsidence in those areas. This information is also addressed in the landslides profile and can be avoided with continued good mitigation practices.

4.3.15 Tornado

Description

Tornadoes are rotating columns of air marked by a funnel-shaped downward extension of a cumulonimbus cloud whirling at destructive speeds of up to 300 mph, usually accompanying a thunderstorm. They can have the same pressure differential that fuels 300 mile wide hurricanes across a path less than 300 yards wide. Closely associated with tornadoes are funnel clouds, which are rotating columns of air and condensed water droplets that unlike tornadoes, do not make contact with the ground.

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

Prior to February 1, 2007, tornado intensity was measured by the Fujita (F) scale. This scale was revised and is now the Enhanced Fujita scale. Both scales are sets of wind estimates (not measurements) based on damage. The new scale provides more damage indicators (28) and associated degrees of damage, allowing for more detailed analysis, better correlation between damage and wind speed. It is also more precise because it takes into account the materials affected and the construction of structures damaged by a tornado. Table 4-59 shows the wind speeds associated with the original Fujita scale ratings and the damage that could result at various levels of intensity. Table 4-59 shows the wind speeds associated with the Enhanced Fujita Scale ratings compared to the original Fujita scale.

Table 4-59 Original and Enhanced Fujita Scales

Fujita Scale		Enhanced Fujita Scale	
F Number	Wind Speed (mph)	EF Number	Wind Speed (mph)
0	40-72	0	65-85
1	73-112	1	86-110
2	113-157	2	111-135
3	158-207	3	136-165
4	208-260	4	166-200
5	261-318	5	201+

Source: National Oceanic and Atmospheric Administration

Tornadoes form when cool, dry air sits on top of warm, moist air. In Colorado, this most often happens in the spring and early summer (i.e., May, June, and July) when cool, dry mountain air rolls east over the warm, moist air of the plains during the late afternoon and early evening hours. However, tornadoes are possible anywhere in the state, at any time of year and at any point during the day.

Tornadoes can cause damage to property and loss of life. While most tornado damage is caused by violent winds, most injuries and deaths result from flying debris. Property damage can include damage to buildings, fallen trees and power lines, broken gas lines, broken sewer and water mains, and the outbreak of fires. Agricultural crops and industries may also be damaged or destroyed. Access roads and streets may be blocked by debris, delaying necessary emergency response. Tornadoes which affect the developed portions of Jefferson County are more likely to cause high dollar damage amounts.

Geographic Extent

Tornadoes are possible anywhere in Colorado, even in mountainous terrain. In 2007, a tornado damaged thousands of trees outside of Woodland Park in Pike National Forest in Teller County. Teller County intersects the southeastern-most corner of Jefferson County. The severe weather conditions that spawn tornadoes are regional events which may impact any extent of the County at a given time, and in this

regard, the possible geographic extent for tornadoes is **extensive**. However, tornadoes as a stand-alone event are single-point (or limited point) occurrences similar to lightning. While knowing that the entire planning area is vulnerable to a tornado, the realistic assessment of tornado occurrences indicates that these single point events occur in a **negligible** density. An average of the two extremes may yield the most likely extent rating.

Based on this information, the geographic extent rating for tornadoes is **limited**.

Previous Occurrences

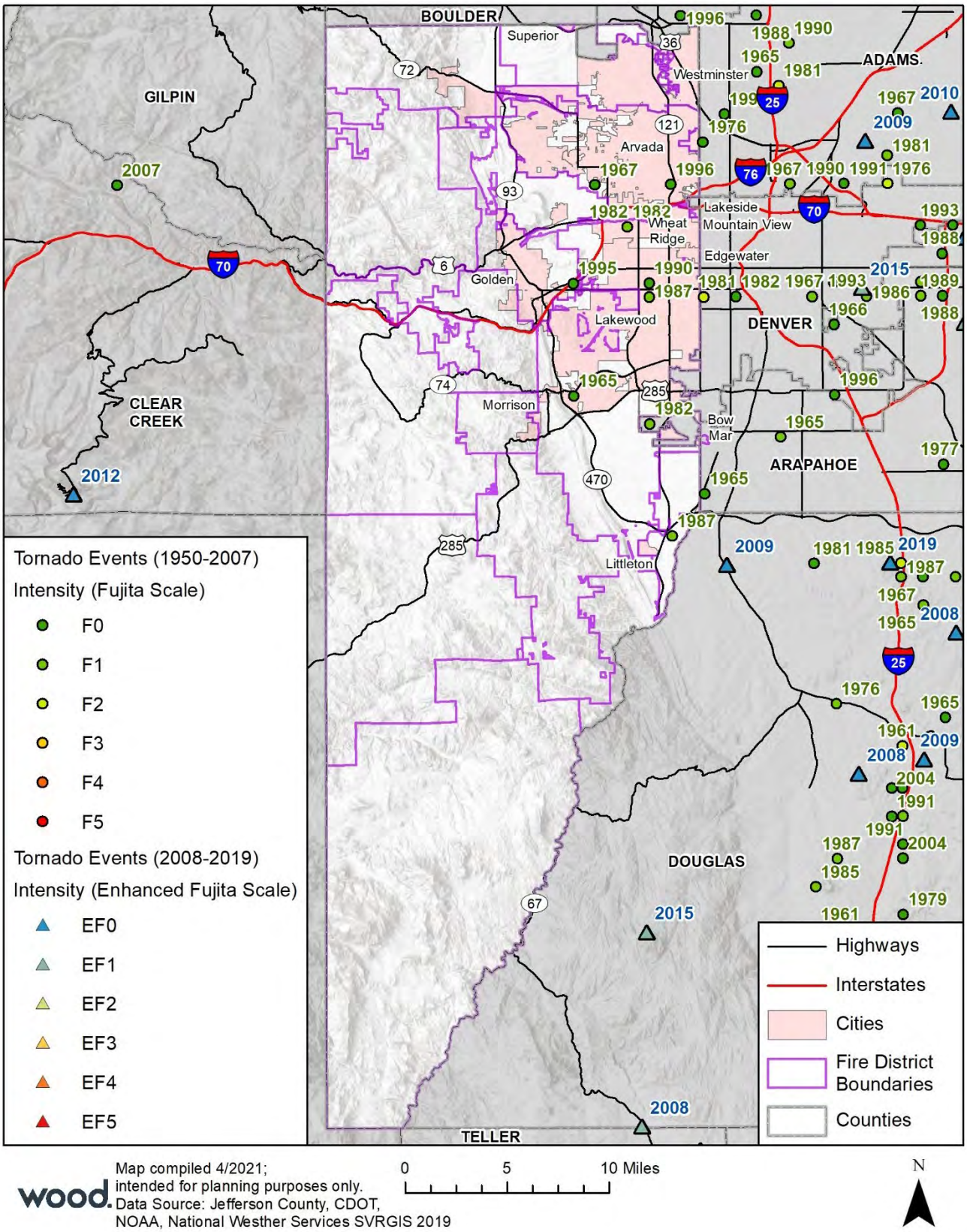
According to the NCEI database, 13 documented tornadoes have occurred in Jefferson County since 1965. The majority of the events were F0 and F1 tornadoes with unknown durations and little to no reported damages. All of the tornadoes have occurred in June and July, with no reported injuries or deaths. A map of previous tornado occurrences in Jefferson County is shown below in Figure 4-44. The following are notable tornadoes that have occurred in or near Jefferson County:

June 3, 1981 – An F2 tornado impacted Jefferson County, touching down just a few blocks east of the Jefferson County line in the City and County of Denver and tracking northeast. This tornado passed over a fairly dense residential area and crossed the US 6 Freeway, causing $2.5 million in damages. Specific details on the duration and length of the tornado were not recorded and specifics regarding the damages were unavailable, but no deaths or injuries were reported.

June 15, 1988 – An F3 tornado touched down in Denver County. The event was reported at 200 yards wide and traveled for 3 miles, causing $25 million in damages. While no one was killed, seven people were injured during the storm.

May 22, 2008 – An F3 tornado estimated at a mile wide at times, traveled for 39 miles across Weld County and into Larimer County, beginning just west of Greeley and extending over the community of Windsor before ending just east of Severance. One man was killed, and more than 75 injuries were reported. With damages estimated at more than $147 million, the storm is one of the most costly disasters in Colorado history. Of special note, Jefferson County provided assistance to the affected communities.

Figure 4-44 Previous Tornado Occurrences in Jefferson County



Probability of Future Occurrences

There have been 13 documented incidents in Jefferson County over the 55 year period since 1965. The methodology for calculating the probability of future occurrences is described in Section 4.3.1. This formula evaluates that the probability of a tornado occurring in any given year is 23.6%. This corresponds to a probability of future occurrences rating of **likely**.

Magnitude and Severity

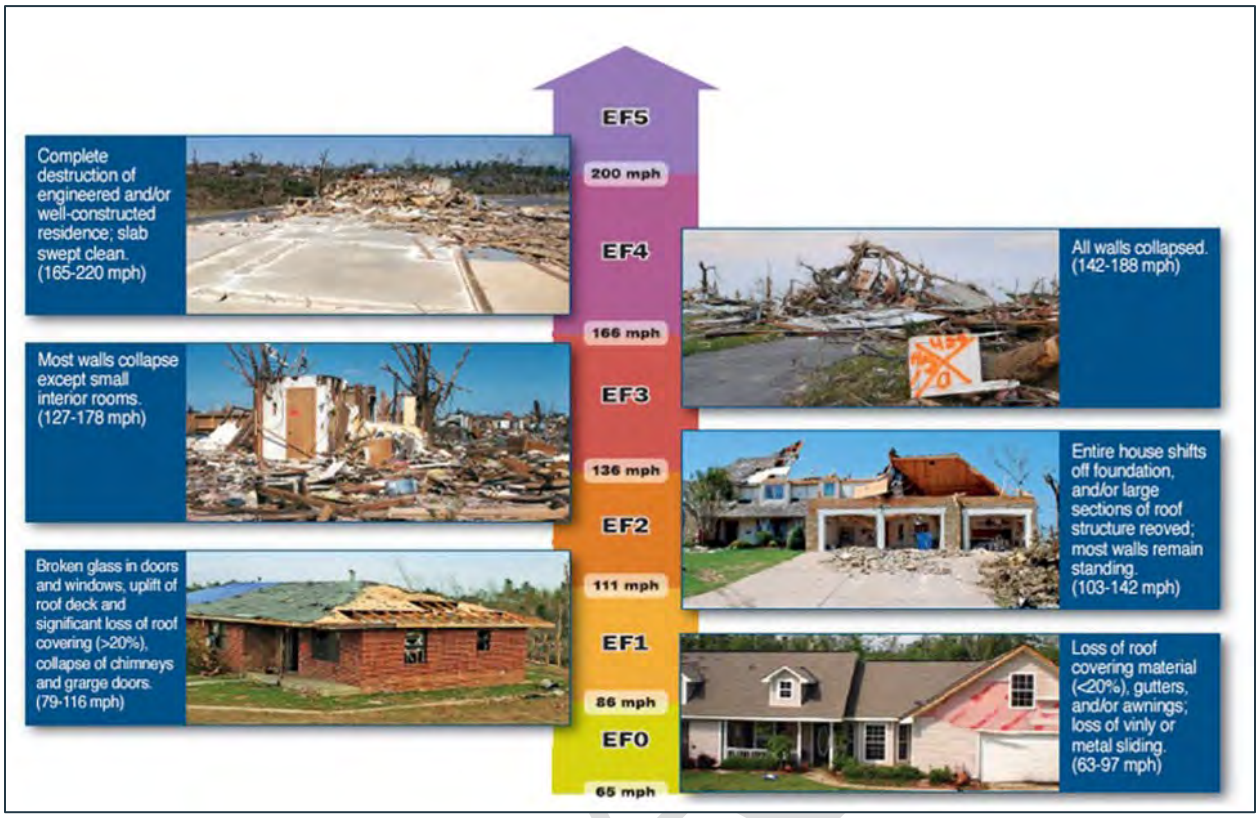
Table 4-60 shows the wind speeds associated with the Enhanced Fujita Scale ratings and the associated damage indicators associated with each rating. Visual examples of the degree of damage which could be expected with each EF rating are shown in Figure 4-45 below.

Table 4-60 Enhanced Fujita Scale with Damage Descriptions

Enhanced Fujita Scale			
Scale	**Wind Speed (mph)**	**Relative Frequency**	**Potential Damage**
EF0	65-85	53.5%	Light. Peels surface off some roofs; some damage to gutters or siding; branches broken off trees; shallow-rooted trees pushed over. Confirmed tornadoes with no reported damage (i.e. those that remain in open fields) are always rated EF0).
EF1	86-110	31.6%	Moderate. Roofs severely stripped; mobile homes overturned or badly damaged; loss of exterior doors; windows and other glass broken.
EF2	111-135	10.7%	Considerable. Roofs torn off well-constructed houses; foundations of frame homes shifted; mobile homes complete destroyed; large trees snapped or uprooted; light object missiles generated; cars lifted off ground.
EF3	136-165	3.4%	Severe. Entire stores of well-constructed houses destroyed; severe damage to large buildings such as shopping malls; trains overturned; trees debarked; heavy cars lifted off the ground and thrown; structures with weak foundations blown away some distance.
EF4	166-200	0.7%	Devastating. Well-constructed houses and whole frame houses completely levelled; cars thrown and small missiles generated.
EF5	>200	<0.1%	Explosive. Strong frame houses levelled off foundations and swept away; automobile-sized missiles fly through the air in excess of 300 ft.; steel reinforced concrete structure badly damaged; high rise buildings have significant structural deformation; incredible phenomena will occur.

Source: National Oceanic and Atmospheric Administration

Figure 4-45 Potential Damage Impacts from a Tornado



Source: National Oceanic and Atmospheric Administration

Information from the event of record is used to calculate a magnitude and severity rating for comparison with other hazards, and to assist in assessing the overall impact of the hazard on the planning area. In some cases, the event of record represents an anticipated worst-case scenario, and in others, it is a reflection of common occurrence. The event of record for Jefferson County is the June 3, 1981 which was an F2. The damages inflicted on critical facilities and services (critical infrastructure) resulted in no loss or disruption of services. Documented deaths and injuries were considered minimal (as none were reported) and the medical response of the County was considered non-impacted. However, $2.5 million dollars of damage ($7.1 million in 2020 dollars) was reported. Based on these factors, the magnitude severity rating for tornadoes is considered **limited**.

Climate Change Considerations

There presently is not enough data or research to quantify the magnitude of change that climate change may have related to tornado frequency and intensity. NASA's Earth Observatory has conducted studies which aim to understand the interaction between climate induced tornadoes. Based on these studies meteorologists are unsure why some thunderstorms generate tornadoes and others don't, beyond knowing that they require a certain type of wind shear. Tornadoes spawn from approximately one percent of thunderstorms, usually supercell thunderstorms that are in a wind shear environment that promotes rotation. Some studies show a potential for a decrease in wind shear in mid-latitude areas. Because of uncertainty of climate induced tornadoes, future updates to the mitigation plan should include the latest research on how the tornado hazard frequency and severity could change. The level of significance of this hazard should be revisited over time.

Vulnerability Assessment

All assets located in Jefferson County can be considered at risk from tornadoes although based on historic tornado paths, the risk for communities in the eastern portion is higher compared to those in western and southern portions of the county which are more mountainous. Most structures, including the

County's critical facilities, should be able to withstand and provide adequate protection from tornadoes rated up to EF4. Those facilities with back-up generators should be fully equipped to handle tornado events should the power go out.

General Property

General damages can be both direct and indirect. Direct damage refers to what the wind event physically destroys. Indirect damage focuses on additional costs, damages and losses from secondary hazards spawned by the event. Depending on the magnitude of the wind events as well as the size of the tornado and its path, a tornado is capable of damaging and eventually destroying almost anything. Construction practices and building codes can help maximize the resistance of the structures to damage. Mobile homes, which are most often occupied by low-income, socially vulnerable residents, are the most dangerous places during a tornado. Studies indicate that 45% of all fatalities during tornadoes occur in mobile homes, compared to 26% in traditional site-built homes (Ashley 2008).

Secondary impacts of damage caused by wind events often result from damage to infrastructure. Downed power and communications transmission lines, coupled with disruptions to transportation, create difficulties in reporting and responding to emergencies. These indirect impacts of a wind event put tremendous strain on a community. In the immediate aftermath, the focus is on emergency services.

People

Community members are the most vulnerable to tornado events. Over the past 70 years there have been no deaths reported in Jefferson County due to a tornado event. During the same time period, there have been no reported injuries from tornadoes. The availability of sheltered locations such as basements, buildings constructed using tornado-resistant materials and methods, and public storm shelters, all reduce the exposure of the population. However, there are also segments of the population that are especially exposed to the indirect impacts of damaging winds and tornadoes, particularly the loss of electrical power. These populations include the elderly or disabled, especially those with medical needs and treatments dependent on electricity. Nursing homes, community-based residential facilities, and other special needs housing facilities are also vulnerable if electrical outages are prolonged, since backup power generally operates only minimal functions for a short time.

Critical Facilities and Infrastructure

Inventory assets exposed to severe wind is dependent on the age of the building, type, construction material used, and condition of the structure. Possible losses to critical infrastructure include:

- Electric power disruption
- Communication disruption
- Water and fuel shortages
- Road closures
- Damaged infrastructure components, such as sewer lift stations and treatment plants
- Damage to homes, structures, and shelters

Because of the unpredictability of wind events' strength and path, most critical infrastructure that is above ground is equally exposed to the storm's impacts.

Economy

Tornadoes can impact exposed critical infrastructure; depending on the impact and the function, this could cause a short-term economic disruption. The most common problems associated with tornadoes and damaging winds are loss of utilities. Downed power lines can cause power outages, leaving large parts of the County isolated, and without electricity, water, and communication. Damage may also limit timely emergency response and the number of evacuation routes. Downed electrical lines following a storm can also increase the potential for lethal electrical shock and can also lead to other hazard events such as wildfires.

Historical, Cultural, and Natural Resources

Damaging winds and tornadoes can cause massive damage to the built and natural environment, uprooting trees and other debris. Historic properties listed on the National Register and the State Register throughout the county may have increased vulnerability to the wind speeds generated by a tornado.

Future Development

As the County continues to develop, the number of people and housing developments exposed to the hazard increases. Proper education on building techniques, strict adherence to building codes, and the use of sturdy building materials, basements, attached foundations, and other structural techniques may minimize the property vulnerabilities. The increased availability of accurate, real-time weather forecasting and alerts the most some protection to both residents and visitors. In some cases, the costs of future mitigation efforts, even in new future development, may outweigh the potential insurance losses; for example, Jefferson County does not generally consider shelters a cost effective mitigation effort in built environments.

Overall Hazard Significance

Historically, tornadoes in Jefferson County do not have a particularly large or frequent impact on the planning area. The geographic extent of the hazard is considered **limited**. The probability of future occurrences is considered **likely** and the magnitude/severity for the event of record is **limited**. In addition, the HMPC considers the hazard to have a **medium** overall impact rating on the County. This equates to an overall impact rating of **medium**.

4.3.16 Wildfire

Description

Wildfires are an annual concern for Jefferson County, potentially causing casualties, fatalities, and environmental damage as well as costing millions of dollars in fire suppression costs. While wildfires can occur year-round in Jefferson County, severe fires are most likely from mid-spring to late fall and are most prominent during the driest summer months of July and August. Fire conditions are impacted by hot weather, vegetation growth, and low moisture content in air and fuel. These conditions, especially when combined with high winds and years of drought, increase the potential for wildfire to occur.

Generally, there are three major factors that sustain wildfires and determine a given area's potential to burn. These factors are fuel, topography, and weather.

Fuel - Fuel is the material that feeds a fire and is a key factor in wildfire behavior. Fuel is generally classified by type and by volume. Fuel sources are diverse, and include everything from dead tree needles and leaves, twigs, and branches to dead standing trees, live trees, brush, and cured grasses. Manmade structures, such as homes and associated combustibles, are also potential fuel sources. The type of prevalent fuel directly influences the behavior of wildfire. Light fuels such as grasses burn quickly and serve as a catalyst for fire spread. "Ladder fuels" are fuels low to the ground that can spread a surface fire upward through brush and into tree tops. These fires, known as crown fires, burn in the upper canopy of forests and are nearly impossible to control. The volume of available fuel is described in terms of fuel loading. Many areas in and surrounding Jefferson County are extremely vulnerable to wildfires as a result of dense vegetation combined with urban interface living.

Another important aspect to know about fuels is the condition of the types of fuels and how that will further fuel or diminish the fire behavior.

Energy Release Component (ERC) is a National Fire Danger Rating System (NFDRS) index related to how hot a fire could burn. It is related to the 24-hour potential worst case total energy (BTUs) released per unit area (square foot) within the flaming front at the head of a fire. Since wind and slope do not enter into the ERC calculation, the daily variations in ERC will be relatively small. Daily variations are due to changes in moisture content of the various fuels present, both live and dead. The ERC is a cumulative or "build-up" type of index. As live fuels cure and dead fuels dry, the ERC values get higher thus providing a good reflection of drought conditions.

1000-Hour Fuel Moisture (1000-hr FM) represents the modeled moisture content in dead fuels in the 3 to 8 inch diameter class and the layer of the forest floor about four inches below the surface. The 1000-hr FM value is based on a running seven-day computed average using length of day, daily temperature, relative humidity extremes (maximum and minimum values), and the 24-hour precipitation duration values.

100-Hour Fuel Moisture (100-hr FM) represents the modeled moisture content of dead fuels in the 1 to 3 inch diameter class. It can also be used as a very rough estimate of the average moisture content of the forest floor from three-fourths inch to four inches below the surface. The 100-hr FM value is computed using length of day, maximum and minimum temperature, relative humidity, and precipitation duration in the previous 24 hours.

Fuel Model G is used for dense conifer stands where there is a heavy accumulation of litter and downed woody material. Such stands are typically over-mature and may also be suffering insect, disease, wind, or ice damage -- natural events that create a very heavy buildup of dead material on the forest floor. The duff and litter are deep and much of the woody material is more than 3 inches in diameter. The undergrowth is variable, but shrubs are usually restricted to openings.

Examples of fuels in Jefferson County include the presence of fine fuels and needle cast combined with the cumulative effects of previous drought years, vegetation mortality, and tree mortality. Forest blowdowns, which are unexplained windfalls that blow down or break numerous trees in an area, are another example. Fuel is the only factor that can generally be addressed by human-driven mitigation.

Topography – An area's terrain and land slopes affect its susceptibility to wildfire spread. Both the fire intensity and the rate of spread increase as slope increases due to the tendency of heat from a fire to rise

via convection. The arrangement and types of vegetation throughout a hillside can also contribute to increased fire activity on slopes. In addition, topography impacts the ability of firefighters to combat the blaze by hampering access for equipment, supplies, materials and personnel.

Weather – Weather components such as temperature, relative humidity, wind, and lightning also affect the potential for wildfires. High temperatures and low relative humidity dry out the fuels that feed the wildfire, increasing the odds that fuel will more readily ignite and burn more intensely. Wind is the most treacherous weather factor. The greater the wind, the faster a fire will spread, and the more intense it will be. In addition to wind speed, wind shifts can occur suddenly due to temperature changes or the interaction of wind with topographical features such as slopes or steep hillsides. Lightning also ignites wildfires, which are often in terrain that is difficult for firefighters to reach. Drought conditions contribute to concerns about wildfire vulnerability. During periods of drought, the threat of wildfire increases. There are no known effective measures for human mitigation of weather conditions. Careful monitoring of weather conditions that drive the activation and enforcement of fire-safety measures and programs, such as bans on open fires, are ongoing weather-related mitigation activities.

The county completed a Community Wildfire Protection Plan (CWPP) in 2012. The CWPP takes an in-depth look at the risk to the county from wildfire, along with actions to mitigate fire vulnerability and impacts. Additionally, the following communities and fire protection districts have completed CWPPs; those plans marked with an asterisk are in the process of being updated as of March 2021:

- City of Golden (2007)*
- Coal Creek Canyon Fire Protection District (2008)
- Elk Creek Fire Protection District (2005)*
- Evergreen Fire Protection District (2020)
- Fairmount Fire Protection District (2007)
- Foothills Fire Protection District (2020)
- Genesee Fire Protection District (2021)*
- Golden Gate Fire Protection District (2011)
- Indian Hills Fire Protection District (2007)*
- Inter-Canyon Fire Protection District (2007)*
- Lower North Fork Fire Protection District (2007)
- North Fork Fire Protection District (2011)
- South Platte (2007)
- West Metro Fire Protection District (2006)*

Insect Infestation

A related threat to forest health with wildfire hazard implications are insect infestations. Increased insect and disease outbreaks among trees are another outcome of the rise in drought conditions in recent decades. Insect infestations can kill trees across wide areas, leading to significant fuel buildup. Dead trees are much more susceptible to burning while the needles are still on the trees; however, once the needles fall off, live trees with needles become a greater hazard than dead needle-free trees.

The Colorado State Forest Service (CSFS) closely tracks insect infestations and their impacts of the health of Colorado forests. The following information is taken from CSFS' 2019 Report on the Health of Colorado's Forests, an extract from which is shown in Figure 4-46.

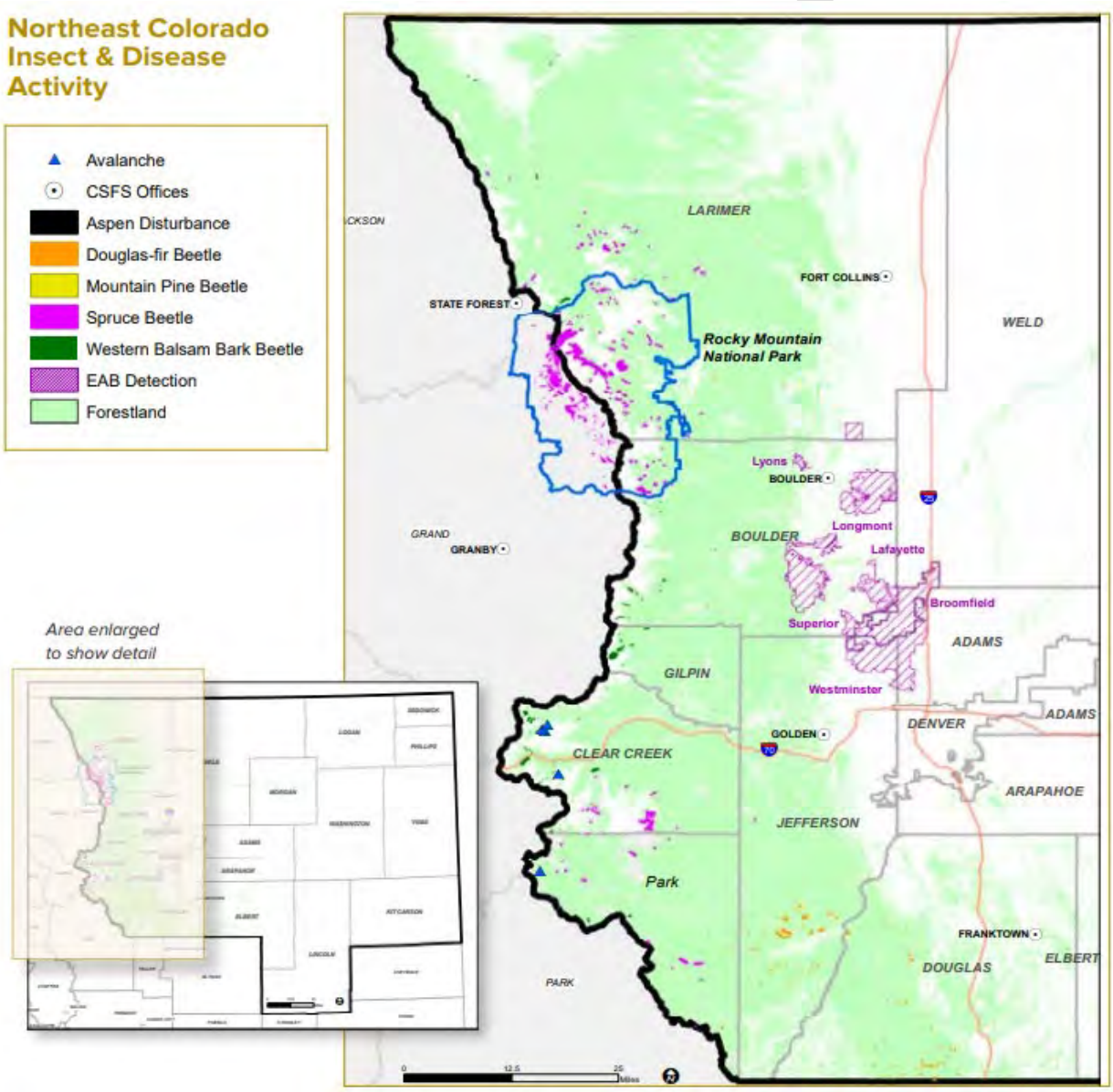
Mountain pine beetle infestations in Colorado began to increase sharply in the early 2000s, reaching a peak from 2008-2013. Infestation levels have declined significantly since then and are no longer considered a major threat in Jefferson County.

Spruce beetle infestations also started to be seen during this period, spiked in the early 2010s, and reached their peak in 2013-2015. The spruce beetle remains Colorado's most widespread and destructive insect pest, infecting 25,000 new acres statewide in 2019; while this is a significant decline from 2013-2015 when 400,000 new acres were infected each year, it remains a significant threat. While spruce beetle infestations are still significant in many surrounding counties, they are not currently a significant threat in Jefferson County.

The Douglas-fir beetle, a close relative of spruce beetle and mountain pine beetle, mainly inhabits overly-dense growths of mature Douglas-fir trees. Approximately 7,400 new acres were infected in 2019, down from 11,000 acres in 2018. As of February 2021 the Douglas-fir beetle is the most active insect threat to the forests of Jefferson County, particularly in the southern portion of the County.

Another emerging concern is the emerald ash borer, which was first detected in Boulder County in 2013, and has begun to spread outside of Boulder County, to include detections in Westminster in 2019. While a significant threat to ash trees, which make up roughly 20% of trees in Colorado's urban communities, it is less of a threat in wildland areas.

Figure 4-46 Colorado Forest Insect and Disease Activity 2019



Source: Colorado State Forest Service 2019 Report on the Health of Colorado's Forests

Geographic Extent

Most of the County is susceptible to wildland fires, with highest risk areas located in the Front Range foothills in western and southern Jefferson County. The Colorado Forest Atlas, formerly known as the Colorado Wildfire Risk Assessment Project (CO-WRAP) is an initiative led by the Colorado State Forest

Service to provide information to the public and wildfire professionals to identify areas in need of wildfire planning, disseminate information, encourage collaboration, plan response actions and prioritize fuels treatments in the state.

The areas of greatest concern for wildfire risk are in the wildland-urban interface (WUI), where development is interspersed or adjacent to landscapes that support wildland fire. While traditionally associated with forested mountain areas, WUI areas are also present in grasslands, prairies, valleys, or in any area where a sustained wildfire may occur and impact developed areas. Fires in the WUI may result in major losses of property and structures, threaten greater numbers of human lives, and incur larger financial costs. In addition, WUI fires may be more dangerous than wildfires that do not threaten developed areas, as firefighters may continue to work on more dangerous conditions in order to protect structures such as businesses and homes. Increased development in WUI areas puts more people and structures potentially at risk. Figure 4-47 shows WUI areas within Jefferson County as determined by the Colorado Forest Atlas. CO-WRAP defines the WUI using housing density data to delineate where people and structures meet and intermix with wildland fuels.

Based on this assessment the geographic extent is classified as **significant**. However, the impacts of major wildfires on air quality can affect much larger areas in and outside Jefferson County.

Figure 4-47 Jefferson County Wildland Urban Interface (WUI) Areas

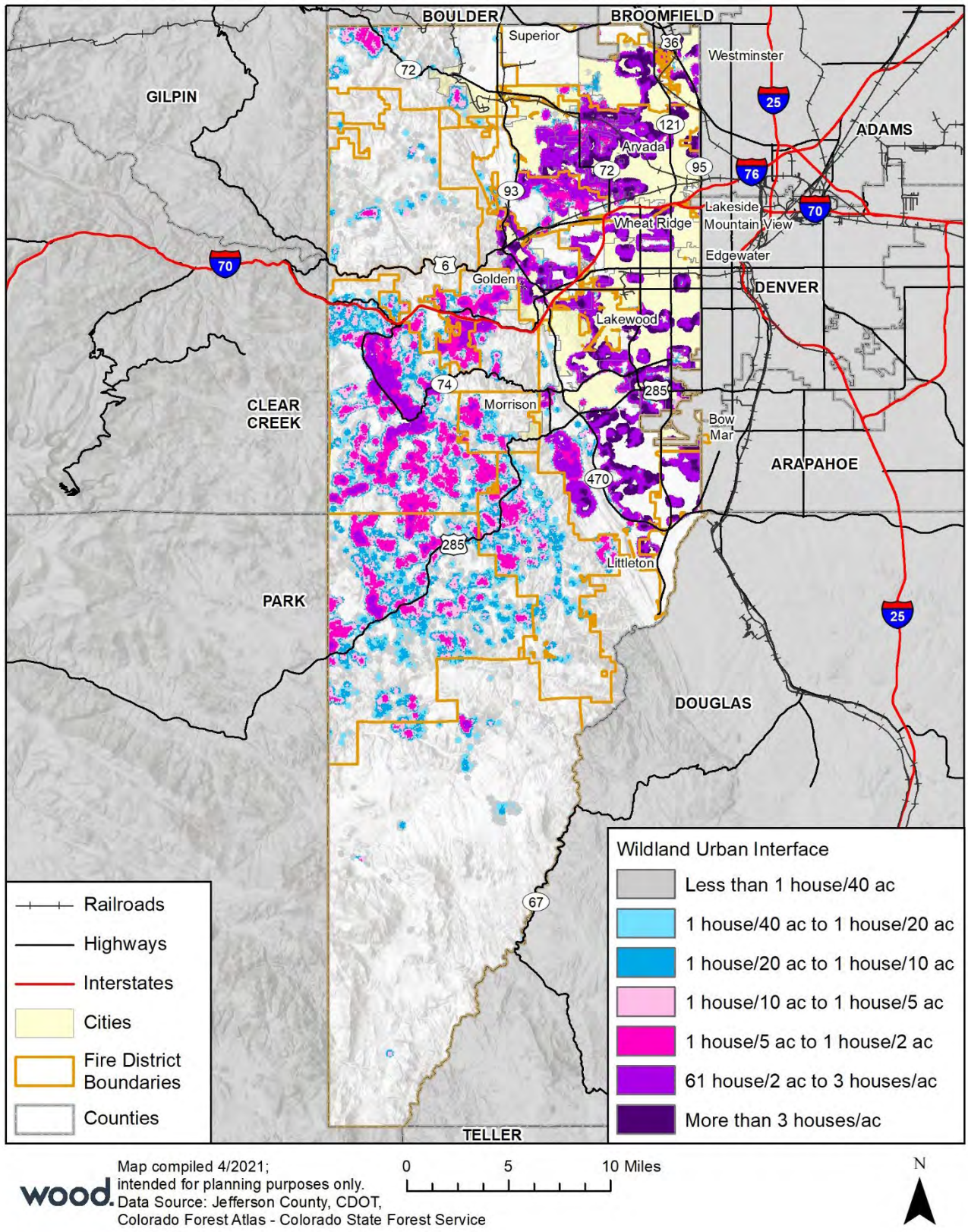
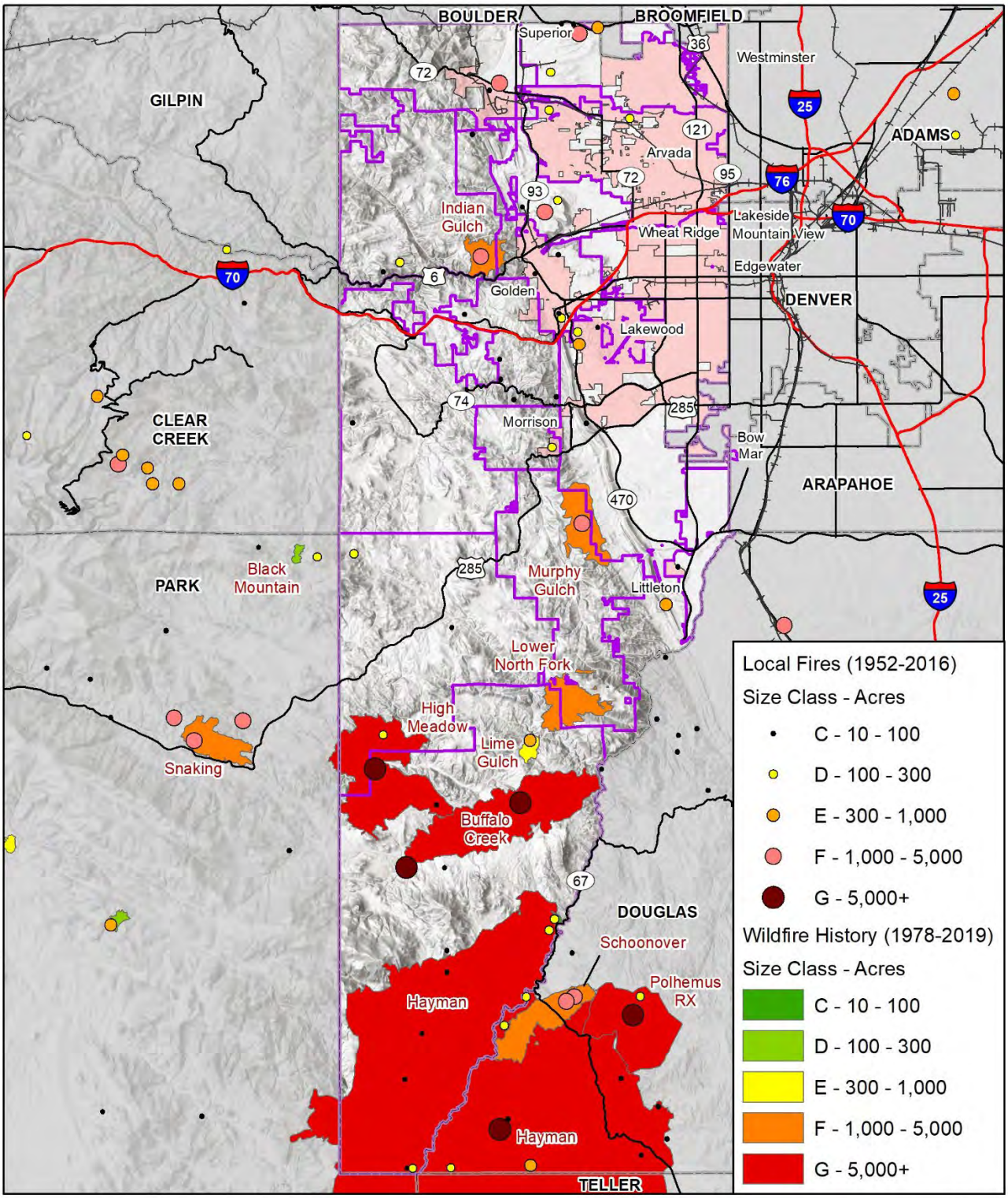


Figure 4-48 Jefferson County Historic Fires, 1952 to 2019



Previous Occurrences

Jefferson County has been impacted by several significant wildfire events, as shown in Figure 4-48. Particularly severe or significant events are profiled below.

September 21-24, 1978 – The Murphy Gulch fire burned approximately 3,300 acres. The first Emergency Fire Fund fire in the Front Range, several structures were lost to the blaze and many subdivisions were evacuated. Interagency resources were ordered to supplement local fire departments. The Federal Type 2 Team took over and managed the closeout. The agencies involved were the Inter-Canyon Fire Protection District (FPD) and Bancroft FPD. The fire burned along the foothills west of the Ken-Caryl Ranch subdivision.

September 7-9, 1988 – The North Table Mountain Fire burned between 1,300 and 2,000 acres. The human caused fire started off CO 93 and crossed the mountain, which threatened subdivisions on east side of mountain. Over 250 firefighters from 20 fire departments, the National Guard, and local law enforcement officers responded, in addition to a helicopter. In many areas, the focus was on structure protection and evacuation. The fire involved the Fairmount FPD as well as a helicopter. The area included the top, west, and east sides of North Table Mountain.

April 23-24, 1989 – The Mt. Falcon fire burned approximately 125 acres. The fire burned in open space properties, which lead to the voluntary fire reimbursement program by the County open space agencies to local fire departments to support the initial attack of the burn.

March 24-25, 1991 – The O'Fallon fire burned approximately 52 acres. Though small in comparison to other fires in this record, the fire occurred in the Denver Mountain Parks' open space areas, which lead to 100 firefighters from 5 different departments responding. Dry winter conditions, gusty winds, and limited access slowed the control efforts, underscoring the role of weather and terrain in fire response.

May 14-15, 1991 – The Elk Creek fire in the Golden Gate FPD burned 102 acres. The steep terrain with limited access led to the use of hand crews formed from 80+ firefighters from 15 departments and ranging across multiple counties. The fire was managed jointly by the FPDs and the Jefferson County Sheriff's Office's newly formed Incident Management Group (IMG).

July 9-11, 1994 – The Carpenter Peak/Chatfield fires each burned small amounts. The fires were caused by dry lightning, as part of a larger fire bust that sparked across the entire Front Range. These particular fires resulted in evacuations from Roxborough Park, and involved 300 firefighters, 40 engines, and National Guard helicopters.

May 18-25, 1996 – The Buffalo Creek fire burned approximately 10,400 acres. High winds caused extreme fire behavior, leading to a 10 mile run in only six hours. 10 homes or other outbuildings were lost. This fire marked the first large WUI fire in the Front Range. Costs for the fire were estimated at $3,835,000.

June 27 – July 5, 1998 – The Beartracks fire burned 500 acres. Heavy fuel loading in roadless area and human caused fire leads to heavy initial attack and extended attack by local fire agencies along with air resources. The fire posed a threat to the Upper Bear Creek drainage area and numerous homes. The Federal Type 2 Incident Management Team (IMT) relieved the IMG on day 3 and managed to closeout.

June 12-25, 2000 – The Hi Meadow fire, caused by humans, fell under initial attack by the local FPD and burned approximately 10,800 acres. The fire 'blew up' on the same day as the 10,000 acre Bobcat fire in Larimer County, causing a Front Range-wide stress on resources. 52 homes were lost along with other miscellaneous structures. This fire was considered the "benchmark" WUI fire for Colorado until the Hayman fire in 2002. The fire burned from Burland Ranchettes on the west to Colorado Highway 126 on the east, and south to the Buffalo Creek Fire burn area and the town of Pine.

The Bobcat Fire also lasted several days and was started by a campfire, though the area had a long history of fire, included several caused by lightning. The control costs were estimated at $3.5 million ($4.3 in 2008) with no private losses, but the fire heavily impacted the watershed and water quality in the surrounding communities. The concurrence of the two fires is significant due to the strains caused on the regional resources and mutual aid capabilities.

2002 Fire Season

The 2002 fire season is the most severe fire season on record in the state of Colorado and in particular for Jefferson County and the Front Range communities. 2002 was one of the most severe droughts on record in Colorado. During 2002, total suppression costs for the fires exceeded $152 million. 3,409 fires were documented during the year for a cumulative total of 244,252 burned acres. This is the highest number of fires in any year in Colorado since 1990 and accounted for more than three times as many burned acres as the next-largest recorded damages for one season. More than 16,500 firefighters responded to the events. Nine firefighters were killed during the year, and one air tanker and one helicopter were lost, killing three additional people. 384 homes were lost statewide, with an additional 624 structures lost.

Four of the fires that Jefferson County suffered during this year resulted in Fire Management Assistance Declarations: the Schoonover, Black Mountain, Snaking and Hayman fires. The first three fires burned from the end of April through the end of May, collectively, and the Hayman fire burned for more than a month. These fires are further profiled below, using information provided by the Jefferson County Office of Emergency Management and the 2008 State Hazard Mitigation Plan.

May 20-27, 2002 – Lightning sparked a wildfire near Deckers. Extremely dry conditions and very strong winds the following day allowed the fire to consume 3,860 acres before it could be contained. Thirteen structures were destroyed, including 4 homes.

April 22 – May 2, 2002 – The Snaking Fire burned approximately 3,000 acres. Caused by humans outside of the 'normal' fire season, the event was exacerbated by high winds. The initial and extended attacks were coordinated mostly through Jefferson and Park Counties, with assistance from air resources. The fire threatened numerous homes and burned north of U.S. Highway 285 from Platte Canyon High School to Crow Hill, with 2 lost structures. The NRCS Emergency Watershed Protection Program authorized $72,883 in response and recovery funds.

May 5-11, 2002 – The Black Mountain Fire burned approximately 300 acres. While smaller than the other fires meriting emergency assistance in the County, the heavy fuel loading and steep terrain of the fire led to many difficulties in the suppression efforts. Local agencies from Jefferson and Park Counties responded along with air resources; with additional assistance from Clear Creek County, the United States Fire Service, Elk Creek FPD and the Evergreen FPD. The fire posed major threats to multiple subdivisions in Conifer and Evergreen and burned north of Conifer Mountain and south of Brook Forest. One injury was reported.

May 21-31, 2002 – The Schoonover Fire was caused by lightning and burned approximately 3,000 acres. Initially under attack by USFS and local FPDs, the fire 'blew up' on the second day to make a 3,000 acre (four mile) run in steep terrain. The fire threatened homes, camps, businesses, watersheds, regional power lines, and other structures. 12 structures and 1 bridge were lost and 2 injuries were reported. The burn area included the area immediately south across the South Platte River from Jefferson County and burned from west of Deckers to near Moonridge. The NRCS Emergency Watershed Protection Program authorized $74,951 in response and recovery funds.

June 8 – Mid-July, 2002 – The Hayman Fire burned more than 138,000 acres. The human caused fire expanded on the second day for a historic 19-mile run and 70,000 acres. Multiple evacuations over a two-week period were required as the fire made additional 'runs' in multiple counties. Over 150 homes and structures were lost, and large areas of damage were caused to Cheeseman Reservoir and South Platte Watershed areas. The fire is considered a nationally significant WUI fire for Colorado and the Rocky Mountain region. The fire is the event of record for the planning area. Insured losses were documented at $38.7 million and more than $5.6 million in recovery and response funds from the NRCS Emergency Watershed Protection Program. The Forest Service spent $38 million in suppression costs and projections for rehabilitation were estimated at $74 million.

July 22-24, 2005 – The North Table Mountain Fire of 2005 burned significantly less land than the previous event in 1988, but threatened multiple subdivisions on all sides. The steep terrain allowed the fire to escape the initial attack. Heavy use of air resources facilitated the transition between the initial attacks to structure protection response on the first day. The fire burned the top, east, north, and west sides of Table Mountain outside of Golden and was started by kids playing with fireworks.

April 2, 2006 – Rocky Flats Fire burned 1,200 acres. The fire was started by humans and exacerbated by high winds to cause an outside of 'normal fire season' event. The fire moved through the open space areas of Rocky Flats NWR and the adjacent lands. The rate of spread, flame lengths, and limited access contributed to the fire threatening to cross several roads and endangered multiple subdivisions, businesses, and Rocky Mountain Airport. A multi-county approach, including Jefferson, Boulder, Gilpin, and Adams was requested. Wind conditions prevented the use of air resources. Difficulties with communications and fire management across multiple jurisdictions were documented.

July 21-23, 2006 – The Centennial Cone Fire burned in the no-man's land adjacent to the Golden Gate FPD. The fire, which burned 22 acres, remained entirely contained within the open space park. However, the significant fire activity in steep terrain with no road access during the height of the 2006 national fire season limited the initial attack. The fire threatened U.S. Highway 6 in Clear Creek Canyon and those subdivisions. Limited air resources helped slow the spread of the fire, and an interagency "hotshot" hand crew supplemented local fire resources on the second day for a direct attack. Summer monsoons helped reduce fire danger on day three as the fire was controlled.

March 26-31, 2012 – The Lower North Fork Wildfire south of Conifer scorched a total of 4,150 acres. Strong southwest winds ahead of an approaching cold front produced high to extreme fire danger across the Front Range Foothills and Palmer Divide. As a result, a 50-acre prescribed burn that had been conducted the previous week reignited in the foothills of Jefferson County, southwest of Denver. The strong wind gusts carried embers from the interior of the burn area, across containment lines and into very dry fuels which initiated the wildfire. It then spread into the crowns of the trees and driven by the strong winds, quickly advanced to the northeast onto private lands. Local firefighters immediately responded to the wildfire, but were unable to contain it, due to the extreme winds and dry and abundant fuels. The combination of very strong winds, record warm temperatures, and extremely dry conditions for most of March all contributed to a rapid increase in fire growth during the afternoon of March 26th. A total of 900 homes were evacuated on the 26th. The fire destroyed 27 homes and resulted in the deaths of three local residents. The property damage alone was estimated to be $11 million. The wildfire was not 100 percent contained until April 2nd.

August 15, 2019 – The Deer Creek Canyon Fire burned 25 acres, doing minimal damage but costing $62,000 in fire suppression, incident support, and restoration.

July 14, 2020 – The Elephant Butte Fire burned 51 acres, mostly on Denver Mountain Parks land near Evergreen, resulting in a State Disaster Declaration. Fire suppression, incident support and restoration costs totaled approximately $900,000.

October 11, 2020 – A wildfire started at Pioneer Landscaping property and burned 40+ acres extending towards the western edge of Spring Mesa subdivision with multiple homes in direct line of fire front, necessitating several evacuations. Approximately $10,000 worth of fence was destroyed, but further loss of property was averted by mitigation efforts with the HOA and utilities prior to the event.

February 7, 2021 – A large grass fire driven by high winds and unusually dry conditions burned 446 acres near Bear Creek Lake Park and Fox Hollow Golf Course. No buildings were damaged but evacuation orders were given to residents east of the fire from Owens Lane to Kipling. The fire was suspected to be human caused.

Probability of Future Occurrences

Since 1980 there have been 23 fire incidents in Jefferson County that have burned 10 or more acres. The methodology for calculating the probability of future occurrences is described in Section 4.3.1. This formula evaluates that the probability of a severe wildfire occurring in any given year is 57.5%. This corresponds to a probability of future occurrences rating of **likely**.

Magnitude and Severity

Wildfire is a significant natural hazard in Jefferson County. The wildland-urban interface is especially at risk as decades of fire suppression have resulted in large concentrations of downed timber and fuels. This problem is exacerbated by the significant amount of residential development in the semi-urban and rural portions of the region. Potential losses from wildfire include human life; structures and other improvements; natural and cultural resources; quality and quantity of the water supply; assets such as

timber, range and crop land, and recreational opportunities; and economic losses. Smoke and air pollution from wildfires can be a severe health hazard. In addition, catastrophic wildfire can lead to secondary impacts or losses, such as future flooding and landslides during heavy rains.

The Colorado Forest Atlas calculates a composite risk rating, defined as the possibility of loss or harm occurring from a wildfire. It identifies areas with the greatest potential impacts from a wildfire – i.e. those areas most at risk - considering all values and assets combined together – WUI Risk, Drinking Water Risk, Forest Assets Risk and Riparian Areas Risk. This risk index has been calculated consistently for all areas in Colorado, allowing for comparison and ordination of areas across the entire state. The Wildfire Risk Classes for Jefferson County are shown in Figure 4-49.

The Colorado Forest Atlas also provides an analysis for Wildland-Urban Interface (WUI) risk based on housing density consistent with Federal Register National standards. The location of people living in the wildland-urban interface and rural areas is essential for defining potential wildfire impacts to people and homes. To calculate the WUI Risk Index, the WUI housing density data was combined with flame length data and response functions were defined to represent potential impacts. The response functions were defined by a team of experts led by Colorado State Forest Service staff. By combining flame length with the WUI housing density data, it is possible to determine where the greatest potential impact to homes and people is likely to occur. The range of values is from -1 to -9, with -1 representing the least negative impact and -9 representing the most negative impact. For example, areas with high housing density and high flame lengths are rated -9, while areas with low housing density and low flame lengths are rated -1. Data is modeled at a 30-meter cell resolution, which is consistent with other Colorado WRA layers. WUI Risk for Jefferson County is mapped in Figure 4-50.

The Colorado Forest Atlas also conducts a Fire Intensity Scale (FIS) analysis, which uses fuels, topography and weather as inputs to determine the relative intensity (from Class 1, lowest to Class 5, highest) of a potential wildfire. According to data from the FIS, the majority of the County has at least a moderate intensity rating with the highest potential wildfire intensity areas south of Littleton and north of the Strontia Springs Reservoir in the Pleasant Park Corridor, see Figure 4-51.

Figure 4-49 Jefferson County Wildfire Risk

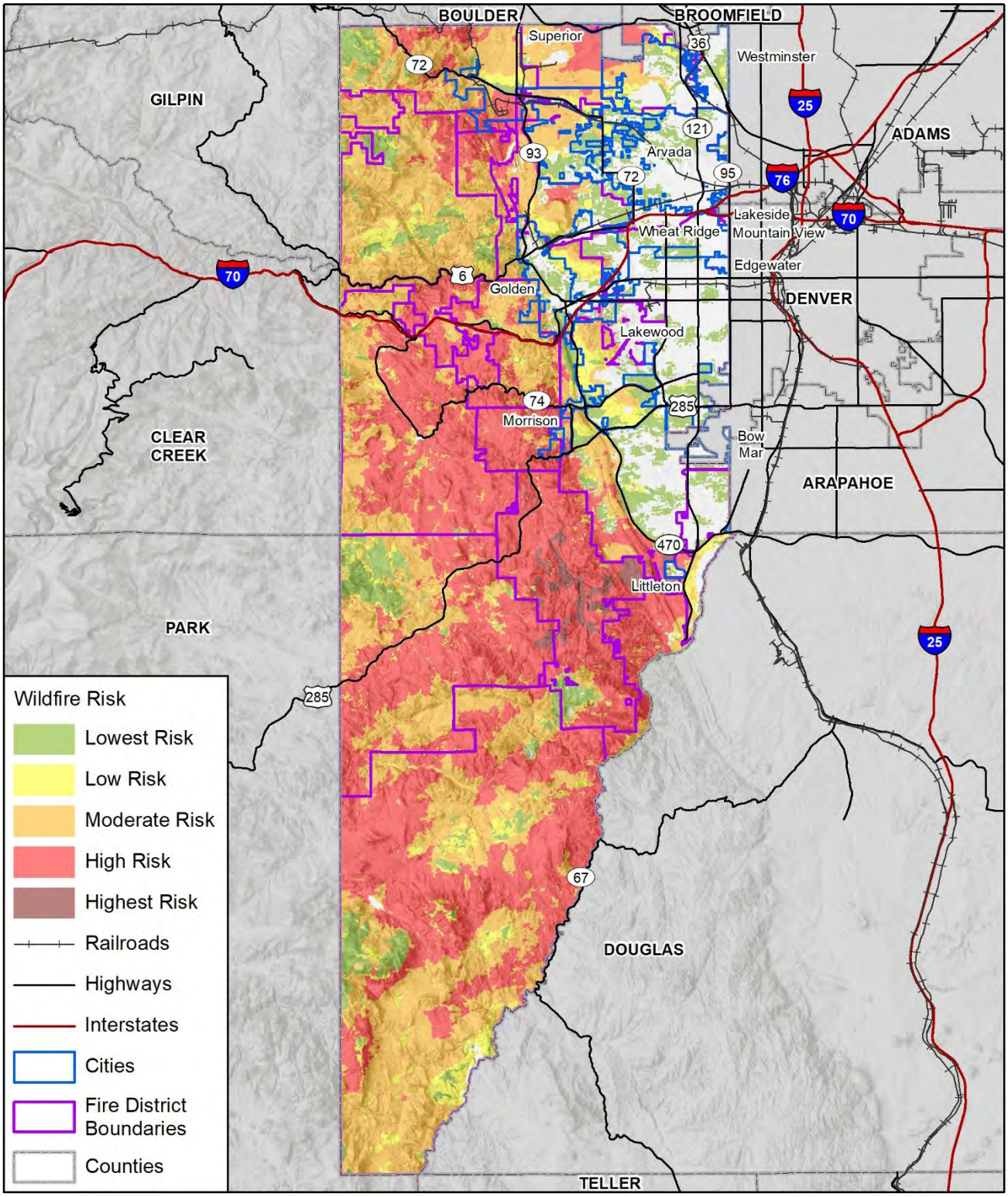


Figure 4-50 Jefferson County WUI Communities and WUI Risk

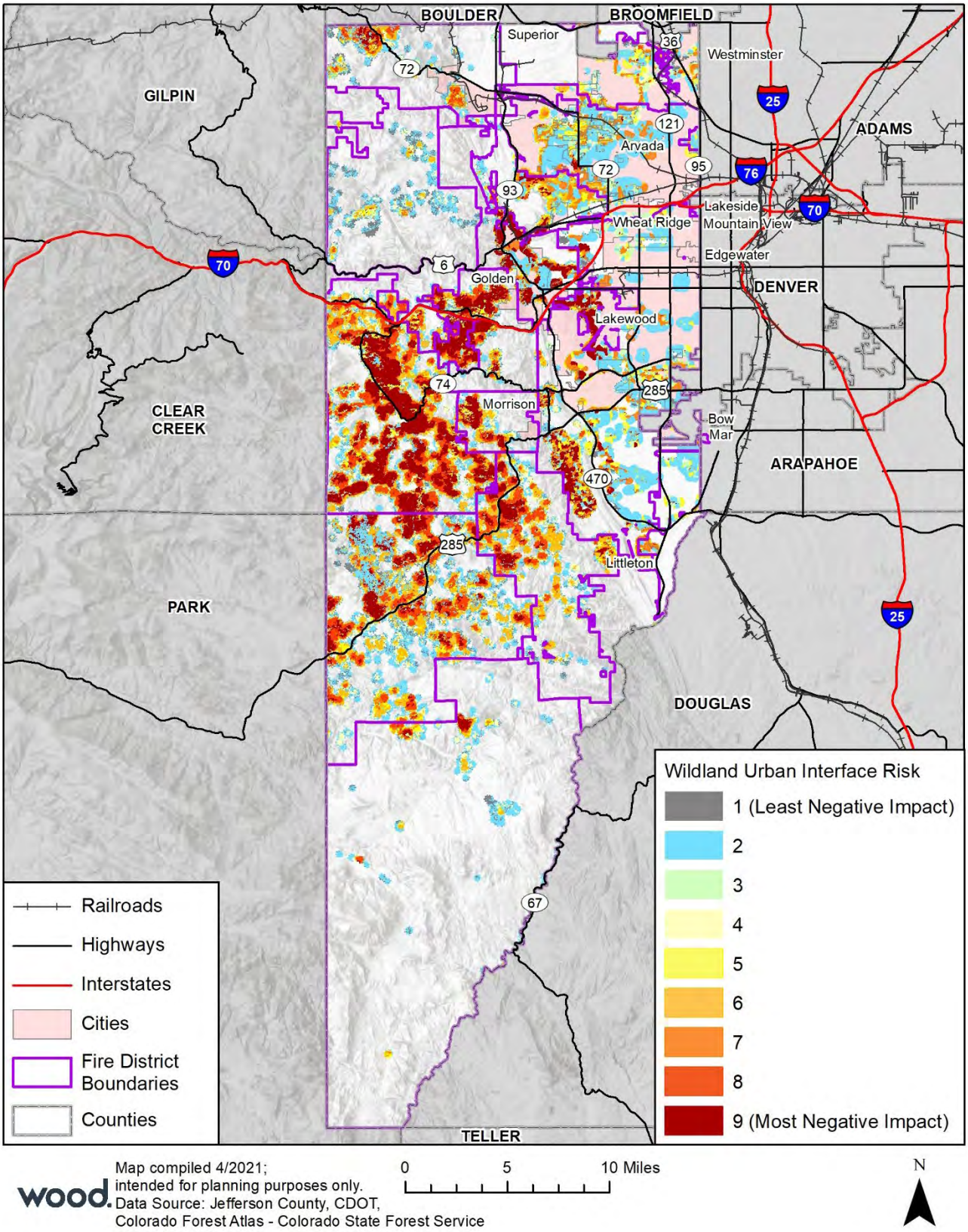
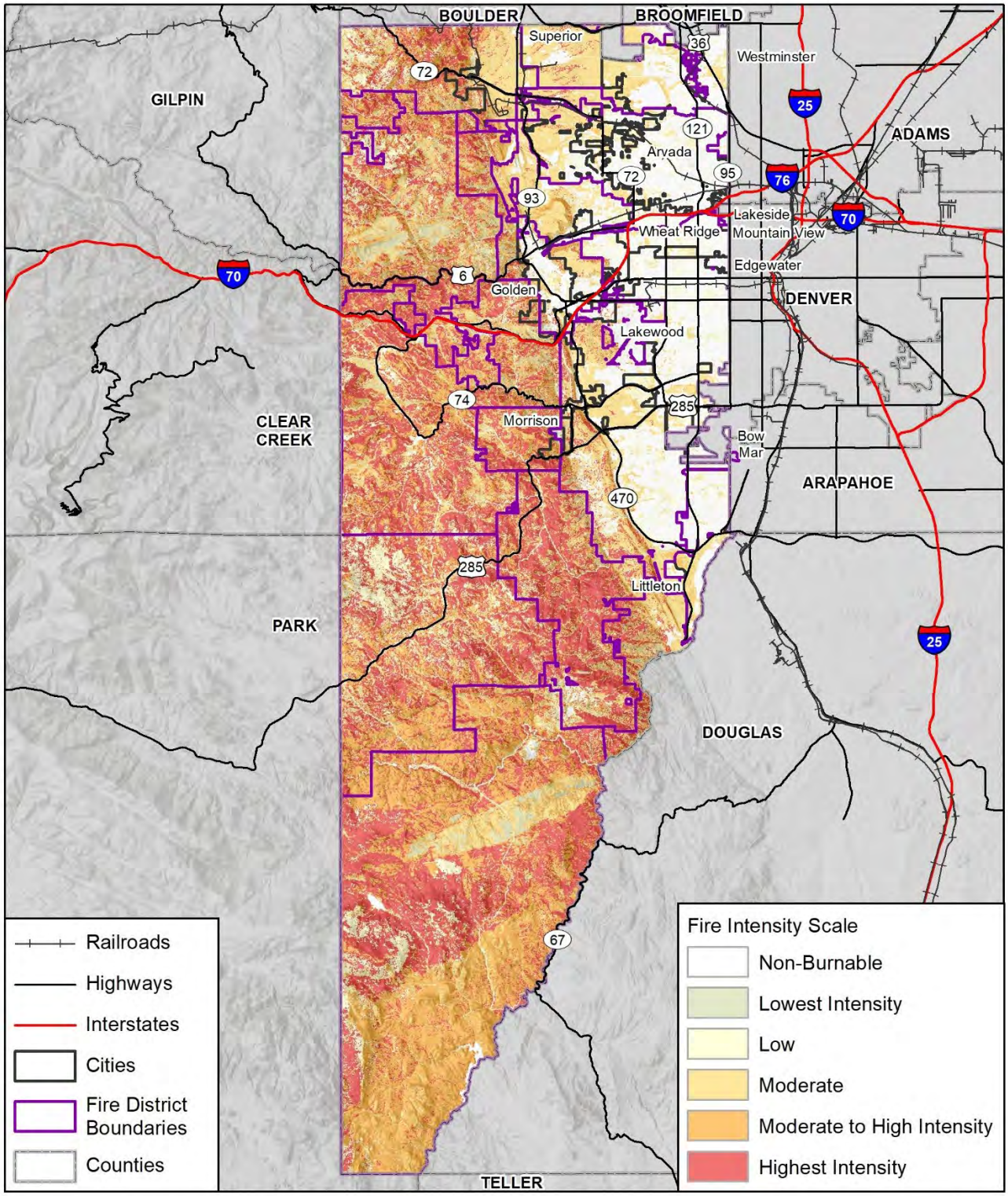


Figure 4-51 Jefferson County Fire Intensity Scale Map



Information from the event of record is used to calculate a magnitude and severity rating for comparison with other hazards, and to assist in assessing the overall impact of the hazard on the planning area. In some cases, the event of record represents an anticipated worst-case scenario, and in others, it is a reflection of common occurrence. The event of record for Jefferson County is the Hayman fire, which occurred in June and July of 2002. The event damaged 41,408 acres in the County, or about one fifth of the total acres burned. 600 buildings were destroyed, 5 wildland firefighters were killed (this was an indirect result of the wildfire, as the firefighters were from Oregon and were killed in a car accident near Grand Junction) and numerous people were evacuated or displaced due to the fire. At that time, the Hayman fire is the most expensive fire in Colorado history, and took more than three weeks to contain and is considered a nationally-significant WUI fire. Based on these factors, the magnitude severity rating for wildfire is considered **critical.**

Climate Change Considerations

Climate is a major determinant of wildfire through its control of weather, as well as through its interaction with fuel availability, fuel distribution and flammability at the global, regional and local levels. With hotter temperatures, drier soil and worsening drought conditions in the County, wildfires have the potential to become more extreme. Currently humans are the main cause of fire ignition globally, although lightning has been predominantly responsible for large fires in Jefferson County. Colorado and the Western United States have seen significant increases in forest area burned in recent years, and the risk of wildfires in the future are expected to increase due to a lengthening fire season and drier conditions. According to a report from the International Panel on Climate Change:

Fire season has already lengthened by 18.7% globally between 1979 and 2013, with statistically significant increases across 25.3% but decreases only across 10.7% of Earth's land surface covered with vegetation; with even sharper changes being observed during the second half of this period. Correspondingly, the global area experiencing long fire weather season has increased by 3.1% per annum or 108.1% during 1979–2013. Fire frequencies under 2050 conditions are projected to increase by approximately 27% globally, relative to the 2000 levels, with changes in future fire meteorology playing the most important role in enhancing global wildfires, followed by land cover changes, lightning activities and land use, while changes in population density exhibit the opposite effects.

Land use, vegetation, available fuels, and weather conditions (including wind, low humidity, and lack of precipitation) are chief factors in determining the number and size of fires in Colorado each year. Generally, fires are more likely when vegetation is dry from a winter with little snow and/or a spring and summer with sparse rainfall. As a result, climate induced hazards in Colorado (specifically, a pattern of extended drought conditions) have contributed to increased concern about wildfire in Jefferson County.

The frequency, intensity, and duration of wildfires have increased across the Western United States since the 1980s. The US Department of Agriculture's "Effects of Climate Variability and Change on Forest Ecosystems" General Technical Report, published in December 2012, found that the Colorado region, among others, will face an even greater fire risk over time. The report expects Colorado to experience up to a five-fold increase in acres burned by 2050. The report's findings are consistent with previous studies on the relationship between climate change and fire risk. Colorado landscapes, including those that characterize Jefferson County, are expected to become hotter and drier as the planet warms, which in turn is expected to increase regional wildfire risk.

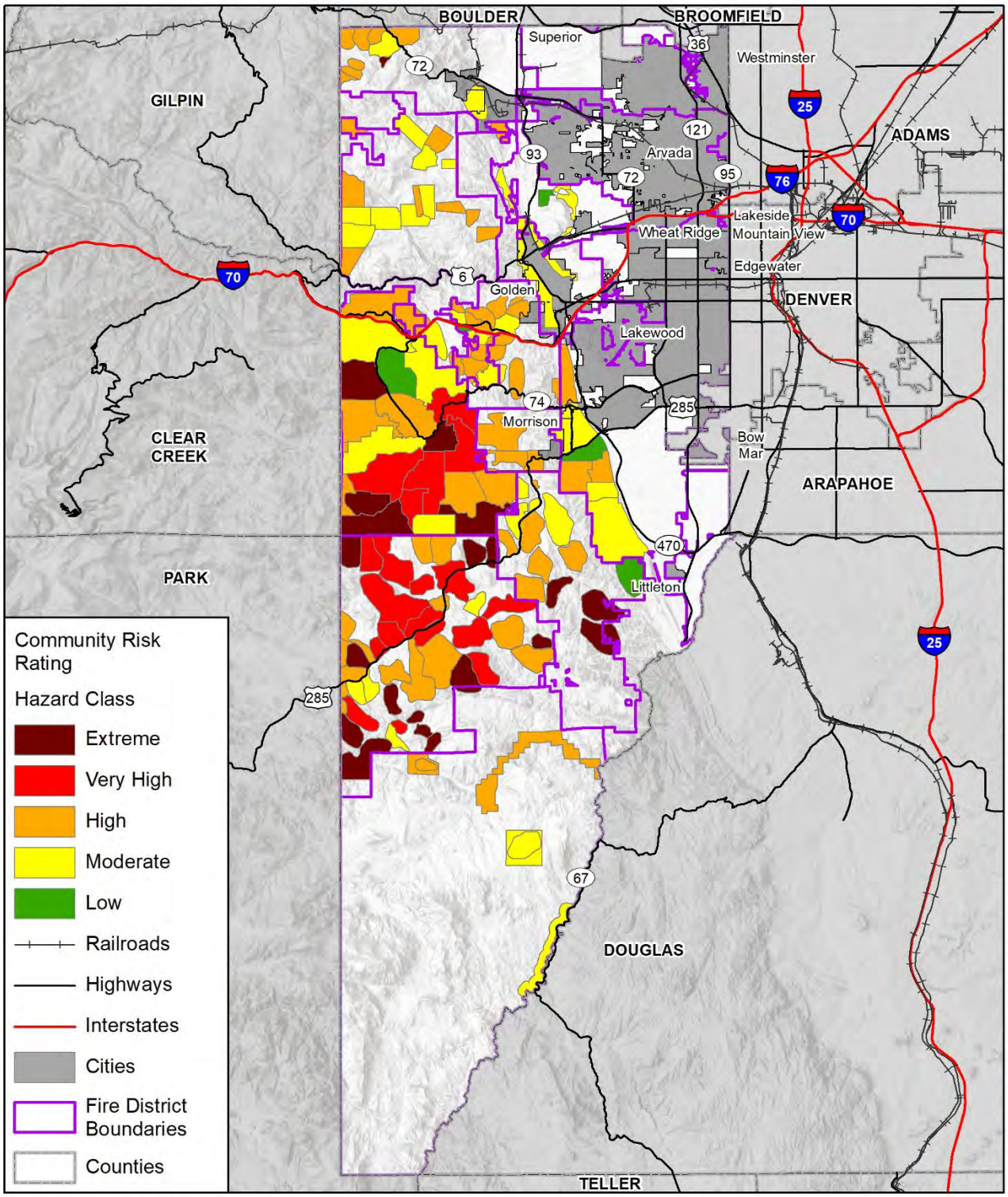
Vulnerability Assessment

Wildfire has the potential to cause widespread damage and loss of life in Jefferson County. The significance of this hazard and the availability of digital hazard data in GIS enables a more detailed vulnerability assessment than many hazards. Because the nature of the wildfire threat to the rural parts of the County is very different from the threat to the urban areas, two different analyses were conducted.

Wildfire threat and risk data was downloaded from the Colorado Forest Atlas (formerly COWRAP) and compared against Jefferson County parcel layer provided by the Assessor's Office. This provided a parcel level count of buildings, people, and critical facilities at risk in the incorporated municipalities and the unincorporated county as a whole.

A second analysis was conducted using Community Wildfire Protection Plan (CWPP) data to give a better picture of the varying wildfire risk in the unincorporated areas of the County.

Figure 4-52 Jefferson County WUI Communities and Hazard Classifications



General Property

Jefferson County's parcel and associated assessor's data were used as the basis for the inventory of developed parcels. Parcels and their attributes, including building and contents value and occupancy type (i.e. residential, commercial, industrial) were compiled and intersected with the wildfire hazard zones defined by the Colorado Forest Atlas, from highest to lowest risk, as shown in Figure 4-49. An address point layer was used to estimate building locations. The results are displayed in Table 6-61 through 4-66.

Table 4-61 Properties at Highest Wildfire Risk

Jurisdiction	Improved Parcels	Building Count	Improved Value	Content Value	Total Value	Population
Unincorporated	499	518	$233,296,256	$116,674,851	$349,864,215	1,316
Total	**499**	**518**	**$233,296,256**	**$116,674,851**	**$349,864,215**	**1,316**

Source: Colorado Forest Atlas & Jefferson County Assessor's Office data

Table 4-62 Properties at High Wildfire Risk

Jurisdiction	Improved Parcels	Building Count	Improved Value	Content Value	Total Value	Population
Arvada	349	350	$156,009,447	$78,438,745	$234,448,192	863
Golden	16	16	$14,685,895	$11,878,165	$26,564,060	27
Lakewood	31	32	$9,570,885	$4,795,243	$14,366,128	70
Unincorporated	13,040	13,648	$5,781,699,522	$2,953,906,398	$8,735,605,920	34,094
Total	**13,436**	**14,046**	**$5,961,965,749**	**$3,049,018,551**	**$9,010,984,300**	**35,054**

Source: Colorado Forest Atlas & Jefferson County Assessor's Office data

Table 4-63 Properties at Moderate Wildfire Risk

Jurisdiction	Improved Parcels	Building Count	Improved Value	Content Value	Total Value	Population
Arvada	2,674	2,721	$1,166,995,414	$594,702,219	$1,761,697,633	6,726
Golden	81	82	$71,051,900	$53,043,803	$124,095,703	152
Lakewood	511	516	$313,914,377	$157,025,189	$470,939,566	1,167
Morrison	21	22	$7,028,841	$3,865,949	$10,894,790	43
Unincorporated	6,465	6,521	$2,942,059,910	$1,561,373,799	$4,503,433,709	16,629
Total	**9,752**	**9,862**	**$4,501,050,442**	**$2,370,010,959**	**$6,871,061,401**	**24,717**

Source: Colorado Forest Atlas & Jefferson County Assessor's Office data

Table 4-64 Properties at Low Wildfire Risk

Jurisdiction	Improved Parcels	Building Count	Improved Value	Content Value	Total Value	Population
Arvada	359	372	$153,370,581	$77,764,195	$231,134,776	913
Golden	29	29	$22,671,461	$19,460,915	$42,132,376	52
Lakewood	279	283	$190,257,165	$96,588,927	$286,846,092	629
Morrison	2	2	$179,353	$89,677	$269,030	4
Unincorporated	1,547	1,569	$732,068,080	$381,329,188	$1,113,397,268	3,894
Total	**2,216**	**2,255**	**$1,098,546,640**	**$575,232,900**	**$1,673,779,540**	**5,491**

Source: Colorado Forest Atlas & Jefferson County Assessor's Office data

Table 4-65 Properties at Lowest Wildfire Risk

Jurisdiction	Improved Parcels	Building Count	Improved Value	Content Value	Total Value	Population
Arvada	1,976	2,107	$1,166,279,560	$637,000,048	$1,803,279,608	5,052
Golden	259	264	$358,763,100	$285,661,344	$644,424,444	526
Lakewood	1,202	1,272	$816,577,558	$431,585,331	$1,248,162,889	2,788
Morrison	28	28	$10,286,039	$5,680,512	$15,966,551	52
Wheat Ridge	580	658	$240,475,070	$123,662,864	$364,137,934	1,376
Unincorporated	5,115	5,189	$2,459,734,233	$1,321,375,963	$3,781,110,196	12,679
Total	**9,160**	**9,518**	**$5,052,115,560**	**$2,804,966,061**	**$7,857,081,621**	**22,472**

Source: Colorado Forest Atlas & Jefferson County Assessor's Office data

Based on this analysis, there are an estimated 35,063 parcels and 36,199 structures at risk of wildfire, with a combined total value exceeding $25.7 billion. Roughly 40% of those are in high or highest risk areas. The greatest concentration of assets at risk are in the unincorporated County, followed by the Cities of Arvada and Lakewood.

The second analysis used the Wildland Urban Interface community layer to indicate where groups of structures define a 'community' in the WUI. These communities have hazard ratings assigned during the CWPP planning process, generally based on NFPA methodologies that evaluate hazard based on types of construction, fuels, topography, and community access/egress. For the WUI analysis in this section, hazard classifications for wildland-urban communities were referenced from the corresponding local CWPPs. In a few instances the hazard classification was modified during the County CWPP process, but based on discussion with the County Wildland Fire Coordinator the preference was to use the hazard classifications originally assigned (this included fire protection districts of: Coal Creek, Elk Creek, Evergreen, Fairmount, Foothills, Genesee, Golden, Golden Gate, Indian Hills, Inter-Canyon, North Fork and West Metro). The community boundaries and hazard classifications used in the analysis are shown above in Figure 4-52. It should be noted that there are large areas within a wildfire hazard area but not a designated WUI community. These areas include portions of northern Jefferson County generally west of Highways 93 and C470, as well as all of southern Jefferson County and generally coincide with the County's Wildfire Hazard Overlay District Zone. Development within these areas was assigned an 'unrated' hazard class.

Results were sorted by risk ranking (extreme to low), and then organized by Fire Protection District (FPD). Table 4-66 through Table 4-70 display the value of structures at risk including estimated contents values, and population estimates. Based on this analysis, there are an estimated 31,130 parcels and 32,755 structures at risk of wildfire, with a combined total value exceeding $20 billion. Roughly 70% of those are in extreme, high or very high risk areas. The greatest concentration of assets at risk are in the unincorporated County, followed by the Cities of Arvada and Lakewood.

Table 4-66 Properties within Extreme Risk CWPP Communities

Fire Protection District	Improved Parcels	Building Count	Improved Value	Content Value	Total Value	Population
Coal Creek	35	36	$6,984,756	$3,492,378	$10,477,134	92
Elk Creek	851	954	$253,322,261	$128,293,083	$381,615,344	2,407
Evergreen	1,193	1,275	$439,340,082	$226,724,346	$666,064,428	3,114
Inter-Canyon	148	152	$57,079,102	$28,566,580	$85,645,682	383
Total	**2,227**	**2,417**	**$756,726,201**	**$387,076,386**	**$1,143,802,587**	**5,995**

Source: Jefferson County Assessor's Office data and CWPPs

Table 4-67 Properties within Very High Risk CWPP Communities

Fire Protection District	Improved Parcels	Building Count	Improved Value	Content Value	Total Value	Population
Elk Creek	2,851	2,977	$1,099,942,690	$578,757,220	$1,678,699,910	7,364
Evergreen	2,195	2,354	$835,022,339	$429,765,139	$1,264,787,478	5,822
Inter-Canyon	5,050	5,335	$1,936,605,396	$1,009,342,542	$2,945,947,938	13,196
Total	**10,096**	**10,666**	**$3,871,570,425**	**$2,017,864,900**	**$5,889,435,325**	**26,382**

Source: Jefferson County Assessor's Office data and CWPPs

Table 4-68 Properties within High Risk CWPP Communities

Fire Protection District	Improved Parcels	Building Count	Improved Value	Content Value	Total Value	Population
Coal Creek	523	532	$188,756,665	$95,472,261	$284,228,926	1,344
Elk Creek	1,097	1,135	$402,446,646	$209,155,550	$611,602,196	2,731
Evergreen	3,108	3,300	$1,330,684,459	$715,828,362	$2,046,512,821	7,324
Fairmount	14	14	$6,894,984	$3,463,620	$10,358,604	33
Foothills	1,326	1,483	$639,581,059	$324,189,473	$963,770,532	3,613
Genesee	647	648	$324,913,152	$162,533,987	$487,447,139	1,645
Golden Gate	113	114	$50,755,564	$25,442,279	$76,197,843	286
Indian Hills	664	736	$237,385,751	$124,552,947	$361,938,698	1,826
Inter-Canyon	844	855	$330,938,271	$166,230,391	$497,168,662	2,168
North Fork	316	408	$59,282,700	$30,211,630	$89,494,330	1,012
West Metro	629	641	$361,778,887	$182,315,079	$544,093,966	1,601
Total	**9,281**	**9,866**	**3,933,418,138**	**$2,039,395,577**	**$5,972,813,715**	**23,582**

Source: Jefferson County Assessor's Office data and CWPPs

Table 4-69 Properties within Moderate Risk CWPP Communities

Fire Protection District	Improved Parcels	Building Count	Improved Value	Content Value	Total Value	Population
Coal Creek	369	374	$129,299,391	$65,854,900	$195,154,291	928
Elk Creek	355	359	$158,691,279	$82,041,126	$240,732,405	910
Evergreen	1,438	1,480	$789,530,450	$427,564,065	$1,217,094,515	3,471
Fairmount	482	487	$215,725,102	$107,974,617	$323,699,719	1,232
Foothills	374	403	$235,286,893	$119,116,484	$354,403,377	992
Genesee	568	583	$274,662,080	$138,270,848	$412,932,928	1,479
Golden	2,426	2,487	$1,172,661,501	$651,736,176	$1,824,397,677	5,893
Golden Gate	191	196	$90,574,892	$45,318,795	$135,893,687	492
Inter-Canyon	309	312	$181,836,597	$90,943,807	$272,780,404	793
North Fork	84	112	$27,096,774	$13,842,312	$40,939,086	281
West Metro	2,244	2,296	$1,149,732,885	$605,660,241	$1,755,393,126	5,704
Total	**8,840**	**9,089**	**$4,425,097,844**	**$2,348,323,368**	**$6,773,421,212**	**22,175**

Source: Jefferson County Assessor's Office data and CWPPs

Table 4-70 Properties within Low Risk CWPP Communities

Fire Protection District	Improved Parcels	Building Count	Improved Value	Content Value	Total Value	Population
Evergreen	1,506	1,548	$805,909,137	$435,132,407	$1,241,041,544	3,710
Fairmount	334	335	$148,320,246	$74,328,744	$222,648,990	852
Genesee	23	34	$20,760,905	$20,760,905	$41,521,810	-
Inter-Canyon	140	142	$89,126,810	$44,563,405	$133,690,215	362
West Metro	546	575	$328,925,720	$165,115,578	$494,041,298	1,441
Total	**686**	**717**	**$418,052,530**	**$209,678,983**	**$627,731,513**	**6,365**

Source: Jefferson County Assessor's Office data and CWPPs

People

Populations living in areas at risk of wildfire are shown in the above tables, and summarized by municipality in Table 4-71 and by fire protection district in Table 4-72. Population was estimated by applying American Community Survey estimated average household size by jurisdiction to the count of residential structures within the WUI hazard class zone.

While the two methodologies understandably yield slightly different results, they both estimate that 84,000 to 89,000 Jefferson County residents live in areas at risk of wildfire. This equates to roughly 15% of the County's population. This represents a significant increase since the 2016 Plan, which identified 55,230 people at risk; however, this increase may be due largely to changes in methodology.

Table 4-71 Population At-Risk to Wildfire

Jurisdiction	Lowest	Low	Moderate	High	Highest	Total
Arvada	5,052	913	6,726	863	-	13,553
Golden	526	52	152	27	-	757
Lakewood	2,788	629	1,167	70	-	4,653
Morrison	52	4	43	-	-	99
Wheat Ridge	1,376	-	-	-	-	1,376
Unincorporated	12,679	3,894	16,629	34,094	1,316	68,611
Total	**22,472**	**5,491**	**24,717**	**35,054**	**1,316**	**89,050**

Source: Colorado Forest Atlas & Jefferson County Assessor's Office data

Table 4-72 Population At-Risk within the CWPP Communities by Fire Protection District

Fire Protection District	Low	Moderate	High	Very High	Extreme	Total
Coal Creek	-	928	1,344	-	92	2,364
Elk Creek	-	910	2,731	7,364	2,407	13,412
Evergreen	3,710	3,471	7,324	5,822	3,114	23,440
Fairmount	852	1,232	33	-	-	2,117
Foothills	-	992	3,613	-	-	4,605
Genesee	-	1,479	1,645	-	-	3,124
Golden	-	5,893	-	-	-	5,893
Golden Gate	-	492	286	-	-	778

Fire Protection District	Low	Moderate	High	Very High	Extreme	Total
Indian Hills	-	-	1,826	-	-	1,826
Inter-Canyon	362	793	2,168	13,196	383	16,902
North Fork	-	281	1,012	-	-	1,293
West Metro	1,441	5,704	1,601	-	-	8,747
Total	**6,365**	**22,175**	**23,582**	**26,382**	**5,996**	**84,500**

Source: Jefferson County Assessor's Office data and CWPP's

Critical Facilities and Infrastructure

To estimate the potential impact of wildfires on critical facilities, the list of facilities identified in Section 4.2 was compared to the wildfire risk layers developed above. The results are shown in Table 4-73 and Table 4-74. All told, 696 critical facilities are located in areas at risk of wildfire, representing 30% of the County's critical facilities. The number at high or highest risk is 163 (7%). The lifeline category of assets with the most exposure is communications facilities; followed by energy; food, water & shelter; and hazardous materials.

Table 4-73 Critical Facilities Located in Fire Hazard Zones by Jurisdiction

Jurisdiction	Lowest	Low	Moderate	High	Highest	Total	%
Arvada	15	3	12	1	0	**31**	**11%**
Golden	14	2	5		0	**21**	**14%**
Lakewood	21	1	14		0	**36**	**8%**
Morrison	2	1	1	2	0	**6**	**27%**
Wheat Ridge	8	0	0		0	**8**	**5%**
Unincorporated	70	72	289	157	6	**594**	**47%**
Total	**130**	**79**	**321**	**160**	**6**	**696**	**30%**

Source: HIFLD and CERC

Table 4-74 Critical Facilities Located in Fire Hazard Zones by Lifeline Category

Lifeline	Lowest	Low	Moderate	High	Highest	Total	%
Communications	80	62	257	112	5	**516**	**44%**
Energy	1	3	8	0	0	**12**	**27%**
Food, Water, Shelter	0	1	3	3	0	**7**	**20%**
Hazardous Material	7	2	11	5	0	**25**	**20%**
Health and Medical	14	0	0	0	0	**14**	**8%**
Safety and Security	9	3	20	11	1	**44**	**13%**
Transportation	19	9	22	29	0	**79**	**17%**
TOTAL	**130**	**80**	**321**	**160**	**6**	**697**	**30%**

Source: HIFLD and CERC

Economy

In addition to the significant direct costs listed above, fires can extensively impact the economy of an affected area, including agricultural, recreation and tourism industries, and water resources. Businesses in affected areas can be impacted due to evacuation, lack of utility service, or through destruction of property.

Historical, Cultural, and Natural Resources

Wildfire is a consistent threat to natural resources in the County, particularly the county's parks and forests. Fire is a natural part of forest growth cycles but can also cause cascading threats to natural resources. After wildfires, the risk of floods and debris flows increases due to the exposure of bare ground and the loss of vegetation. Secondary effects of wildfires also include erosion, landslides, introduction of invasive species, and changes in water quality. It should be noted that many of the historic and cultural resources mentioned in Table 4-9 are located in wildfire hazard areas.

Future Development

Growth in the wildland urban interface has been significant in the past 25 years in Jefferson County. Despite the known risks, these areas continue to be seen as desirable to a great many people. An analysis of the Year Built field in County Assessor's Office data shows that from 2015 through 2020, 6,237 new structures have been built in wildfire risk areas, including 604 in areas at high or highest risk. This shows that development of primary and secondary residences in wildfire hazard areas continues. Wildfire risk to future development in these areas is tempered by the County's land use regulations. However, lots created prior to the adoption of those regulations can still be built upon.

West Metro Fire cited concerns about growth and development occurring both within and outside of the wildland/urban interface, increasing wildfire vulnerability in those areas.

Arvada Fire Protection District cited concerns about growth on the western edge of their jurisdiction in areas that are prone to high winds and have large open areas of vegetation. If fires begin in these areas, they are highly likely to spread directly towards these developments.

The County has adopted sections of the WUI code, to include fire resistive construction requirements, mitigation standards, and road & driveway standards. However, the fire protection water supply and fire sprinkler requirements sections of the WUI Code have not been adopted. The County might wish to review the WUI code in conjunction with wildland representatives to identify additional provisions it might be beneficial to adopt. The Future Avoided Cost Explorer (FACE) developed by the Colorado Water Conservation Board provides an in-depth look at the potential economic impacts and expected annual damages from future flood, drought and wildfire events. The tool looks at three different climate scenarios (current climate conditions, 2050 future – moderately warmer climate and 2050 – severely warmer climate) as well as compares current population to low, medium and high growth population scenarios.

Table 4-75 compares the estimated annual damages for Jefferson County due to wildfires for each of the climate and population scenarios. The tool estimates current losses of $32M annually, or $50/person, the highest in the State. Under current climate conditions, this is anticipated to increase to $32-33M annually based on population growth; an increasingly warmer climate could increase that to $53-$54 M annually.

Table 4-75 Potential Future Economic Losses from Wildfires in Jefferson County

Climate Scenarios	Population Scenarios		
	Low Growth (~653,000)	Medium Growth (~695,000)	High Growth (~740,000)
Current Conditions	Total damages: $32 M	Total damages: $33 M	Total damages: $33 M
	Total damages per person: less than $50	Total damages per person: less than $50	Total damages per person: less than $40
Moderate-Severely Warmer Climate by 2050	Total damages: $53 M	Total damages: $53-$54 M	Total damages: $53-$54 M
	Total damages per person: less than $80	Total damages per person: less than $80	Total damages per person: less than $70

Source: Colorado Water Conservation Board (CWCB) Future Avoided Cost Explorer: Hazards https://cwcb.colorado.gov/FACE

Overall Hazard Significance

Wildfires in Jefferson County are a significant concern. The geographic extent of the hazard is considered **significant.** The probability of future occurrences is considered **likely**, and the magnitude/severity for the event of record is **critical.** In addition, the HMPC considers the hazard to have a **high** impact on the County. This equates to an overall impact rating of **high**.

4.3.17 Windstorm

Description

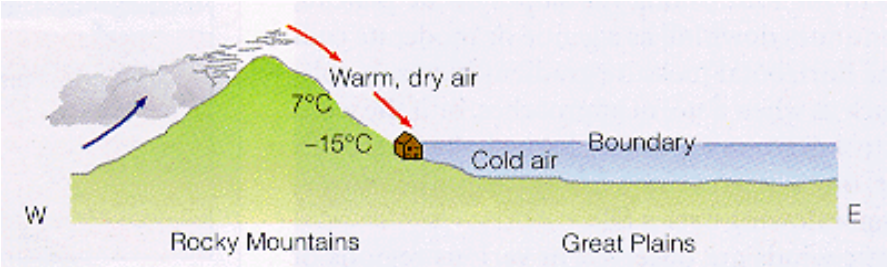
High winds can occur year-round in Jefferson County. In the spring and summer, high winds often accompany severe thunderstorms. Damaging winds are typically those which exceed 60 mph. There are seven types of damaging winds:

- **Straight-line winds**—Any thunderstorm wind that is not associated with rotation; this term is used mainly to differentiate from tornado winds. Most thunderstorms produce some straight-line winds as a result of outflow generated by the thunderstorm downdraft.
- **Downdrafts**—A small-scale column of air that rapidly sinks toward the ground.
- **Downbursts**—A strong downdraft with horizontal dimensions larger than 2.5 miles resulting in an outward burst or damaging winds on or near the ground. Downburst winds may begin as a microburst and spread out over a wider area, sometimes producing damage similar to a strong tornado. Although usually associated with thunderstorms, downbursts can occur with showers too weak to produce thunder.
- **Microbursts**—A small, concentrated downburst that produces an outward burst of damaging winds at the surface. Microbursts are generally less than 2.5 miles across and short-lived, lasting only 5 to 10 minutes, with maximum wind speeds up to 168 mph. There are two kinds of microbursts: wet and dry. A wet microburst is accompanied by heavy precipitation at the surface. Dry microbursts, common in places like the high plains and the intermountain west, occur with little or no precipitation reaching the ground.
- **Gust front**—A gust front is the leading edge of rain-cooled air that clashes with warmer thunderstorm inflow. Gust fronts are characterized by a wind shift, temperature drop, and gusty winds out ahead of a thunderstorm. Sometimes the winds push up air above them, forming a shelf cloud or detached roll cloud.
- **Derecho**—A derecho is a widespread thunderstorm wind caused when new thunderstorms form along the leading edge of an outflow boundary (the boundary formed by horizontal spreading of thunderstorm-cooled air). The word “derecho” is of Spanish origin and means “straight ahead.” Thunderstorms feed on the boundary and continue to reproduce. Derechos typically occur in summer when complexes of thunderstorms form over plains, producing heavy rain and severe wind. The damaging winds can last a long time and cover a large area.
- **Bow Echo**—A bow echo is a linear wind front bent outward in a bow shape. Damaging straight-line winds often occur near the center of a bow echo. Bow echoes can be 200 miles long, last for several hours, and produce extensive wind damage at the ground.

Straight-line winds may exacerbate existing weather conditions, such as blizzards, by increasing the effect on temperature and decreasing visibility due to the movement of particulate matters through the air, as in dust and snowstorms. High winds may also exacerbate fire conditions by drying out the ground cover, propelling fuel, such as tumbleweeds, around the region, and increasing the ferocity of existing fires. These winds may damage crops, push automobiles off roads, damage roofs and structures, and cause secondary damage due to flying debris. Shorter duration winds, such as wind gusts, can cause substantial damage to power lines. Winds with an intermediate duration, which sharply increase and last for a minute, are called squalls. Long-duration wind speeds have various names associated with their average strength, such as breeze, gale, storm, hurricane, and typhoon.

Downslope winds in Colorado are referred to as Chinook winds, after the Native American tribe of the Pacific Northwest. As shown in Figure 4-53, these downslope winds can occur with violent intensity in areas where mountains stand in the path of strong air currents. These warm and dry winds occur when the winds from the west blow across the Continental Divide and descend from the foothills and out onto the plains.

Figure 4-53 Chinook Wind Pattern



Source: University of Colorado at Boulder ATOC Weather Lab

Wind can be very dangerous. Areas of wind shear, caused by various weather phenomena, can make treacherous situations for airplanes and other flying aircraft. When winds become too strong on the ground, boats can capsize, trees can be stripped of their branches or uprooted, and man-made structures become vulnerable to damage or destruction. The NWS can issue High Wind Watch, High Wind Warning, and Wind Advisory to the public. The following are the definitions of these issuances:

- **High Wind Watch**—This is issued when there is the potential of high wind speeds developing that may pose a hazard or are life-threatening.
- **High Wind Warning**—The 1-minute surface winds of 35 knots (40 mph) or greater lasting for one hour or longer, or winds gusting to 50 knots (58 mph) or greater, regardless of duration, that are either expected or observed over land.
- **High Wind Advisory**—This is issued when high wind speeds may pose a hazard. Sustained winds 25 to 39 mph and/or gusts to 57 mph.

Jefferson County wind patterns range from light and breezy to severe gale force winds. There is usually some level of a constant breeze due to Jefferson County's mountainous, Front Range, and plains topography.

Geographic Extent

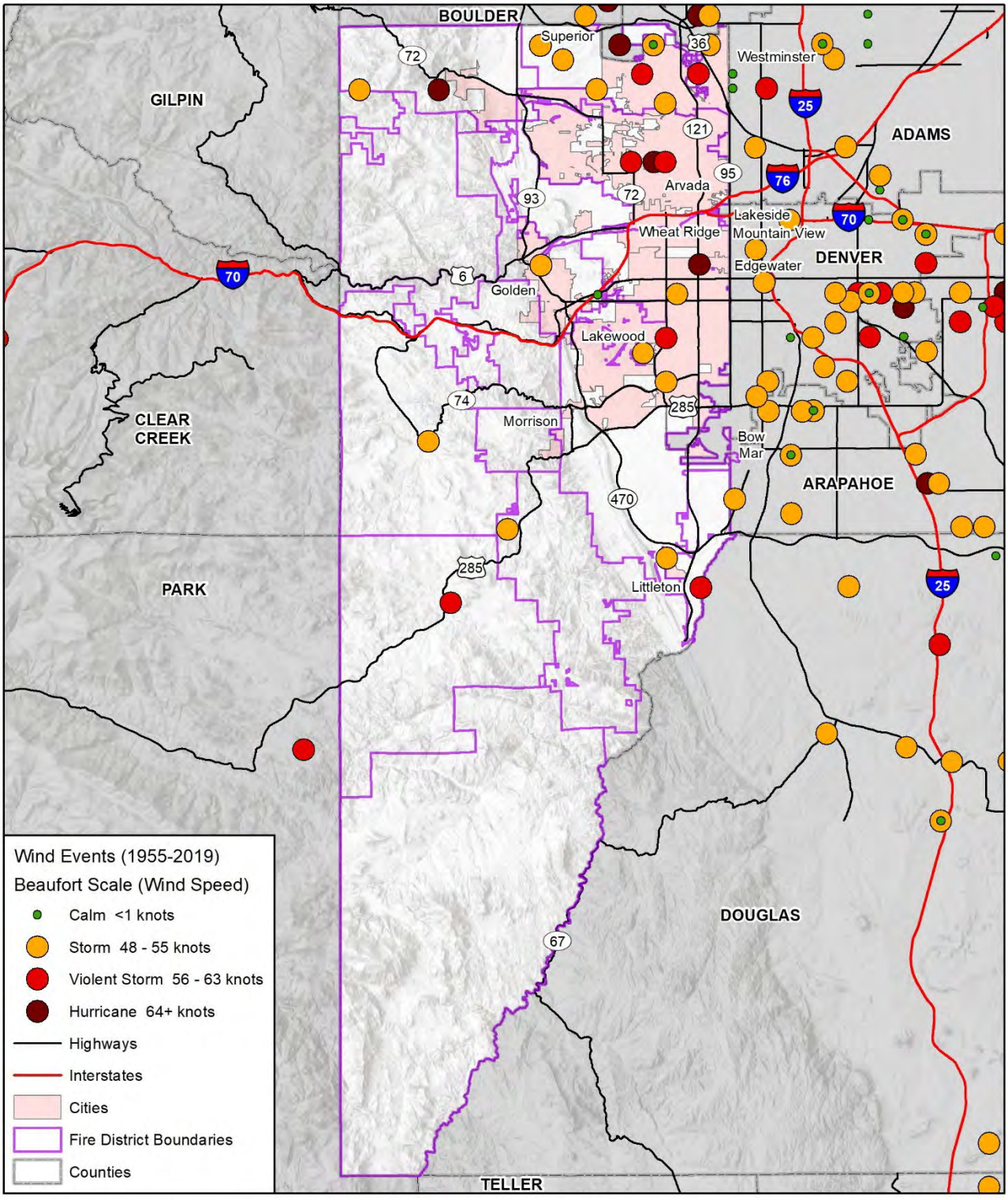
The entire planning area is susceptible to wind, windstorms, and wind associated with other storm systems that can have negative impacts on a community. Depending on the origination of the atmospheric system, its direction of travel, and its duration, a part of the planning area can be affected or the entire County. Figure 4-54 depicts wind zones for the United States. The map shows that the majority of the County falls into Zone II which is characterized by high winds of 160 mph. Typically, however, the hazard is predicted to affect between 50% and 75% of the planning area. Based on this information, the geographic extent rating for windstorms is **significant**.

Figure 4-54 Wind Zones in the United States

Previous Occurrences

High winds associated with other severe weather and stand-alone windstorms are common occurrences in Jefferson County. The mountainous terrain and foothills topography lends itself to regular conflicts between systems of high and low pressure. Most of Colorado's most costly storms are hail-related and occurred in the Denver-metro area. Hail is usually accompanied by high winds; however the damages are not broken out to distinguish hail from wind damage. Figure 4-55 below shows recorded high wind events in Jefferson County between 1955 and 2019.

Figure 4-55 Jefferson County High Wind Events 1955-2019



The NCEI database recorded 184 separate High Wind events between January of 2000 and December of 2020 with wind speeds over 50 knots (approximately 57 mph). The most significant of those events are recorded below.

June 14, 1976 – 78 mph winds recorded at the Jefferson County Airport near Broomfield, 66 mph at Littleton.

June 6, 1983 – Report of a thunderstorm with associated winds measured at 61 knots (70 mph).

August 15. 1982 – Report of a thunderstorm with associated winds measured at 61 knots (70 mph).

August 13, 1983 – Report of a thunderstorm with associated winds measured at 84 knots (97 mph).

June 9, 1987 – Report of a thunderstorm with associated winds measured at 63 knots (73 mph). One death reported.

April 19, 1989 – Report of a thunderstorm with associated winds measured at 68 knots (78mph).

May 16, 1990 – Report of a thunderstorm with associated winds measured at 60 knots (69 mph).

May 26, 1993 – Report of a thunderstorm with associated winds measured at 70 knots (81mph).

October 26, 1995 – Report of a thunderstorm associated winds measured at 61 knots in Coal Creek Canyon (70 mph).

June 22, 1997 – Report of a dry microburst which produced 69 mph winds at the Jefferson County Airport.

June 10. 2000 – Report of a dry microburst which produced 67 mph winds at the Jefferson County Airport.

July 30, 2004 – Report of a thunderstorm associated winds measured at 62 knots (71 mph) in Evergreen.

July 20, 2009 – Golf ball-sized hail and strong winds battered roofs, uprooted trees and pounded vehicles in Wheat Ridge, Lakewood, and Arvada, and portions of neighboring Arapahoe County. The insured losses are totaled at more than $767.6 million in damage for Colorado's 2009 severe weather season as of August 2009.

November 12, 2011 – Hurricane force winds up to 115 mph downed trees and power lines across the Front Range Mountains and foothills. The event resulted in 4 reported injuries and several thousand residential power outages.

April 17, 2018 – A powerful damaging wind event with gusts ranging from 60 to 90 mph. Approximately 64,000 Xcel Energy customers experienced some type of outage. One woman died as a result of the event after being struck in the head by a falling tree branch.

February 10, 2020 – Strong winds blew down power lines and power poles in the Town of Morrison. No property damage was reported, but downed power lines caused several power outages that forced some school and business closures.

Probability of Future Occurrences

According to the NCEI, there have been 184 separate events with NCEI-recorded high winds above 57 mph (50 knots) in Jefferson County from January 2000 to December 2020. The methodology for calculating the probability of future occurrences is described in Section 4.3.1. This formula evaluates that the probability of a Windstorm occurring in any given year is 100%.

This corresponds to a probability of future occurrences rating of **highly likely**.

Magnitude and Severity

Damage from windstorms can be difficult to quantify. Wind, by itself, has not historically caused high insured dollar losses. For the insurance industry to track a weather event, it must be a large enough storm that insurance companies may declare it a catastrophe, and then damage estimates for auto and homeowner claims are collected and published. This generally equates to damages in excess of $25

million, though significant events impacting small communities are also tracked occasionally. Figure 4-56 demonstrates how destructive wind can be.

Figure 4-56 July 20, 2009 Damage in Wheat Ridge

Source: Fox News Online Photo Gallery

Table 4-76 shows The Beaufort Wind Scale. The replication of the scale only reflects land-based effects.

Table 4-76 The Beaufort Wind Scale

Beaufort Number	Description	Windspeed (Knots)	Land Conditions
0	Calm	<1	Calm. Smoke rises vertically.
1	Light air	1 – 3	Wind motion visible in smoke.
2	Light breeze	4 – 6	Wind felt on exposed skin. Leaves rustle.
3	Gentle breeze	7 – 10	Leaves and smaller twigs in constant motion.
4	Moderate breeze	11 – 16	Dust and loose paper raised. Small branches begin to move.
5	Fresh breeze	17 – 21	Branches of a moderate size move. Small trees begin to sway.
6	Strong breeze	22 – 27	Large branches in motion. Whistling heard in overhead wires. Umbrella use becomes difficult. Empty plastic garbage cans tip over.
7	Near Gale	28 – 33	Whole trees in motion. Effort needed to walk against the wind.
8	Gale	34 – 40	Some twigs broken from trees. Cars veer on road. Progress on foot is seriously impeded.
9	Strong gale	41 – 47	Slight structural damage occurs; slate blows off roofs
10	Storm	48 – 55	Seldom experienced on land; trees uprooted or broken; considerable structural damage
11	Violent storm	56-63	
12	Hurricane	64+	

Source: National Oceanographic and Atmospheric Association

Table 4-77 and Table 4-78 show typical levels of damage that can be expected based on windspeed.

Table 4-77 Damage to Institutional Buildings from High Wind

Damage Description	Wind Speed Range (Expected Speed)
Threshold of visible damage	59-88 MPH (72 MPH)
Loss of roof covering (<20%)	72-109 MPH (86 MPH)

Damage Description	Wind Speed Range (Expected Speed)
Damage to penthouse roof & walls, loss of rooftop HVAC equipment	75-111 MPH (92 MPH)
Broken glass in windows or doors	78-115 MPH (95 MPH)
Uplift of lightweight roof deck & insulation, significant loss of roofing material (>20%)	95-136 MPH (114 MPH)
Façade components torn from structure	97-140 MPH (118 MPH)
Damage to curtain walls or other wall cladding	110-152 MPH (131 MPH)
Uplift of pre-cast concrete roof slabs	119-163 MPH (142 MPH)
Uplift of metal deck with concrete fill slab	118-170 MPH (146 MPH)
Collapse of some top building envelope	127-172 MPH (148 MPH)
Significant damage to building envelope	178-268 MPH (210 MPH)

Source: National Oceanographic and Atmospheric Association

Table 4-78 Damage to Electric Transmission Lines from High Wind

Damage Description	Wind Speed Range (Expected Speed)
Threshold of visible damage	70-98 MPH (83 MPH)
Broken wood cross member	80-114 MPH (99 MPH)
Wood poles leaning	85-130 MPH (108 MPH)
Broken wood poles	98-142 MPH (118 MPH)

Source: National Oceanographic and Atmospheric Association

Information from the event of record is used to calculate a magnitude and severity rating for comparison with other hazards, and to assist in assessing the overall impact of the hazard on the planning area. In some cases, the event of record represents an anticipated worst-case scenario, and in others, it is a reflection of common occurrence. The significant wind and windstorm events of record for Jefferson County are identified in the Previous Occurrences section of the windstorm hazard profile. Wind damage is usually identified by the number of insurance claims made as a result of a severe weather event. Wind is not broken out from a hailstorm, rainstorm, or a tornado. The damages inflicted on critical facilities and services (critical infrastructure) for Jefferson County are not specific to windstorm activity alone.

Based on these factors, the magnitude severity ratings for windstorm in Jefferson County would be **negligible;** however, if the windstorm is considered a component of the larger weather system its magnitude and severity rating would be upgraded to **limited.**

Climate Change Considerations

According to the best data available at the time of this plan update, the future impacts of climate induced severe wind events are unclear.

Vulnerability Assessment

It can be assumed that the entire planning area is exposed to some extent to high wind events. Certain areas are more exposed due to geographic location and local weather patterns. Populations living at higher elevations with large stands of trees or power lines may be more susceptible to wind damage and black out. It is not uncommon for residents living in more remote areas of the county to be isolated after such events.

General Property

All property is vulnerable during high wind events, but properties in poor condition or in particularly vulnerable locations may risk the most damage. Generally, damage is minimal and goes unreported. Property located at higher elevations and on ridges may be more prone to wind damage. Property located under or near overhead lines or near large trees may be damaged in the event of a collapse. Wind

pressure can create a direct and frontal assault on a structure, pushing walls, doors, and windows inward. Conversely, passing currents can create lift and suction forces that act to pull building components and surfaces outward. The effects of winds are magnified in the upper levels of multi-story structures. As positive and negative forces impact the building's protective envelope (doors, windows, and walls), the result can be roof or building component failures and considerable structural damage.

People

Windstorms can cause injury and death in Jefferson County. The highest risk demographic is to first responders who are dealing with emergency situations resulting from the windstorm. Those working or recreating outdoors will be susceptible to injury from wind borne debris. Winds can also be hazardous to hikers in areas of beetle or fire killed trees, which occurred when a hiker was killed by a falling tree in Rocky Mountain National Park in 2007.

Vulnerable populations also include the elderly, low income or linguistically isolated populations, people with life-threatening illnesses, and residents living in areas that are isolated from major roads. Power outages can be life threatening to those dependent on electricity for life support. In Jefferson County, 11% of Medicare Beneficiaries rely on electricity to live independently in their homes. Isolation of these populations is a significant concern. These populations face isolation and exposure during wind events and could suffer more secondary effects of the hazard. Hikers and climbers in the area may also be more vulnerable to severe wind events.

Critical Facilities and Infrastructure

High winds can cause significant damage to trees and power lines, blocking roads with debris, incapacitating transportation, isolating population, and disrupting ingress and egress. Of particular concern are roads providing access to isolated areas and to the elderly. Severe windstorms and downed trees can create serious impacts on power and above-ground communication lines. Loss of electricity and phone connection would leave certain populations isolated because residents would be unable to call for assistance.

Economy

Economic impacts of severe wind are typically short term. These events can disrupt travel into and out of all areas of the county and create perilous conditions for residents, tourists, and nature alike.

The effect of high winds on power delivery is a relevant factor when assessing current development exposure. Xcel Energy provided data from one high wind event in 2009 when 2 days of high winds interrupted power for 67,128 customers. Xcel estimated it cost $167,820 to repair the outage equating to a cost of roughly $25,000 for every 10,000 customers impacted by high winds. FEMA Standard Values for Loss of Service for Utilities, located in Appendix C of the FEMA BCA Reference Guide, estimates that a power supply interruption costs the average person $126 per day of service outage. By this estimate, this event caused $16,916,256 in economic impacts or $8,458,128 per day of service interruption due to high winds.

Historical, Cultural, and Natural Resources

The environment is highly exposed to high winds. Environmental impacts include the downing of trees and localized flattening of plants by high wind. Natural habitats such as streams and trees risk major damage and destruction.

Future Development

Construction sites are particularly vulnerable to windstorms. Wind-borne construction materials can become hazards to life and property. New construction designed in accordance with the Jefferson County wind load map should be able to withstand or at least resist wind damage if properly constructed. Backup power systems in critical facilities could help mitigate impacts from power outages associated with windstorms.

The ongoing development along State Highway 93 is in a region of the County that is very vulnerable to high winds. Construction sites, both residential and transportation related (the Jefferson Parkway, a multi-

lane arterial planned to connect Highway 93 to Highway 36 through Arvada) could be at risk of wind borne construction materials.

Overall Hazard Significance

Windstorms in Jefferson County can have a particular impact on the planning area. Alone they can rip roofs from houses, collapse fences, tear off siding, project flying debris through windows, and uproot large trees. When accompanying other severe weather, like hail, damages are compounded. The geographic extent of the hazard is considered **significant**. The probability of future occurrences is considered **highly likely** and the magnitude/severity for the event of record is **limited**. The HMPC considers the hazard to have an overall impact rating of **medium** on Jefferson County. Overall, the data indicates that the overall hazard significance rating is **medium**.

4.3.18 Cyber Attack

Description

The 2018 Colorado State Hazard Mitigation Plan defines cyber attacks as "deliberate exploitation of computer systems, technology-dependent enterprises, and networks." Cyber-attacks use malicious code to alter computer operations or data. The vulnerability of computer systems to attacks is a growing concern as people and institutions become more dependent upon networked technologies. The Federal Bureau of Investigation (FBI) reports that, "cyber intrusions are becoming more commonplace, more dangerous, and more sophisticated," with implications for private- and public-sector networks. Cyber threats can take many forms, including:

Phishing attacks: Phishing attacks are fraudulent communications that appear to come from legitimate sources. Phishing attacks typically come through email but may come through text messages as well. Phishing may also be considered a type of social engineering meant to exploit employees into paying fake invoices, providing passwords, or sending sensitive information.

Malware attacks: Malware is malicious code that may infect a computer system. Malware typically gains a foothold when a user visits an unsafe site, downloads untrusted software, or may be downloaded in conjunction with a phishing attack. Malware can remain undetected for years and spread across an entire network.

Ransomware: Ransomware typically blocks access to a jurisdiction's/agency's/ business' data by encrypting it. Perpetrators will ask for a ransom to provide the security key and decrypt the data, although many ransomware victims never get their data back even after paying the ransom.

Distributed Denial of Service (DDoS) attack: Perhaps the most common type of cyber attack, a DDoS attack seeks to overwhelm a network and causes it to either be inaccessible or shut down. A DDoS typically uses other infected systems and internet connected devices to "request" information from a specific network or server that is not configured or powerful enough to handle the traffic.

Data breach: Hackers gaining access to large amounts of personal, sensitive, or confidential information has become increasingly common in recent years. In addition to networked systems, data breaches can occur due to the mishandling of external drives.

Critical Infrastructure/SCADA System attack: There have been recent critical infrastructure Supervisory Control and Data Acquisition (SCADA) system attacks aimed at taking down lifelines such as power plants and wastewater facilities. These attacks typically combine a form of phishing, malware, or other social engineering mechanisms to gain access to the system.

The 2018 Colorado State Hazard Mitigation Plan concludes: "This is a newly developing threat, so as more resources are devoted to countering the hazard, the risk of a disruption would hopefully decrease. Mitigation opportunities for this hazard include continued diligence of the state's Office of Information Technology (OIT), as well as for other government and private sector entities to continue to monitor, block, and report cyber-attacks, and continually assess the vulnerability of systems."

Geographic Extent

Cyber-attacks can and have occurred in every location regardless of geography, demographics, and security posture. Incidents may involve a single location or multiple geographic areas. A disruption can have far-reaching effects beyond the location of the targeted system; disruptions that occur far outside the state can still impact people, businesses, and institutions within the county. All the populated areas of Jefferson County are potentially susceptible to cyber-attacks, making the geographic extent **significant**.

Previous Occurrences

The cybersecurity firm Verizon DBIR reports there were a total of 3,950 data breaches worldwide in 2020, including 346 public sector systems. The number of breaches has continued to increase, and the average number of identities stolen has increased to almost one million per incident.

The Privacy Rights Clearinghouse, a nonprofit organization based in San Diego, maintains a timeline of 9,741 data breaches resulting from computer hacking incidents in the United States from 2005-2019. The database lists 47 data breaches against systems located in Colorado, totaling over 400,000 impacted

records; it is difficult to know how many of those affected Jefferson County residents. Attacks happening outside of the state can also impact local businesses, personally identifiable information, and credit card information. Table 4-79 shows several of the more significant cyber attacks in Colorado in recent years.

Table 4-79 Major Cyber Attacks Impacting Colorado, 2005-2020

Date Reported	Target	Total Records	Description
July 21, 2005	University of Colorado, Boulder	49,000	Data exposure/ personal identifiable information
August 2, 2005	University of Colorado, Denver	36,000	Data exposure/ personal identifiable information
July 17, 2007	Western Union, Greenwood Village	20,000	Credit card breach
April 22, 2014	Centura Health, Englewood	12,286	Health information breach
July 3, 2017	PVHS-ICM Employee Health and Wellness, Fort Collins	10,143	Data exposure/health information
February 2018	Colorado Department of Transportation (CDOT)	N/A	Data encryption/ ransomware
February 2019	Fort Collins Loveland Water District	Unknown	Ransomware
August 2019	Regis University	N/A	DDoS
Fall 2019	Town of Erie	N/A	Hacked email account led to $1 million being wired to a falsified contractor's account.
November 2019	Archuleta County	N/A	Ransomware
December, 2019	Southeast Metro Storm Water Authority (SEMSWA)	N/A	Ransomware
December 2019	Aurora Water	2% of customers	Data Breach
April 2020	Rangely District Hospital	N/A	Ransomware
June 2020	Children's Hospital Colorado	2,553	Data Breach
June 2020	Colorado Information Analysis Center (CIAC)	Unknown	Data Breach
July 2020	City of Lafayette	N/A	Ransomware

Source: Privacy Rights Clearinghouse, Colorado Sun

A 2017 study found ransomware payments over a two-year period totaled more than $16 million. Even if a victim is perfectly prepared with full offline data backups, recovery from a sophisticated ransomware attack typically costs far more than the demanded ransom. However, according to a 2016 study by Kaspersky Lab, roughly one in five ransomware victims who pay their attackers never recover their data.

Recent years have seen a major increase in ransomware attacks, particularly against local government systems, and Colorado has been no exception. In February 2018, Colorado Department of Transportation

computers were hit by ransomware; the State refused to pay the ransom and spent $1.7 million to contain and recover lost data. In November 2019, a ransomware attack on Archuleta County resulted in a 12-day outage and severe impact to its dispatch system; attackers demanded $300,000. Rangely District Hospital in Rangely, Colorado, fell victim to a ransomware attack that encrypted files that included patient health information in April of 2020; the hospital said it did not pay the ransom. In July 2020 the City of Lafayette had to shut down their computer network after a ransomware attack; the city reportedly paid the $45,000 ransom.

Reports of successful attacks against SCADA systems are less common. In February 2021, a hacker gained system access to a water treatment plant in Oldsmar, Florida and increased the levels of sodium hydroxide to dangerous levels; however this change was immediately detected by plant staff and corrected.

A large, sophisticated malware attack, known as Olympic Destroyer, was launched against the 2018 Winter Olympics in PyeongChang, South Korea. The attack initially took down servers, email, Wi-Fi, and ticketing systems, which could have severely disrupted the games. Fortunately, the organizing committee had a robust cybersecurity group that was able to quickly restore most functions.

Probability of Future Occurrences

Small-scale cyber attacks such as DDoS attacks occur daily, but most have negligible impacts at the local or regional level. Data breaches are also extremely common, but again most have only minor impacts on government services.

Perhaps of greatest concern to Jefferson County are ransomware attacks, which are becoming increasingly common. It is difficult to predict the odds of Jefferson County being hit with a successful ransomware attack in any given year, but it is safe to say it is **likely** to be attacked in the coming years.

The possibility of a larger disruption affecting systems within the county is a constant threat, but it is difficult to quantify the exact probability due to such highly variable factors as the type of attack and intent of the attacker. Major attacks specifically targeting systems or infrastructure in the county cannot be ruled out.

Magnitude and Severity

There is no universally accepted scale to explain the severity of cyber-attacks. The strength of a DDoS attack is often explained in terms of a data transmission rate. One of the largest DDoS disruptions ever, the October 21, 2016 Dyn attack, peaked at 1.2 terabytes per second and impacted some of the internet's most popular sites to include Amazon, Netflix, PayPal, Twitter, and several news organizations.

Data breaches are often described in terms of the number of records or identities exposed. The largest data breach ever reported occurred in August 2013, when hackers gained access to all three billion Yahoo accounts. The hacking incidents associated with Colorado in the Privacy Rights Clearinghouse database are of a smaller scale, ranging from just 32 records to approximately 60,000, along with several cases in which an indeterminate number of records may have been stolen.

Ransomware attacks are often described in terms of the amount of ransom requested, or by the amount of time and money spent to recover from the attack. Increasingly, they can also be escribed in terms of services impacted, such as phone, email, websites, or even 911 services. One report from cybersecurity firm Emsisoft estimates the average successful ransomware attack costs $81 million and can take 287 days to recover from. Overall the potential magnitude of a cyber attack can be seen as **limited** due to the lack of deaths and injuries, but the economic costs can be significant.

Climate Change Considerations

There are no known effects of climate induced impacts on human-caused hazards such as cyber attacks.

Vulnerability Assessment

The impact of a cyber-attack can vary depending on the type of attack and the intent of the malicious actor. Though a cyber disruption can have limited impacts within a system's own operations, it may cause cascading impacts.

People

Most cyber attacks do not cause injuries or fatalities, and impacts to the public are more likely to be financial losses and an inability to access systems such as public websites and permitting sites. Indirect impacts could include interruptions to traffic control systems or other infrastructure, which could result in casualties. More significantly, a ransomware attack or similar attack on a hospital or 911 system could have significant life safety impacts.

Data breaches and subsequent identify thefts can have huge impacts on the public. The Internet Crime Complaint Center (IC3) estimates that identity theft alone resulted in $2.7 billion in losses to businesses and $149 million in losses to individuals.

According to the Cyber & Infrastructure Security Agency (CISA), cyber risks to 9-1-1 systems can have "severe impacts, including loss of life or property; job disruption for affected network users; and financial costs for the misuse of data and subsequent resolution." CISA also compiled a recent list of attacks on 9-1-1 systems including a DDoS in Arizona, unauthorized access with stolen credentials in Canada, a network outage in New York, and a ransomware attack in Baltimore.

General Property

The vast majority of cyber attacks affect only data and computer systems and have minimal impact on general property.

Critical Facilities and Infrastructure

While the vast majority of cyber attacks affect only data and computer systems, sophisticated attacks against utilities and infrastructure sites have occurred. Such attacks typically target the Supervisory Control and Data Acquisition (SCADA) systems of critical infrastructure, which can potentially result in system failures on a scale equal with natural disasters. Facilities and infrastructure, such as the electrical grid, could become unusable as a result of a cyber attack. A cyber attack took down the power grid in Ukraine in 2015, leaving over 230,000 people without power. Agencies that rely on electronic backup of critical files are vulnerable.

The delivery of services can be impacted since governments rely to a great extent upon electronic delivery of services. Most agencies rely on server backups, electronic backups, and remote options for Continuity of Operations/Continuity of Government. Some departments in the participating jurisdictions have the option to move to a paper method including permitting, DMV services, payments to and from the county, and payroll. However, access to documents on the network, OneDrive access, and other operations that require collaboration across the county will be significantly impacted.

Loss of government servers due to a cyber attack could affect the ability of responders to do their jobs. Cyber-attacks can interfere with emergency response communications, access to mobile data terminals, and access to critical preplans and response documents.

The delivery of services can be impacted since governments rely, to a great extent, upon electronic delivery of services. An attack could raise questions regarding the security of using electronic systems for government services.

Jefferson County Business Innovation & Technology recommends the following free actions be adopted by all participating jurisdictions, many of which have done so:

- Sign up for the MS-ISAC. https://learn.cisecurity.org/ms-isac-registration
- Sign up for CTIS https://www.anomali.com/learn/isacs/ctis
- Sign up for the DHS CISA external vulnerability scanning. Email vulnerability@cisa.dhs.gov and ncats@hq.dhs.gov
- Sign up and configure MDBR, unless an alternative solution exists. https://www.cisecurity.org/ms-isac/services/mdbr/
- Join the Jeffco Monthly IT meetings.
- Annually complete the NCSR. https://www.cisecurity.org/ms-isac/services/ncsr/

Economy

Economic impacts from a cyber attack can be debilitating. The cyber attack in 2018 that took down the City of Atlanta cost at least $2.5 million in contractor costs and an estimated $9.5 million additional funds to bring everything back online. The attack in Atlanta took “more than a third of the 424 software programs offline” and recovery lasted more than 6 months. The 2018 cyber attack on the Colorado Department of Transportation (CDOT) cost an estimated $1.5 million. None of these statistics take into account the economic losses to businesses and ongoing IT configuration to mitigate from a future cyber-attack. In all, the FBI’s Internet Crime Complaint Center (IC3) reports that cybercrime have caused $10.2B in losses from 2015-2019; 2019 alone saw $3.5 billion in economic losses, including $65 million in Colorado.

Historical, Cultural, and Natural Resources

The vast majority of cyber incidents have little to no impact on historic, cultural or natural resources. A major cyber terrorism attack could potentially impact the environment by triggering a release of a hazardous materials, or by causing an accident involving hazardous materials by disrupting traffic-control devices.

Future Development

Changes in development have no impact to the threat, vulnerability, and consequences of a cyber attack. Cyber attacks can and have targeted small and large jurisdictions, multi-billion dollar companies, small mom-and-pop shops, and individual citizens. The decentralized nature of the internet and data centers means that the cyber threat is shared by all, regardless of new construction and changes in development.

Overall Hazard Significance

The geographic extent of the hazard is considered **significant**. The probability of future occurrences is considered likely and the magnitude/severity for the event of record is limited. The HMPC considers the hazard to have an overall impact rating of medium on Jefferson County.

4.3.19 Pandemic

Description

A pandemic can be defined as a public health emergency that attacks a large population across great geographic distances. Pandemics are larger than epidemics in terms of geographic area and number of people affected. Epidemics tend to occur seasonally and affect much smaller areas. Pandemics, on the other hand, are most often caused by new subtypes of viruses or bacteria for which humans have little or no natural resistance. Consequently, pandemics typically result in more deaths, social disruption, and economic loss than epidemics.

There are three conditions that must be met before a pandemic begins:

1. A new virus subtype must emerge that has not previously circulated in humans (and therefore there is no pre-existing immunity),
2. This new subtype must be able to cause disease in humans, and
3. The virus must be easily transmissible from human to human.

As of January 2021, Jefferson County, the nation, and the world are dealing with the COVID-19 pandemic, confirming that pandemic is a key public health hazard in the county. This hazard risk assessment includes an analysis of pandemic risk in Jefferson County and an analysis of the impacts of the hazards profiled in this plan on public health.

A pandemic has much greater potential for loss of life and significant social disruption due to higher rates of transmission and more severe health impacts. The COVID-19 virus has a much higher rate of transmission than the seasonal flu, primarily by airborne transmission of droplets/bodily fluid. Common symptoms include fever, cough, fatigue, shortness of breath or breathing difficulties, and loss of smell and taste. While most people have mild symptoms, some people develop acute respiratory distress syndrome with roughly one in five requiring hospitalization and a fatality rate of approximately 1%. A key challenge in containing the spread has been the fact that it can be transmitted by people who are asymptomatic.

Geographic Extent

Pandemics occur not only on a county or state level, but on a national and global scale. It is likely that most communities in Jefferson County would be affected, either directly or by secondary impacts. More highly-populated areas may be affected sooner and may experience higher infection rates.

The current COVID-19 pandemic has affected all 64 Colorado counties. Jefferson County has reported 33,961 cases and 707 deaths, as of January 25, 2021. All communities in the county are likely to be impacted, either directly or indirectly. Some indirect consequences may be the diversion of resources that may be otherwise available.

Previous Occurrences

Since the early 1900s, five lethal pandemics have swept the globe:

- **1918-1919 Spanish Flu:** The Spanish Flu was the most severe pandemic in recent history. The number of deaths was estimated to be 50-100 million worldwide and 675,000 in the United States. Its primary victims were mostly young, healthy adults. At one point, more than 10 percent of the American workforce was bedridden.
- **1957-1958 Asian Flu:** The 1957 Asian Flu pandemic killed 1-2 million people worldwide, including about 70,000 people in the United States, mostly the elderly and chronically ill. Fortunately, the virus was quickly identified, and vaccine production began in May 1957.
- **1968-1969 H3N2 Hong Kong Flu:** The 1968 Hong Kong Flu pandemic killed 34,000 Americans. Again, the elderly were more severely affected. This pandemic peaked during school holidays in December, limiting student-related infections, which may have kept the number of infections down. Also, people infected by the Asian Flu ten years earlier may have gained some resistance to the new virus.
- **2009-2010 H1N1 Swine Flu:** This influenza pandemic emerged from Mexico in early 2009 and was declared a public health emergency in the U.S. on April 26. By June, approximately 18,000 cases had been reported in the U.S. and the virus had spread to 74 countries. Most cases were fairly mild, with symptoms similar to the seasonal flu, but there were cases of severe disease requiring hospitalization

and a number of deaths. The CDC estimates that 43-89 million people were infected worldwide, with an estimated 8,870 to 18,300 H1N1 related deaths, including 12,469 deaths in the United States.

- **2020-Ongoing COVID-19:** The COVID-19 or novel coronavirus pandemic began in December 2019 and was declared a pandemic in March of 2020. As of February 25, 2021, 99.4 million cases have been reported around the world with over 2 million deaths, including 28 million cases and 503,000 deaths in the US. Jefferson County has seen 33,961 cases so far resulting in 1,882 hospitalizations and 707 deaths. The pandemic is expected to last through much of 2021.

Probability of Future Occurrences

Even before the COVID-19 pandemic began, the Colorado Department of Public Health and Environment (CDPHE) considered a pandemic to be inevitable. However, there is no definite way to predict when the next pandemic might happen. Some indicators will be present, but not every new virus turns into a pandemic. Based on the five pandemics that have affected the United States in roughly the last 100 years, a pandemic occurs on average roughly every 20 years, giving it a probability of **occasional**.

Magnitude and Severity

The magnitude of a public health emergency will range significantly depending on the aggressiveness of the virus in question and the ease of transmission. Pandemic influenza, for example, is more easily transmitted from person-to-person but advances in medical technologies have greatly reduced the number of deaths caused by influenza over time.

Today, a much larger percentage of the world's population is clustered in cities, making them ideal breeding grounds for epidemics. Additionally, the explosive growth in air travel means the virus could literally be spread around the globe within hours. Under such conditions, there may be very little warning time. Most experts believe we will have just one to six months between the time that a dangerous new influenza strain is identified and the time that outbreaks begin to occur in the United States. Outbreaks are expected to occur simultaneously throughout much of the nation, preventing shifts in human and material resources that normally occur with other natural disasters. These and many other aspects make influenza pandemic unlike any other public health emergency or community disaster. Pandemics typically last for several months to 1-2 years, and can have **critical** or even catastrophic impacts.

The Pandemic Intervals Framework (PIF) is a six-phased approach to defining the progression of an influenza pandemic. This framework is used to guide influenza pandemic planning and provides recommendations for risk assessment, decision-making, and action. While the PIF is specifically tailored to an influenza pandemic, the intervals provide a common method to describe pandemic activity which can inform public health actions. The duration of each pandemic interval might vary depending on the characteristics of the virus and the public health response.

The six-phase approach was designed for the easy incorporation of recommendations into existing national and local preparedness and response plans. Phases 1 through 3 correlate with preparedness in the pre-pandemic interval, including capacity development and response planning activities, while Phases 4 through 6 signal the need for response and mitigation efforts during the pandemic interval.

Pre-Pandemic Interval

In nature, influenza viruses circulate continuously among animals (primarily birds). Even though such viruses might develop into pandemic viruses, in Phase 1 no viruses circulating among animals have been reported to cause infections in humans.

Phase 1 is the natural state in which influenza viruses circulate continuously among animals but do not affect humans.

In Phase 2 an animal influenza virus circulating among domesticated or wild animals is known to have caused infection in humans and is thus considered a potential pandemic threat. Phase 2 involves cases of animal influenza that have circulated among domesticated or wild animals and have caused specific cases of infection among humans.

In Phase 3 an animal or human-animal influenza virus has caused sporadic cases or small clusters of disease in people but has not resulted in human-to-human transmission sufficient to sustain community-level outbreaks. Limited human-to-human transmission may occur under some circumstances, for

examples, when there is close contact between an infected person and an unprotected caregiver. Limited transmission under these circumstances does not indicate that the virus has gained the level of transmissibility among humans necessary to cause a pandemic. Phase 3 represents the mutation of the animal influenza virus in humans so that it can be transmitted to other humans under certain circumstances (usually very close contact between individuals). At this point, small clusters of infection have occurred.

Pandemic Interval

Phase 4 is characterized by verified human to human transmission of the virus able to cause "community-level outbreaks." The ability to cause sustained disease outbreaks in a community marks a significant upward shift in the risk for a pandemic. Phase 4 involves community-wide outbreaks as the virus continues to mutate and become more easily transmitted between people (for example, transmission through the air)

Phase 5 is characterized by verified human to human spread of the virus into at least two countries in one World Health Organization (WHO) region. While most countries will not be affected at this stage, the declaration of Phase 5 is a strong signal that a pandemic is imminent and that the time to finalize the organization, communication, and implementation of the planned mitigation measures is short. Phase 5 represents human-to-human transmission of the virus in at least two countries.

Phase 6, the pandemic phase, is characterized by community-level outbreaks in at least one other country in a different WHO region in addition to the criteria defined in Phase 5. Designation of this phase will indicate that a global pandemic is underway. Phase 6 is the pandemic phase, characterized by community-level influenza outbreaks.

Climate Change Considerations

According to the best available data, the changing climate is expected to exacerbate future pandemics. Climate change will influence vector-borne disease prevalence, although the direction of the effects (increased or decreased incidence) will be location- and disease specific. The intensity and extent of certain diseases is projected to increase. Climate induced hazards threatens to increase the spread of infectious diseases because changing heat, rain, and humidity levels allow disease carrying vectors and pathogens to come into closer contact with humans. If Colorado's climate becomes warmer, mosquito populations could swell, making the region more favorable for disease transmission. Warmer weather could also play a role in elevated seasonal deer mouse populations. Disadvantaged populations such as people with compromised health and the economically disadvantaged are expected to bear a greater burden as a result of their current reduced access to medical care and limited resources for adaptation strategies.

Additional research is needed to determine the effects of climate change on the frequency and duration of epidemics and pandemics. Ongoing efforts to reduce Colorado's greenhouse gas emissions and adapt to a changing climate, such as the Colorado Climate Plan, may help to reduce the impacts of climate induced on pandemics.

Vulnerability Assessment

Preparing for, responding to, and recovering from a pandemic requires a strategy that includes a holistic suite of public health activities designed to lessen the impact on morbidity and mortality. These activities include education, vaccination, prophylaxis, isolation/quarantine, a robust contact tracing program, and the closure of public facilities. In addition, clear, concise communication with the public and with other agencies remains a critical component, as does the ability of the involved agencies to achieve collaboration and coordination. By their very nature, most pandemics, once started, will not be stopped until they have run their course. This course can be shortened and weakened by a number of factors, with vaccination being the most effective method for protecting the population. Pandemic plans describe strategies of preparedness, response, and recovery to attempt to decrease illnesses and deaths during the pandemic period to manageable levels (i.e., that do not overwhelm the critical infrastructures of the State), and to promote community resiliency and rapid recovery.

People

Pandemics have the ability to affect large segments of the population for long periods of time. The number of hospitalizations and deaths will depend on the virulence of the virus. Risk groups cannot be predicted with certainty; the elderly, people with underlying medical conditions, and young children are usually at higher risk, but as discussed above this is not always true for all influenza strains. People without health coverage or access to good medical care are also likely to be more adversely affected. Mental health of the public could also be impacted depending on the length of the event and public health guidance on prevention. Medications may be limited to help prevent or treat the disease. Vaccines typically take several months to years to manufacture and would likely become available in small quantities at first. It may become necessary to ration limited amounts of medications, vaccinations, and other health care supplies.

As noted under Previous Occurrences, the COVID-19 pandemic has resulted in 99.4 million cases worldwide with over 2 million deaths as of January 25, 2021. The U.S. has seen 25 million cases with 420,000 deaths, and Jefferson County specifically has seen 33,961 cases resulting in 1, 882 hospitalizations and 707 deaths. In addition to the direct impacts, the pandemic has completely disrupted life for many people. Most large gatherings have had to be cancelled, and many schools have closed. Sheltering in place and social distancing have been highly encouraged and, in some places, mandated, leaving some individuals isolated for months.

Medical staff can become overburdened with hundreds of additional cases on top of their normal workload. All other responders will be impacted in similar proportions to the general public, thereby reducing available responders. Adverse impacts are expected to be severe for unprotected personnel and uncertain for trained and protected personnel, depending on the nature of the incident.

The COVID-19 pandemic has had severe impacts on healthcare workers and other responders. The difficulty of trying to protect themselves and their families while still doing their jobs was exacerbated initially by shortages of personal protective equipment (PPE). The mental health impacts on responders and healthcare workers have not been fully quantified but are likely to have impacts for months if not years to come.

General Property

For the most part, property itself is not generally impacted by a human disease epidemic or pandemic. However, as concerns about contamination increase, property may be quarantined or destroyed as a precaution against spreading illness. Additionally, traditional sheltering facilities including homeless shelters or facilities stood up to support displaced persons due to an evacuation or other reason due to a simultaneous disaster occurring cannot be done in a congregate setting. This requires additional planning considerations or use of facilities that allow for non-congregate shelter settings which may require an approval of a request to FEMA for non-congregate sheltering, and may have an increased cost (such as the use of individual hotel rooms) as opposed to traditional congregate sheltering facilities.

Critical Facilities and Infrastructure

Hospitals and morgues will be heavily affected and may be overwhelmed. Other critical facilities and infrastructure are not directly affected by a pandemic but may have difficulty maintaining operations and maintenance activities due to a significantly decreased workforce. Schools may be forced to close.

Medical staff can become overburdened with hundreds of additional cases on top of their normal workload. All other responders will be impacted in similar proportions to the general public, thereby reducing available responders. Adverse impacts are expected to be severe for unprotected personnel and uncertain for trained and protected personnel, depending on the nature of the incident.

The COVID-19 pandemic has had severe impacts on healthcare workers and other responders. The difficulty of trying to protect themselves and their families while still doing their jobs was exacerbated initially by shortages of personal protective equipment (PPE). The mental health impacts on responders and healthcare workers have not been fully quantified but are likely to have impacts for months if not years to come.

Other responders will be impacted similarly to the general public, although the nature of their jobs may make social distancing more difficult which could potentially lead to higher infection rates, thereby reducing available responders.

Unscheduled sick leave from a large portion of the workforce could result in loss of productivity and delivery of services. Even without large numbers of infected workers, social distancing requirements and workplace closures can have a major impact on the government's ability to deliver services, as seen during the COVID-19 pandemic. As residents are quarantined due to the pandemic, as seen during the COVID-19 pandemic the demand for deliveries of essential goods will also increase.

Ability to respond and recover may be questioned and challenged if planning, response, and recovery are not timely and effective. Help from the federal government and from other states would likely be limited, as all personnel would be deployed throughout the country already. While the federal government would do what they can, communities would have to rely on their own resources for a much longer period of time as compared to other disasters. It is expected that the government will work towards a solution that will end the pandemic, typically by helping to distribute vaccines and antiviral agents. Continual public messaging and outreach is vital.

Economy

In a normal year, lost productivity due to illness costs U.S. employers an estimated $530 billion. During a pandemic, that figure would likely be considerably high and could trigger a recession or even a depression. Local economy and finances may be adversely affected, possibly for an extended period of time. Unscheduled sick leave from a large portion of the workforce could result in millions, even billions, of dollars lost in productivity. Business restrictions due to social distancing requirements can also be significant. In a normal year, lost productivity due to illness costs U.S. employers an estimated $530 billion. During a pandemic, that figure would likely be considerably high and could trigger a reception or even a depression.

The economic impact of the COVID-19 pandemic and associated closures has been significant, triggering a recession and high unemployment; the unemployment rate jumped for 4.4% in March of 2020 to 14.7% in April and stayed in the double-digits through most of the summer. Some studies estimate that 1 in 5 renters are at risk of eviction. The stock market suffered major losses in the early days of the pandemic. The restaurant, retail, and oil and gas industries have been particularly hard hit, with numerous businesses closing or filing for bankruptcy. And among household with children, food insecurity – defined as when a household does not have sufficient food for its members to maintain healthy and active lives and lacks the resources to obtain more food – has more than doubled from 14% in 2018 to 32% in July 2020.

Historical, Cultural, and Natural Resources

Impacts to these resources are typically minimal. However, reduced tourism during outbreaks could lead to additional economic impacts.

Future Development

Population growth and development contribute to pandemic exposure. Future development in and around Jefferson County has the potential to change how infectious diseases spread through the community and impact human health in both the short and long term. New development may increase the number of people and facilities exposed to public health hazards and greater population concentrations (often found in special needs facilities and businesses) put more people at risk. During a disease outbreak those in the immediate isolation area would have little to no warning, whereas the population further away in the dispersion path may have some time to prepare and mitigate against disease depending on the hazard, its transmission, and public notification.

Overall Hazard Significance

The geographic extent of the hazard is considered **extensive**. The probability of future occurrences is **occasional**, and the magnitude/severity for the event of record is **critical**. The HMPC considers the hazard to have an overall impact rating of **high** for Jefferson County.

5 Mitigation Strategy

Requirement §201.6(c)(3): [The plan shall include] a mitigation strategy that provides the jurisdiction's blueprint for reducing the potential losses identified in the risk assessment, based on existing authorities, policies, programs and resources, and its ability to expand on and improve these existing tools.

This section describes the mitigation strategy process and mitigation action plan for the Jefferson County Hazard Mitigation Plan. This section describes how the County accomplished Phase 3 of FEMA's 4-phase guidance - Develop the Mitigation Plan - and includes the following from the 10-step planning process:

- Planning Step 6: Set Goals
- Planning Step 7: Review Possible Activities
- Planning Step 8: Draft an Action Plan

The results of the planning process, the risk assessment, the goal setting, the identification of mitigation actions, and the hard work of the HMPC led to the mitigation strategy and mitigation action plan for this LHMP update. As part of the plan update process, a comprehensive review and update of the mitigation strategy portion of the plan was conducted by the HMPC. As part of this process, the goals and objectives from the 2016 Plan were reviewed and reaffirmed. While the goals were not changed, some objectives were modified to better reflect current priorities. The mitigation actions from the 2016 Plan were also reviewed, assessed for progress, and evaluated for their inclusion in this plan update. Section 5.1 below identifies the updated goals and objectives of this plan; Section 5.2 details the progress on 2016 mitigation actions; Section 5.3.1 describes how new actions were identified and prioritized; and Section 5.4 summarizes the updated mitigation action plan.

5.1 Goals and Objectives

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

Up to this point in the planning process, the Hazard Mitigation Planning Committee (HMPC) has organized resources, assessed natural hazards and risks, and documented mitigation capabilities. A profile of the County's vulnerability to natural hazards resulted from this effort, which is documented in the preceding section. The resulting goals, objectives, and mitigation actions were originally developed based on this profile in 2010 and updated in 2016 and have again been updated for 2021. The HMPC developed the updated mitigation strategy based on a series of meetings and worksheets designed to achieve a collaborative mitigation planning effort, as described further in this section.

Goals were defined for the purpose of this mitigation plan as broad-based public policy statements that:

- Represent basic desires of the community;
- Encompass all aspects of community, public and private;
- Are nonspecific, in that they refer to the quality (not the quantity) of the outcome;
- Are future-oriented, in that they are achievable in the future; and
- Are time-independent, in that they are not scheduled events.

Goals are stated without regard for implementation, that is, implementation cost, schedule, and means are not considered. Goals are defined before considering how to accomplish them so that the goals are not dependent on the means of achievement. Goal statements form the basis for objectives and actions that will be used as means to achieve the goals. Objectives define strategies to attain the goals and are more specific and measurable. Mitigation Actions are specific actions that help achieve goals and objectives.

To facilitate the goals update of this plan HMPC members were provided a breakdown of the list of goals from the 2016 Jefferson County Multi Hazard Multi Jurisdiction plan, along with goals and objectives from a number of related plans, including the 2018 State of Colorado Hazard Mitigation Plan. This review was

conducted to ensure the plan's mitigation strategy reflected current policies and priorities, updated risk assessment information, and was integrated with existing plans and policies. They were told that they could use, combine, or revise the statements provided or develop new ones, keeping the risk assessment in mind.

The team reaffirmed the three goals from the 2016 plan, however, the language was revised slightly to include human-caused hazards. Several objectives were revised as well. These were compiled into a document which was discussed and accepted with minor revisions and consensus of the HMPC at a follow-up mitigation planning meeting.

Based upon the risk assessment review and goal setting process, the HMPC approved these goals and objectives for the 2021 plan.

Goal 1: Increase public education and awareness about natural and human-caused hazards and how to mitigate against them.

a) Continue public outreach efforts on the hazards identified in this plan.
b) Improve plans, procedures, and systems for public notification and warning.
c) Provide education on hazard resistant construction techniques and create incentives for the public to mitigate hazards on their own property.
d) Engage constituency to take personal responsibility for their own exposure and mitigation.
e) Increase public awareness of the need for funding for disaster mitigation & preparedness.
f) Understand the impacts of climate change on severity and frequency of hazards.

Goal 2: Reduce impacts of hazards on life, property, and the environment.

a) Continue to manage development and placement of structures in hazard-prone areas.
b) Protect existing property to the extent possible.
c) Utilize the risk assessment as the basis for jurisdictional response and evacuation plans.
d) Protect critical facilities and infrastructure to minimize loss of critical services following an event.
e) Strongly communicate wildfire mitigation with all land use proposals and existing land uses.
f) Continue CWPP efforts including periodic updates and implementation of wildfire mitigation including wildfire fuel breaks, wildfire safe zones and defensible space, fuels reduction and biomass use.
g) Increase wildfire mitigation efforts specifically on public lands and open space.
h) Reduce the economic impact to public and private entities from hazards.
i) Enhance ability of businesses to mitigate and recover from disasters.
j) Continue to reduce flood losses through compliance with National Flood Insurance Program, and continue to participate with Community Rating System, where applicable.
k) Encourage measures to enable the County and jurisdictions to better withstand a multi-year drought.
l) Improve wildfire education and training for dispatchers and emergency responders.
m) Improve the ability of local government and the private sector to defend against and recover from cyber attacks.
n) More systemic preparation/adaptation to reduce more chronic but widespread impacts, such as strain on the power grid and premature aging of infrastructure.
o) Maintain and strengthen existing natural systems/ecosystems/biodiversity to improve disaster resilience.

Goal 3: Strengthen and develop partnerships in regard to mitigating hazard impacts.

a) Promote planning efforts that foster cooperation and coordination among jurisdictions, agencies, and community aide organizations involved in hazard mitigation and response.
b) Maximize the use of shared resources and community resilience projects to leverage funding for hazard mitigation projects between all levels of government and the private sector.
c) Encourage coordination between mitigation efforts on public land and adjacent private properties.
d) Develop links between emergency planning and land and water use planning.
e) Strengthen community partnerships to enhance the ability of local government to adapt to changing climate conditions and mitigate and respond to hazard events.
f) Create a standing multi-jurisdictional hazard mitigation committee to provide mitigation fund governance, track plan implementation, and coordinate mitigation activities throughout the County.
g) Implement the recommendations of the Wildfire Risk Reduction Task Force 2020 report.

5.2 Progress on Previous Mitigation Actions

Jefferson County and the majority of the participating jurisdictions have been successful in implementing actions identified in the 2016 Plan. The 2016 mitigation strategy contained a total of 74 mitigation actions, 12 of which were identified as having been completed. Seven actions were deleted as being no longer relevant. These completed and deleted actions are shown in Table 5-1

Table 5-1 2016 Mitigation Actions Completed or Deleted

Jurisdiction	Mitigation Action Title	Hazard	2020 Status
Jefferson County	Massey Draw Floodplain Improvements	Flood	Completed
Jefferson County	Beer Sisters Reservoir Rehabilitation	Dam Failure and Flood	Completed
Arvada	Multi-Jurisdictional Storm Ready Program Participation	Hail, Extreme Heat, Winter Storms, Lightning, Tornado, Severe Wind	Completed
Lakewood	Revise Emergency Operations Plan (EOP) for Maple Grove Reservoir	Dam Failure	Completed
Lakewood	Lakewood Energy Assurance Plan Update	All	Completed
Lakewood	Multi-Jurisdictional Storm Ready Program Participation	Hail, Extreme Heat, Winter Storms, Lightning, Tornado, Severe Wind	Completed
Wheat Ridge	Maple Grove Dam operations plan	Flood	Completed
Wheat Ridge	NFIP/CRS/CIP/Stormwater Utility.	Dam Failure, Flood	Completed
Denver Water	Flood inundation maps.	Flood	Completed
Denver Water	Training/exercising at Foothills Treatment Plant	Wildfire	Completed
Jefferson Conservation District	Last Resort Creek and Kennedy Gulch Fuels Reduction	Wildfire	Completed
Lookout Mountain Water	Expand storage capacity at upper Beaver Brook reservoir	Drought	Completed
Jefferson County	Drake outfall	Flood	Deleted
Jefferson County	Fairmount drainage improvement program	Flood	Deleted
Edgewater	Continued Validation of Flood Response Protocol Identified in 2007 EOP through Practical Training and Exercises Design.	Flood	Deleted (not participating for 2021)
Lakewood	Burying Power Lines to Green Mountain Repeater Site	Severe Wind, Winter Storm, Tornadoes, Lightning	Deleted
Mountain View	Storm Water Drainage	Flood	Deleted (not participating for 2021)
Denver Water	Sediment removal from Strontia Springs Dam.	Dam Failure	Deleted
Jefferson Conservation District	Educate Homeowners on Wildfire Hazards and Mitigation	Wildfire	Deleted
Jefferson Conservation District	Doubleheader Ranch Hazardous Fuels Reduction	Wildfire	Deleted
Pleasant View Metro District	Flood mitigation of Lena Gulch through West Blade Park located at 16780 Mt Vernon Road.	Flood	Deleted (not participating for 2021)

Source: HMPC

While only 12 actions were reported as having been fully completed, considerable progress has been made on other actions. Many others were reported as being in progress or are already being implemented on an annual basis. Furthermore, some mitigation actions included multiple related projects. For example, while Jefferson Conservation District is shown as only having completed one action, that action actually reflects two to five wildfire projects per year, averaging 300 acres per year treated.

Some of the challenges of implementation of projects included:

- Lack of funding, including ability to provide matching funds.
- Difficulty passing benefit cost analysis required for certain FEMA grants.
- Public opposition to fire mitigation in JeffCo Open Space – specifically in Apex Open Space where there was public opposition to reducing fuel loads.
- Conflicting priorities, and intervention of major hazard events

5.2.1 Continued Compliance with NFIP

Recognizing the importance of the National Flood Insurance Program (NFIP) in mitigating flood losses, an emphasis will be placed on continued compliance with the NFIP by Jefferson County and all participating communities have been mapped for flood hazards: Arvada, Edgewater, Golden, Lakewood, Morrison, and Wheat Ridge. As NFIP participants, these communities have and will continue to make every effort to remain in good standing with NFIP. This includes continuing to comply with the NFIP's standards for updating and adopting floodplain maps and maintaining and updating the floodplain zoning ordinance. Jefferson County and the communities of Arvada, Golden, Lakewood, Morrison, and Wheat Ridge will also continue to participate in the Community Rating System (CRS) to go above and beyond the requirements of the NFIP, and have continued to improve their CRS ratings as described in Section 2.7.4.

Additional details related to NFIP participation are discussed in Section 2.7 and in the flood vulnerability discussion in Section 4.3.9.

5.3 Identification of Mitigation Actions

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

In order to identify and select mitigation measures to support the mitigation goals, each hazard identified in Section 4.1: Identifying Hazards was evaluated in regard to the various options for mitigation. Hazards that pose a significant threat to the community were considered the priority in the development of hazard specific mitigation measures.

The Planning Team considered the following categories of mitigation actions, as defined in FEMA's 2013 *Local Mitigation Planning Handbook*:

- **Plans and regulations:** These actions include government authorities, policies, or codes that influence the way land and buildings are developed and built.
- **Structure and infrastructure projects:** These actions involve modifying existing structures and infrastructure to protect them from a hazard or remove them from a hazard area. This could apply to public or private structures as well as critical facilities and infrastructure. This type of action also involves projects to construct manmade structures to reduce the impact of hazards.
- **Natural systems protection:** These are actions that minimize damage and losses and also preserve or restore the functions of natural systems.
- **Education and awareness:** These are actions to inform and educate citizens, elected officials, and property owners about hazards and potential ways to mitigate them. These actions may also include participation in national programs, such as StormReady or Firewise Communities. Although this type of mitigation reduces risk less directly than structural projects or regulation, it is an important foundation. A greater understanding and awareness of hazards and risk among local officials, stakeholders, and the public is more likely to lead to direct actions.

The Planning Team also considered the following categories as defined in the Community Rating System:

- **Prevention:** Administrative or regulatory actions or processes that influence the way land and buildings are developed and built.
- **Property protection:** Actions that involve the modification of existing buildings or structures to protect them from a hazard or remove them from the hazard area.
- **Structural:** Actions that involve the construction of structures to reduce the impact of a hazard.

- **Natural resource protection:** Actions that, in addition to minimizing hazard losses, also preserve or restore the functions of natural systems.
- **Emergency services:** Actions that protect people and property during and immediately after a disaster or hazard event.
- **Public information/education and awareness:** Actions to inform and educate citizens, elected officials, and property owners about the hazards and potential ways to mitigate them.

At planning meeting #3, the Planning Team was provided with handouts describing the categories and listing examples of potential mitigation actions for each category, as well as for the identified hazards. FEMA's 2013 document *Mitigation Ideas: A Resource for Reducing Risk to Natural Hazards* was referenced and made available for reference, along with FEMA's 2020 *Mitigation Action Portfolio*. Attendees were then asked to submit mitigation action ideas via an online poll. Action submissions included details describing how the actions will be implemented and administered, to include cost estimates, potential funding sources, and estimated timeline for completion. Each action was required to be tied to one or more of the goals and objectives.

It was not always feasible or realistic for every jurisdiction to develop mitigation actions against every identified hazard. However, actions were compared against identified hazards to ensure that the plan contains a comprehensive range of mitigation actions and projects for each of the most high risk hazards. An emphasis on new and existing buildings and infrastructure was stressed. While the Planning Team focused primarily on those hazards identified as posing the highest risk to the jurisdiction, mitigation actions were also suggested for some low priority hazards.

Similarly, while the primary focus was on developing mitigation actions in the categories described above, some jurisdictions identified actions that do not fall into one of the above categories and which may be better defined as planning or preparedness actions. Some of these actions were nonetheless included in the plan, as the jurisdiction felt they were important actions to reduce losses from future disasters even if they do not meet the strict definition of mitigation.

HMPC members considered actions that would mitigate impacts to both new and existing buildings and infrastructure. The HMPC noted that the Hazard section of the Jefferson County Comprehensive Land Use Plan and related Land Use Code is oriented towards reducing impacts to future development and will be used as the primary implementation mechanism for ongoing land use planning related to hazards. This plan works in tandem with the Land Use Plan and puts forth recommendations that will reduce losses to both new and existing infrastructure but can be viewed as having a primary focus on reducing impacts to existing buildings, populations, and infrastructure.

5.3.1 Prioritization Process

Once the new mitigation actions were identified, the HMPC members were provided with several sets of decision-making tools, including FEMA's recommended criteria, STAPLE/E (which considers social, technical, administrative, political, legal, economic, and environmental constraints and benefits).

- **Social:** Does the measure treat people fairly?
- **Technical:** Will it work? (Does it solve the problem? Is it feasible?)
- **Administrative:** Is there capacity to implement and manage the project?
- **Political:** Who are the stakeholders? Did they get to participate? Is there public support? Is political leadership willing to support the project?
- **Legal:** Does your organization have the authority to implement? Is it legal? Are there liability implications?
- **Economic:** Is it cost-beneficial? Is there funding? Does it contribute to the local economy or economic development? Does it reduce direct property losses or indirect economic losses?
- **Environmental:** Does it comply with environmental regulations or have adverse environmental impacts?

In accordance with the DMA requirements, an emphasis was placed on the importance of a benefit-cost analysis in determining project priority (the 'economic' factor of STAPLE/E). Other criteria used to recommend what actions might be more important, more effective, or more likely to be implemented than another included:

- Does the action protect lives?
- Does the action address hazards or areas with the highest risk?
- Does the action protect critical facilities, infrastructure or community assets?
- Does the action meet multiple objectives (Multiple Objective Management)?

The above criteria were used to prioritize actions in an iterative process over the course of the plan update process. At the start of the process, participating jurisdictions were asked to validate or update the priorities of their continuing actions from the 2016 Plan. When submitting new mitigation actions, planning team members were asked to prioritize those as well. Finally, once all new and continuing actions had been collated into a draft mitigation strategy, jurisdictions were asked to verify or update the priorities of each action compared to their other actions.

5.4 Mitigation Action Plan

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

This section outlines the development of the final updated mitigation action plan. The action plan consists of the specific projects, or actions, designed to meet the plan's goals. Over time the implementation of these projects will be tracked as a measure of demonstrated progress on meeting the plan's goals.

The total number of actions identified by each jurisdiction is summarized in Table 5-2, including those actions completed, deleted, or continued from the 2016 HMP.

Table 5-2 Mitigation Actions Summary by Jurisdiction

Jurisdiction	# of Actions in 2016 HMP	# of Actions Completed	# of Actions Deleted	# of Actions Continued	New Actions Added	# of Actions in 2021 HMP
Jefferson County	20	2	2	16	22	**38**
City of Arvada	6	1	0	5	11	**16**
City of Edgewater	3	0	1	2	3	**5**
City of Golden	2	0	0	2	7	**9**
City of Lakewood	6	3	1	2	6	**8**
Town of Morrison	2	0	0	2	7	**9**
City of Wheat Ridge	10	2	0	8	2	**10**
Arvada Fire Protection District	NA	NA	NA	NA	2	**2**
Elk Creek Fire Protection District	NA	NA	NA	NA	2	**2**
Evergreen Fire Rescue	2	0	0	2	2	**4**
Fairmount Fire Rescue	2	0	0	2	2	**4**
Foothills Fire Protection District	NA	NA	NA	NA	2	**2**
Genesee Fire Protection District	NA	NA	NA	NA	1	**1**
Golden Gate Fire	2	0	0	2	1	**3**
Indian Hills Fire Protection District	1	0	0	1	1	**2**
Inter-Canyon Fire Protection District	NA	NA	NA	NA	1	**1**
North Fork Fire Protection District	2	0	0	2	1	**3**
West Metro Fire Protection District	1	0	0	1	1	**2**
Denver Water	6	2	1	3	1	**4**

Jurisdiction	# of Actions in 2016 HMP	# of Actions Completed	# of Actions Deleted	# of Actions Continued	New Actions Added	# of Actions in 2021 HMP
Lookout Mountain Water District	6	1	0	5	6	**11**
Jefferson Conservation District	3	1	2	0	1	**1**
Total	**74**	**12**	**7**	**55**	**82**	**137**

Source: HMPC

The 2021 Jefferson County mitigation action plan lists the actions developed and prioritized as described above, to include continuing actions from the 2016 Plan. The action plan details how the participating jurisdictions will reduce the vulnerability of people, property, infrastructure, and natural and cultural resources to future disaster losses. The action plan summarizes who is responsible for implementing each of the prioritized actions as well as when and how the actions will be implemented. All actions are tied to specific goals and objectives to ensure alignment with the Plan's overall mitigation strategy. Additionally, projects were tied to specific infrastructure Lifeline categories, to better align with the latest FEMA guidance and grant requirements. Over time the implementation of these projects will be tracked as a measure of demonstrated progress on meeting the plan's goals.

Many of these mitigation actions are intended to reduce impacts to existing development. In addition actions are identified to reduce impacts to future development. These actions include those that promote wise development and hazard avoidance, such as building code, mapping, and zoning improvements, and continued enforcement of floodplain development regulations. Actions that protect critical infrastructure note which lifeline category is protected using the following abbreviations:

- COM: Communications
- ENG: Energy
- FWS: Food, Water, Sheltering
- HAZ: Hazardous Waste
- H&M: Health & Medical
- S&S: Safety & Security
- TRN: Transportation

Jefferson County's mitigation actions are listed in Table 5-3 below. Mitigation actions for the other participating jurisdictions are summarized in Table 5-2 above and detailed in each jurisdiction's Annex.

Table 5-3 Jefferson County Mitigation Action Plan

Number	Title and Description	Hazards Mitigated	Related Goals & Lifelines	Lead Agency & Partners	Cost Estimate & Potential Funding	Priority	Timeline	Status & Implementation Notes
Jefferson County 1	**Major drainageway culvert improvements with Mile High Flood District.** Multiple locations of roadway crossings with significantly undersized culverts to be replaced with culverts to accommodate the 100 year flood flows. Benefits include reduced flood losses safety for emergency vehicles and the public during major flood events.	Flood	Goals 2,3; Lifelines S&S, TRN	Jefferson County Transportation and Engineering in conjunction with the Mile High Flood District	$9,000,000; MHFD	Medium	Design phase in 2016-2019 & proposed construction in 2018-2021	Annual Implementation. Structures identified and replaced yearly
Jefferson County 2	**Minor culvert improvements.** Multiple locations of roadways with existing culvert crossings either failing or in eminent danger of failure. Benefits include reduced flood losses and provide for public safety	Flood	Goals 2; Lifelines S&S, TRN	Jefferson County Transportation and Engineering, Jefferson County Road and Bridge	$1,000,000 per year County General Fund	High	Continuing, with culvert inspection and replacement ongoing.	Annual Implementation. Structures identified and replaced yearly
Jefferson County 3	**Weaver Creek major drainageway master plan and FHAD.** The Weaver Creek Drainageway has many areas in which the existing channel and culverts lack the capacity to safely convey the major flood events. A Master Plan is needed to properly plan and budget for needed improvements. The current Flood Hazard Area Delineation was prepared over 35 years ago and needs to be updated to accurately reflect the regulatory 100 year floodplain. Benefits include reduced flood losses.	Flood	Goals 2,3; Lifelines S&S, TRN	Jefferson County Transportation and Engineering in conjunction with the Mile High Flood District and the City of Lakewood	$250,000 Mile High Flood District, $150,000, County $93,000, City of Lakewood $7,000	Medium	Ongoing	In Progress. Master Plan complete. FHAD nearing completion.
Jefferson County 4	**Notification polygons for dam failure and flash flooding.** Develop pre-established notification polygons or equivalent for citizens who reside in dam failure hazard areas. Can also be established for floodplains. The technology currently exists in the CodeRED system employed by all county 911 entities. The project will require taking the dam inundation maps and floodplain	Dam Failure; Flood	Goals 1,2; Lifelines COM, FWS, H&M, S&S	Jefferson County Emergency Communication Authority (JCECA); Dam owners, floodplain managers, Mile	Minimal, need in-kind labor In-kind	High	Ongoing	In Progress. Jefferson County SO and County staff time; dams are done. Flood polygons are incomplete but JCOS GIS created a tool to build them

Number	Title and Description	Hazards Mitigated	Related Goals & Lifelines	Lead Agency & Partners	Cost Estimate & Potential Funding	Priority	Timeline	Status & Implementation Notes
	maps for the targeted areas and creating a polygon in the CodeRED system. Benefits include Faster notification will give citizens more time to evacuate from flood-prone areas which could prevent injury or death from flooding.			High Flood District				
Jefferson County 5	**Update CWPPs to reflect changing conditions and new development.** This project will update Community Wildfire Protection Plans (CWPPs) to reflect changing conditions and new development. Most plans were crafted in 2010 and with new development and changing conditions the accuracy of the data is questionable. Implementation would most likely require the hiring of a specific consulting firm to gather data and create new plans. Benefits include Better data will ultimately lead to better mitigation activities, better planning, and ultimately a more effective response.	Wildfire	Goals 2,3; Lifelines COM, ENG, FWS, S&S, TRN	Jefferson County OEM	To be determined based on community size, but approximately $15-40k per plan Grant funding – state and federal	High	Ongoing	Finalize. The FMO will use the updated AOP, HMP, and fire district CWPPs to update the county CWPP
Jefferson County 6	**Mitigate wildfire hazards on public lands and open space properties.** There are fuel load concerns on County and other open space properties. Residential and other development are potentially at risk due to extensive WUI. This project will perform hazard fuel mitigation in areas identified as high-hazard in countywide and individual CWPPs. Different methods might include tree thinning, mastication, and controlled burning. Benefits include reduced wildfire losses	Wildfire	Goals 2; Lifelines COM, ENG, S&S	Jefferson County OEM and Open Space. ID other partners - USFS, State, FPDs, JeffCo Conservation District, Denver Mountain Parks, municipalities etc.	Varies depending on the fuel type and acreage. $2,000 per acre is a good estimate. Grant funding – state and federal	High	Ongoing	In Progress. Utilized seasonal fuels crew when Sheriff's Office still held those positions. Jeffco Forest Health Plan IDs fire mitigation strategies, BRIC grant to build capacity for fire mitigation

Number	Title and Description	Hazards Mitigated	Related Goals & Lifelines	Lead Agency & Partners	Cost Estimate & Potential Funding	Priority	Timeline	Status & Implementation Notes
Jefferson County 7	**Develop partnerships and begin needs assessment for seismic mitigation of critical infrastructure within JeffCo.** The Golden Fault and other seismic sources in the region present the potential for a low probability but potentially high consequence earthquake event. This project would begin with a needs assessment to identify critical facilities likely to incur strong ground shaking that could lead to nonstructural and structural damage. Facilities identified for further review would undergo a FEMA rapid visual assessment (FEMA 154) to identify building hazards and potential mitigation options. Benefits include While the risk of earthquake in the area is low, the potential damage could be catastrophic. Performing seismic mitigation would help ensure uninterrupted governmental service for critical infrastructure. This is the first step in reducing earthquake losses including reduced potential for injuries; reduced potential for facility damage and loss of function.	Earthquake	Goals 2,3; Lifelines COM, ENG, FWS, HAZ, H&M, S&S, TRN	Jefferson County Planning & Zoning; USGS, CGS	$30-80K depending on scope and number of facilities assessed NEHRP, FEMA, DHSEM	Low	Ongoing	Not Started. Low priority considering risk.
Jefferson County 8	**Education and awareness of geologic hazards.** Due to relative infrequency of geologic hazards in the planning area, the public is not generally well informed about the risks associated with this type of hazard. Work in conjunction with Jill Carlson at Colorado Geological Survey; create GIS layers available to public that identify hazards such as landslide and debris flow and disseminate information. Benefits include While the risk of earthquake in the area is low, the potential damage could be catastrophic. Raising awareness of hazards will enable the public to understand how to survive an earthquake. Improved mapping of debris	Avalanche, Earthquake, Erosion and Deposition, Expansive Soils, Landslide/ Debris Flow/ Rockfall, Subsidence	Goals 1; Lifelines NA	Jefferson County OEM, Local Government (interested parties)	To be determined Grant funding – state and federal	Medium	Ongoing	In Progress. Preparedness campaign update. Hazard study, mitigation and education on Dinosaur Ridge

Number	Title and Description	Hazards Mitigated	Related Goals & Lifelines	Lead Agency & Partners	Cost Estimate & Potential Funding	Priority	Timeline	Status & Implementation Notes
	flow and landslide areas could lead to targeted mitigation projects.							
Jefferson County 9	**Flood education and outreach.** Increase the flood awareness of residents of Jefferson County to protect people and property. This project would build upon annual floodplain notification efforts associated with the County's CRS program participation. Efforts include distributing the MHFD flood awareness brochure to residents in the floodplain. Benefits include increased awareness of the risk and dangers of flooding can reduce the impact of flooding to the citizens of Jefferson County.	Flood	Goals 1,3; Lifelines NA	Jefferson County Planning and Zoning, OEM, MHFD	TBD	Medium	Ongoing with annual efforts	In Progress. Preparedness campaign update. Continued public outreach
Jefferson County 10	**Perform hazard fuel mitigation in areas identified as high hazard in countywide and individual CWPPs.** This project will perform hazard fuel mitigation in areas that have been identified as high-hazard in countywide and individual CWPPs. Different methods might include tree thinning, mastication, and controlled burning. The CWPP will be referenced for specific areas and recommended treatments. Benefits include fuel mitigation projects improve public safety, reduce risk to firefighters, reduce potential for structure losses and help forest ecology.	Wildfire	Goals 2; Lifelines COM, ENG, S&S	Jefferson County Sheriff's Office in partnership with Jefferson County fire districts and Jefferson Conservation District	Varies depending on the fuel type and acreage. $2,000 per acre is a typical estimate Grant funding – state (CSFS) and federal (FEMA PDM or HMGP)	High	Ongoing	In Progress. Utilized seasonal fuels crew when Sheriff's Office still held those positions. Mitigated fuels on 250 acres of JCOS land 2016-2020; Mitigating 1,000 acres by 2025. JCD also completed 1400 acres of fuel reduction treatments from 2016-2020
Jefferson County 11	**South Weir Gulch rehabilitation.** This project provides for the construction of a combination of channel improvements and drop structures to control severe erosion and safely convey runoff from Union Boulevard east to Pierson Street south of Florida Avenue. Currently this section of the South Wier Gulch drainageway is very steep and is rapidly eroding the existing channel. This has resulted in a portion of the channel with almost vertical walls 15-20 feet deep. This erosion has progressed	Dam Failure	Goals 2; Lifelines FWS, S&S	Jefferson County Transportation and Engineering, Mile High Flood District. (The property is privately owned)	$200,000 Design; $2,500,000 Construction Mile High Flood District up to 50% of the cost.	Low	TBD	Not Started. Due to cost and a higher priority of replacing failing culverts this project is no longer a project to be completed on the 5 year plan.

Number	Title and Description	Hazards Mitigated	Related Goals & Lifelines	Lead Agency & Partners	Cost Estimate & Potential Funding	Priority	Timeline	Status & Implementation Notes
	to the rear yard fences of adjacent residences. Benefits include reduction of erosion, improve long term water quality of the stream. Reduction of property loss in area and it will eliminate a safety hazard in the area.							
Jefferson County 12	**National Flood Insurance Program (NFIP) and Community Rating System (CRS) participation.** This project provides for the continual participation in both the NFIP and CRS floodplain management programs, which enables properties within the county to get flood insurance at reduced rates. In addition, the floodplain management regulations reduce the flood risks for new and reconstructed buildings within the county. Benefits include reducing flood losses for new construction within the county and allow older properties access to flood insurance to help protect existing buildings.	Flood	Goals 1,2,3; Lifelines COM, ENG, FWS, HAZ, H&M, S&S, TRN	Jefferson County Planning and Zoning	Within current county budget. Programs are funded from the county's general fund.	High	Ongoing	Ongoing. Moved up to a Class 5
Jefferson County 13	**Storm Ready program participation.** This is a National Weather Service (NWS) Program helps communities to better prepare to save lives from the onslaught of severe weather through advanced planning, education and awareness. This is an accredited program through the National Oceanic & Atmospheric Administration & the National Weather Service. Benefits include Once Application has been submitted to the NWS, the application will be reviewed and the Storm Ready chair will assign a team to visit the applicant and discuss options. The end result being a Certified Storm Ready Office and serving residents and County Offices better. An added benefit to this is, once a Community is certified as Storm Ready the Insurance Services	Extreme Temps, Hailstorm, Lightning, Severe Winter Storms, Tornado, Windstorm	Goals 1,2,3; Lifelines COM, ENG, FWS, HAZ, H&M, S&S, TRN	Jefferson County Office of Emergency Management	None or $5,000, if it is necessary to upgrade equipment, training, staff hours, OT hours, and/or host trainings. EMPG	Medium	Ongoing	In Progress. Application submitted to NWS, will update based on recommendations.

Number	Title and Description	Hazards Mitigated	Related Goals & Lifelines	Lead Agency & Partners	Cost Estimate & Potential Funding	Priority	Timeline	Status & Implementation Notes
	Organization can provide Community Rating System points which may be applied to lower National Flood Insurance Program (NFIP) flood insurance rates.							
Jefferson County 14	**Bi-lingual publications for Jeffco residents.** This program will allow publications such as Colorado Life Trak, Jeffco emergency preparedness campaigns, pamphlets to be translated for our Spanish speaking residents of Jeffco. A language assessment should be completed to see if other translations are needed for our residents. Benefits include Giving the Jefferson county bi-lingual speaking communities a resource to use in preparing their homes/families for potential hazards.	Avalanche; Cyber; Dam Failure; Drought; Earthquake; Erosion/ Deposition; Expansive Soils; Extreme Temps; Flood; Hailstorm; Landslides; Lightning; Pandemic; Winter Storms; Subsidence; Tornado; Wildfire; Windstorm	Goals 1; Lifelines NA	Jefferson County Office of Emergency Management	$10,000 for the translation $2,000 for the assessment Possible Grants with 50/50 match	Medium	TBD	Not Started.

Number	Title and Description	Hazards Mitigated	Related Goals & Lifelines	Lead Agency & Partners	Cost Estimate & Potential Funding	Priority	Timeline	Status & Implementation Notes
Jefferson County 15	**Public awareness for those in dam inundation areas.** There are 30 High Hazard and 11 Significant Risk dam in Jefferson County. Currently there is no notification system to those living downstream of the dam or information that they live in a potentially hazardous area. Our goal is to create and distribute a pamphlet notifying home and business owners that are in a dam inundation area. It will be similar to the mailer distributed to people that live in flood plains. Part of this project is to create digital map layers of the inundation maps that can be incorporated into the county's GIS database. Benefits include Notification of those living in dam inundation areas will increase their awareness that they are in a higher hazard area. Or hope is that this awareness will improve preparedness for those in the area. This, along with better mapping will improve warning capabilities that will potentially save lives in case of a disaster.	Dam Failure	Goals 1,2; Lifelines NA	Jefferson County Office of Emergency Management; Jefferson County Emergency Communication Authority, Jefferson County GIS, Colorado Dam Safety	45000 Possible CDEM/PDM Grants	Medium	TBD	Not Started.
Jefferson County 16	**Geographic Information System layer updates.** Much of Jefferson County is considered to be in the Wildland Urban Interface (WUI). With diversity of land ownership in Jeffco it has been a challenge to develop GIS layers for wildfires and completed fire management (fuels reduction) projects. Benefits include Having these layers available will be useful during wildfire events, developing future fuels reduction projects and reevaluating completed projects for maintenance/ reentry.	Wildfire	Goals 2; Lifelines COM, ENG, FWS, HAZ, H&M, S&S, TRN	Jefferson County Office of Emergency Management; Jefferson County GIS	$35,000	High	Ongoing	In Progress. County IT ESRI story map developed

Number	Title and Description	Hazards Mitigated	Related Goals & Lifelines	Lead Agency & Partners	Cost Estimate & Potential Funding	Priority	Timeline	Status & Implementation Notes
Jefferson County 17	**Discovery of a community-wide slash collection center.** Community wide slash collection site aimed to provide slash removal opportunities to a larger more inclusive community wide audience. This opportunity currently does not exist and the operational components or costs have not yet been finalized.	Flood; Tornado; Severe Winter Storms; Wildfire; Windstorm;	Goals 1; 2; 3; Lifelines TRN; S&S; FWS	Jefferson County, Parks. Local municipalities and community partners.	$100,000 - $1,000,000 Program use fee and local authority.	High	2023	New in 2021.
Jefferson County 18	**Forest health.** Update the Jefferson County Open Space Forest Health Plan and reduce tree density and fuel sources on 1,000 of our 17,000 acres of forested lands.	Wildfire;	Goals 1; 2; 3; Lifelines S&S; FWS; ENG; TRN; COM	Jefferson County Open Space Colorado Forest Restoration Institute, Forest Stewards Guild	More than $1,000,000 Department Budget and Grants	High	2026	New in 2021.
Jefferson County 19	**Habitat restoration.** Stronger ecosystems are more resilient to catastrophic event such as flooding, fire, and erosion, so restoring our land is essential to preserve natural aesthetics, restore wildlife habitat, and improve water quality.	Drought; Erosion and Deposition;	Goals 1; 2; 3; Lifelines FWS	Jefferson County Open Space	Unknown Department Budget and Grants	Medium	2026	New in 2021.
Jefferson County 20	**Fuel break thinning in right-of-way along evacuation routes within the Wildfire Urban Interface.** This project will identify areas within Jefferson County and State right-of-way along evacuation routes in the Wildfire Urban Interface where forest growth has encroached on public streets and roads. Once identified, fuel breaks and debris removal will be enacted within areas that require mitigation. Benefits include safer ingress and egress for citizens and first responders in the event of an emergency.	Dam Failure; Flood; Landslides; Severe Winter Storms; Wildfire	Goals 1; 2; 3; Lifelines S&S; TRN; H&M;	Jefferson County Colorado State Forest Service, Colorado DOT, Multiple Fire Districts, Jefferson County Sheriff, Coalition for the Upper South Platte	Unknown Grants	High	2022-2026	New in 2021.

Number	Title and Description	Hazards Mitigated	Related Goals & Lifelines	Lead Agency & Partners	Cost Estimate & Potential Funding	Priority	Timeline	Status & Implementation Notes
Jefferson County 21	**Stabilize the landslide near the reinforced soil slope (RSS) at the Rocky Mountain Metropolitan Airport (RMMA).** The RSS was constructed as part of the safety area at the RMMA in 2014. Since that time, inclinometers have indicated there has been continued movement along a failure plane. The toe of the slope is near Colorado Highway 128 and failure of the RSS would impact Colorado Highway 128. The preliminary mitigation design includes a series of reinforced concrete piers with a series of tiebacks to stabilize the mass. The benefits include continued operations at the RMMA, public safety and limiting the impact to the state highway system. The RMMA is mainly within Jefferson County, however, the mitigation will occur in an area within the City & County of Broomfield.	Landslides, Debris flows, Rockfalls;	Goals 1,2,3; Lifelines S&S; TRN;	Jefferson County - Rocky Mountain Metropolitan Airport, CDOT, Colorado Geological Survey	More than $1,000,000 legal settlement, department budget and grants	High	2021-2022	New in 2021.
Jefferson County 22	**Defensible space and structure hardening mitigation grant fund.** Our current regulations work to create defensible space around new structures. The building code requires fire resistant building materials for new homes and additions. Our regulations do not address creating defensible space around existing structures or requiring upgrades to houses and buildings built years ago. A mitigation grant fund would help finance and incentivize making existing development less susceptible to wildfire risk by helping people afford and incentivizing the installation of defensible space and fire resistant materials. Program would also provide a platform to educate existing mountain area residents about the risks of wildfire and what can be done to mitigate those risks.	Wildfire;	Goals 1; 2; 3; Lifelines S&S; FWS;	Development and Transportation Fire Districts, Emergency Management, Strategy Innovation and Finance, Sheriff, Realtors and Insurance agencies.	$10,000 - $100,000 Seek additional grants, work with home owner insurance providers, work with realtors, County general fund	High	Would hope to establish funding that would be distributed on an annual basis.	New in 2021.

Number	Title and Description	Hazards Mitigated	Related Goals & Lifelines	Lead Agency & Partners	Cost Estimate & Potential Funding	Priority	Timeline	Status & Implementation Notes
Jefferson County 23	**County road clear zone fund.** The County maintains hundreds of miles of roads serving our mountain communities**.** These roads provide critical evacuation routes for thousands of county citizens who live, work and/or recreate in the mountains. Most of these roads were built many years ago and have right of ways that barely exceed the width of pavement. This project would help address the concern that roadside trees would fall and block transportation during hazard events such as winter storms, wildfires, floods etc. The project entails establishing a desired clear zone around our roadways. The first phase is determining where the most constrained, important roads are and if they are constrained who owns land on each side of the road. This would require research through property ownership databases. The project would also provide resources to purchase easements/fee simple rights to clear trees and other possible impediments from roadsides. Finally, the grant would help fund the clearance of the roadside clear zone. This project if completed would help to ensure that evacuation routes stand a much higher chance of remaining clear during hazard events.	Avalanche; Dam Failure; Erosion and Deposition; Flood; Landslides; Severe Winter Storms; Wildfire; Windstorm;	Goals 1; 2; 3; Lifelines S&S; H&M; TRN;	Development and Transportation Sheriff, CDOT,	$100,000 - $1,000,000 Grants, County Funds,	High	2021-2024 Initial research phase would take 6 months. Remainder of project would be ongoing.	New in 2021.
Jefferson County 24	**Modernize existing FEMA Zone A floodplains that are outside the MHFD utilizing Lidar.** There are approximately 2000 acres of FEMA Zone A floodplains outside of the MHFD that have limited accuracy. The effective boundaries were based on 10-40 foot contours that have a significant margin of error. Utilizing the available Lidar, the boundaries could be remapped with a higher level of confidence. Accurate maps benefit	Flood;	Goals 1; 2; 3; Lifelines S&S; FWS; H&M; COM; TRN;	Jefferson County P&Z Other Jefferson County divisions/departments, CWCB, FEMA	$100,000 - $1,000,000 grants	High	2021-2024	New in 2021.

Number	Title and Description	Hazards Mitigated	Related Goals & Lifelines	Lead Agency & Partners	Cost Estimate & Potential Funding	Priority	Timeline	Status & Implementation Notes
	property owners, first responders, County staff and FEMA staff.							
Jefferson County 25	**Update FEMA Zone AE floodplains that are outside of the MHFD.** Update the studies associated with the FEMA Zone AE floodplains that are outside of the MHFD and mainly in the mountain areas of the County. The FEMA Zone AE floodplains include approximately 700 acres. The effective data is based on studies that are generally 30+ years old and have varying degrees of accuracy. The benefits would include accurate mapping in areas that have had increased development in that time period which would benefit the citizen, County staff and FEMA staff.	Flood;	Goals 1; 2; 3; S&S; Lifelines FWS; H&M; ENG; COM; TRN;	Jefferson County P&Z Other Jefferson County departments/divisions, CWCB, FEMA	$100,000 - $1,000,000 grants	High	2022-2025	New in 2021.
Jefferson County 26	**Update the South Fork of Deer Creek floodplain.** The South Fork of Deer Creek is partially within the MHFD and is classified as a flood prone area. Completing a study will better define the floodplain risk associated with this segment.	Flood;	Goals 1; 2; 3; S&S; Lifelines COM;	Jefferson County MHFD, CWCB, FEMA	$10,000 - $100,000 grants & MHFD	Medium	2022-2024	New in 2021.
Jefferson County 27	**Purchase properties from the SFHA to reduce flood losses.** Within the MHFD, utilize the MHFD Property Acquisition Reserve (or similar) to acquire properties within the Floodplain Overlay District. Outside of the MHFD, apply for funding to purchase properties within the SFHA to reduce property damage, injuries and loss of life due to flood risk.	Dam Failure; Flood;	Goals 1; 2; 3; S&S; Lifelines H&M; TRN;	Jefferson County Jefferson County departments/divisions, MHFD, CWCB, FEMA	More than $1,000,000 grants, MHFD, CIP	High	2021-2026	New in 2021.
Jefferson County 28	**Bear Creek bank stabilization.** The bank along Bear Creek downstream of the Evergreen Lake dam, requires stabilization to reduce flood risk, sediment transport and deposition. There are outfalls that along this segment that increase sediment loading to Bear Creek. Benefits include reducing the flood risk in	Erosion and Deposition; Flood;	Goals 1; 2; 3; Lifelines FWS, S&S	Jefferson County Jefferson County divisions, CWCB, Bear Creek Watershed	$100,000 - $1,000,000 grants	Medium	2022-2026	New in 2021.

Number	Title and Description	Hazards Mitigated	Related Goals & Lifelines	Lead Agency & Partners	Cost Estimate & Potential Funding	Priority	Timeline	Status & Implementation Notes
	the historic commercial area of Evergreen, improved fisheries and reduction of the sediment load in Bear Creek.			Association & Bear Creek Watershed Foundation				
Jefferson County 29	**Development and formalization of a standing Local Hazard Mitigation Committee.** Implementation and maintenance of the plan is critical to the overall success of hazard mitigation planning. Jefferson County will convene and facilitate a hazard mitigation committee for the participating jurisdictions to implement this Plan going forward.	Avalanche; Cyber; Dam Failure; Drought; Earthquake; Erosion/Deposition; Expansive Soils; Extreme Temps; Flood; Hailstorm; Landslides; Lightning; Pandemic; Winter Storms; Subsidence; Tornado; Wildfire; Windstorm	Goals 2; 3; Lifelines COM, ENG, FWS, HAZ, H&M, S&S, TRN	TBD Jefferson County Emergency Management, Jefferson County Planning & Zoning, Jefferson County Open Space, Participating Agencies	Unknown Staff time	High	2021	New in 2021. Was not implemented after last HMP update.
Jefferson County 30	**Drainage and Flood Control Improvement for Weaver Creek at Belleview Avenue.** Replace three existing corrugated metal culvert crossings of Weaver Creek along Belleview. The existing structures were identified in the 2018 master plan as overtopping during the 10 year flood. New structures will be designed to pass the 1% chance flood. The increased capacity of the three structures will allow for emergency services and residents to use Belleview Avenue during a flood event.	Flood;	Goals 2; Lifelines TRN	Jefferson County Transportation and Engineering Mile High Flood District	More than $1,000,000 50/50 match of all project costs between Jefferson County and Mile High Flood District	High	2023	New in 2021.

Number	Title and Description	Hazards Mitigated	Related Goals & Lifelines	Lead Agency & Partners	Cost Estimate & Potential Funding	Priority	Timeline	Status & Implementation Notes
Jefferson County 31	**Drainage and Flood Control Improvement for Dutch Creek at Yukon Street.** The existing corrugated metal culvert overtops by 2 feet during the 10 year flood and 3 feet during the 100 year event. This amount of overtopping makes the road impassible for emergency vehicles and local traffic during storm events. The new culvert will pass the 100 year flood to allow for vehicle access.	Flood;	Goals 2; Lifelines S&S; TRN	Jefferson County Engineering and Transportation Mile High Flood District	More than $1,000,000 50/50 split of project cost between Jefferson County and Mile High Flood District	High	2025	New in 2021.
Jefferson County 32	**Drainage and Flood Improvements for Leyden Creek at Croke Canal.** During the 2013 floods in Colorado Leyden Creek overtopped its banks and excess spill flooded Croke Canal. This additional flow flooded homes and properties downstream of Indiana St. The proposed project would create a low flow channel for Leyden Creek under Indiana St and Croke Canal. A spillway would be installed at Croke Canal to prevent flows from entering the canal.	Flood;	Goals 2; Lifelines FWS; TRN	Jefferson County Engineering and Transportation City of Arvada, Mile High Flood District, CDOT	More than $1,000,000 Cost share between Jefferson County, City of Arvada, and Mile High Flood District.	Low	2026	New in 2021.
Jefferson County 33	**Hazard Education and Outreach.** Jeffco Rangers and natural resources staff are tasked with making 350,000 in-person, in-parks educational contacts with park visitors by 2025 through the Conservation Greenprint. Many of these educational contacts include information about natural hazards such as floods, fire, winter storms, rockfall, heat stroke and stress in pets and people; and wildlife safety and awareness.	Extreme Temps; Flood; Landslides; Lightning; Severe Winter Storms; Wildfire;	Goals 1; Lifelines NA	Jeffco Parks, Jeffco Open Space, Jefferson County OEM	this cost is tied to general operations department budget	High	350,000 contacts by 2025	New in 2021. Will integrate with preparedness campaign.
Jefferson County 34	**Rockfall Hazard Advisory and Education.** Design, fabricate and install bi-lingual pedestrian/hiker/climber-oriented rockfall hazard educational and advisory signs at key park locations such as Dinosaur Ridge, South Table Mountain, North Table Mountain and Clear Creek Canyon. A sign at Dinosaur	Landslides	Goals 1; Lifelines NA	Jeffco Open Space Friends of Dinosaur Ridge	Less than $10,000 department budget	High	2025	New in 2021.

Number	Title and Description	Hazards Mitigated	Related Goals & Lifelines	Lead Agency & Partners	Cost Estimate & Potential Funding	Priority	Timeline	Status & Implementation Notes
	Ridge alone will reach over 250,000 people annually.							
Jefferson County 35	**Create a county-wide clearinghouse for past, present and future wildfire mitigation efforts.** Draw on Geographic Information Systems data or mapping provided by partner agencies to build collective knowledge, prioritize mitigation efforts and enhance collaboration regarding public and private land mitigation efforts. GIS data mapping is now done by Jefferson County Open Space on its land. An inventory of community mitigation efforts across Jefferson County led by different entities such as fire rescue agencies, HOAs, cities, etc. will also help expand activities into additional areas that are not currently served. For example: 1. Home assessment programs in process 2. Community Wildfire Protection Plans 3. Community Wildfire Protection Implementation Plans 4. Homeowner cost share, tax benefits and grants available	Wildfire	Goals 1,2,3; Lifelines FWS, S&S	Jeffco Wildland Risk Reduction Commission	Minimal	Medium	2022	New in 2021. This was a recommendation in the 2020 Jeffco Wildland Risk Reduction Task Force report.
Jefferson County 36	**Create, brand, maintain, and promote a one-stop webpage on reducing wildfire risk in Jefferson County.** Webpage will focus on wildfire mitigation and emergency preparedness. 1. Identify the target audience and core content with the help of the Community Education working group. 2. Gather the best content used by the county, CSU Extension Service, Colorado State Forest Service and other resources to help populate web page. 3. Package content as a user-friendly “toolbox” of mitigation and emergency preparedness information.	Wildfire	Goals 1,2,3; Lifelines FWS, S&S	Jeffco Wildland Risk Reduction Commission	Minimal	Medium	2023	New in 2021. This was a recommendation in the 2020 Jeffco Wildland Risk Reduction Task Force report.

Number	Title and Description	Hazards Mitigated	Related Goals & Lifelines	Lead Agency & Partners	Cost Estimate & Potential Funding	Priority	Timeline	Status & Implementation Notes
	4. Link to other websites focused on mitigation, wildfire prevention and emergency preparedness, etc. A number of existing web pages provide helpful models for what Jeffco's one- stop web page could look like such as the highly-touted CAL FIRE or Rotary Wildfire Ready. Jeffco Open Space recently launched TerraSource - a web page that more broadly promotes good land stewardship, including a section on forest health and fire mitigation. 5. Determine where this website will be housed (e.g., on www.jeffco.us, TerraSource, free- standing site, etc.). 6. Promote web page widely among fire rescue districts, HOAs, Chambers of Commerce, service club, real estate groups and others, and encourage them to share information with their distribution lists. Emphasize the value of consistent information when promoting web page. 7. Maintain and update website regularly, tapping task force members and the Task Force Community Education Team as a source and a sounding board for new content.							
Jefferson County 37	**Implement residential wildfire mitigation program.** Provide funding for fire districts to conduct more home assessments for wildfire mitigation. Implement a defensible space home assessment certification program. Educate HOAs and homeowners. The lead agencies would be broad so I would recommend adding the wildland fire risk reduction commission as the lead, fire districts, HOAs. Funding would be approx. $500,000. The timeframe would be 2021-2026.	Wildfire	Goals 1,2,3; Lifelines FWS, S&S	Jeffco Wildland Risk Reduction Commission, Fire Districts, HOAs	$500,000; TBD	Medium	2026	New in 2021.

Number	Title and Description	Hazards Mitigated	Related Goals & Lifelines	Lead Agency & Partners	Cost Estimate & Potential Funding	Priority	Timeline	Status & Implementation Notes
Jefferson County 38	**Polly Deane Reservoir Remediation.** Polly Deane Reservoir located in Easton Regional Park is owned by Bergen Ditch and Reservoir Company. A man-made lake that was partially expanded in mid-1970's, it is located in an urban area and is normally used for storage of irrigation water used by Foothills Park and Recreation District, a major Bergen shareholder (including shares leased from JeffCo). Due to seepage below the dam discovered in spring of 2019, the Colorado Dam Safety Branch has placed a restriction on storage within the reservoir. Bergen has secured a FEMA grant for analysis and design of remedial work on the dam and that work is currently in process to be completed September 2021. Preliminary conclusion is that the toe drain system for the reservoir needs to be replaced along with a full replacement of the reservoir outlet drain, including increasing drain capacity through the outlet. The potential flood area in the event of dam failure places it in a high hazard category with loss of structures and public improvements, and potential loss of life. These improvements will allow the dam to meet or exceed current standards and for the storage restriction to be removed.	Dam Failure; Flood	Goals 1,2,3; Lifelines FWS, S&S	Bergen Ditch and Reservoir Company; Colorado Dam Safety, Jefferson County, FEMA for analysis and remedial design	$100,000 - $1,000,000; Federal, State, Local Grants; CWCB construction LOAN; assessments paid by Bergen shareholders.	High	Remedial design and cost estimate -- September 2021; construction 2022 or 2023	New in 2021.

Table 5-4 summarizes the above actions by hazards addressed to demonstrate that the plan addresses a broad range of identified hazards. See the Annexes for additional details on jurisdictional actions. The numbers correspond to the mitigation action number in the first column of Table 5-3 or the corresponding table in the jurisdiction's annex.

Table 5-4 Mitigation Actions Summarized by Hazard

Jurisdiction	Avalanche	Cyber	Dam Failure	Drought	Earthquake	Erosion and Deposition	Expansive Soils	Extreme Temps	Flood	Hailstorm	Landslides, etc.	Lightning	Pandemic	Severe Winter Storms	Subsidence	Tornado	Wildfire	Windstorm
Jefferson County	8,14, 23,29	14,29	4,11,14,15,20, 23,27, 29, 38	14,19, 29	7,8,14, 29	8,14, 19,23, 28,29	8,14, 29	13,14, 29,33	1,2,3,4,9,12, 14,17,20,23, 24,25,26,27, 28,29,30,31, 32,33,38	13,14, 29	8,14, 20,21, 23,29, 33	13,14, 29,33, 34	14,29	13,14,17 ,20,23,29,33	8,14, 29	13,14, 17,29	5,6,10,14,16, 17,18, 20,22, 23,29, 33,35, 36,37	13,14, 17,23, 29
City of Arvada		14	8,14	6,7,8, 9,10,14, 16	14	3,8,14	8,14	6,7,8, 9,14	1,2,5,6,7,8,9, 11,12,13,14,15	8,9,14	14	14	14	4,6,7, 8,9,14	14	14	6,7,8, 9,10, 14,16	6,7,8, 9,10, 14,16
City of Edgewater	5	4,5	5	5	5	5	5	5	1,2,3,5	5	5	5	5	5	5	5	5	5
City of Golden		6							1,2,3,4								5	
City of Lakewood		5	1,3,7	6,7,8				5,6,7, 8	1,2,3,4,6,7	6,7		7		5,6,7		7		5,6,7
City of Wheat Ridge	7	7	7	7,10	7	7,8	7	6,7,10	1,2,3,4,5,7,9	6,7	7	6,7	7	6,7	7	6,7	7	6,7
Town of Morrison		6,7	8	6,7	3	3	3		1,2,3,4,6,7,8					6,7	3		3	4,5,6, 7
Arvada FPD				1,2													1,2	1,2
Elk Creek FPD			1		1				1		1		1			1	1,2	1
Evergreen FPD																	1,2,3,4	
Fairmount FPD		3						4		4		2		2,4		2	1,2	2
Foothills FPD																	1,2	

Jurisdiction	Avalanche	Cyber	Dam Failure	Drought	Earthquake	Erosion and Deposition	Expansive Soils	Extreme Temps	Flood	Hailstorm	Landslides, etc.	Lightning	Pandemic	Severe Winter Storms	Subsidence	Tornado	Wildfire	Windstorm
Genesee FPD																	1	
Golden Gate FPD																	1,2,3	
Indian Hills FPD																	1,2	
Inter-Canyon FPD																	1	
North Fork FPD																	1,2,3	
West Metro FPD																	1,2	
Denver Water			2	2					4								1,3,4	
Lookout Mountain Water District			8	1,2,3,5,6,7,8,9,10,11					2,3								4,6,7,8,9,10,11	
Jefferson Conservation District																	1	

6 Plan Implementation and Maintenance

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

Implementation and maintenance of the plan is critical to the overall success of hazard mitigation planning. This is Phase 4 of FEMA's 4 phase process and Step 10 of the 10-step planning process. This section outlines how this plan will be implemented and updated.

6.1 Implementation

Once adopted, the plan faces the truest test of its worth: implementation. While this plan contains many worthwhile projects, the Hazard Mitigation Planning Committee (HMPC) will need to decide which action(s) to undertake first. Two factors will help with making that decision: 1) the priority assigned the actions in the planning process; and 2) funding availability. Low or no-cost projects most easily demonstrate progress toward successful plan implementation.

Implementation will be accomplished by adhering to the schedules identified for each action (see Section 5.4 for County actions and the jurisdictional annexes for jurisdiction specific actions) and through constant, pervasive, and energetic efforts to network and highlight the multi-objective, win-win benefits of each project to the Jefferson County community and its stakeholders. These efforts include the routine actions of monitoring agendas, attending meetings, and promoting a safe, sustainable community. The three main components of implementation are:

- **IMPLEMENT** the action plan recommendations of this plan;
- **UTILIZE** existing rules, regulations, policies and procedures already in existence; and
- **COMMUNICATE** the hazard information collected and analyzed through this planning process so that the community better understands what can happen where, and what they can do themselves to be better prepared. Also, publicize the "success stories" that are achieved through the HMPC's ongoing efforts.

Simultaneously to these efforts, the HMPC will constantly monitor funding opportunities that could be leveraged to implement some of the more costly actions. This will include creating and maintaining a bank of ideas on how to meet required local match or participation requirements. When funding does become available, the HMPC will be in a position to capitalize on the opportunity. Funding opportunities to be monitored include special pre- and post-disaster funds, special district budgeted funds, state and federal earmarked funds, and other grant programs, including those that can serve or support multi-objective applications.

6.1.1 Role of the All-Hazard Mitigation Planning Committee in Implementation and Maintenance

With adoption of this plan, the Hazard Mitigation Planning Committee (HMPC) will transition into the Jeffco All-Hazard Mitigation Advisory Committee (Jeffco AHMAC) as approved by the Board of County Commissioners (BCC). The AHMAC will act as an advisory body tasked with plan implementation and maintenance. Its primary duty is to see the plan successfully carried out and to report to the community governing boards and the public on the status of plan implementation and mitigation opportunities. This will allow for a single point of centralization for all federally focused mitigation information, strategies, efforts and project prioritization for the entire county. The group will seat its authority and report to the BCC on the status of plan implementation and mitigation opportunities. Additionally, the Jeffco AHMAC supports the forecasted annual reporting requirements by both DHSEM and FEMA.

The scope of the AHMAC will primarily focus efforts around FEMA mitigation dollars, though other funding opportunities may be monitored, including those that can serve or support multi-objective applications. Membership will include, at minimum, the 21 participating agencies that adopted the plan. In adopting the HMP, participating agencies will be eligible for FEMA mitigation dollars. The Chair of the AHMAC will be a rotating position appointed per the group's bylaws (under development).

The Jeffco AHMAC will:

- Act as the County's central forum for all-hazard mitigation issues;
- Disseminate hazard mitigation ideas and activities to all participants;
- Pursue the implementation of the HMP and AHMAC recommended actions;
- Keep the concepts of mitigation in the forefront of community decision-makers by identifying plan recommendations when other community goals, plans, and activities overlap, influence, or directly affect increased community vulnerability to disasters;
- Maintain a vigilant monitoring of multi-objective cost-share opportunities to help the community implement the plan's recommended actions for which no current funding exists;
- Steward implementation and updates of this plan;
- Report on plan progress and recommended changes to the Jefferson County BCC;
- Inform and solicit input from the public; and
- Assess, prioritize, recommend or deny FEMA mitigation grant applications that are not associated with a participating agency that compliment or conflict with the goals, objectives and pre-identified mitigation projects in the HMP.

Other duties include reviewing and promoting mitigation proposals, considering stakeholder concerns about hazard mitigation, passing concerns on to appropriate entities, and posting relevant information on the County website and local newspapers.

By adopting this plan, each participating jurisdiction agrees to engage in the ongoing implementation and maintenance activities described in the plan. Each jurisdiction that also meets State of Colorado and FEMA requirements for mitigation grant programs, will identify one representative for the AHMAC, subject to approval by the Jefferson County Board of County Commissioners.

6.2 Plan Maintenance

Plan maintenance implies an ongoing effort to monitor and evaluate plan implementation and to update the plan as required or as progress, roadblocks, or changing circumstances are recognized.

6.2.1 Monitoring

In order to track progress and update the mitigation strategies identified in the action plan, the HMPC will revisit this plan annually or after a significant hazard event or disaster declaration. Jefferson OEM is responsible for initiating this review and convening members of the AHMAC on a once yearly basis, or more frequently as needed. The annual review will be held in January of each year, beginning in 2022.

This plan will be updated, approved and adopted within a five-year cycle as per Requirement §201.6(c)(4)(i) of the Disaster Mitigation Act of 2000. With the initial approval of this plan occurring in mid-2021, the plan will need to be updated, re-approved by the Colorado Division of Homeland Security and Emergency Management (DHSEM) and FEMA Region VIII, and re-adopted by all participating jurisdictions no later than June of 2026. The County will monitor planning grant opportunities from DHSEM and FEMA for funds to assist with mitigation projects, as well as with the 5-year update. These grants should be pursued as early as 2024, as some grants have a three-year performance period to expend the funds, plus there is no guarantee that the grant will be awarded when initially submitted. This allows time to resubmit the grant in 2025 if needed.

6.2.2 Evaluation

Updates to this plan will follow the latest FEMA and DHSEM planning guidance. Evaluation of progress can be achieved by monitoring changes in vulnerabilities identified in the plan. Changes in vulnerability can be identified by noting:

- Decreased vulnerability as a result of implementing recommended actions:
- Increased vulnerability as a result of failed or ineffective mitigation actions: and/or
- Increased vulnerability as a result of new development (and/or annexation).

The AHMAC will use the following process to evaluate progress and any changes in vulnerability as a result of plan implementation.

- A representative from the responsible entity identified in each mitigation measure will be responsible for tracking and reporting on an annual basis to the AHMAC on project status and provide input on

whether the project as implemented meets the defined objectives and is likely to be successful in reducing vulnerabilities.
- If the project does not meet identified objectives, the AHMAC will determine what alternate projects may be implemented
- New projects identified will require an individual assigned to be responsible for defining the project scope, implementing the project, and monitoring success of the project.
- Projects that were not ranked high priority but were identified as potential mitigation strategies will be reviewed as well during the monitoring and update of this plan to determine feasibility of future implementation.
- Changes will be made to the plan to accommodate for projects that have failed or are not considered feasible after a review for their consistency with established criteria, the time frame, priorities, and/or funding resources.

6.2.3 Updates

Updates to this plan will:

- Consider changes in vulnerability due to project implementation;
- Document success stories where mitigation efforts have been completed or proven effective;
- Document areas where mitigation actions were not effective;
- Document any new hazards that may arise or were previously overlooked;
- Document hazard events and impacts that occurred within the five-year period;
- Incorporate new data or studies on hazards and risks;
- Incorporate new capabilities or changes in capabilities;
- Incorporate documentation of continued public involvement;
- Incorporate documentation to update the planning process that may include new or additional stakeholder involvement;
- Incorporate growth and development-related changes to building inventories;
- Incorporate new project recommendations or changes in project prioritization;
- Include a public involvement process to receive public comment on the updated plan prior to submitting the updated plan to DHSEM/FEMA;
- Align with the latest FEMA and State of Colorado guidance; and
- Include re-adoption by all participating entities following DHSEM/FEMA approval.

6.3 Integration into Existing Planning Mechanisms

Another important implementation mechanism that is highly effective and low-cost is integrating the hazard mitigation plan recommendations and their underlying principles into other existing or new plans and mechanisms. Mitigation is most successful when it is incorporated into the day-to-day functions and priorities of government and development. The mitigation plan can be considered as the hub of a wheel with spokes radiating out to other related planning mechanisms that will build from the information and recommendations contained herein. Properly implemented, the HMP should serve as one of the foundational documents of the jurisdictions' emergency management programs, since everything emergency management does should relate back in one way or another to the hazards the jurisdiction faces.

As stated in Section 6.1 of this plan, implementation through existing plans and/or programs is recommended, where possible. The County and participating entities already have existing policies and programs to reduce losses to life and property from natural hazards. These are summarized in this plan's capability assessment. This plan builds upon the momentum developed through previous and related planning efforts and mitigation programs and recommends implementing projects, where possible, through these other program mechanisms. These existing mechanisms include those listed in the Section 2.7 Capability Assessment, as well as those in Section 3.4 of the Planning Process. AHMAC members involved in the updates to these mechanisms will be responsible for integrating the findings and recommendations of this plan with these other plans, as appropriate.

The following sections provides some guidance on how Jefferson County and participating jurisdictions may use the updated HMP to inform and improve other plans, procedures, and programs. Additional

detail on how the jurisdictions will integrate the HMP into their planning mechanisms can be found in the Annexes.

6.3.1 Comprehensive Plans

Integrating hazard mitigation into the jurisdiction's comprehensive or general plan is considered a best practice by both FEMA and the American Planning Association. The Jefferson County Comprehensive Plan was last updated in 2017, and included hazards information from the 2016 HMP, which is cited as a supporting document to the Comprehensive Plan. Jefferson County OEM will work with the Planning Department to ensure that hazards data and mitigation goals and objectives inform the next Comprehensive Plan update.

6.3.2 Threat and Hazard Identification and Risk Assessment (THIRA)

Jefferson County has completed a County-level Threat and Hazard Identification and Risk Assessment (THIRA). CPG201 Threat and Hazard Identification and Risk Assessment (THIRA) establishes Step 1 as "Identify the Threats and Hazards of Concern" and lists HIRAs and HMPs as possible sources of threat/hazard information.

The criteria for selecting which Threats/Hazards are "of concern" are defined as:

- Factor #1: Likelihood of a Threat or Hazard Affecting a Community
- Factor #2: The Impacts of a Threat or Hazard

Each natural and human-caused hazard profiled in the HIRA (Section 4) contains a section analyzing the probability of future events, which provides a data-driven answer to Factor #1. Similarly, the vulnerability assessment section of the hazard profiles address what impacts can realistically be expected from both routine and extreme events of each hazard, which specifically addresses Factor #2.

Step 2 of CPG 201 is to "Give the Threats and Hazards Context" by creating a scenario for each hazard of concern, with specifics like time of day, area, and magnitude of the event, which are then used to establish capability targets for each of the 32 core capabilities. All the hazards profiled in the HIRA contain detailed information to ensure the hazard scenarios are plausible. For some hazards, such as flooding, detailed GIS analysis has been done that can easily be incorporated as THIRA scenarios. Other hazards include details on the most extreme historical events on record that can quickly be updated to modern scenarios.

6.3.3 Recovery Plan

The risk and vulnerability data in the HMP should help inform the post-disaster recovery planning process, especially by ensuring that the recovery elements of those plans fully take into account the dangers posed by other hazards, rather than focusing exclusively on the most recent hazard event. The HMP in turn will be revisited during recovery to help identify opportunities to incorporate mitigation in the recovery and rebuilding process, including maximizing FEMA PA and HMGP funding where applicable.

The FEMA publication "Pre-Disaster Recovery Planning Guide for State Governments" notes:

> "…much of the research involved in the development of mitigation plans can be used to inform the pre-disaster recovery planning effort.
>
> "The pre-disaster recovery planning process will benefit from and build upon hazard mitigation as:
>
> - The mitigation planning process identifies local hazards, risks, exposures, and vulnerabilities;
> - Implementation of mitigation policies and strategies will reduce the likelihood or degree of disaster-related damage, decreasing demand on resources post-disaster;
> - The process will identify potential solutions to future anticipated community problems; and
> - Mitigation activities will increase public awareness of the need for disaster preparedness.
>
> "Pre-disaster recovery planning efforts also increase resilience by:

- Establishing partnerships, organizational structures, communication resources, and access to resources that promote a more rapid and inclusive recovery process;
- Describing how hazard mitigation will underlie all considerations for reinvestment;
- Laying out a process for implementation of activities that will increase resilience; and
- Increasing awareness of resilience as an important consideration in all community activities."

6.3.4 Continuity of Operations Plans (COOP)

All departments and agencies of Jefferson County government are required to maintain a Continuity of Operations Plan (COOP) that details that agency's critical functions and how they will protect those functions in order to continue to provide essential services during a disaster or interruption. By defining and describing the hazards facing the county, including frequency and severity, the HIRA informs agency COOP plans by giving context to what types of disasters of interruptions are most likely to occur. Critical facilities and assets located in hazard areas in Section 4.2 should be prioritized for COOP planning.

6.3.5 Integrated Preparedness Plan (IPP)

Hazard mitigation principles and procedures should be included in Integrated Preparedness Planning Workshops. Any training and exercise needs identified in the Capabilities Assessment (Section 2.7) and Mitigation Strategy (Section 5) should also be included in the jurisdictions' IPP.

6.3.6 Public Awareness and Education Programs

The County's ongoing public education and outreach efforts should reflect the hazards and vulnerabilities described in this Plan. In addition to preparing for disasters, public education should include ways in which the public can reduce their vulnerability to natural and human caused hazards. Furthermore, mitigation activities and success stories should be communicated to the public to show the benefits of effective mitigation planning.

6.3.7 Critical Infrastructure Protection Plan

Critical facilities and assets identified in Section 4.2 should be included in Critical Infrastructure Protection Planning (CIPP), with prioritization given to assets located in hazard-prone areas. Hazardous materials facilities in particular should be viewed both as critical assets in need of protection, and as potential hazards in their own right.

6.3.8 Capital Improvements Plan

Many of the mitigation actions listed in the Mitigation Strategy (Section 5) came from the County's Capital Improvements Plan, and thus have already been identified for funding. Other high-dollar actions listed or identified in the future can also be added to the Capital Improvements Plan to ensure that hazard mitigation projects continue to receive funding. The prioritization of actions listed in Table 5-3, while not binding on capital improvement planning, can be used to inform the prioritization of those actions. Even projects for which the county intends to seek grant funding may also need to be addressed in the Capital Improvements Plan, given that most mitigation grants require significant local matching funds.

6.3.9 Sustainability Plans

Sustainability is a separate area of concern from hazard mitigation, but there are areas where the two fields overlap and influence one another positively or negatively.

Sustainability plans should be reviewed to identify where there may be synergy between sustainability and mitigation/resiliency. For example, sustainability efforts aimed at increasing County's adaptability to climate change can also make the county more resilient to drought and severe weather. Increasing the percentage of food obtained locally could make the county more resilient to supply-chain interruptions or the impacts of disasters in other states. Adding more trees and grass to urban areas to reduce the heat island effect could help mitigate the impact of extreme weather events, as well as reducing flood risk by increasing the amount of permeable surfaces. This may help raise the priority of some sustainability efforts, as well as suggest complimentary mitigation efforts.

It is equally important to identify areas where sustainability efforts may work to reduce the county's resilience to hazards. For example, a sustainability goal of promoting use of public transit and reducing private car ownership could potentially make it harder to evacuate the public during a disaster if public

transit is damaged and offline (as was observed during Hurricane Sandy). Similarly, reduced production of solid waste could lead to a reduction in the number of public resources such as dump trucks, which means that in a disaster those resources would not be available for debris removal and similar tasks. The intent of this review is not to say that sustainability goals should not be pursued, but rather to identify areas of concern that should be considered during implementation of these goals. For example, evacuation plans may need to be revised to reflect a larger percentage of families without cars; or contracts may need to be put in place to obtain additional dump trucks in a disaster.

6.4 Continued Public Involvement

Continued public involvement is also imperative to the overall success of the Plan's implementation. This updated HMP will be posted on the county's website for reference and can be used to help inform the county's ongoing public education and outreach program, such as the completion of mitigation actions that reduce the community's vulnerability, can be shared with the public through forums like the Local Emergency Planning Committee (LEPC), public meetings, and through social media. This helps keep the concept of hazard mitigation alive and helps show the public that their government officials are working to keep them safe.

The update process provides an opportunity to publicize success stories from the Plan implementation and seek additional public comment. When the Planning Team reconvenes for the five-year plan update, they will coordinate with all stakeholders participating in the planning process—including those that joined the committee since the planning process began—to update and revise the plan. The plan maintenance and update process will include continued public and stakeholder involvement and input through participation in designated committee meetings, surveys, web postings, and press releases to local media.

Continued public outreach and education is an aspect of the mitigation strategy Section 5 of this plan. Activities related to public involvement during the 2021 update are documented in Section 3 and Appendix B.