2021 Clear Creek County Hazard Mitigation Plan

Public Review Draft

2021-2026

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1 Introduction

1.1 Executive Summary

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

- Clear Creek County
- City of Idaho Springs
- Town of Empire
- Town of Georgetown
- Town of Silver Plume
- Clear Creek Fire Authority

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 HMPs be updated every five years for the jurisdictions to be eligible for federal mitigation assistance. All sections of the 2016 Clear Creek County HMP 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.

The goals and objectives of the 2021 Clear Creek County HMP are:

- Goal 1: Increase awareness of natural hazards and how to mitigate against them.
  - Objective 1.1: Provide public outreach on the hazards identified in this plan and how to mitigate against them.
  - Objective 1.2: Promote specific actions homeowners and business owners can take to reduce impact of a natural hazard.
- Goal 2: Reduce impact of natural hazards on people, property, and the environment.
  - Objective 2.1: Develop projects focused on preventing loss of life and injuries from natural hazards.
  - Objective 2.2: Protect critical infrastructure and assets to minimize loss of critical services.
  - Objective 2.3: Minimize revenue losses in the community from natural hazard impacts.
  - Objective 2.3: Protect natural resources by adopting and implementing sustainable flood-management policies, debris management programs, snow removal, tree trimming and replacement, wildfire risk reduction, or energy conservation programs.
  - Objective 2.4: Identify possible construction, renovation, retrofitting or refurbishment to protect vulnerable structures and cultural resources from the effects of natural hazards.
- Goal 3: Stimulate coordinated efforts among partners to mitigate against natural hazard impacts.
  - Objective 3.1: Integrate hazard mitigation activities into preparedness, response and recovery activities.
  - Objective 3.2: Maintain regular, coordinated efforts to implement mitigation actions.
  - Objective 3.2: Establish a regular mechanism to monitor mitigation projects.

The 2016 Clear Creek County HMP (also referred to as “Plan”) will serve as a blueprint for coordinating and implementing hazard mitigation policies, programs, and projects in Clear Creek County. It provides a list of mitigation goals and related actions that may assist the participating jurisdictions 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 Clear Creek County's and participating jurisdictions' eligibility for federal disaster assistance, specifically the 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.

Chapter 1 contains the Plan Introduction and this Executive Summary.

Chapter 2 Community Profile describes the planning area, consisting of Clear Creek 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.

Chapter 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.

Chapter 4 Hazard Identification and Risk Assessment identifies the natural 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 was taken into account for each hazard. The hazards profiled in the 2021 Plan are listed in Table 1-1, and their assessed significance are summarized in Table 1-2 below.

Table 1-1: Hazard Risk Rankings

Hazard	Overall Risk Rating
Wildfire	High
Winter Storm	High
Flood	High
Severe Wind, Hail, & Lightning	Medium
Drought	Medium
Landslide, Mud/Debris Flow, and Rockfall	Medium
Avalanche	Medium
Dam Incident	Medium
Earthquake	Low
Erosion and Deposition, Expansive Soil, and Subsidence	Low
Extreme Heat	Low
Tornado	Low
Space Weather	Low

Chapter 5 Mitigation Strategy describes what the County and jurisdictions will do to reduce their vulnerability to the hazards identified in Chapter 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.

Chapter 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.

It is important that local decision-makers stay involved in mitigation planning to provide new ideas and insight for future updates to the Clear Creek County HMP. As a long-term goal, the HMP 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 Clear Creek County.

Table 1-2: Hazard Analysis Summary

Hazard	Overall Significance	Key Points
Flood	High	• Countywide an estimated $11.4 million in property losses is at risk to a 1% annual chance flood hazard. The unincorporated areas of the county together make up the majority of this risk, with an estimated $7.2 million in losses. • Georgetown and Silver Plume are also at high risk of flooding, with estimated losses of $3.1 million and $0.6 million respectively.
Wildfire	High	• A total of 4,160 parcels and 4,706 buildings are located in areas exposed to wildfire risk, with a total value of approximately $1.27 billion. The greatest exposure is located in the unincorporated parts of the County. • Wildfires within Clear Creek County and in adjacent counties can deter tourism and affect the local economy and air quality. • Wildfires can cause a range of secondary hazards, such as contamination of reservoirs, destabilized slopes and landslides, increased erosion, and flooding.
Winter Storm	High	• Severe winter weather can isolate residents and travelers by closing roads into and out of the County. • Most winter storms have not resulted in reported damages, but those that do can be significant. Average annualized losses from winter storms in the County are $620,000.
Avalanche	Medium	• Since 1950 there have been 33 avalanche fatalities in the County. • Backcountry recreationalists, road crews, and motorists along the main roadways are the most at risk to avalanche dangers. • Human actions are the most common causes of avalanches.
Dam Incident	Medium	• Approximately 2,505 people and 1,536 buildings are exposed within the dam inundation areas in the County.

Hazard	Overall Significance	Key Points
		• A dam failure and loss of water from a critical reservoir or structure could include direct and indirect business and industry damages or disruption of the local economy and key county resources (e.g. potable water).
Drought & Extreme Heat	Medium	• Climate change may increase the frequency and severity of drought which could lead to impacts to the recreation and tourism industry. • Extreme heat events are unlikely throughout the County, and the magnitude of heat events is low.
Hail, Lightning, & Severe Wind	Medium	• There have been 148 recorded hail, lightning and severe wind events in Clear Creek County since 1972, resulting in over $16,825,000 in property damages –all from severe wind events. • Lightning events have caused 14 injuries since 1982. • 11% of Medicare Beneficiaries in the County rely on electricity-dependent medical equipment to live independently, making them vulnerable to events that may result in power outages.
Landslide, Mud/Debris Flow, and Rockfall	Medium	• Landslides, debris flow, and rockfalls do occur with some regularity in Clear Creek County. The direct effect on the populace is low, but there is potential for severe injury or death from rockfalls. • The secondary effect of closed roads is a more likely threat, especially if the closed roads cut off emergency personnel from those who need assistance. • As incidents of wildfires increase and hillsides are void of vegetation, rain-soaked hillsides are more likely to slide resulting in increased damage countywide. • Landslides may cause negative environmental consequences, including water quality degradation.
Earthquake	Low	• Colorado has much lower seismic activity compared to other Western states. • Resulting damages to building stock and utility lifelines, and income-related losses could equate to millions of dollars based on HAZUS-MH modeling. • Earthquake risk is relatively the same across all participating jurisdictions, though impacts could be greater in areas with historic buildings and concentrations of people, such as Idaho Springs and Georgetown.
Erosion and Deposition, Expansive Soil, and Subsidence	Low	• Overall significance of this hazard is **Low**, except the subsidence hazard is **High** for Idaho Springs, and erosion /deposition hazard is **Medium** for Empire and Georgetown. • Human activities greatly influence the rate and extent of erosion and deposition. • Riverine erosion can reduce water quality and impact aquatic habitat as well as impacting private property and critical infrastructure.

Hazard	Overall Significance	Key Points
		• Abandoned mine information is incomplete. There are likely to be hazardous areas in addition to known locations. • Many older sinkholes have been covered with recent soil infilling and are completely concealed at the surface.
Space Weather	Low	• The processes that trigger space weather are continuously occurring on the surface of the sun. • NOAA monitors solar activities and issues advisories, watches, and warnings in the event of larger space weather events. • Impacts from the various types of space weather often include power outages, electrical disruptions, and disruptions to global communications networks, satellites, and GPS systems. • While space weather events occur frequently, events which impact Earth and specifically Clear Creek County occur far less frequently.
Tornado	Low	• There have been two recorded tornado events in the County since 1950. Neither resulted in property damage or injuries. • Elderly and individuals who depend on electricity for medical needs are vulnerable to power outages caused by a tornado. 11% of Medicare Beneficiaries in the County rely on electricity-dependent equipment. • All property is potentially vulnerable during tornado events, but mobile homes are disproportionately at risk due to the design of the homes. 5.5% of total housing in the County are mobile homes.

1.2 Purpose

The following guiding principles for this plan process guided the Planning Team during the plan update:

- To reduce or eliminate the long-term risks to loss of life and property damage in the jurisdictions from the full range of natural disasters.
- To identify policies, actions, and tools for long-term implementation in order to reduce risk and future losses stemming from natural hazards that are likely to impact the jurisdictions.
- To create communities whose activities reflect a comprehensive commitment by government, business, non-profit organizations and the public to eliminate or reduce risks and adverse impacts from natural, technological and human-caused hazards.

Hazard mitigation is defined as a way to alleviate the loss of life, personal injury, and property damage that can result from a disaster through long- and short-term strategies. It involves strategies such as planning, policy changes, programs, projects, and other activities that can mitigate the impacts of hazards. The responsibility for hazard mitigation lies with many, including private property owners; business and industry; and local, state, and federal government.

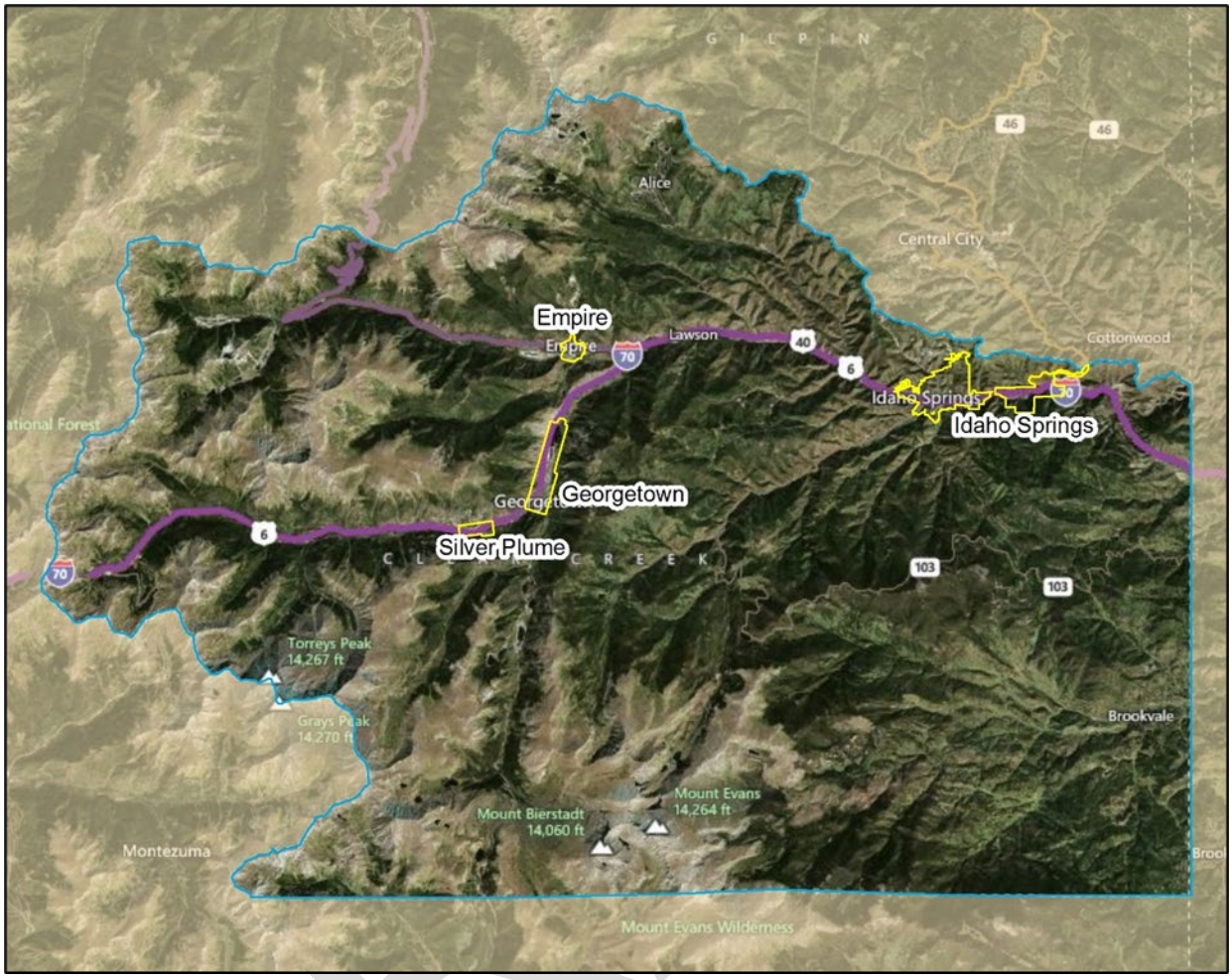
The federal Disaster Mitigation Act (DMA) of 2000 (Public Law 106-390) required state and local governments to develop HMPs as a condition for federal disaster grant assistance. Prior to 2000, federal disaster funding focused on disaster relief and recovery, with limited funding for hazard mitigation planning. The DMA increased the emphasis on planning for disasters before they occur.

Clear Creek 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. The DMA encourages communities to work together on pre-disaster planning. The planning network called for by the DMA helps local governments articulate accurate needs for mitigation, resulting in faster allocation of funding and more cost-effective risk reduction projects. This HMP was prepared for Clear Creek County, the City of Idaho Springs, the Towns of Empire, Georgetown, and Silver Plume, and the Clear Creek Fire Authority to reduce risks from natural disasters and to comply with the DMA (Figure 1-1).

This plan was also developed to position Clear Creek County and its participating jurisdictions for the eligibility of certain federal mitigation funding assistance, specifically, the FEMA HMA grant programs, which include the Hazard Mitigation Grant Program (HMGP), Building Resilient Infrastructure and Communities (BRIC), and Flood Mitigation Assistance (FMA) grant programs.

The participating jurisdiction are dedicated to implementing the actions and strategies outlined in this updated HMP. The Plan will be maintained regularly to address changes in hazards or vulnerabilities and will be updated within the next five years.

Figure 1-1: Clear Creek County and Participating Communities

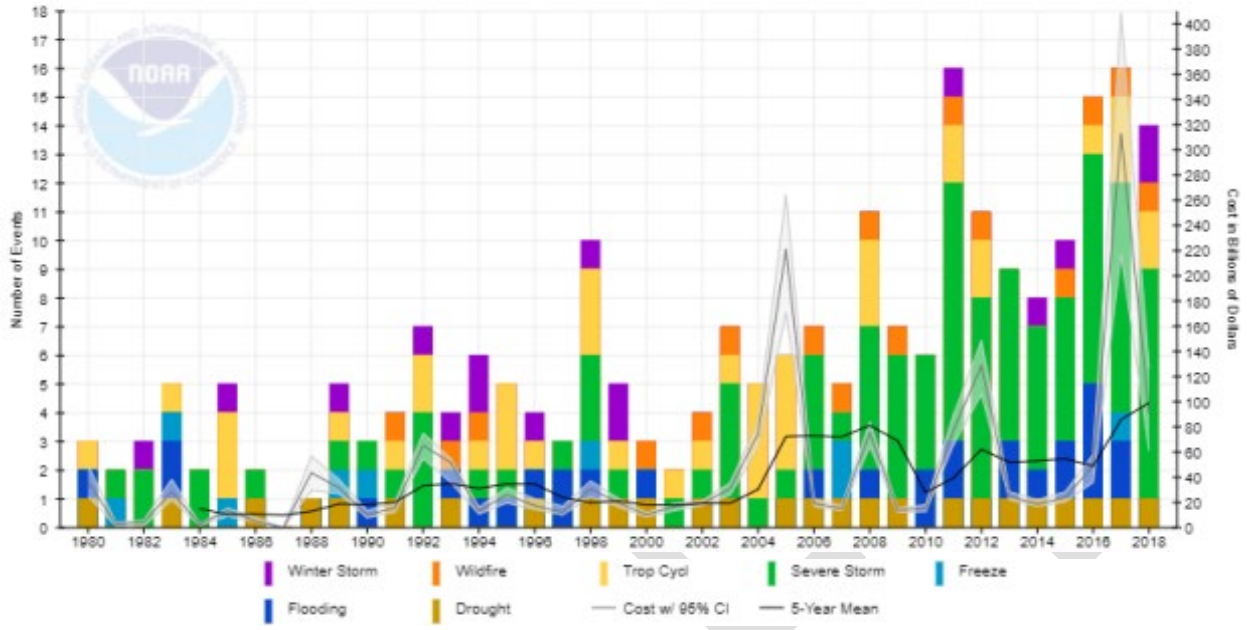


Source: 2016 Clear Creek County HMP

1.3 Background and Scope

Each year in the United States, disasters take the lives of hundreds of people, injure thousands more, and do extensive damage to public and private property. Nationwide, taxpayers pay billions of dollars annually to help communities, organizations, businesses, and individuals recover from disasters. Additional expenses to insurance companies and non-governmental organizations are not reimbursed by tax dollars, making the costs of disasters several times higher than calculated amounts. Figure 1-2 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 1-2: Billion-Dollar Disasters in the US, 1980-2018

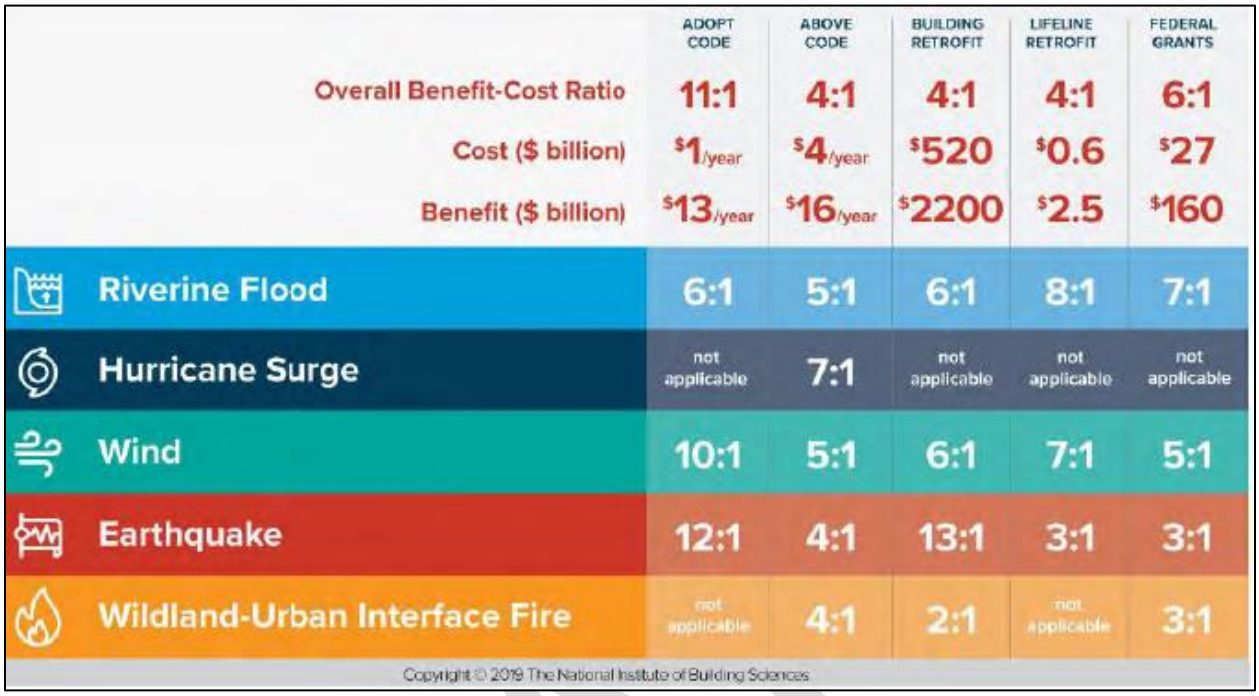


Source: NOAA

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 1-3.

This Plan was prepared pursuant to the requirements of the Disaster Mitigation Act of 2000 (Public Law 106-390, also known as the DMA) 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. While the DMA 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 1-3: Financial Benefits of Hazard Mitigation



	ADOPT CODE	ABOVE CODE	BUILDING RETROFIT	LIFELINE RETROFIT	FEDERAL GRANTS
Overall Benefit-Cost Ratio	11:1	4:1	4:1	4:1	6:1
Cost ($ billion)	$1/year	$4/year	$520	$0.6	$27
Benefit ($ billion)	$13/year	$16/year	$2200	$2.5	$160
Riverine Flood	6:1	5:1	6:1	8:1	7:1
Hurricane Surge	not applicable	7:1	not applicable	not applicable	not applicable
Wind	10:1	5:1	6:1	7:1	5:1
Earthquake	12:1	4:1	13:1	3:1	3:1
Wildland-Urban Interface Fire	not applicable	4:1	2:1	not applicable	3:1

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

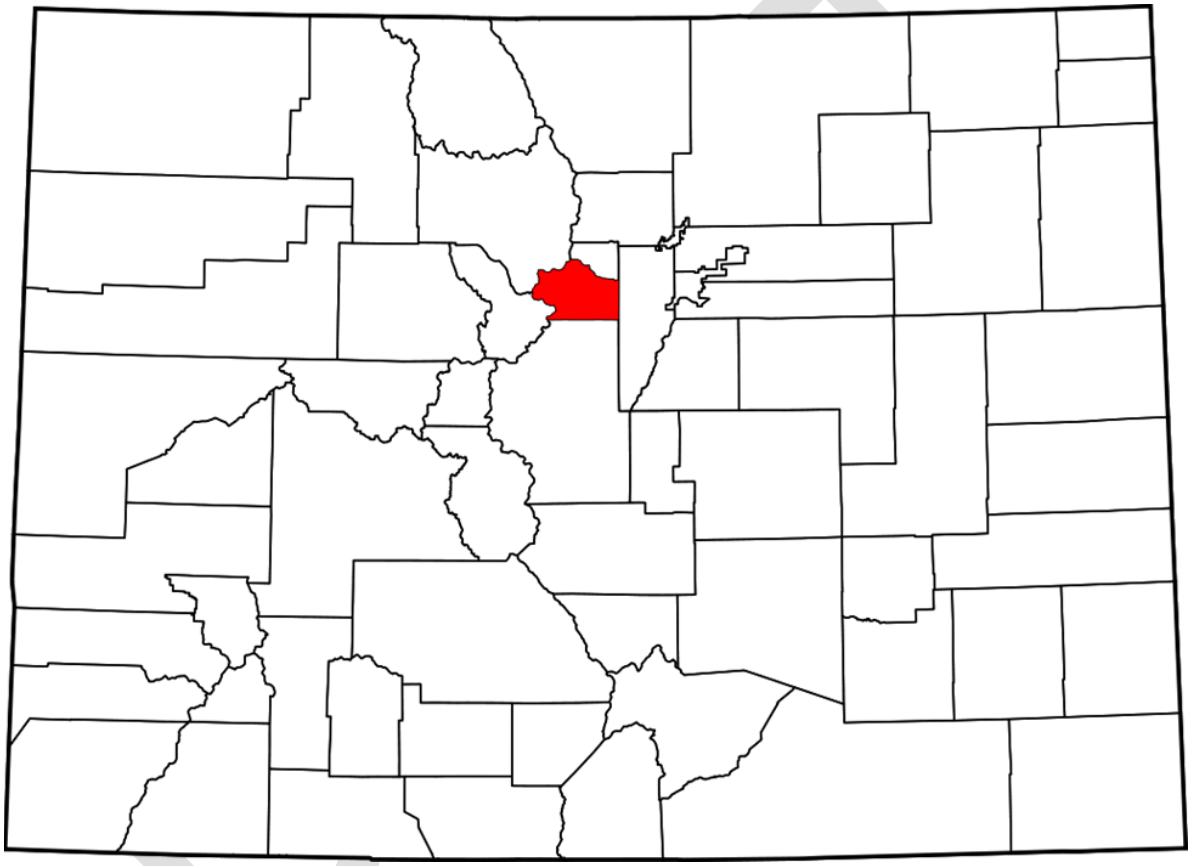
This Plan builds on 10 years of mitigation planning in Clear Creek County, starting with participation in the 2011 Denver Regional Council of Governments (DRCOG) HMP. Clear Creek County developed its first stand-alone HMP in 2016 and has updated it for 2021.

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 Clear Creek County planning area is committed to reducing future disaster impacts and maintaining eligibility for federal funding.

2 Community Profile and Capability Assessment

Clear Creek County covers approximately 396 square miles of land area and is located on the eastern slope of the Rocky Mountains, centrally located within the state of Colorado. Clear Creek County is located approximately 20 miles to the west of the City and County of Denver and is part of the Denver Metropolitan Area. Clear Creek County shares borders with Jefferson County to the east, Gilpin and Grand counties to the north, Summit County to the west, and Park County to the south (see Figure 2-1). A detailed base map of the county is shown below in Figure 2-2. Elevation ranges from 6,900 feet above mean sea level to 14,278 feet at Grays Peak, the highest peak in the County.

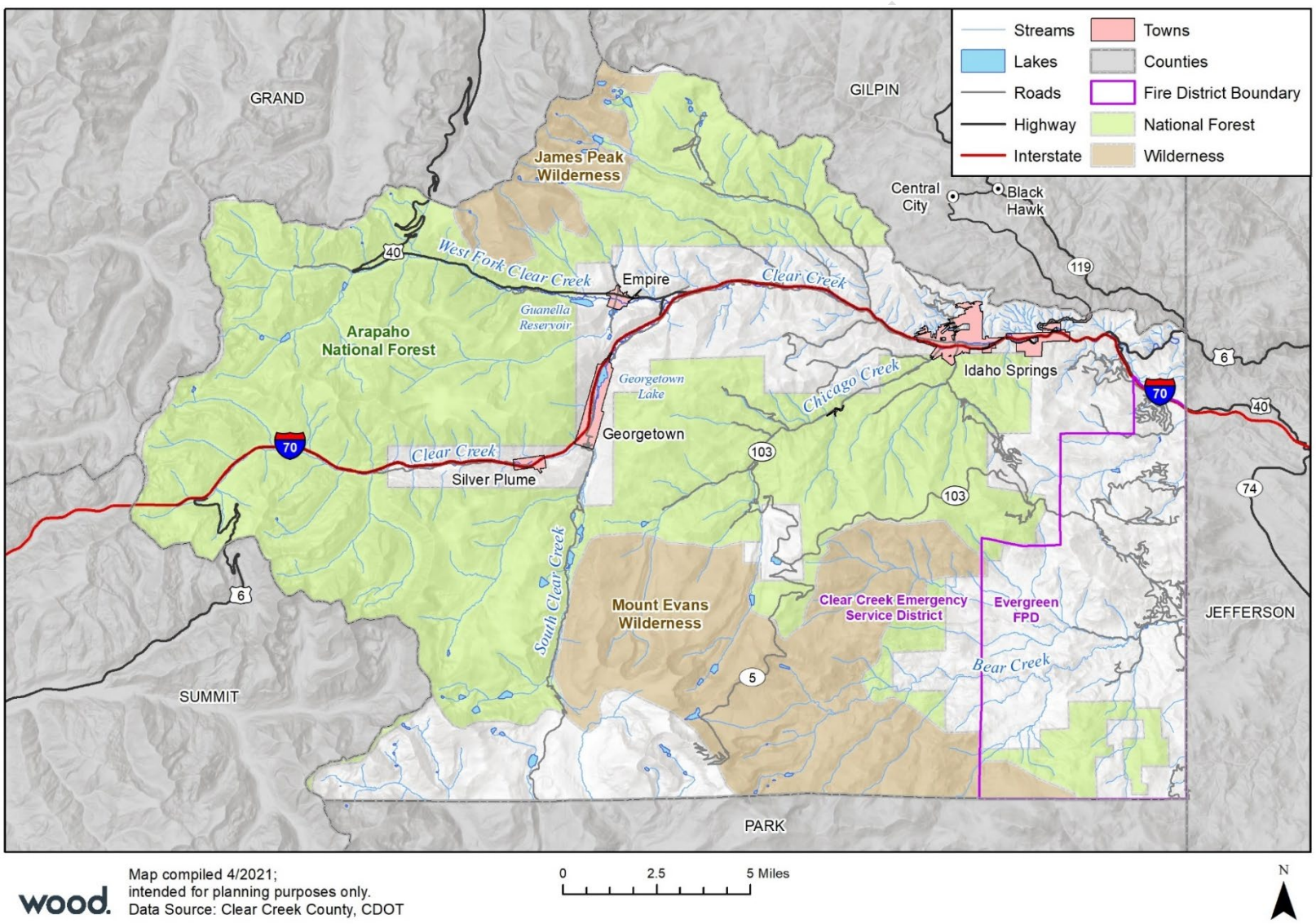
Figure 2-1: Location of the Clear Creek County Planning Area within the State of Colorado



Source: 2016 Clear Creek County HMP

The County is ranked 39th out of Colorado's 64 counties by population, with an estimated 2019 population of 9,495. An estimated 6,034 residents, almost two-thirds of the total population, live in unincorporated areas of the County. The City of Idaho Springs is the largest incorporated community in the County with a 2019 population of 1,858. The next largest community is Georgetown, which also serves as the County seat, with a population of 1,131. The remaining incorporated Towns of Empire and Silver Plume have populations of 303 and 169 respectively. A small portion of Central City, including the Central City Parkway that extends towards the City of Idaho Springs, extends into Clear Creek County; however, Central City is not a participating jurisdiction in this plan update. Major transportation routes in the County include I-70, U.S. Highway 40 and U.S. Highway 6.

Figure 2-2: Clear Creek County



2.1 Historical Overview

Clear Creek County was founded as a result of George Andrew Jackson's discovery of gold on January 7, 1859. Four months later, what is now Idaho Springs, was inundated with miners. The first settlement was two miles above Idaho Springs and was named Spanish Bar, due to evidence of earlier mining by Spaniards.

Mining districts were founded creating their laws and civil government in order to protect their claims from claim jumper, thieves, and other unlawful acts. On November 1, 1861, the territorial legislature of Colorado subdivided the territory into 17 counties, and Idaho Springs was named county seat in the legislative act of establishment. Colorado Governor Gilpin appointed the first three county commissioners to organize the civil government of Clear Creek County. In November 1861, the commissioners met and divided the county into seven voting precincts. The first county election resulted in elections for a sheriff, clerk and recorder, treasurer, assessor, county attorney, superintendent of schools, and a probate judge.

As more and more miners moved into the county, the prospecting moved west following Clear Creek, which runs most of the length of the County. John Dumont settled in the Mill City area. In 1860, the settlement was renamed Dumont, in honor of the founder, John M. Dumont. Shortly after, Dumont was awarded their first post office.

Further west, the Griffith brothers, David and George, were instrumental in settling Georgetown where they discovered the rich silver veins. The Griffith Mining District incorporated in June 1860. The miners established procedures for recording property transactions, settling boundary or mineral disputes, claim size, and a variety of civil laws: restrictions on timber harvesting, health regulations, etc. Shortly after the formation of the Griffith Mining District, several early residents joined together to form the "Georgetown Company," claiming 640 acres for a townsite. The commercial district was tagged "Main Street," a name which would continue into the 20th century. The center of the nascent town was roughly in the area of the I-70 interchange, close to the present-day Rutherford Stables. In the fall of 1867, citizens of the area began meeting to discuss the formation of a town. In 1867, the Colorado Legislature called a special election, and the county seat was moved from Idaho Springs to Georgetown. On January 28, 1868, the Territorial Legislature passed a law incorporating the Town of Georgetown.

Silver Plume is a Home Rule Town and was incorporated in 1880. Silver Plume is a former silver mining camp along Clear Creek in the Front Range of the Rocky Mountains. The federally designated Georgetown-Silver Plume National Historic District comprises Silver Plume, the neighboring Town of Georgetown, and the Georgetown Loop Historic Mining and Railroad Park between the two towns.

2.2 Climate

Weather is fairly moderate and can vary drastically throughout the County. In summer, the day temperature ranges from 60 to 80 degrees Fahrenheit (°F). The County experiences an average of 300 days of sunshine per year. In winter, the day temperature ranges from 20 to 45°F with an average snowfall ranging from 70 inches in lower lying areas to 400 inches at Loveland Ski Resort.

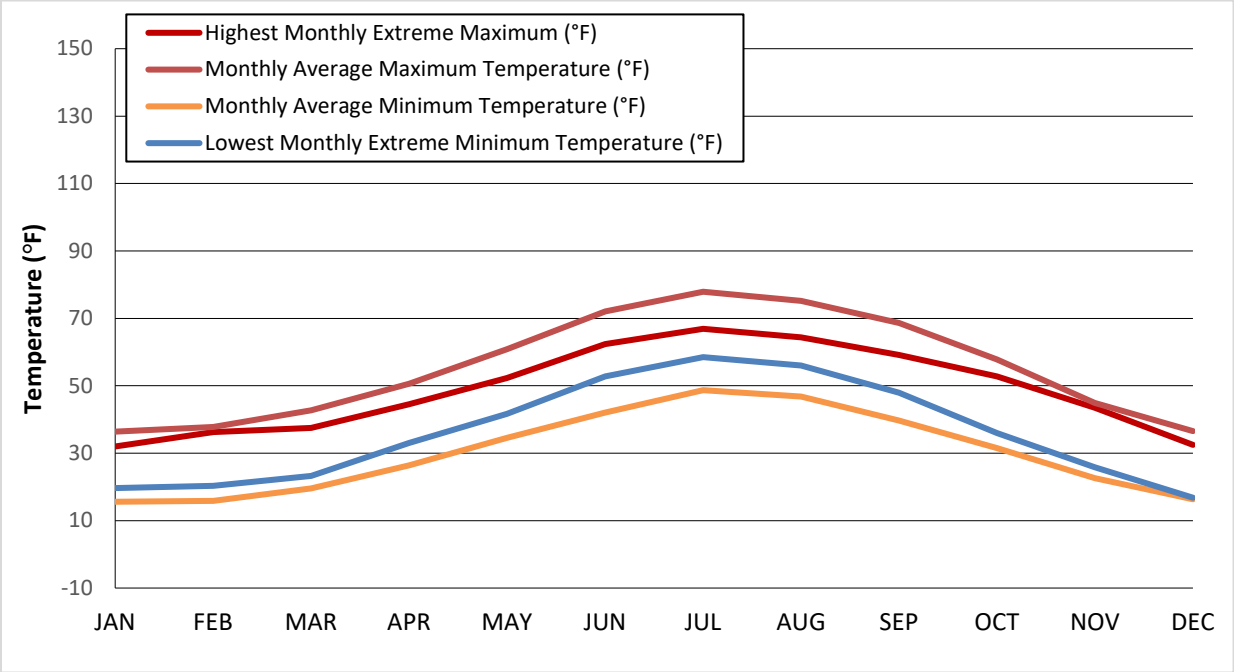
The High Plains Regional Climate Center reports data from the Town of Georgetown weather station in Clear Creek County. Table 2-1 contains temperature summaries for the station. Figure 2-3 graphs the daily temperature averages and extremes from 1893 through 2015 for the Town of Georgetown.

Table 2-1: Clear Creek County Temperature Summary Georgetown Station

Period of record	1893-2020
Winter[a] Average Minimum Temperature	15.9°F
Winter[a] Mean Temperature	26.5ºF
Summer[a] Average Maximum Temperature	75.1°F
Summer[a] Mean Temperature	60.5ºF
Maximum Temperature	92°F; June 23, 1954
Minimum Temperature	-28°F; January 4, 1972
Average Annual Number of Days >90°F	0.2
Average Annual Number of Days <32°F	87.2

a. Winter: December, January, February; Summer: June, July, August
ºF degrees Fahrenheit
Source: High Plains Regional Climate Center (https://hprcc.unl.edu/stationtool/index.php)

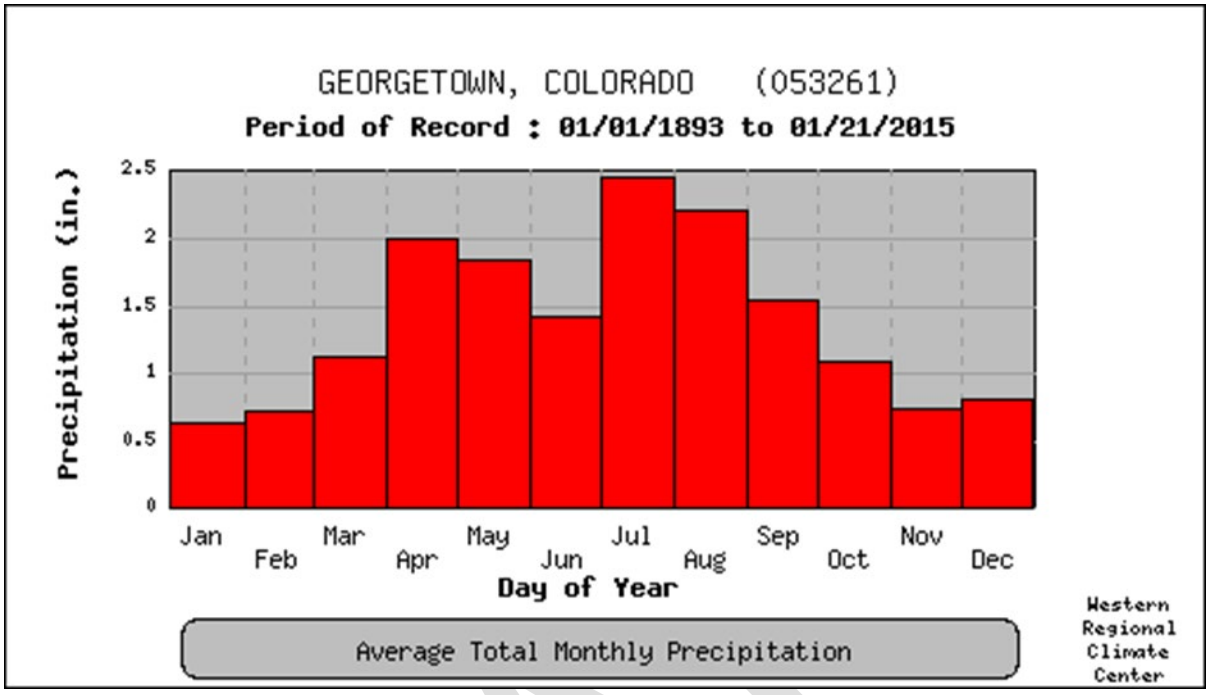
Figure 2-3: Georgetown Station Monthly Temperature Data (1893–2015)



Source: Western Regional Climate Center, www.srcc.lsu.edu/

Precipitation is highest during July and August. The average annual precipitation is 16.44 inches of rain and 92.8 inches of snowfall. Severe thunderstorms occur mostly in the summer. Based on information from NOAA, Colorado receives an average of 520,833 cloud-to-ground lightning strikes per year. Figure 2-4 shows the average monthly precipitation of rainfall in Clear Creek County.

Figure 2-4: Average Monthly Rainfall Precipitation for Clear Creek County (1893-2015)



2.3 Geology and Soils

Gold ore was discovered in 1859 near the mouth of the Chicago Creek. This discovery led to the spread of searches along the area of Trail Creek. Gold, silver, copper, zinc and lead was mined until 1952. Igneous rocks and meta-sedimentary rocks of Precambrian age can be found throughout the planning area. Schist of Precambrian age predominates in the Idaho Springs region of Clear Creek County; numerous lenses of granite gneiss and pegmatite can be found as well. Tertiary-aged dikes, sills, and irregular bodies of pegmatite are also scattered throughout the Idaho Springs region.

The geology is similar around Empire; tertiary stocks of quartz monozonite and dikes of bostonite and alaskite intrude into the terrain of Idaho Springs Precambrian metamorphic rocks. Gold and copper were the primary products mined. Around Georgetown, the most intrusive rocks are Silver Plume Granite with the Idaho Springs Precambrian metamorphic rocks. Tertiary stocks and dikes of various compositions are abundant in the area. Mineralization occurs in two types of silver, lead, zinc veins and veins of pyritic gold.

2.4 Demographics

Information on population levels and other demographic information helps to make informed decisions about future planning. Population directly relates to land needs for housing, industry, stores, public facilities and services, and transportation. Population changes are useful socio-economic indicators, as a growing population generally indicates a growing economy, and a decreasing population signifies economic decline.

The U.S. Census Bureau American Community Survey (ACS) estimated the Clear Creek County population at 9,495 as of 2019. Table 2-2 shows planning area population data from 2000 through 2019. The total Clear Creek County population increased 1.9% from 2000 to 2019; this included a decline of 3% between 2000 and 2013, followed by a 5% increase from 2013 to 2019.

Table 2-2: Clear Creek County Population

	2000	2010	2013	2019
City of Idaho Springs	1,931	1,719	1,685	1,858
Town of Empire	354	281	276	303
Town of Georgetown	1,093	1,036	1,028	1,131
Town of Silver Plume	202	170	166	169
Unincorporated Areas[1]	5,730	5,897	5,876	6,034
County Total	**9,310**	**9,103**	**9,031**	**9,495**

Source: United States Census Bureau
https://www.census.gov/acs/www/data/data-tables-and-tools/data-profiles/2019/
[1]Includes non-participating communities

The City of Idaho Springs and the Town of Georgetown are the County's largest population centers. However, the majority of county residents live outside the incorporated areas and this percentage generally continues to increase. In 2000, 61.5% of the county's residents lived outside the incorporated areas, compared to 64.8% in 2010, and 63.5% in 2019.

Select U.S. Census ACS 2015-2019 demographic and social characteristics for Clear Creek County are shown in Table 2-3.

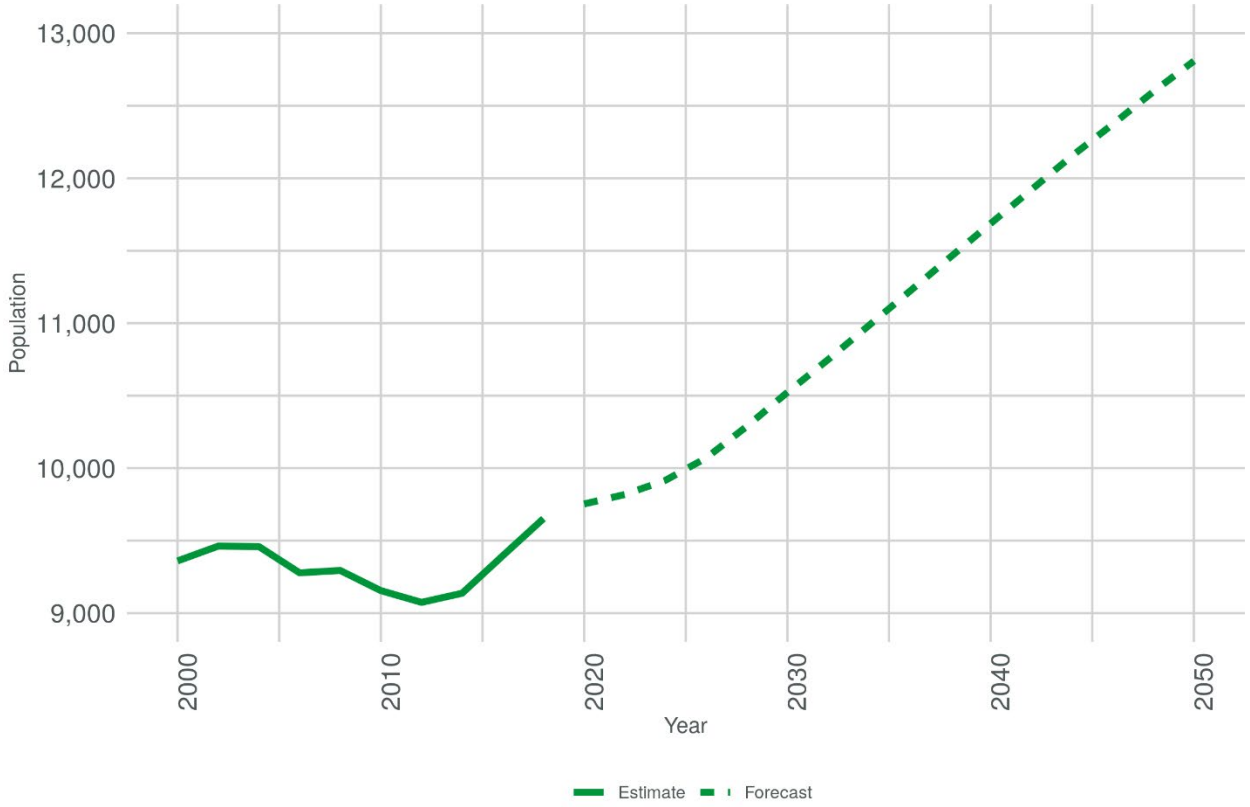
Table 2-3: Clear Creek County Demographic and Social Characteristics (2019)

	Clear Creek County	City of Idaho Springs	Town of Empire	Town of Georgetown	Town of Silver Plume
Gender/Age (% of Total Population)					
Male	50.3	48.0	50.5	50.8	56.8
Female	49.7	52.0	49.5	49.2	43.2
Under 5 years	3.9	8.0	3.0	2.6	7.7
65 years and over	19.4	19.9	22.1	20.4	28.4
Race/Ethnicity (% of Total Population)					
White	94.2	86.1	95.0	92.5	100.0
American Indian/Alaska Native	0.3	0.0	0.7	0.6	0.0
Asian	1.0	0.0	1.3	1.0	0.0
Black or African American	1.2	4.4	1.3	1.1	0.0
More Than One Race	3.2	9.5	1.7	4.9	0.0
Hispanic or Latino (of any race)[1]	7.0	8.8	6.6	8.0	1.8
Education (% of Total Population, 25+ years)					
High school graduate or higher	98.6	97.2	94.2	98.1	97.8

Source: U.S. Census Bureau, 2015-2019 5-Year American Community Survey,https://www.census.gov/acs/www/data/data-tables-and-tools/data-profiles/2019/
[1]The U.S. Census Bureau considers the Hispanic/Latino designation an ethnicity, not a race. The population self-identified as "Hispanic/Latino" is also represented within the categories in the "Race" demographic.

Figure 2-5 shows 5-year population changes in Clear Creek County from 2000 to 2019, as well as forecasted growth through the year 2050 according to the Colorado State Demography Office. Clear Creek County is expected to grow to almost 13,000 residents by 2050.

Figure 2-5: Clear Creek County Population and Forecasted Growth, 2000 to 2050



Source: State Demography Office 2021

2.5 Social Vulnerability

Local vulnerability to disasters depends on more than the relationship between a place and its exposure to hazards. 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.

The term vulnerability should be used to describe the 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 vulnerability causes 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 only 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.

This 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.

The Centers 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 looks at 15 factors, which are aggregated into four main themes: socioeconomic status, household composition & disability, minority status & language, and housing & transportation. Table 2-4 shows countywide estimates for those four themes and 15 factors, along with relative rankings showing how Clear Creek County compares to other counties in Colorado and nationally. The rankings show the percentage of counties that Clear Creek County is more vulnerable than, i.e. – high numbers are worse.

Table 2-4: Clear Creek County Social Vulnerability Characteristics

Theme	Variable	Countywide Estimate	Ranking Compared to Colorado Counties	Ranking Compared to US Counties
Socioeconomic status			**3.2% Very Low**	**0.1% Very Low**
	Below poverty	5.5%	7.9% Very Low	1.9% Very Low
	Unemployment	1.9%	4.8% Very Low	4.3% Very Low
	Income	$3,738	17.5% Low	3.6% Very Low
	No high school diploma	1.7%	1.6% Very Low	0.2% Very Low
Household composition and disability			**15.9% Low**	**3.0% Very Low**
	Age 65 or older	18.9%	60.3% Above Ave	58.2% Above Ave
	Age 17 or younger	15.7%	9.5% Very Low	2.5% Very Low
	Disability	9.7%	23.8% Low	5.4% Very Low
	Single-parent households	6.3%	39.7% Below Ave	20.7% Low
Minority status and language			**17.5% Low**	**48.3% Average**
	Minority	10.8%	7.9% Very Low	36.6% Below Ave
	Speaking English “less than well”	1.0%	28.6% Below Ave	57.9% Above Ave
Housing and transportation			**17.5% Low**	**14.0% Low**
	Multiunit structures	5.1%	52.4% Average	70.7% Above Ave
	Mobile homes	6.4%	34.9% Below Ave	30.3% Below Ave
	Crowding	1.5%	27.0% Below Ave	33.6% Below Ave
	No vehicle	2.5%	22.2% Low	5.5% Very Low
	Group quarters	1.3%	34.9% Below Ave	25.8% Below Ave
Overall Social Vulnerability			**6.4% Very Low**	**2.0% Very Low**

Source: U.S. Centers for Disease Control and Prevention, https://www.atsdr.cdc.gov/placeandhealth/svi/index.html

The data shows that Clear Creek County’s social vulnerability is very low overall compared to both the State and the Nation. However, the County’s vulnerability is above average in the following areas:

- Multi-unit housing (defined as more than 10 units per structure), which can be more difficult to evacuate during emergencies.

- Percentage of people over the age of 65, who may be more affected by disasters.
- Percentage of people who speak English "less than well," complicating disaster communications.

It should be noted that even though the County may have relatively few people in a category compared to other counties, there are still people in that category who may be disproportionately impacted by disasters and may need extra consideration or assistance.

Figure 2-6 displays the overall SoVI data for Clear Creek County by census tract, while Figure 2-6 through Figure 2-10 illustrate the four categories the CDC analyzes. The low population density in Clear Creek County leads to very large census tracts, meaning there is less granularity in the data than in more densely populated areas. However, the data can still be used to assess relative vulnerability within the County.

Another social vulnerability not captured in the CDC data is the lack of broadband service in certain areas of the County. The lack of broadband services, or in some cases high speed internet services, can make it challenging to inform people in these areas of emergency situations or community outreach related to hazards in general.

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

Figure 2-6: Clear Creek County Overall Social Vulnerability

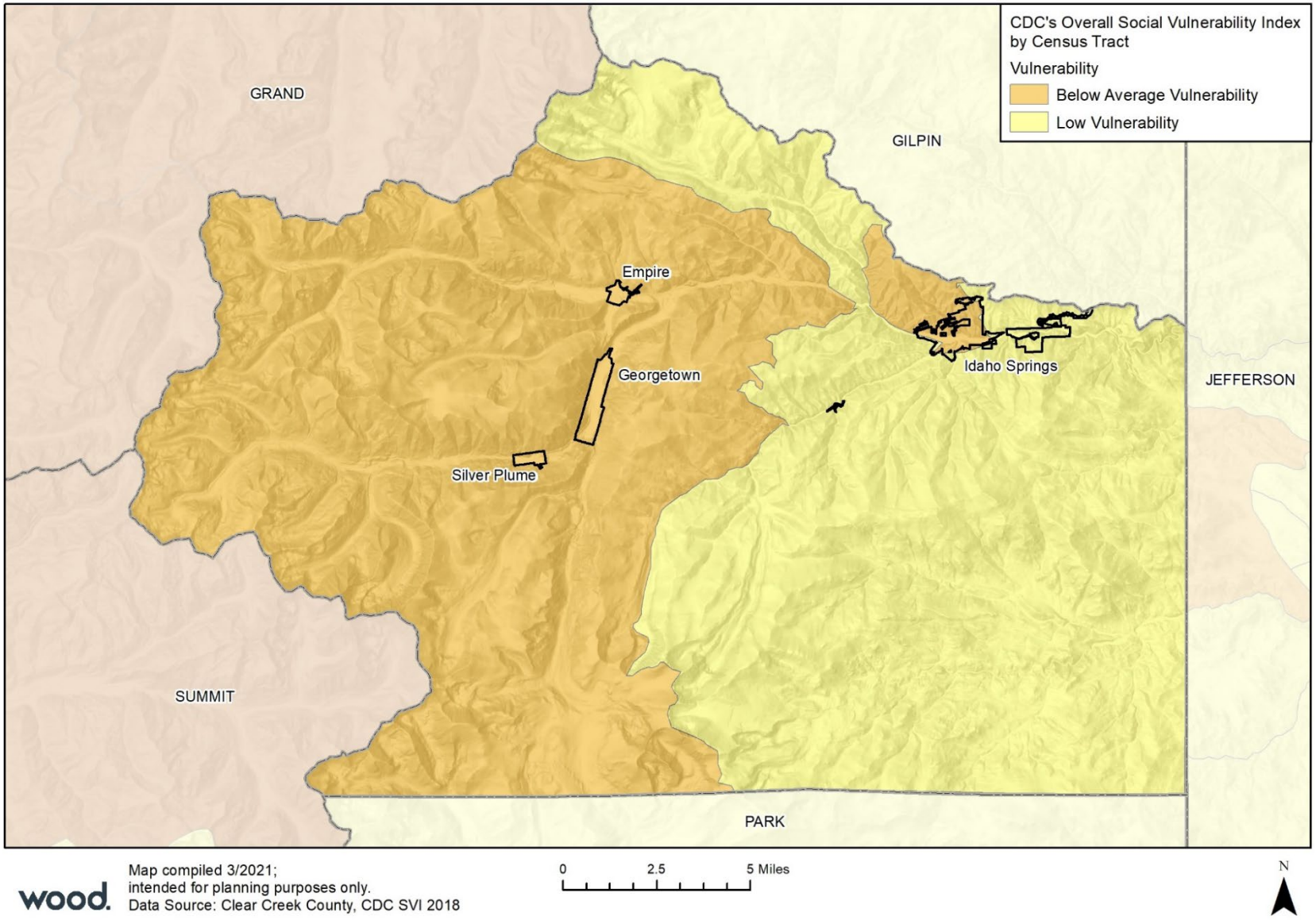


Figure 2-7: Clear Creek County SVI Socioeconomic Status

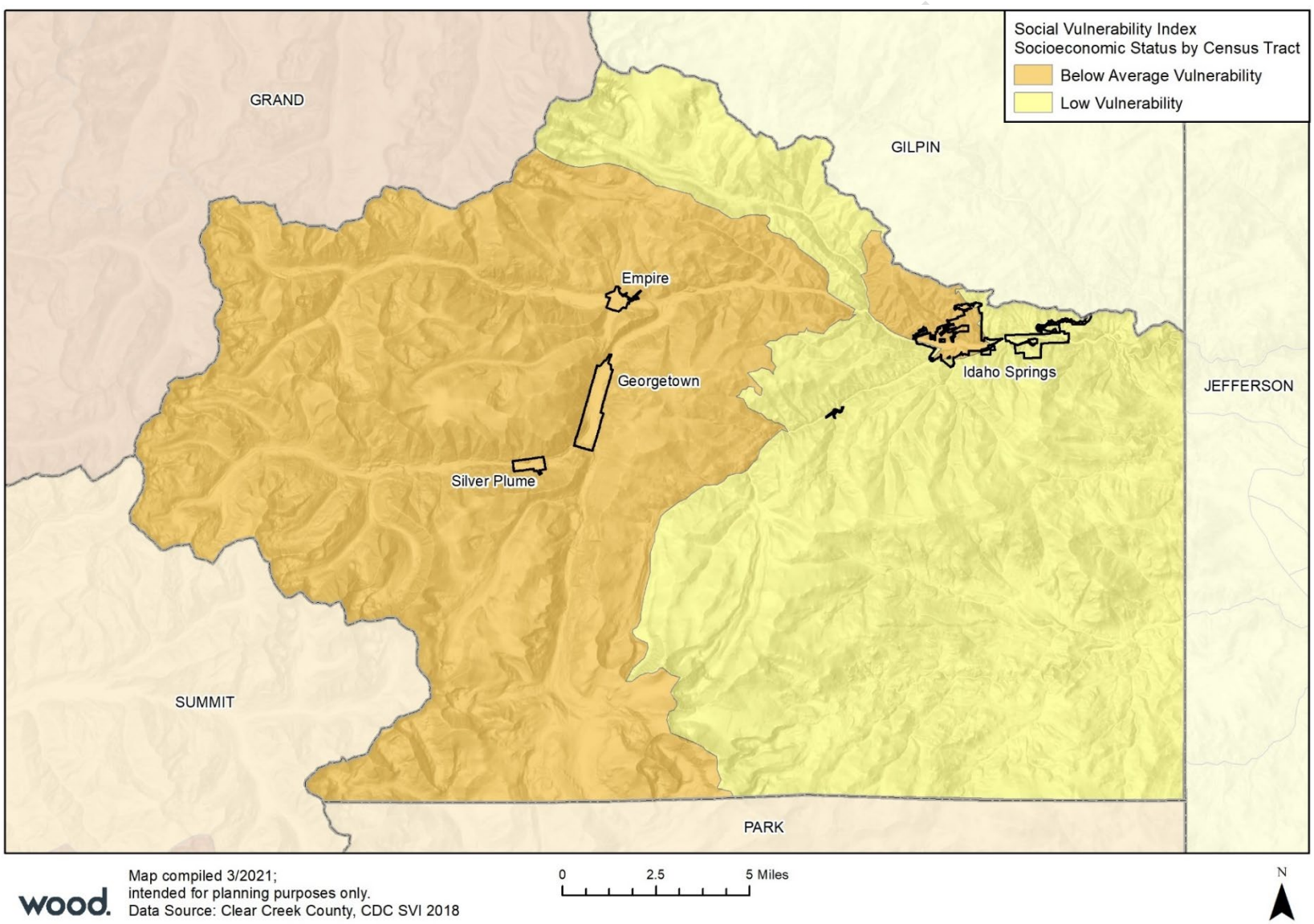


Figure 2-8: Clear Creek County SVI Household Composition and Disability Status

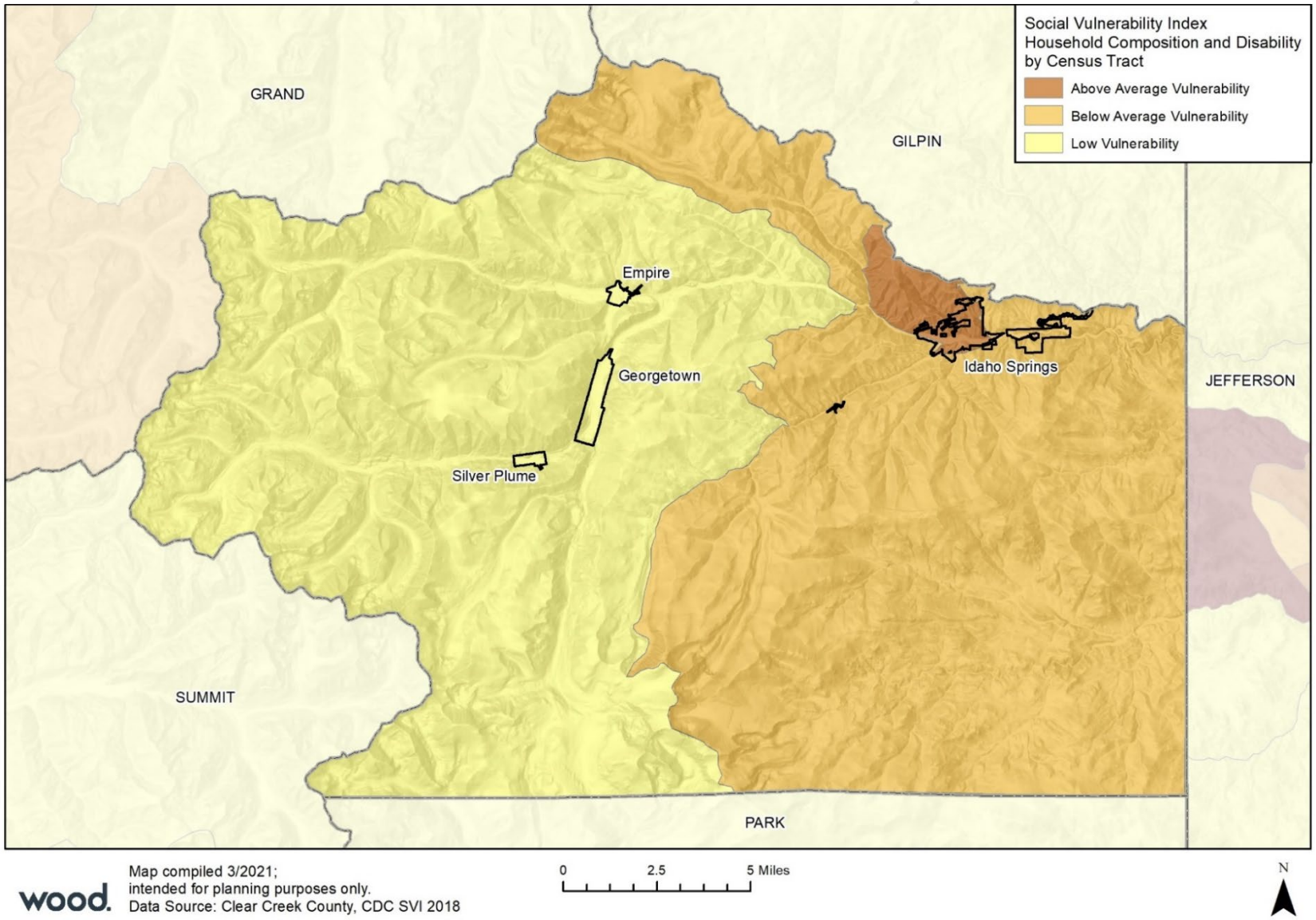


Figure 2-9: Clear Creek County SVI Minority and Language Status

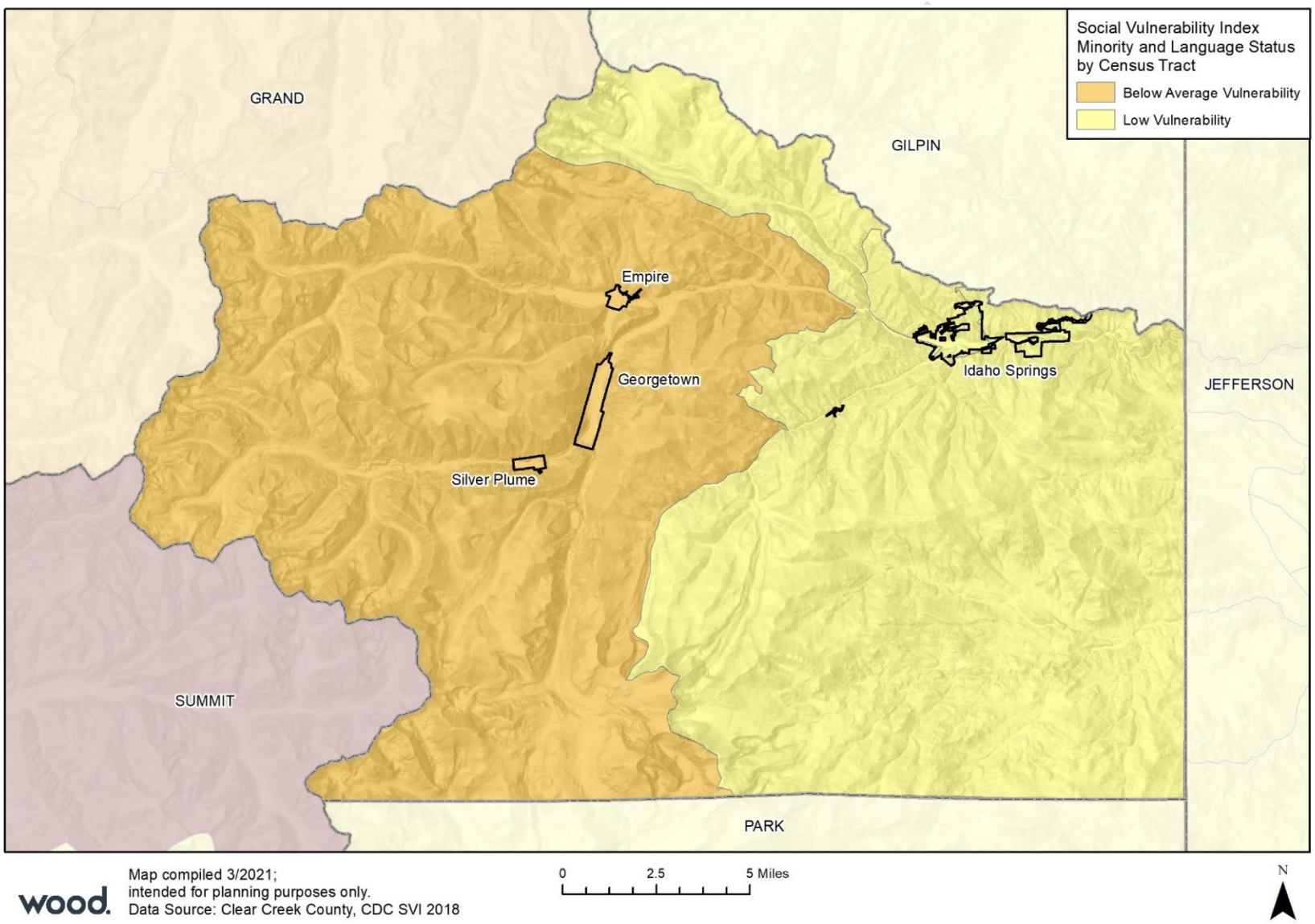
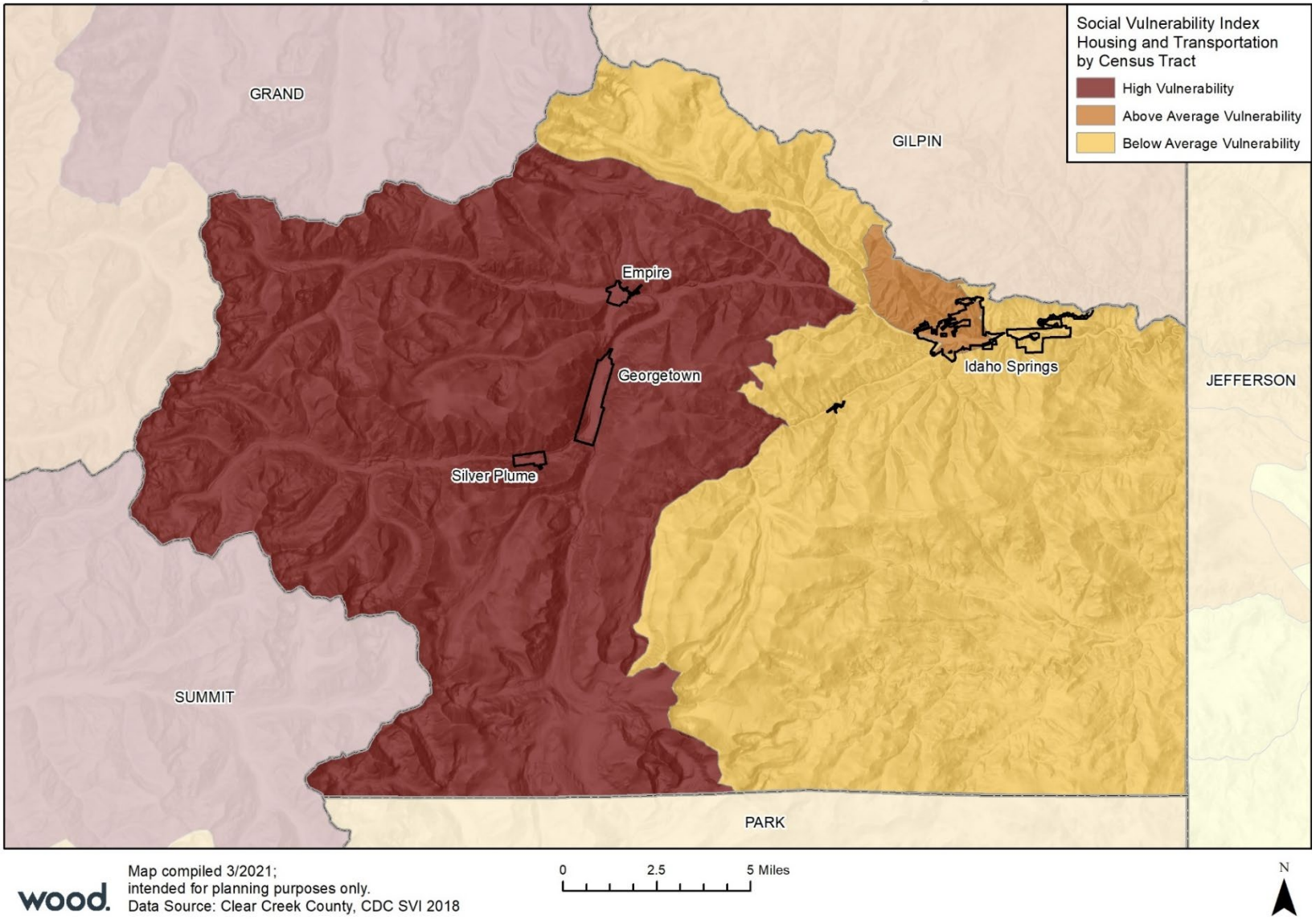


Figure 2-10: Clear Creek County SVI Housing and Transportation Status



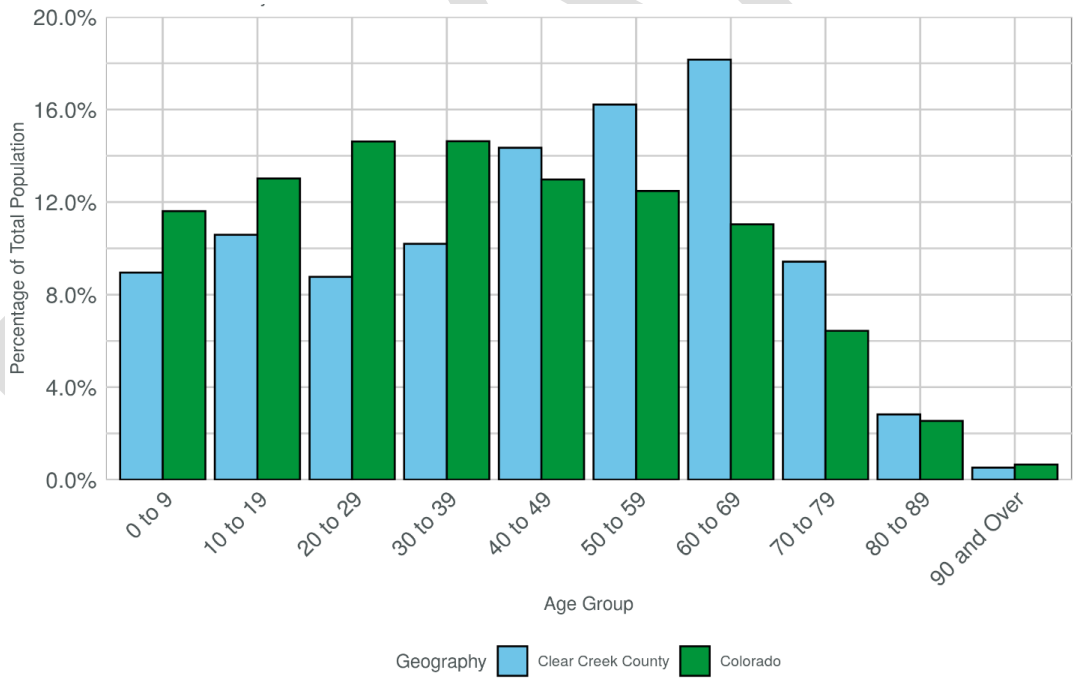
2.5.1 Age Distribution

As discussed above, as a group the elderly are more likely to lack the physical and economic resources necessary for response to hazard events and are more likely to suffer health-related consequences making recovery slower. They are more likely to be vision, hearing, or mobility impaired, and more likely to experience mental impairment or dementia. Additionally, the elderly are more likely to live in assisted-living facilities where emergency preparedness occurs at the discretion of facility operators. Elderly residents living in their own homes may have more difficulty evacuating and could be stranded in dangerous situations. This population group is more likely to need special medical attention, which may not be readily available during natural disasters due to isolation caused by the event. Specific planning attention for the elderly is an important consideration given the current aging of the national population.

Children under 14 are also particularly vulnerable to disaster events because of their young age and dependence on others for basic necessities. Very young children may additionally be vulnerable to injury or sickness; this vulnerability can be worsened during a natural disaster because they may not understand the measures that need to be taken to protect themselves from hazards.

The overall age distribution for the planning area is illustrated in Figure 2-11. Based on 2019 U.S. Census data estimates, 19.4% of the planning area's population is 65 or older and 15.9% is under the age of 18. U.S. Census data does not provide information regarding disabilities in the planning area's over-65 population. U.S. Census estimates for 2019 indicate that 7.3% of Clear Creek County families have children under 18 and are below the poverty line.

Figure 2-11: Clear Creek County Age Distribution – 2019



Source: State Demography Office 2021

2.5.2 People with Disabilities

The 2019 U.S. Census ACS estimates indicated that there are approximately 40 million non-institutionalized Americans living with disabilities. This equates to about 12.6% of the total civilian non-institutionalized population. People with disabilities are more likely to have difficulty responding to a hazard

event than the general population. Local government is the first level of response to assist these individuals, and coordination of efforts to meet their access and functional needs is paramount to life safety efforts. It is important for emergency managers to distinguish between functional and medical needs in order to plan for incidents that require evacuation and sheltering. Knowing the percentage of population with a disability will allow emergency management personnel and first responders to have personnel available who can provide services needed by those with access and functional needs. According to the 2019 ACS 5-year Estimates, 9.9% of the population in the planning area lives with some form of disability.

2.5.3 Ethnic Population

Research shows that minorities are less likely to be involved in pre-disaster planning and experience higher mortality rates during a disaster event. Post-disaster recovery can be less effective for ethnic populations and is often characterized by cultural insensitivity. Since higher proportions of ethnic minorities live below the poverty line than the majority white population, poverty can compound vulnerability. In Clear Creek County, 6.7% of individuals speak a language other than English at home, compared to 16.9% of the statewide population. According to the U.S. Census, the ethnic composition of the planning area is predominantly white, at about 94.2%. The largest minority population is Hispanic or Latino at 7.0%.

2.6 Economy

Select 2019 economic characteristics estimated for Clear Creek County by the U.S. Census Bureau are shown in Table 2-5.

Table 2-5: Clear Creek County Economic Characteristics

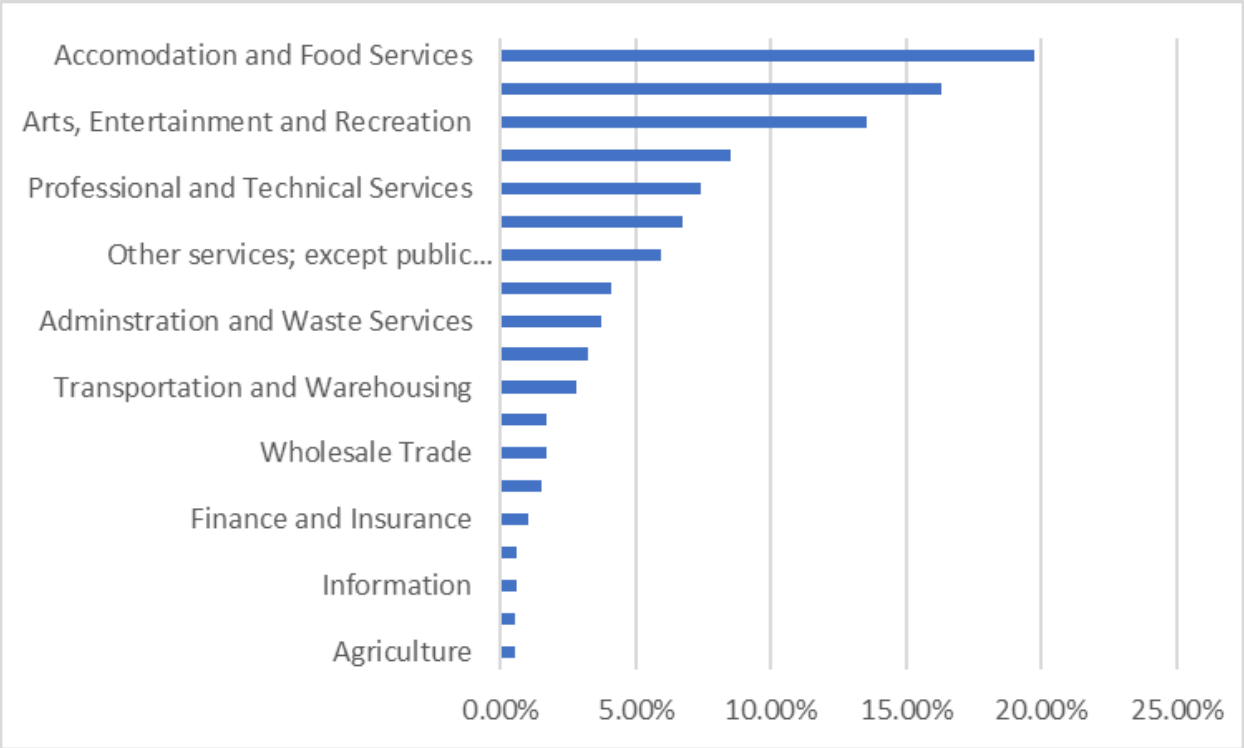
	Clear Creek County	City of Idaho Springs	Town of Empire	Town of Georgetown	Town of Silver Plume
Families Below Poverty Level	4.1%	6.6%	7.5%	3.7%	0%
Individuals Below Poverty Level	7.8%	10.3%	17.8%	5.2%	7.7%
Median Home Value	$378,300	$250,500	$223,400	$294,900	$257,800
Median Household Income	$67,060	$43,886	$46,250	$54,083	$65,625
Per Capita Income	$39,203	$29,975	$28,597	$41,269	$40,828
Population >16 Years Old in Labor Force	65.8%	67.8%	63.4%	63.3%	58.5%
Population Employed	63.8%	66.8%	62.3%	60.8%	58.5%

Source: U.S. Census ACS 2015-2019 5 Year Estimates

2.6.1 Occupations and Industries

According to the State Demography Office, in 2019 the County's economy is largely based in the accommodation and food services (19.7%), government (16.3%), and arts, entertainment, and recreation (13.5%) industry sectors. Figure 2-12 shows the distribution of industry types in Clear Creek County, based on the share of total employment.

Figure 2-12: Percent of Total Employment by Industry in Clear Creek County



Source: Colorado Department of Local Affairs, State Demography Office, 2019 Community Demographic Profiles

2.7 Housing

In the United States, individual households are expected to use private resources to prepare for, respond to, and recover from disasters to some extent. This means that households living in poverty are automatically disadvantaged when confronting hazards. Additionally, the poor typically occupy more poorly built and inadequately maintained housing. Mobile or modular homes, for example, are more susceptible to damage in earthquakes and floods than other types of housing. Mobile homes represent 5.5% of the total housing stock in Clear Creek County.

Table 2-6 shows select housing characteristics from the and the ACS Five-Year estimates for 2019 for the planning area.

Table 2-6: Clear Creek County Select Housing Characteristics

	Clear Creek County	Idaho Springs	Empire	Georgetown	Silver Plume
Total Housing Units	5,793	977	186	803	146
# Occupied Housing Units	4,395	908	145	551	84
Vacancy Rate	24.1%	7.1%	22.0%	31.4%	42.5%
% Owner-Occupied	77.2%	53.7%	72.4%	63.0%	65.5%
% Renter-Occupied	22.8%	46.3%	27.6%	37.0%	34.5%
Average # of Persons per Household	2.13	2.05	2.09	1.87	2.01

	Clear Creek County	Idaho Springs	Empire	Georgetown	Silver Plume
% of Rental Households paying 35% or more of income on housing	37.0%	45.2%	50.0%	41.1%	31.0%
Source: U.S. Census Bureau, ACS 5-Year Estimates 2014-2019					

2.8 Future Trends in Development

As shown in Figure 2-5 above, Clear Creek County is projected to maintain steady population growth in the coming years. The municipal planning partners have adopted plans that govern land use decision and policy making in their jurisdictions. Decisions on land use will be governed by these programs. This plan will work together with these programs to support wise land use in the future by providing vital information on the risk associated with natural hazards in the planning area.

It is the goal that all municipal planning partners will incorporate this HMP update in their comprehensive plans (if applicable) by reference. This will help ensure that future development trends can be established with the benefits of the information on risk and vulnerability to natural hazards identified in this plan.

2.9 Government

2.9.1 Clear Creek County

The Clear Creek County government is made up of the following offices and departments:

- Administration
- Animal Shelter
- Archives and Records
- Assessor
- Clerk and Recorder
- Community Development
- CSU Extension Program
- Emergency Management
- EMS
- Fire Authority
- Health and Human Services
- Housing Authority
- Mapping and GIS
- Open Space
- Public and Environmental Health
- Public Works
- Sheriff
- Special Project Division
- Treasurer and Public Trustee
- Veteran Service Office
- Victim Advocates
- Waste and Recycling

2.9.2 City of Idaho Springs

The City of Idaho Springs is governed by a Mayor and City Council and includes the following departments:

- Administration
- Building Department
- City Clerk
- Municipal Court
- Police
- Public Works

2.9.3 Town of Empire

The Town of Empire is a statutory town and was incorporated on April 12, 1882. The Town of Empire has an elected mayor and a board of trustees, and an appointed planning commission. Fire and EMS services

are provided by the CCFA and Clear Creek County Sheriff's Office. The Town of Empire government is made up of the following offices and departments:

- Mayor
- Town Clerk
- Police Department
- Public Works Department
- Zoning Officer
- Board of Trustees
- Planning Commission

2.9.4 Town of Georgetown

The Town of Georgetown is governed by a town administrator and a town council and includes the following departments:

- Administration
- Building
- Court
- Lake, Parks, and Trails
- Police
- Road and Bridge
- Water and Wastewater

2.9.5 Town of Silver Plume

The Town of Silver Plume government is made up of the following offices and departments:

- Mayor
- Town Clerk
- Bookkeeper
- Public Works Director
- Building Inspector
- Zoning Board
- Planning Commission
- Board of Adjustment

2.9.6 Clear Creek Fire Authority

Clear Creek Fire Authority (CCFA) is a consolidated fire protection and emergency service agency serving the municipalities of Empire, Georgetown, Idaho Springs and Silver Plume and the unincorporated lands of Clear Creek County, Colorado previously represented by the Clear Creek Emergency Services District (ESD). An eight-member Board of Directors governs the CCFA and each director is appointed by a municipality or the ESD.

2.9.7 Evergreen Fire Protection District

Evergreen Fire Protection District (EFPD) is not seeking adoption of the Clear Creek County HMP but was an active stakeholder throughout the 2021 plan update process.

As shown in Figure 2-2, Evergreen Fire Protection District protects a sizable portion of Clear Creek County that includes several well populated subdivisions, schools, Mt. Evans Outdoor Lab, and Mt. Evans Wilderness Area. EFPD participates routinely in the Clear Creek County Multi Agency Coordination (MAC)

Group. EFPD's district is impacted by watersheds that originate in Clear Creek County and a significant portion of their mitigation work involves fuel breaks within Clear Creek County. For more information on EFPD mitigation activities, see the Jefferson County Hazard Mitigation Plan.

2.10 Capability Assessment

The planning team performed an inventory and analysis of existing authorities and capabilities called a "capability assessment." A capability assessment creates an inventory of an agency's mission, programs and policies, and evaluates its capacity to carry them out.

2.10.1 Legal and Regulatory Capabilities

Table 2-7 lists planning and land management tools typically used by local jurisdictions to implement hazard mitigation activities and indicates those that are in place in Clear Creek County and the participating jurisdictions.

Table 2-7: Clear Creek County Regulatory Mitigation Capabilities

Regulatory Tool (ordinances, codes, plans)	Clear Creek County	Idaho Springs	Georgetown	Empire	Silver Plume	CCFA
General or Comprehensive plan	Yes	Yes	Yes	No	Yes	Yes
Zoning ordinance	Yes	Yes	Yes	Yes	Yes	N/A
Subdivision ordinance	Yes	Yes	No	Yes	Yes	N/A
Growth management	Yes	Yes	No	No	Yes	N/A
Floodplain ordinance	Yes	Yes	Yes	No	Yes	N/A
Floodplain Management Plan	Yes	Yes	Yes	Yes	Yes	Yes
Other special purpose ordinance (stormwater, steep slope, wildfire)	Yes	Yes	No	No	Yes	Yes
Building code	Yes	Yes	Yes, 2015 IBC	Yes	Yes	Yes, 2009 IBC
Fire Department ISO Rating	Yes, Rating 5	Yes, Rating 5	Yes, Rating 5	Yes, Rating 5	Yes, Rating 5	Yes, Rating 5
Erosion or sediment control program	Yes	Yes	No	No	No	N/A
Stormwater management	Yes	Yes	No	Yes	No	N/A
Site plan review requirements	Yes	Yes	Yes	Yes	Yes	N/A
Capital improvement plan	Yes	Yes	No	Yes	No	Yes
Economic development plan	Yes	Yes	No	Yes	No	N/A
Local emergency operations plan	Yes	Yes	No	No	No	N/A
Other special plans	Yes	Yes	No	No	No	No

Regulatory Tool (ordinances, codes, plans)	Clear Creek County	Idaho Springs	Georgetown	Empire	Silver Plume	CCFA
Flood insurance study or other engineering study for streams	Yes	Yes	No	No	No	N/A
Elevation certificates	Yes	Yes	No	No	No	N/A
BCEGS Ratings (1-10)	No	No	No	No	No	N/A
Community Wildfire Protection Plan (CWPP)	CCFA	CCFA	Yes, 2016	CCFA	CCFA	2009, Under revision

2.10.2 Administrative and Technical Capabilities

Table 2-8 identifies the County personnel responsible for activities related to mitigation and loss prevention in Clear Creek County and its jurisdictions.

Table 2-8: Clear Creek County Administrative/Technical Mitigation Capabilities

Administrative/Technical Resources	Clear Creek County	Idaho Springs	Georgetown	Empire	Silver Plume	CCFA
Planner/engineer with knowledge of land development/land management practices	Yes	Yes	Yes (contract)	No	No	N/A
Planner/engineer/scientist with an understanding of natural hazards	Yes	Yes	No	No	No	N/A
Engineer/professional trained in construction practices related to buildings and/or infrastructure	Yes (limited)	Yes (limited)	Yes (contract)	Yes	No	N/A
Resiliency Planner	No	No	No	No	No	N/A
Transportation Planner	Yes	No	No	No	No	N/A
Personnel skilled in GIS	Yes	Yes	Yes (County)	Yes	Yes	
Full time building official	Yes	Yes	No	No	No	N/A
Floodplain manager	Yes	Yes	No	No	Yes	N/A
Emergency manager	Yes	Yes	No	Yes	No	N/A
Grant writer	No	No	No	Yes	No	N/A
Other personnel	Yes	Yes	No	No	No	N/A
GIS Data Resources (Hazard areas, critical	Yes	Yes	Yes (County)	Yes	Yes	N/A

Administrative/Technical Resources	Clear Creek County	Idaho Springs	Georgetown	Empire	Silver Plume	CCFA
facilities, land use, building footprints, etc.)						
Warning Systems/Services (Reverse 9-11,	Yes	Yes	Yes	Yes	Yes	N/A

2.10.3 Financial Capabilities

Table 2-9 identifies financial tools or resources that Clear Creek County and its jurisdictions could use to help fund mitigation activities.

Table 2-9: Clear Creek County Financial Mitigation Capabilities Matrix

Financial Capabilities Used to Fund Mitigation Activities	Clear Creek County	Idaho Springs	Georgetown	Empire	Silver Plume	CCFA
Community Development Block Grants	Yes	Yes	No	No	Yes	N/A
Capital improvements project funding	No	No	Yes	Yes	Yes	N/A
Authority to levy taxes for specific purposes	Yes (with voter approval)	Yes (with voter approval)	No	Yes, with board and voter approval	Yes, with voter approval	N/A
Fees for water, sewer, gas, or electric services	No	No	Yes	Yes	Yes, water and sewer	N/A
Impact fees for new development	Yes		Yes	Yes, in Ordinanc e	Yes	N/A
Incur debt through general obligation bonds	Yes (with voter approval)	Yes	No	Yes, with board and voter approval	No	N/A
Incur debt through special tax bonds	Yes (with voter approval)	Yes (with voter approval)	No	No	No	N/A
Incur debt through private activities	Yes (with voter approval)	Yes (with voter approval)	No	No	No	N/A
Withhold spending in hazard prone areas	No	Yes (with voter approval)	No	No	No	N/A

2.10.4 Education and Outreach Capabilities

Table 2-10 lists additional education and outreach capabilities, such as specific programs, which Clear Creek County and its jurisdictions utilize to implement hazard mitigation activities.

Table 2-10: Clear Creek County Education and Outreach Capabilities

Capability/Program	Clear Creek County	Idaho Springs	Georgetown	Empire	Silver Plume	CCFA
Local Citizen Groups That Communicate Hazard Risks	CWPIPs, Public Health	No	No	No	Yes – Clear Creek County	Ongoing fire safety program at K-6 schools
Firewise	No	No	No	No	No	No
StormReady	No	No	No	No	No	N/A
Other			Town has regular communication tools	Monthly town newsletter, town website	Quarterly town newsletter and new town website	Ongoing CCFA fire prevention information at special events.

2.10.5 State and Regional Partnerships

Colorado Division of Homeland Security and Emergency Management

The Colorado Division of Homeland Security and Emergency Management, part of the Department of Public Safety, is comprised of three offices:

- Office of Emergency Management
- Office of Grants Management
- Office of Prevention and Security/Colorado Information Analysis Center

The Division of Homeland Security and Emergency Management operates under the following mission: "The mission of the Division of Homeland Security and Emergency Management is to support the needs of local government and partner with them before, during, and after a disaster and to enhance preparedness statewide by devoting available resources toward prevention, protection, mitigation, response, and recovery, which will ensure greater resiliency of our communities." The Division vision is: "…to unify homeland security and emergency management within the Colorado Department of Public Safety to support tribal and local government and ensure State and Federal agency coordination."

Colorado Water Conservation Board

The Colorado Water Conservation Board (CWCB) is an agency of the State of Colorado. The CWCB Flood Protection Program is directed to review and approve statewide floodplain studies and designations prior to adoption by local governments. The CWCB is also responsible for the coordination of the NFIP in Colorado and for providing assistance to local communities in meeting NFIP requirements. This includes CWCB prepared or partnered local floodplain studies.

Colorado Geological Survey

The Colorado Geological Survey (CGS) is a non-regulatory state government agency within the Colorado School of Mines. The mission of CGS is to help reduce the impact of geologic hazards on the citizens of Colorado, to promote responsible economic development of mineral and energy resources, provide

geologic insight into water resources, provide avalanche safety training and forecasting, and to provide geologic advice and information to a variety of constituencies.

Colorado State Forest Service

The mission of the Colorado State Forest Service is to provide for the stewardship of forest resources and to reduce related risks to life, property, and the environment for the benefit of present and future generations. Its fire preparedness and response strategic priority is to provide leadership in wildland fire protection for state and private lands in Colorado and reduce wildfire-related loss of life, property, and critical resources.

Denver Regional Council of Governments

The DRCOG is a planning organization where local governments in Adams, Arapahoe, Boulder, Broomfield, Denver, Clear Creek, Douglas, Gilpin, and Jefferson counties collaborate to establish guidelines, set policy, and allocate funding in the areas of:

- Transportation and Personal Mobility
- Growth and Development
- Aging and Disability Resources

DRCOG endures today as one of the nation's three oldest councils of governments. Representatives of the region's counties, cities and towns work together to make life better. They are guided by the Metro Vision regional growth and development plan, which defines goals and actions needed to ensure the region remains a great place to live, work and play. For more than 50 years, the cities and counties of the Denver region have worked together as DRCOG to further a shared vision of the future of the metro area and to make life better for residents. That vision has taken various forms over the years. The current version, referred to as Metro Vision, is founded on six core principles which local communities developed in collaboration with the region's business, civic and environmental leaders and formally adopted in 1992. The six core principles of Metro Vision are:

- To protect and enhance the region's quality of life
- To be aspirational and long-range in focus
- Offer direction for local implementation
- Respect local plans
- Encourage communities to work together
- Plan is dynamic and flexible

2.10.6 Opportunities for Capability Enhancement

The 2020-2021 HMP update provided the County and participating jurisdictions an opportunity to review and update the capabilities currently in place to mitigate hazards. This also provided an opportunity to identify where capabilities could be improved or enhanced. Specific opportunities could include the update or development of the following plans, which should also cross reference this hazard mitigation plan (see also Section 6.4):

- Discus and track mitigation progress at monthly Multi Agency Coordination (MAC) Group meetings
- Update the County Community Wildfire Protection Plan (County).
- Develop a detailed wildfire mitigation strategy.
- Develop an Economic Development Plan.
- Update Comprehensive Plans to include linkages to the hazard mitigation plan and consideration of hazards in land use planning (County, Idaho Springs, Empire, Georgetown, Silver Plume).

- Become StormReady® certified communities (County, Idaho Springs, Empire, Georgetown, Silver Plume).
- Develop and implement a Capital Improvement Plan (Empire).
- Integrate Hazard Mitigation Plans and updates and expand the scope of Empire's Emergency Operations Plan to include information for all possible hazard responses and update all emergency operations (Empire).
- Integrate Hazard Mitigation Plans and updates into the Town of Empire Comprehensive Master Plan to encourage more frequent use and further education and evaluation of all hazards and how they impact land use planning (Empire).

3 Planning Process

DMA Requirements §201.6(b) and §201.6(c)(1):
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:
An opportunity for the public to comment on the plan during the drafting stage and prior to plan approval;
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; and
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 Clear Creek County

Clear Creek County the Towns of Empire, Georgetown, and Silver Plume participated in previous regional hazard mitigation plans as part of DRCOG 2011 Natural Hazard Mitigation Plan. The City of Idaho Springs did not participate in the DRCOG 2011 Plan. In 2015, the County, Towns, and City decided to develop a separate plan to focus on the hazards and risks specific to the county overall and to better develop mitigation actions to address them. To achieve this, Clear Creek County developed the first Clear Creek County HMP in 2015-2016.

The plan underwent a comprehensive update in 2021 to comply with the five-year update cycle required by the DMA 2000. The planning process and update of this plan was originally initiated in mid-2021 under the coordination of the Clear Creek County Office of Emergency Management. A consultant team from Wood Environment & Infrastructure, Inc. (Wood) was hired to help facilitate the planning process and prepare the final updated Plan. This plan update was developed to focus on the goals and objectives and the hazards pertaining to Clear Creek County. The updated HMP complies with FEMA guidance for Local Hazard Mitigation Plans. The update followed the requirements in the Disaster Mitigation Act (DMA) of 2000 and FEMA's 2013 Local Hazard Mitigation Planning Handbook.

3.1.1 What's New in the Plan Update

This HMP update involved a comprehensive review and update of each section of the 2016 plan and includes an assessment of the progress in evaluating, monitoring, and implementing the mitigation strategy outlined in the initial plan. The planning process provided an opportunity to review jurisdictional priorities related to hazard significance and mitigation action, and revisions were made where applicable to the plan. Only the information and data still valid from the 2016 plan was carried forward as applicable into this HMP update.

During the 2021 update process, the Hazard Mitigation Planning Committee (HMPC) updated each section of the previously approved plan to include new information and improve the organization and formatting of the plan's contents. The HMPC and Wood analyzed each section using FEMA's local plan update guidance to ensure that the plan met the latest requirements. Upon review the HMPC and Wood determined that nearly every section of the plan would need some updates to align with the latest FEMA planning guidance and requirements. The overall format and structure of the plan changed to align the plan with modern

hazard mitigation planning practices and to simplify the document from 22 chapters to 6. The Risk Assessment in Chapter 4 was substantially revised to incorporate recent events and reflect recent development trends with an updated Geographic Information System (GIS)-based risk assessment. Information within has been updated throughout the plan where appropriate. The mitigation strategy in Chapter 5 has been updated to reflect current priorities and mitigation actions moving forward from the 2016 plan.

3.2 Local Government Participation

Clear Creek County's HMP is a multi-jurisdictional plan that geographically covers everything within Clear Creek County, as described further in Chapter 2 Community Profile and Capability Assessment. The following jurisdictions with the authority to regulate development participated in the planning process and are seeking FEMA approval of this plan. All jurisdictions that participated in the 2016 Plan participated again in the 2020 Plan, with the addition of CCFA:

- Clear Creek County
- City of Idaho Springs
- Town of Empire
- Town of Georgetown
- Town of Silver Plume
- Clear Creek Fire Authority (CCFA)

The DMA planning regulations and guidance stress that each local government seeking FEMA approval of their mitigation plan must participate in the planning effort in the following ways:

- Participate in the process as part of the HMPC,
- Detail areas within the planning area where the risk differs from that facing the entire area,
- Identify specific projects to be eligible for funding, and
- Have the governing board formally adopt the plan.

For the Clear Creek County Hazard Mitigation Plan's 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,
- Advertising, coordinating, and participating in the public input process, and
- Coordinating the formal adoption of the plan by the governing boards.

3.3 Planning Process

Clear Creek County and Wood worked together to establish the planning process for Clear Creek County's plan update using the DMA planning requirements and FEMA's associated guidance. The original FEMA planning guidance is structured around a four-phase process:

- Organize Resources
- Assess Risks
- Develop the Mitigation Plan
- Implement the Plan and Monitor Progress

FEMA's March 2013 Local Mitigation Planning Handbook recommends a nine-step process within the original four phase process. Into this four-phase process, Wood integrated a more detailed 10-step

planning process used for FEMA's Community Rating System (CRS) and FMA programs. Thus, the modified 10-step process used for this plan meets the funding eligibility requirements of the HMA grants (including HMGP, BRIC grant, HHPD grant, and FMA grant), CRS, and the flood control projects authorized by the U.S. Army Corps of Engineers (USACE). Table 3-1 summarizes the four-phase DMA process, the detailed CRS planning steps and work plan used to develop the plan and the nine handbook planning tasks from FEMA's 2013 Local Mitigation Planning Handbook. The sections that follow describe each planning step in more detail.

Table 3-1: Mitigation Planning Process Used to Update the Plan

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
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)

3.3.1 Phase 1: Organize the Resources

Planning Step 1: Organize the Planning Effort

Wood worked with the Clear Creek County Office of Emergency Management (OEM) to establish the framework and organization for the update of this Plan. Wood and OEM identified the key county, municipal, and other local government and initial stakeholder representatives. Invitations were emailed to invite them to participate as a member of the HMPC and to attend a kickoff meeting. Representatives from the following County, municipal, and special district agencies participated on the HMPC and the development of the plan:

Clear Creek County

- Office of Emergency Management
- Community Planning
- Finance
- Human Resource
- Public Health
- Building
- Environmental Health
- Water Resources
- GIS
- Sheriff
- Clerk and Recorder
- EMS
- Recreation Center
- Treasurer
- Tourism
- Assessor
- IT
- Road and Bridge
- Board of County Commissioners

City of Idaho Springs

- Public Works
- Police
- Administration
- Chamber of Commerce

Town of Empire

- Town Clerk
- Police Chief
- Mayor

Town of Georgetown

- Administration
- Police

Town of Silver Plume

- Town Clerk
- Mayor

Clear Creek Fire Authority

- Chief
- Deputy Chief

A list of specific HMPC representatives is included in Appendix C. Other local, state, federal, and private stakeholders invited to participate in the HMPC are discussed under Planning Step 3.

During the plan update process, the HMPC communicated with a combination of virtual meetings, phone conversations, and email correspondence. Three planning meetings with the HMPC were held during the plan's development between March and June 2021. The meeting schedule and topics are listed in the following table. The meetings were virtually due to the global COVID-19 pandemic that required social distancing. The sign-in sheets and agendas for each of the meetings are included in Appendix D.

Table 3-2: Schedule of Meetings

HMPC Meeting	Meeting Topic	Meeting Date
1	Kickoff Meeting: Introduction to DMA Planning and overview of Update Process	March 24, 2021
2	Risk Assessment Summary/Goals Development	April 28, 2021
3	Mitigation Strategy Development	June 2, 2021

HMPC Meeting #1 – Kickoff Meeting

During the kickoff meeting, Wood presented information on the scope and purpose of the plan, participation requirements of HMPC members, and the proposed project work plan and schedule. A plan for public involvement (Step 2) and coordination with other agencies and departments (Step 3) was 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. Each jurisdiction provided updates through a data collection workbook created by Wood and mitigation action trackers or provided information directly to Wood for incorporation into the plan update.

HMPC Meeting # 2 – Risk Assessment Summary/Goals Development

On April 28, 2021, the HMPC convened virtually to review and discuss the results of the risk and vulnerability assessment update. Twenty-four members of the HMPC and stakeholders were present for the discussion. Wood presented preliminary risk assessment results 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 Hazard Identification and Risk Assessment (HIRA) update. A survey was developed by Wood and shared with the Planning Team after the meeting, that asked the members to rank each hazard and asked to rank the human-caused hazards that should be included in the plan update. The survey also asked the Planning Team to review the 2016 mitigation goals and determine if they were still valid, comprehensive, and reflect current priorities and updated risk assessments. Refer to the meeting summary in Appendix B for notes related to each hazard discussed and results from the post meeting survey.

HMPC Meeting #3 – Mitigation Strategy Development

The HMPC convened virtually on June 2, 2021 with 23 people participating to discuss updating the mitigation action plan from 2016 and finalize the goals and objectives for this planning process. The group reviewed the public survey results and noted the differences between hazard ratings for the jurisdictions and the public's perception of risks to the various hazards. The group discussed the criteria for mitigation action selection and prioritization using a worksheet provided by Wood (refer to Appendix B). 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 proposed.

Planning Step 2: Involve the Public

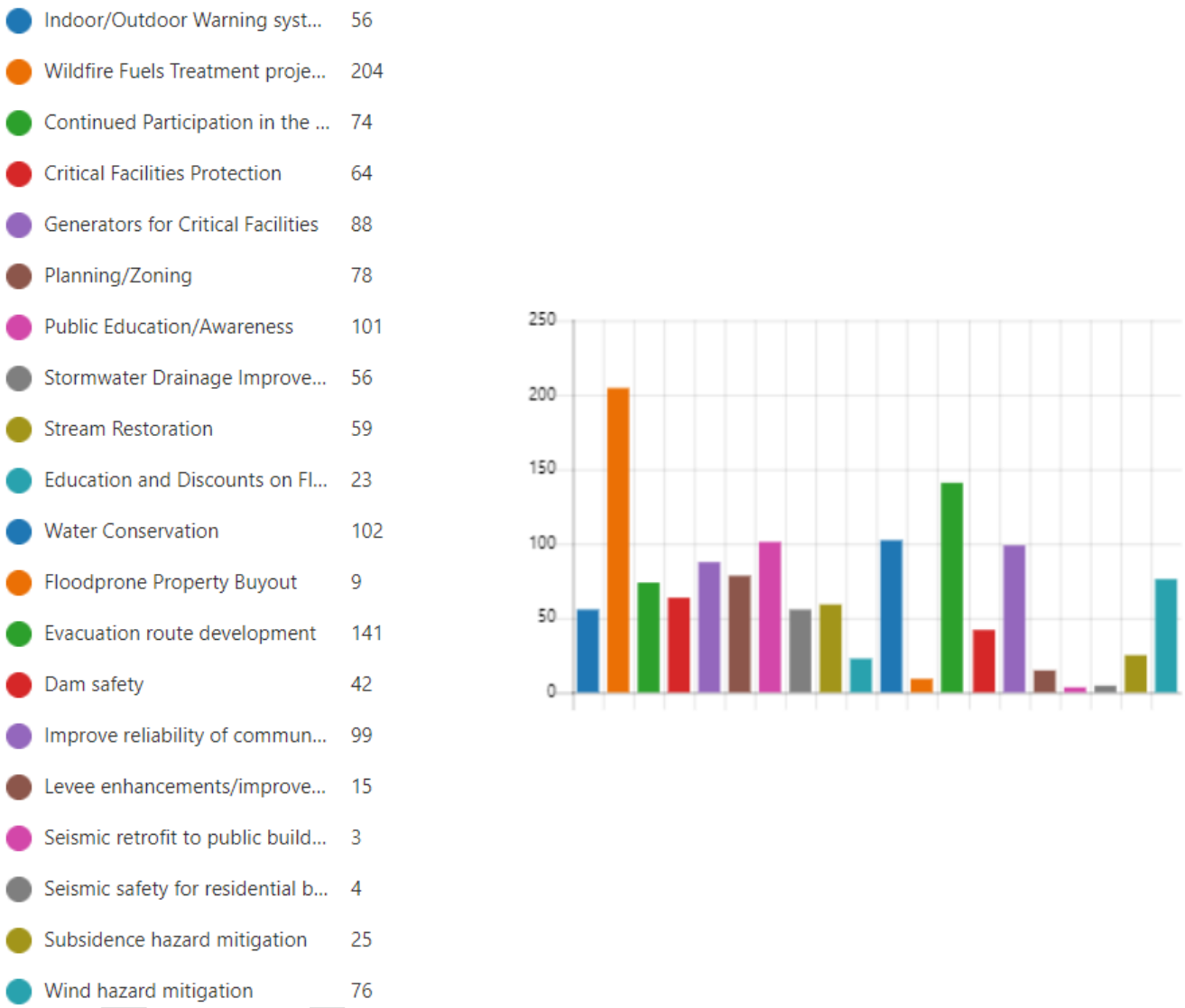
At the kickoff meeting, the HMPC discussed options for soliciting public input on the mitigation plan and developed an outreach strategy by consensus. Public and stakeholder input was done through a combination of an online survey and a hard copy survey. During the plan update's drafting stage, the HMPC provided links to a public survey via Microsoft Forms, and made hardcopy surveys available at multiple locations around the County. The survey was advertised by the County and participating jurisdictions through social media, posted to the County's website, and shared through local newsletters.

Figure 3-1: Example of Survey Posting on Social Media

The survey provided an opportunity for public input during the planning process, prior to finalization of the plan update. The public survey received responses from 221 individuals; 215 responses were received online, and an additional 6 individuals completed the hard copy version of the survey. Responses reflect the public perception that the most significant hazards to be wildfire followed by winter storms, drought, severe wind.

Figure 3-2 below displays the results from Question 4, which asked respondents to consider potential mitigation actions and to indicate which types of actions should have the highest priority in the updated County Mitigation Strategy. These results were considered during the planning process and in the development of new mitigation actions. As indicated by the survey excerpt below, the public feels the highest priority action items should include wildfire fuels treatment projects (204 responses), evacuation route development (141), water conservation treatment (102 responses), public education/awareness (101 responses), improve reliability of communication systems (99 responses), generators for critical facilities (88 responses) Planning and zoning (78 responses) and wind hazard mitigation (76 responses). Full results of the public survey are provided in Appendix F. This information was discussed with the HMPC to use when evaluating hazard risks and considering mitigation actions.

Figure 3-2: Responses to Question 4: Indicate the Types of Mitigation Actions That You Think Should Have the Highest Priority in the Clear Creek County Multi-Jurisdictional Hazard Mitigation Plan



The public was given an opportunity to review and comment on the draft plan in xx 2021. Clear Creek County made copies of the plan available on the County website and a hardcopy was made available at the _____. A public input comment form was available with the online plan. The plan was advertised by the County through their Facebook, Twitter and the County website. The public was given a two-week period to review and provide comments. In total xx individuals responded to the online public input form…

Planning Step 3: Coordinate with Other Departments

There are numerous organizations whose goals and interests interface with hazard mitigation in Clear Creek County. Coordination with these organizations and other community planning efforts is vital to the success of this plan's update and implementation. The HMPC determined that data collection, mitigation strategy development, and plan approval would be greatly enhanced by inviting state and federal agencies and power and communications organizations to participate in the process. An opportunity for neighboring

communities, local and regional agencies involved in hazard mitigation activities was provided either through invitation to meetings, phone, and email communication during the process, or provided an opportunity to review and comment on the plan prior to finalization. The following agencies were reached out to during the planning process. Some were present at HMPC meetings (indicated by an asterix) and/or supplied information to the HMPC that was used to inform the risk assessment. Neighboring jurisdictions were asked to comment on the plan prior to its finalization.

State and Federal Agencies

- Colorado Department of Natural Resources – Dam Safety*
- Colorado Department of Homeland Security and Emergency Management*
- Colorado Department of Transportation*
- Colorado State Patrol – Golden Incident and Resources Management*
- U.S. Forest Service*
- National Weather Service Boulder*
- U.S. Environmental Protection Agency – Response and Planning*
- Colorado State University Extension
- Colorado Division of Fire Prevention & Control

Neighboring Jurisdictions

- Grand County*
- Gilpin County*
- Summit County
- Park County
- Jefferson County

Special Districts/Private Businesses

- Lookout Mountain Water District*
- Clear Creek Metro Recreation District*
- Evergreen Fire Protection District*
- CCRE District 1*
- Xcel Energy
- Century Link
- Mile High Flood District
- American Red Cross

Integration with Other Community Planning Efforts and Hazard Mitigation Activities

Coordination with other community planning efforts is also paramount to the success of this Plan. Hazard mitigation planning involves identifying existing policies, tools, and actions that will reduce a community's risk and vulnerability from natural hazards. Clear Creek County uses a variety of comprehensive planning mechanisms, such as master plans and ordinances, to guide growth and development. Integrating existing planning efforts and mitigation policies and action strategies into this plan establishes a credible and comprehensive plan that ties into and supports other community programs. Table 3-3 below provides a summary of the key existing plans, studies, and reports that were reviewed during the update process. Information on how they informed the update are noted where applicable.

Table 3-3: Summary of Key Plan, Studies and Reports

Plan, Study, Report Name	How Plan, Study or Report Informed the HMPC
Clear Creek County Community Wildfire Protection Plan (2008)	Reviewed information on past wildfires and wildfire risk to inform the risk assessment
Fall River Watershed Community Wildfire Protection Plan (2009)	Informed the risk assessment, wildfire section
Colorado State Hazard Mitigation Plan (2018 Update)	Reviewed information on past hazard events and hazard risk information to inform the risk assessment Reviewed State goals and objectives
Colorado Drought Mitigation and Response Plan (2018 Update)	Reviewed information on pasts droughts and their impacts on the planning area. Incorporated information into the risk assessment
Colorado Flood Mitigation Plan (2018 Update)	Reviewed information on past flood events and risk analysis for the planning area to inform the risk assessment
Updated Flood Insurance Study (2019) for Clear Creek County and Incorporated Areas	Provided updated flood risk data for specific hazard areas located within the County and allowed the County to meet the minimum NFIP and CWCB regulations.
Comprehensive/Master Plans: Clear Creek County (2017), City of Idaho Spring (2017), Town of Empire (2000), Town of Georgetown (2016)	Informed the Community Profile and capability assessments.
Upper Clear Creek Watershed Plan 2014 Update	Informed the risk assessment.
2017 Colorado Wildfire Risk Assessment Summary Report: Clear Creek County	Informed the risk assessment, wildfire section.
USDA Risk Management Agency Crop Indemnity Reports (2007-2020)	Provided data related to crop losses due to drought and hail.

Integration of 2016 Plan into Other Planning Mechanisms

Clear Creek County Community Master Plan

The participating jurisdictions integrated the 2016 HMP into existing planning mechanisms by including references to natural hazards and mitigation in the 2017 Clear Creek County Community Master Plan. Hazards and Public Safety are a subsection of Chapter 5 and establishes several goals which further inform policies for the County to enact over the next 10 to 20 years in pursuit of natural hazards awareness and hazard mitigation. The goals included in the Community Master Plan area as follows:

- Goal A: Protect the people, property, and natural, cultural, and environmental resources of Clear Creek County through a variety of policies and management measures.
- Goal B: Increase awareness of natural hazards and their mitigation by continuing to develop informative programs and increasing the accessibility of these programs to the public.
- Goal C: Coordinate and integrate hazard mitigation activities between communities, emergency response providers, and local governments.

Envision Idaho Springs Comprehensive Plan

The City of Idaho Springs incorporated the 2016 HMP into their 2017 Envision Idaho Springs Comprehensive Plan. The Environment Plan Element includes the following goal:

- "We will preserve water quality, protect from the effects of hazardous conditions, foster appropriate management of our natural resources, and aspire to minimize impacts from development on our community."

Specific mention of several notable hazards and how they impact the city and its future growth are included throughout the plan.

Empire Comprehensive Master Plan

The Town of Empire Comprehensive Master Plan identifies several hazards, such as wildfire and flood, and considers these in the context of the town's future growth. Consideration for how hazards may integrate future growth is given in this plan's policies, such as in restricting homes and home sites on vegetated hillsides where they may be more vulnerable to wildfire.

Georgetown Comprehensive Plan

The Town of Georgetown has included principles of hazard mitigation in their 2016 Comprehensive Plan. These include a brief analysis of several hazards to which the town is exposed and the identification of strategies and priority actions which in turn support the goal to "protect citizens and property from environmental hazards, conserve natural resources, and preserve the environment". The plan does not specifically reference the 2016 Clear Creek County HMP, however future updates to the Georgetown Comprehensive Plan could more specifically integrate the 2021 Clear Creek County HMP.

3.3.2 Phase 2: Assess Risks

Planning Steps 4 and 5: Identify the Hazards and Assess the Risks

Chapter 4: Risk Assessment is the result of a comprehensive effort to identify and document all the hazards that have, or could, impact the planning area. This section was updated to reflect recent hazard events and current assets within the County and jurisdictions. Where data permitted, GIS were used to display, analyze, and quantify hazards and vulnerabilities. The HMPC 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. A more detailed description of the risk assessment process and the results are included in Chapter 4. The capability assessment is included in Chapter 2 Community Profile and Capability Assessment.

3.3.3 Phase 3: Develop the Mitigation Plan

Planning Steps 6 and 7: Set Goals and Review Possible Activities

Wood facilitated a brainstorming and discussion session with the HMPC during their second meeting to update the goals and objectives from the 2016 plan. During the third HMPC meeting Wood facilitated a discussion session with the HMPC around a comprehensive range of mitigation alternatives, and a method of selecting and defending recommended mitigation actions using a series of selection criteria. This included a review of progress on each action identified in the 2016 plan. Some new mitigation actions resulted from this process that were added to the plan in 2021. This process and its results are described in greater detail in Chapter 5.

Planning Step 8: Draft and 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 shared electronically for HMPC review and comment. Other agencies were invited to comment on this draft as well. HMPC and agency comments were integrated into the second draft, which was advertised and distributed to collect public input and comments. 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.

3.3.4 Phase 4: Implement the Plan and Monitor Progress

Planning Step 9: Adopt the Plan

To secure buy-in and officially implement the plan, the plan was adopted by the governing boards of each participating jurisdiction on the dates included in the adoption resolutions in Appendix E.

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

The HMPC developed and agreed upon an overall strategy for plan implementation and for monitoring and maintaining the plan over time. A discussion on the progress with implementation is included in Chapter 5. 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 Chapter 6, which also include an updated overall implementation strategy and maintenance and a strategy for continued public involvement.

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.

Table 4-1: Hazard Risk Rankings

Hazard	Overall Risk Rating
Wildfire	High
Winter Storm	High
Flood	High
Severe Wind, Hail, & Lightning	Medium
Drought	Medium
Landslide, Mud/Debris Flow, and Rockfall	Medium
Avalanche	Medium
Dam Incident	Medium
Earthquake	Low
Erosion and Deposition, Expansive Soil, and Subsidence	Low
Extreme Heat	Low
Tornado	Low
Space Weather	Low

4.1 Hazard Identification

This section of the Clear Creek County Hazard Mitigation Plan describes the local Hazard Identification and Risk Assessment summary undertaken by the county and participating jurisdictions. 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 hazards and provides a framework for developing and prioritizing mitigation actions to reduce risk from future hazardous events.

A key step to mitigate disaster losses is to develop a comprehensive understanding of the community's hazards, vulnerabilities, and risks. The following terms are used throughout the Plan to facilitate comparisons between communities.

- **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. A hazard may be naturally occurring (flood, tornado, etc.) or it may be human caused (active threat, hazmat, etc.).
- **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.
- **Risk**: The potential for damage, loss, or other impacts created by the interaction of hazards with vulnerabilities.

The relationship between hazards, vulnerabilities, and risk is depicted in Figure 4-1. The risk assessment evaluates potential loss from hazards by assessing the vulnerability of the county's population, built environment, critical facilities, and other assets. Environmental and social impacts are also taken into consideration wherever possible. This risk assessment covers the entire geographical area of Clear Creek County. Since this is a multi-jurisdictional plan, the Planning Team also evaluated how the hazards and risks vary from jurisdiction to jurisdiction.

Figure 4-1: Risk Graphic

Clear Creek County has completed a countywide Threat and Hazard Identification and Risk Assessment (THIRA) in accordance with CPG201. However, despite the similarity in their names, the HIRA and THIRA are two very different documents following very different methodologies. As described in Section 6.3, this updated HIRA can serve to help complete Steps 1-2 of the THIRA process.

4.1.1 Disaster Declaration History

Federal disaster declarations are typically issued for hazard events that cause more damage than state and local governments can handle without assistance from the federal government. However, no specific dollar loss threshold has been established for these declarations. A federal disaster declaration puts federal recovery programs into motion to help disaster victims, businesses, and public entities. Some of the programs are matched by state programs. The planning area has experienced seven events since 1969 for which federal disaster declarations were issued. These events are listed in Table 4-2.

Review of these events helps identify targets for risk reduction and ways to increase a community's capability to avoid large-scale events in the future. Still, many natural hazard events do not trigger federal disaster declaration protocol but have significant impacts on their communities. These events are also important to consider in establishing recurrence intervals for hazards of concern. More detailed event tables can be found in the individual hazard profile sections.

Table 4-2: Federal Disaster Declarations in Clear Creek County

Declaration	Description	Incident Date
EM-3436 DR-4498	COVID-19 Pandemic	3/13/2020 3/28/2020
DR-4145 EM-3365	Severe Storms, Flooding, Landslides and Mudslides	09/14/2013 09/12/2013
EM-3224	Hurricane Katrina Evacuation	09/05/2005
EM-3185	Snow	04/09/2003
DR-1421	Wildfires	06/19/2002
DR-1186	Severe Storms, Heavy Rain, Flash Floods, Flooding, Mudslides	08/01/1997
DR-261	Severe Storms and Flooding	05/19/1969

Source: FEMA. DR = Major Disaster Declaration; EM = Emergency Declaration

The U.S. Department of Agriculture's (USDA) Secretary of Agriculture is authorized to designate counties as disaster areas to make emergency loans (EM) to producers suffering losses in those counties and in counties that are contiguous to a designated county. In addition to EM eligibility, other emergency assistance programs, such as Farm Service Agency (FSA) disaster assistance programs, have historically used disaster designations as an eligibility requirement trigger. Table 4-3 provides the USDA Secretarial disaster declarations that included Clear Creek County from the years 2012-2020.

Table 4-3: USDA Secretarial Disaster Declarations in Clear Creek County 2012-2015

Disaster Number	Crop Disaster Year	Cause
S3260	2012	Drought, High Winds, and Heat
S3456	2013	Drought, High Winds, Wildfire, Heat, and Insects
S3548	2013	Drought, High Winds, Wildfire, Heat, and Insects
S4386	2018	Drought
S4468	2019	Drought
S4481	2019	Drought
S4917	2020	Drought

Source: U.S. Department of Agriculture

4.1.2 Identified Hazards of Concern

For this plan update, the planning team considered the full range of natural hazards that could impact the planning area and then listed hazards that present the greatest concern. The process incorporated review of state and local hazard planning documents, as well as information on the frequency, magnitude, and costs associated with hazards that have impacted or could impact the planning area. Anecdotal information regarding natural hazards and the perceived vulnerability of the planning area's assets to them was also used.

Historical data, catastrophic potential, relevance to the jurisdiction, and the probability and potential magnitude of future occurrences were all used to identify and prioritize the list of hazards most relevant to Clear Creek County. Hazard data was obtained from various federal, state, and local sources such as FEMA, the Colorado Geological Survey (CGS), the Colorado Dam Safety Division, the National Oceanic and Atmospheric Administration's (NOAA) National Center for Environmental Information (NCEI), the United States Geological Survey (USGS), and others. Local and national news reports were also used to research historic events. Together, these sources were examined to assess the significance of these hazards to the county. The hazards selected for inclusion in this plan include those that have occurred historically or have the potential to cause significant human and/or monetary losses in the future.

The hazards profiled in the 2016 Plan were reviewed, and the planning team decided not to make any changes in the list of hazards for 2021. The planning team considered adding technological or human-caused hazards but elected to keep the plan focused on natural hazards. Based on the review, this plan addresses the following hazards of concern:

- Avalanche
- Dam Incident
- Drought
- Earthquake
- Erosion and Deposition
- Expansive Soil
- Extreme Heat
- Flood
- Hail
- Landslide, Mud/Debris Flow, Rockfall
- Lightning
- Severe Wind
- Space Weather
- Subsidence
- Tornado
- Wildfire
- Winter Storm

Several of these hazards were profiled together because of their common occurrence or damage assessments, such as drought and extreme heat, and hail, lightning, and severe winds.

The HMPC also reviewed the following natural hazards from the 2018 Colorado State Hazard Mitigation Plan but determined they do not present sufficient risk in Clear Creek County to justify inclusion.

- Animal Disease Outbreak
- Dense Fog
- Pest Infestation (impacts on other hazards discussed where appropriate)
- Radon/CO/Methane/Other Seeps

4.1.3 Risk Assessment Methodology

A risk ranking was performed for the hazards of concern described in this plan. This risk ranking assesses the probability of each hazard's occurrence as well as its likely impact on the people, property, and economy of the planning area. The risk ranking was conducted by the planning team based on the hazard

risk assessment presented during the second planning team meeting, community survey results, and personal and professional experience with hazards in the planning area. The results are used in establishing mitigation priorities.

Hazard Profiles

Each hazard was profiled as follows:

Table 4-4: Hazard Profile Elements

Description	General description of the hazard and associated problems, followed by details on the hazard specific to Clear Creek County.
Past Events	Overview history of the hazard's occurrences, compiled from multiple data sources, to include information provided by the planning team and the public. Significant incidents are profiled in greater detail and include scope, severity, and magnitude, and known impacts.
Location	Discusses what parts of the County are most likely to be affected by the hazard.
Magnitude and Severity:	Summarizes the anticipated magnitude and severity of a hazard event based largely on previous occurrences and specific aspects of the planning area. Speed of onset and duration are also factored in.
Probability of Future Occurrence	Estimates the likelihood or probability of future occurrences of the hazard.
Climate Change Considerations	Discusses how the projected impacts of climate change may affect the likelihood and severity of the hazard in the future.
Vulnerability	Describes the likely impacts of the hazard on people, property, critical infrastructure, government services, the economy, and historical, cultural, and natural resources.
Development Trends	Summarizes how projected trends in land use, and development have the potential to increase or decrease the impact of the hazard.
Risk Summary	Summarizes the key pieces of information for each hazard.

Vulnerability Assessment

With Clear Creek 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. 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 information presented is for planning level assessments only. 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
- Modeling of earthquake loss potential with HAZUS-MH using a 2,500-year probabilistic scenario
- 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 Clear Creek 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 Clear Creek 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.

Hazard Rankings

Hazards then were ranked based on the following factors:

Table 4-5: Hazard Ranking Methodology

Spatial Extent: How much of the planning area is potentially at risk from the hazard?	**Potential Severity:** What are the likely impacts of the hazard?	**Frequency of Occurrence:** How often is the hazard likely to occur?	**Overall Significance:** Based on a combination of the previous three factors.
Extensive: 50-100% of planning area	**Catastrophic:** Multiple deaths, shutdown of facilities for 30 days or more, >50% of property is severely damaged.	**Highly Likely:** Near 100% probability each year.	**High:** widespread potential impact.
Significant: 10-50% of planning area	**Critical:** Multiple severe injuries, shutdown of facilities for at least 2 weeks, >25% of property is severely damaged.	**Likely:** Between 10 and 100% probability per year or at least one chance in ten years.	**Medium:** moderate potential impact.
Limited: Less than 10% of planning area	**Moderate:** Some injuries, shutdown of critical facilities for more than one week, >10% of property is severely damaged.	**Occasional:** Between 1 and 10% probability per year or at least one chance in next 100 years.	**Low:** minimal potential impact.
	Negligible: Minor injuries, minimal quality-of-life impact, interruption of facilities and services for 24 hours or less, less than 10% of property is severely damaged.	**Unlikely:** Less than 1% probability in next 100 years.	

4.1.4 Climate Change

The 2021 Clear Creek County Hazard Mitigation Plan update takes into account considerations of how changing climate conditions 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.

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 change 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 Clear Creek 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 Chapter 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 Clear Creek 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.

4.1.5 Hazard Significance Summary

Table 4-6 summarizes the risk across the planning area associated with each hazard based on the criteria listed in Section 4.1.3. The individual ratings are based on or interpolated from the analysis of the hazards in the sections that follow. During the 2021 Plan update, the individual ratings and significance of the hazards was revisited and updated. Public concern was also considered from an online survey and public review of the draft Plan.

Table 4-7 shows how the risk associated with each hazard varies across the participating jurisdictions. On the subsequent pages, Table 4-8 through Table 4-12 break down the hazard rankings for each participating jurisdiction.

Table 4-6: Hazard Analysis Summary

Hazard	Spatial Extent	Potential Severity	Frequency of Occurrence	Overall Significance
Wildfire	Extensive	Critical	Likely	High
Winter Storm	Extensive	Moderate	Highly Likely	High
Flood	Significant	Critical-Moderate	Likely	High
Severe Wind	Extensive	Moderate	Highly Likely	Medium
Hail	Extensive	Moderate	Highly Likely	Medium
Lightning	Extensive	Moderate	Highly Likely	Medium
Drought	Extensive	Negligible-Moderate	Likely	Medium
Landslide	Significant	Critical	Likely	Medium
Avalanche	Significant	Moderate	Likely	Medium
Dam Incident	Limited	Critical	Unlikely	Medium
Erosion	Extensive	Negligible	Likely	Low
Earthquake	Significant	Critical	Unlikely	Low
Subsidence	Significant	Negligible	Likely	Low
Extreme Heat	Extensive	Negligible	Unlikely	Low
Space Weather	Extensive	Negligible	Unlikely	Low
Tornado	Significant	Negligible	Unlikely	Low
Expansive Soil	Limited	Negligible	Occasional	Low

Spatial Extent
Extensive: 50-100% of planning area
Significant: 10-50% of planning area
Limited: Less than 10% of planning area

Potential Severity
Catastrophic: Multiple deaths, shutdown of facilities for 30 days or more, >50% of property is severely damaged
Critical: Multiple severe injuries, shutdown of facilities for at least 2 weeks, >25% of property is severely damaged
Moderate: Some injuries, shutdown of critical facilities for more than one week, >10% of property is severely damaged
Negligible: Minor injuries, minimal quality-of-life impact, interruption of facilities and services for 24 hours or less, less than 10% of property is severely damaged.

Frequency of Occurrence
Highly Likely: Near 100% probability each year.
Likely: Between 10 and 100% probability per year or at least one chance in ten years.
Occasional: Between 1 and 10% probability per year or at least one chance in next 100 years.
Unlikely: Less than 1% probability in next 100 years.

Significance
High: widespread potential impact
Medium: moderate potential impact
Low: minimal potential impact

Table 4-7: Overall Hazard Rankings by Jurisdiction

Hazard	Clear Creek County	City of Idaho Springs	Town of Empire	Town of Georgetown	Town of Silver Plume	Clear Creek Fire
Wildfire	High	High	High	High	High	High
Winter Storm	High	High	High	High	High	High
Flood	High	High	High	High	High	High
Severe Wind	Medium	High	High	High	High	Medium
Hail	Medium	High	Low	Low	Low	Medium
Lightning	Medium	High	Low	Medium	Low	Medium
Drought	Medium	Medium	High	Medium	Medium	Medium
Landslide	Medium	High	High	High	High	Medium
Avalanche	Medium	Medium	Medium	Medium	High	Medium
Dam Failure	Medium	Medium	Medium	Medium	Low	Medium
Erosion	Low	Low	Medium	Medium	Low	Low
Earthquake	Low	Low	Low	Low	Low	Low
Subsidence	Low	High	Low	Low	Low	Low
Extreme Heat	Low	Low	Low	No Exposure	Low	Low
Space Weather	Low	Low	Low	Low	Low	Low
Tornado	Low	Low	Low	Low	Low	Low
Expansive Soil	Low	Low	Low	Low	Low	Low

Spatial Extent
Extensive: 50-100% of planning area
Significant: 10-50% of planning area
Limited: Less than 10% of planning area

Potential Severity
Catastrophic: Multiple deaths, shutdown of facilities for 30 days or more, >50% of property is severely damaged
Critical: Multiple severe injuries, shutdown of facilities for at least 2 weeks, >25% of property is severely damaged
Moderate: Some injuries, shutdown of critical facilities for more than one week, >10% of property is severely damaged
Negligible: Minor injuries, minimal quality-of-life impact, interruption of facilities and services for 24 hours or less, less than 10% of property is severely damaged.

Frequency of Occurrence
Highly Likely: Near 100% probability each year.
Likely: Between 10 and 100% probability per year or at least one chance in ten years.
Occasional: Between 1 and 10% probability per year or at least one chance in next 100 years.
Unlikely: Less than 1% probability in next 100 years.

Significance
High: widespread potential impact
Medium: moderate potential impact
Low: minimal potential impact

Table 4-8: Hazard Rankings for Unincorporated Clear Creek County and Clear Creek Fire Protection District

Hazard	Spatial Extent	Potential Severity	Frequency of Occurrence	Overall Significance
Wildfire	Extensive	Critical	Likely	High
Winter Storm	Extensive	Moderate	Highly Likely	High
Flood	Significant	Critical-Moderate	Likely	High
Severe Wind	Extensive	Moderate	Highly Likely	Medium
Hail	Extensive	Moderate	Highly Likely	Medium
Lightning	Extensive	Moderate	Highly Likely	Medium
Drought	Extensive	Negligible-Moderate	Likely	Medium
Landslide	Significant	Critical	Likely	Medium
Avalanche	Significant	Moderate	Likely	Medium
Dam Incident	Limited	Critical	Unlikely	Medium
Erosion	Extensive	Negligible	Likely	Low
Earthquake	Significant	Critical	Unlikely	Low
Subsidence	Significant	Negligible	Likely	Low
Extreme Heat	Extensive	Negligible	Unlikely	Low
Space Weather	Extensive	Negligible	Unlikely	Low
Tornado	Significant	Negligible	Unlikely	Low
Expansive Soil	Limited	Negligible	Occasional	Low

Spatial Extent
Extensive: 50-100% of planning area
Significant: 10-50% of planning area
Limited: Less than 10% of planning area

Potential Severity
Catastrophic: Multiple deaths, shutdown of facilities for 30 days or more, >50% of property is severely damaged
Critical: Multiple severe injuries, shutdown of facilities for at least 2 weeks, >25% of property is severely damaged
Moderate: Some injuries, shutdown of critical facilities for more than one week, >10% of property is severely damaged
Negligible: Minor injuries, minimal quality-of-life impact, interruption of facilities and services for 24 hours or less, less than 10% of property is severely damaged.

Frequency of Occurrence
Highly Likely: Near 100% probability each year.
Likely: Between 10 and 100% probability per year or at least one chance in ten years.
Occasional: Between 1 and 10% probability per year or at least one chance in next 100 years.
Unlikely: Less than 1% probability in next 100 years.

Significance
High: widespread potential impact
Medium: moderate potential impact
Low: minimal potential impact

Table 4-9: Hazard Rankings for the City of Idaho Springs

Hazard	Spatial Extent	Potential Severity	Frequency of Occurrence	Overall Significance
Hail	Extensive	Critical	Highly Likely	High
Lightning	Extensive	Critical	Highly Likely	High
Severe Wind	Extensive	Critical-Moderate	Highly Likely	High
Wildfire	Extensive	Critical	Likely	High
Winter Storm	Extensive	Moderate	Highly Likely	High
Landslide	Significant	Critical	Highly Likely	High
Subsidence	Extensive	Moderate	Likely	High
Flood	Significant	Critical-Moderate	Likely	High
Drought	Extensive	Negligible-Moderate	Likely	Medium
Avalanche	Limited	Negligible	Unlikely	Medium
Dam Incident	Limited	Critical	Unlikely	Medium
Earthquake	Significant	Critical	Unlikely	Low
Erosion	Extensive	Negligible	Likely	Low
Extreme Heat	Extensive	Negligible	Unlikely	Low
Space Weather	Extensive	Negligible	Unlikely	Low
Tornado	Significant	Negligible	Unlikely	Low
Expansive Soil	Limited	Negligible	Occasional	Low

Spatial Extent
Extensive: 50-100% of planning area
Significant: 10-50% of planning area
Limited: Less than 10% of planning area

Potential Severity
Catastrophic: Multiple deaths, shutdown of facilities for 30 days or more, >50% of property is severely damaged
Critical: Multiple severe injuries, shutdown of facilities for at least 2 weeks, >25% of property is severely damaged
Moderate: Some injuries, shutdown of critical facilities for more than one week, >10% of property is severely damaged
Negligible: Minor injuries, minimal quality-of-life impact, interruption of facilities and services for 24 hours or less, less than 10% of property is severely damaged.

Frequency of Occurrence
Highly Likely: Near 100% probability each year.
Likely: Between 10 and 100% probability per year or at least one chance in ten years.
Occasional: Between 1 and 10% probability per year or at least one chance in next 100 years.
Unlikely: Less than 1% probability in next 100 years.

Significance
High: widespread potential impact
Medium: moderate potential impact
Low: minimal potential impact

Table 4-10: Hazard Rankings for the Town of Empire

Hazard	Spatial Extent	Potential Severity	Frequency of Occurrence	Overall Significance
Severe Wind	Extensive	Critical-Moderate	Highly Likely	High
Wildfire	Extensive	Critical	Likely	High
Winter Storm	Extensive	Moderate	Highly Likely	High
Drought	Extensive	Critical-Moderate	Likely	High
Landslide	Significant	Critical	Highly Likely	High
Flood	Significant	Critical-Moderate	Likely	High
Avalanche	Limited	Negligible	Unlikely	Medium
Dam Incident	Limited	Critical	Unlikely	Medium
Erosion	Extensive	Moderate	Likely	Medium
Lightning	Extensive	Moderate	Likely	Low
Hail	Extensive	Negligible	Likely	Low
Earthquake	Significant	Critical	Unlikely	Low
Subsidence	Significant	Negligible	Likely	Low
Extreme Heat	Extensive	Negligible	Unlikely	Low
Space Weather	Extensive	Negligible	Unlikely	Low
Tornado	Significant	Negligible	Unlikely	Low
Expansive Soil	Limited	Negligible	Occasional	Low

Spatial Extent
Extensive: 50-100% of planning area
Significant: 10-50% of planning area
Limited: Less than 10% of planning area

Potential Severity
Catastrophic: Multiple deaths, shutdown of facilities for 30 days or more, >50% of property is severely damaged
Critical: Multiple severe injuries, shutdown of facilities for at least 2 weeks, >25% of property is severely damaged
Moderate: Some injuries, shutdown of critical facilities for more than one week, >10% of property is severely damaged
Negligible: Minor injuries, minimal quality-of-life impact, interruption of facilities and services for 24 hours or less, less than 10% of property is severely damaged.

Frequency of Occurrence
Highly Likely: Near 100% probability each year.
Likely: Between 10 and 100% probability per year or at least one chance in ten years.
Occasional: Between 1 and 10% probability per year or at least one chance in next 100 years.
Unlikely: Less than 1% probability in next 100 years.

Significance
High: widespread potential impact
Medium: moderate potential impact
Low: minimal potential impact

Table 4-11: Hazard Rankings for the Town of Georgetown

Hazard	Spatial Extent	Potential Severity	Frequency of Occurrence	Overall Significance
Severe Wind	Extensive	Critical-Moderate	Highly Likely	High
Wildfire	Extensive	Critical	Likely	High
Winter Storm	Extensive	Moderate	Highly Likely	High
Landslide	Significant	Critical	Highly Likely	High
Flood	Significant	Critical-Moderate	Likely	High
Lightning	Extensive	Moderate	Highly Likely	Medium
Drought	Extensive	Negligible-Moderate	Likely	Medium
Avalanche	Limited	Moderate	Likely	Medium
Dam Incident	Significant	Critical	Unlikely	Medium
Erosion	Extensive	Moderate	Likely	Medium
Hail	Extensive	Negligible	Likely	Low
Earthquake	Significant	Critical	Unlikely	Low
Subsidence	Significant	Negligible	Likely	Low
Space Weather	Extensive	Negligible	Unlikely	Low
Tornado	Significant	Negligible	Unlikely	Low
Expansive Soil	Limited	Negligible	Occasional	Low
Extreme Heat	No Exposure	No Exposure	No Exposure	No Exposure

Spatial Extent
Extensive: 50-100% of planning area
Significant: 10-50% of planning area
Limited: Less than 10% of planning area

Potential Severity
Catastrophic: Multiple deaths, shutdown of facilities for 30 days or more, >50% of property is severely damaged
Critical: Multiple severe injuries, shutdown of facilities for at least 2 weeks, >25% of property is severely damaged
Moderate: Some injuries, shutdown of critical facilities for more than one week, >10% of property is severely damaged
Negligible: Minor injuries, minimal quality-of-life impact, interruption of facilities and services for 24 hours or less, less than 10% of property is severely damaged.

Frequency of Occurrence
Highly Likely: Near 100% probability each year.
Likely: Between 10 and 100% probability per year or at least one chance in ten years.
Occasional: Between 1 and 10% probability per year or at least one chance in next 100 years.
Unlikely: Less than 1% probability in next 100 years.

Significance
High: widespread potential impact
Medium: moderate potential impact
Low: minimal potential impact

Table 4-12: Hazard Rankings for the Town of Silver Plume

Hazard	Spatial Extent	Potential Severity	Frequency of Occurrence	Overall Significance
Landslide	Extensive	Critical	Highly Likely	High
Severe Wind	Extensive	Critical-Moderate	Highly Likely	High
Wildfire	Extensive	Critical	Likely	High
Winter Storm	Extensive	Moderate	Highly Likely	High
Avalanche	Significant	Moderate	Highly Likely	High
Flood	Significant	Critical-Moderate	Likely	High
Drought	Extensive	Negligible-Moderate	Likely	Medium
Hail	Extensive	Negligible	Likely	Low
Lightning	Extensive	Negligible	Likely	Low
Erosion	Extensive	Negligible	Likely	Low
Earthquake	Significant	Critical	Unlikely	Low
Subsidence	Significant	Negligible	Likely	Low
Extreme Heat	Extensive	Negligible	Unlikely	Low
Space Weather	Extensive	Negligible	Unlikely	Low
Dam Incident	Limited	Moderate	Unlikely	Low
Tornado	Significant	Negligible	Unlikely	Low
Expansive Soil	Limited	Negligible	Occasional	Low

Spatial Extent
Extensive: 50-100% of planning area
Significant: 10-50% of planning area
Limited: Less than 10% of planning area

Potential Severity
Catastrophic: Multiple deaths, shutdown of facilities for 30 days or more, >50% of property is severely damaged
Critical: Multiple severe injuries, shutdown of facilities for at least 2 weeks, >25% of property is severely damaged
Moderate: Some injuries, shutdown of critical facilities for more than one week, >10% of property is severely damaged
Negligible: Minor injuries, minimal quality-of-life impact, interruption of facilities and services for 24 hours or less, less than 10% of property is severely damaged.

Frequency of Occurrence
Highly Likely: Near 100% probability each year.
Likely: Between 10 and 100% probability per year or at least one chance in ten years.
Occasional: Between 1 and 10% probability per year or at least one chance in next 100 years.
Unlikely: Less than 1% probability in next 100 years.

Significance
High: widespread potential impact
Medium: moderate potential impact
Low: minimal potential impact

4.2 Assets at Risk

4.2.1 General Property

General property exposure to hazards is based on Clear Creek County's parcel data containing assessor information such as total number of parcels, improvement values, and parcel types by jurisdiction. Only those parcels with improvement values greater than $0, were used for analysis; non-developed or non-improved parcels were excluded for the purposes of conducting the vulnerability assessment. Additionally, Clear Creek County has 3,315 parcels identified as mining sites that show improvements but no structures; for purposes of this analysis, these mining parcels were also excluded from the analysis. A total of 5,817 parcels and 6,893 buildings were analyzed.

Counts and values are based on the latest County assessor's data (as of January 2021), which was provided in GIS and tabular (spreadsheet) formats. Improvement values and parcel type attributes were joined to the parcel geometries in GIS, to enable spatial analysis and mapping. Values for building contents were estimated as a percent of the improvement value based on parcel type using standard FEMA HAZUS: 50% of the improvement value for residential structures (including mobile homes), 150% for industrial and 100% for the other property types. Finally, total values were aggregated by adding the improvement and content values for parcels in each jurisdiction. Table 4-13 shows there are a total of 6,893 buildings with a combined value of $1.17 billion potentially at risk across Clear Creek County.

Table 4-13: Total Property Exposure by Jurisdiction

Jurisdiction	Improved Parcels	Buildings	Improved Value	Content Value	Total Value	Population
Empire	201	245	$6,785,470	$3,996,180	$10,781,650	306
Georgetown	694	771	$38,666,910	$21,007,315	$59,674,225	1,110
Idaho Springs	856	1,029	$30,053,470	$19,516,940	$49,570,410	1,828
Silver Plume	162	181	$6,387,410	$3,777,915	$10,165,325	178
Unincorporated	3,904	4,667	$672,800,910	$367,076,570	$1,039,877,480	6,318
Total	**5,817**	**6,893**	**$754,694,170**	**$415,374,920**	**$1,170,069,090**	**9,740**

Source: Wood Analysis of Clear Creek County Assessor's Data

Table 4-14 further breaks down property exposure by parcel type. The below information shows that residential parcels account for 85% of improved parcels countywide. Residential properties represent 44% of the total value of properties exposed, although this number is skewed by the high values of mining parcels in the unincorporated County; excluding those mining parcels, residential properties represent 77% of the total value of properties potentially exposed.

Table 4-14: Property Exposure by Jurisdiction and Property Type

Jurisdiction	Property Type	Improved Parcels	Buildings	Improved Value	Content Value	Total Value
Empire	Agriculture	1	1	$490	$490	$980
	Commercial	6	7	$364,580	$364,580	$729,160
	Exempt	7	7	$656,400	$656,400	$1,312,800
	Mining	1	1	$150	$150	$300
	Residential	177	220	$5,578,580	$2,789,290	$8,367,870

Jurisdiction	Property Type	Improved Parcels	Buildings	Improved Value	Content Value	Total Value
	Improved Vacant	9	9	$185,270	$185,270	$370,540
	Total	**201**	**245**	**$6,785,470**	**$3,996,180**	**$10,781,650**
Georgetown	Commercial	30	35	$1,325,410	$1,325,410	$2,650,820
	Exempt	27	34	$1,436,380	$1,436,380	$2,872,760
	Mining	1	1	$280	$280	$560
	Residential	619	684	$35,319,190	$17,659,595	$52,978,785
	Improved Vacant	17	17	$585,650	$585,650	$1,171,300
	Total	**694**	**771**	**$38,666,910**	**$21,007,315**	**$59,674,225**
Idaho Springs	Commercial	74	97	$4,792,550	$4,792,550	$9,585,100
	Exempt	57	65	$3,414,400	$3,414,400	$6,828,800
	Industrial	1	1	$7,040	$10,560	$17,600
	Mining	1	1	$30	$30	$60
	Residential	705	845	$21,080,100	$10,540,050	$31,620,150
	Improved Vacant	18	20	$759,350	$759,350	$1,518,700
	Total	**856**	**1,029**	**$30,053,470**	**$19,516,940**	**$49,570,410**
Silver Plume	Commercial	6	8	$248,910	$248,910	$497,820
	Exempt	17	18	$760,960	$760,960	$1,521,920
	Residential	131	146	$5,218,990	$2,609,495	$7,828,485
	Improved Vacant	8	9	$158,550	$158,550	$317,100
	Total	**162**	**181**	**$6,387,410**	**$3,777,915**	**$10,165,325**
Unincorporated	Agriculture	20	25	$59,470	$59,470	$118,940
	Commercial	54	106	$11,225,050	$11,225,050	$22,450,100
	Exempt	124	254	$44,249,390	$44,249,390	$88,498,780
	Mining	127	170	$337,536,670	$168,768,335	$506,305,005
	Residential	3,431	3,954	$273,912,010	$136,956,005	$410,868,015
	Improved Vacant	148	158	$5,818,320	$5,818,320	$11,636,640
	Total	**3,904**	**4,667**	**$672,800,910**	**$367,076,570**	**$1,039,877,480**
Grand Total		**5,817**	**6,893**	**$754,694,170**	**$415,374,920**	**$1,170,069,090**

Source: Wood Analysis of Clear Creek County Assessor's Data

For hazards with a geospatial component and where good data was available, the parcel layer was overlaid with the hazard layer to determine the parcels exposed to the hazards. The hazards that had enough geospatial data to conduct this parcel level hazard analysis were Dam Failure/Incidents, Flood, and Wildfire.

4.2.2 People

Population estimates were calculated for hazards with a geospatial component and for which data was available for GIS-based parcel analysis. These were based on dividing the total 2019 Census population by the total number of residential parcels to get an average number of people per parcel for each jurisdiction. Average population per residential parcel was calculated as:

- Empire 1.73

- Georgetown 1.92
- Idaho Springs 2.07
- Silver Plume 2.02
- Unincorporated County 2.23.

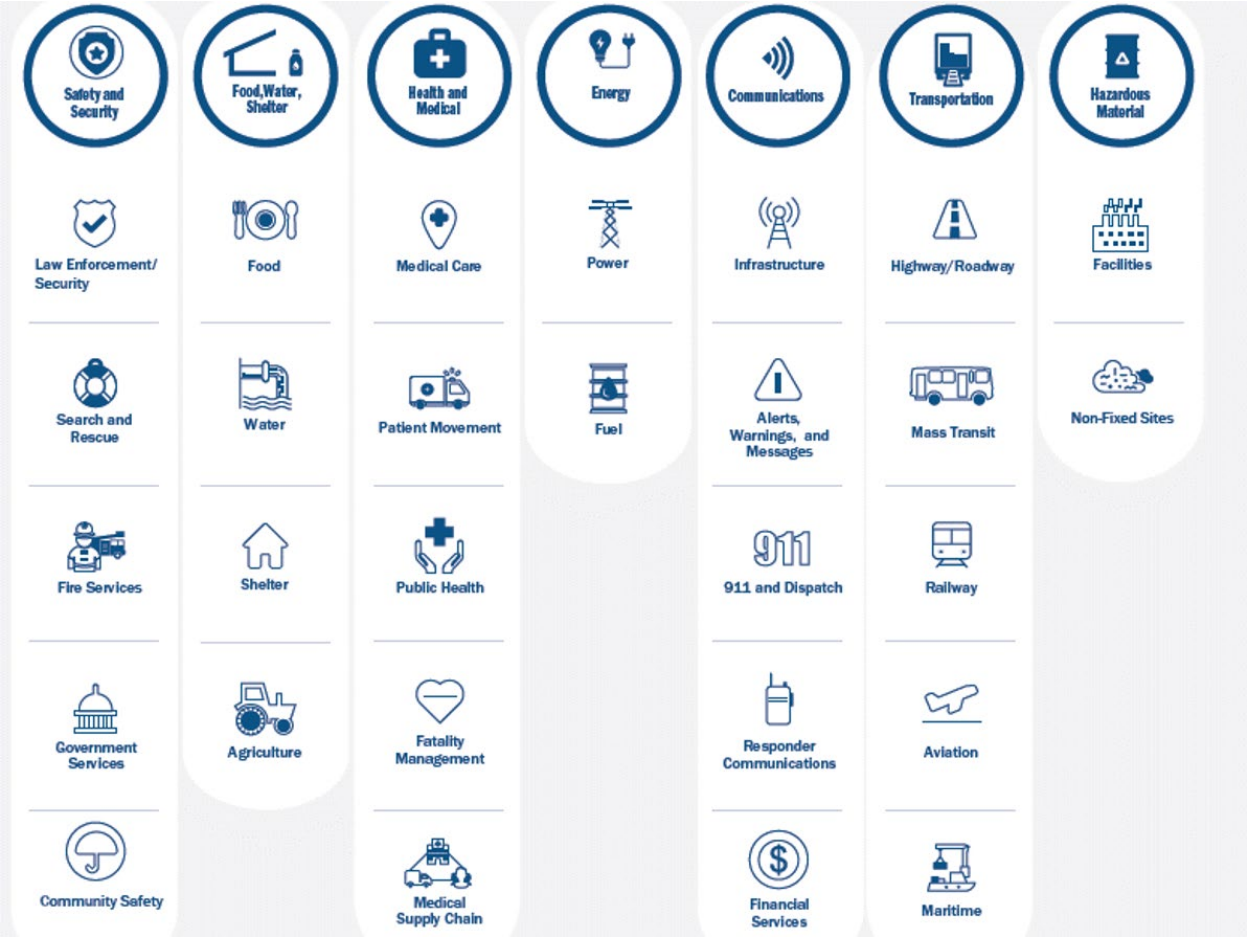
This value was then multiplied by the number of residential parcels that overlap with a hazard layer to get an estimate of the population exposed to that hazard. For more details on economic assets, development trends, and other population and demographic information refer to Chapter 2 Community Profile.

4.2.3 Critical Facilities and Infrastructure

A critical facility is one that is essential in providing utility or direction either during the response to an emergency or during the recovery operation. To develop a comprehensive list of critical facilities in Clear Creek County, several data sources were compiled including GIS databases of critical facilities and infrastructure from the County, and the 2020 Homeland Infrastructure Foundation-Level Data (HIFLD) data. The inventory of critical facilities identified in Clear Creek County is summarized in Table 4-15 and broken down by type in Table 4-16. Figure 4-3 maps the general location of these facilities.

FEMA Lifeline categories are the U.S. Department of Homeland Security's recommended way to standardize the classification of critical facilities and infrastructure which 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.

Figure 4-2: Lifeline Categories



Source: FEMA

Specific information on facilities, names, and other key details by participating communities may be accessed by permission of the jurisdiction or infrastructure owner.

Table 4-15: Clear Creek County Critical Facilities by Jurisdiction

Jurisdiction	Communications	Energy	Food, Water, Shelter	Hazardous Material	Health and Medical	Safety and Security	Transportation	Total
Empire	2	-	3	1	1	3	4	**14**
Georgetown	4	1	2	5	1	8	7	**28**
Idaho Springs	2	1	4	8	5	4	17	**41**
Silver Plume	-	-	-	-	-	2	4	**6**
Unincorporated	22	3	9	3	31	10	50	**128**
Total	**30**	**5**	**18**	**17**	**38**	**27**	**82**	**217**

Source: Wood Analysis of Clear Creek County and HIFLD data

Table 4-16: Critical Facilities by Jurisdiction and Type

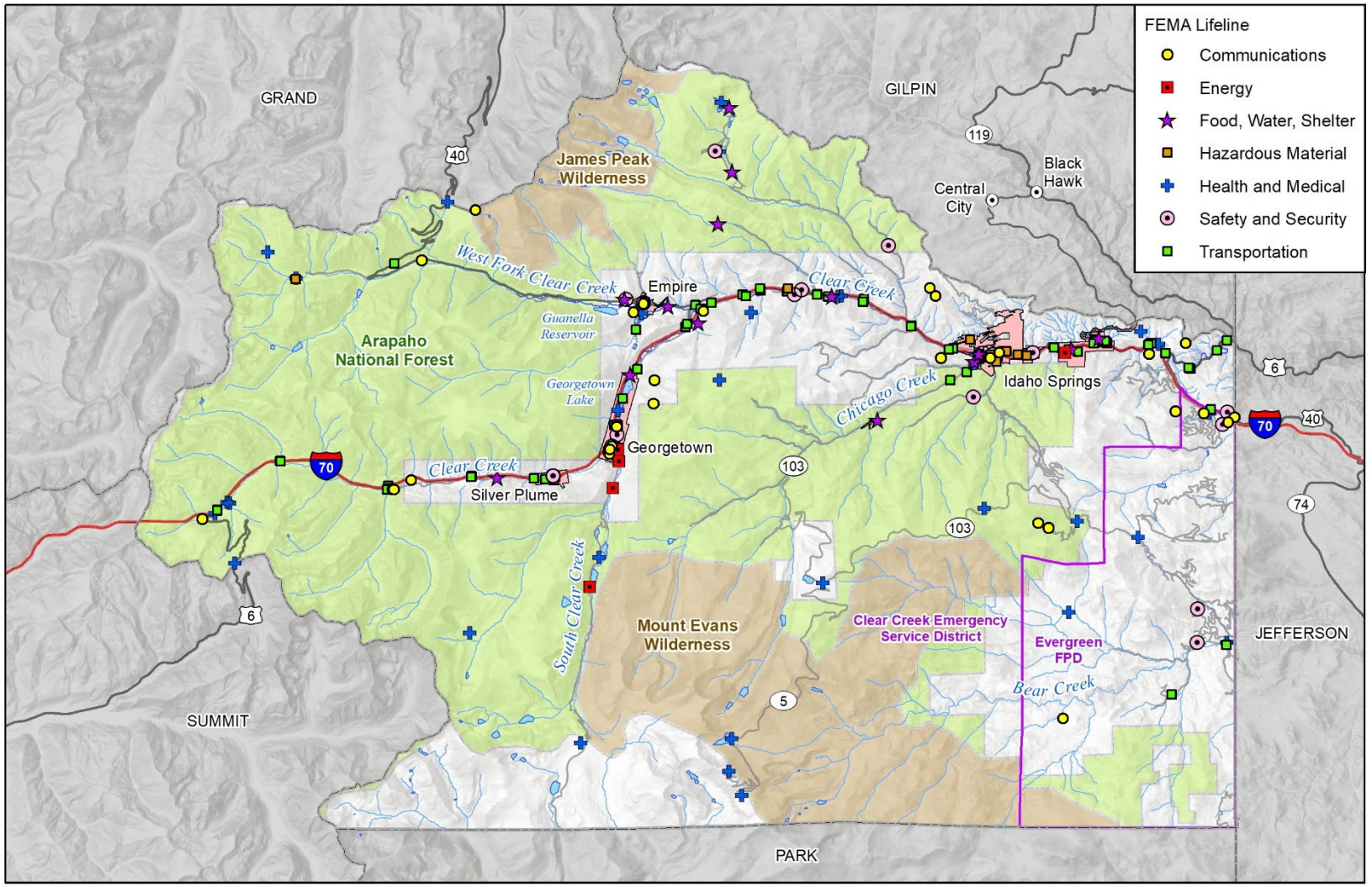
Jurisdiction	FEMA Lifeline	Facility Type	Count
Empire	Communications	Communications	2
	Food, Water, Shelter	Water Facility	3
	Hazardous Material	Hazmat	1
	Health and Medical	Emergency Air Transportation	1
	Safety and Security	Government Building	2
		Police Station	1
	Transportation	Bridge	4
		Total	**14**
Georgetown	Communications	Communications	4
	Energy	Substation Power Plant	1
	Food, Water, Shelter	Community Center	1
		Wastewater Treatment Facility	1
	Hazardous Material	Hazmat	4
		Tier II	1
	Health and Medical	Emergency Air Transportation	1
	Safety and Security	EOC	1
		Fire Station	1
		Government Building	3
		Police	1
		School	1
		Sheriff	1
	Transportation	Bridge	7
		Total	**28**
Idaho Springs	Communications	Communications	2
	Energy	Substation Power Plant	1
	Food, Water, Shelter	Administrative Offices	1
		Recreation Center	1
		Water Facility	2
	Hazardous Material	Hazardous Waste Facility	1
		Hazmat	6
		Tier II	1
	Health and Medical	Health Clinic	2
		Emergency Air Transportation	1
		EMS	2
	Safety and Security	Government Building	2
		Police	1
		School	1
	Transportation	Bridge	17

Jurisdiction	FEMA Lifeline	Facility Type	Count
		Total	**41**
Silver Plume	Safety and Security	Fire Station	1
		Government Building	1
	Transportation	Bridge	4
		Total	**6**
Unincorporated	Communications	Communications	22
	Energy	Substation Power Plant	1
		Water Electric Plant	2
	Food, Water, Shelter	Camp	1
		Wastewater Treatment Facility	4
		Water Facility	3
		Water Storage	1
	Hazardous Material	Hazmat	1
		Tier II	2
	Health and Medical	Emergency Air Transportation	30
		EMS	1
	Safety and Security	Fire Station	6
		Government Building	2
		School	2
	Transportation	Bridge	47
		CDOT Facility	1
		Government Building	2
		Total	**128**
Grand Total			**217**

Source: Wood Analysis of Clear Creek County and HIFLD data

Critical facilities that are located in areas at risk of hazards are within the Vulnerability Assessment section of each hazard profile below.

Figure 4-3: Critical Facilities



Map compiled 5/2021;
intended for planning purposes only.
Data Source: Clear Creek County, CDOT, National Inventory of Bridges, HIFLD

0 2.5 5 Miles

N

4.2.4 Historic, Cultural and Natural Resources

Assessing the vulnerability of Clear Creek County to disasters also involves inventorying the natural, historic, 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 and laws for reconstruction, restoration, rehabilitation, and/or replacement are often specific for these types of designated resources (e.g., under the NEPA and Section 106 of the National Historic Preservation Act).
- 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.

Historic and Cultural Resources

A historic property not only includes buildings or other types of structures such as bridges and dams but can also refer to prehistoric or Native American sites, roads, byways, historic landscapes, and such other features. Historic properties and cultural resources are also valuable economic assets that increase property values and attract businesses and tourists. Far from being at odds with economic development, preservation of these assets is often an important catalyst for economic development (e.g., historic downtown revitalization programs leading to growth in heritage tourism).

Some key information on historic assets and properties in Clear Creek County was obtained from the National Register of Historic Places (NRHP). The NRHP database, administered by the National Park Service, is the Nation's official list of cultural resources worthy of preservation, and the NRHP overall 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, archeology, engineering, and culture.

Colorado has a similar historical resource record version, called the Colorado State Register of Historic Properties (CSRHP). This database contains 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.

There are 25 historic resources in Clear Creek County listed in the National Register of Historic Places, and an additional 7 listed in the Colorado State Register of Historic Properties, as summarized in Table 4-13.

Table 4-17: Historic and Cultural Resources in Clear Creek County

Historic Place Name	Location	Date Listed	Data Source
Alpine Hose Company No. 2	Georgetown	1/25/1973	NRHP
Anne Evans Mountain Home	Evergreen	1/28/1992	NRHP
Argo Tunnel and Mill	Idaho Springs	1/31/1978	NRHP
B.P.O. Elks Lodge #607	Idaho Springs	5/14/1997	CSRHP
Bryan Hose House	Idaho Springs	3/19/1998	NRHP

Historic Place Name	Location	Date Listed	Data Source
Charlie Tayler Waterwheel	Idaho Springs	9/9/1998	CSRHP
Dodge Ranch	Evergreen vicinity	12/13/1995	CSRHP
Dumont School	Dumont	3/1/1996	NRHP
Echo Lake Park	Idaho Springs	2/24/1995	NRHP
Empire Town Hall	Empire	9/9/1998	CSRHP
Evans-Elbert Ranch	Idaho Springs	9/11/1980	NRHP
Georgetown Loop Railroad	Georgetown	12/18/1970	NRHP
Georgetown-Silver Plume Historic District	Georgetown-Silver Plume	11/13/1966	NRHP
Grace Episcopal Church	Georgetown	8/14/1973	NRHP
Hamill House	Georgetown	5/31/1972	NRHP
Hoop Creek Stone Bridge	Empire vicinity	6/14/2000	CSRHP
Hose House No. 2	Idaho Springs	3/19/1998	NRHP
Hotel de Paris	Georgetown	4/28/1970	NRHP
Idaho Springs Downtown Commercial District	Idaho Springs	1/5/1984	NRHP
Lebanon and Everett Mine Tunnels	Silver Plume	10/7/1971	NRHP
McClellan House	Georgetown	12/5/1972	NRHP
Methodist Episcopal Church	Idaho Springs	3/5/1998	NRHP
Mill City House	Dumont	4/30/2009	NRHP
Miner Street Bridge	Idaho Springs	2/4/1985	NRHP
Mint Saloon	Empire	2/3/1993	NRHP
Ore Processing Mill and Dam	Georgetown	5/6/1971	NRHP
Peck House	Empire	3/25/1993	NRHP
Santiago Mine / Santiago Complex / Santiago Mill Site	Waldorf vicinity	5/23/2013	CSRHP
Silver Plume Depot	Silver Plume	5/6/1971	NRHP
Squaw Mountain Lookout	Idaho Springs vicinity	9/9/1998	CSRHP
Summit Lake Park	Idaho Springs	2/24/1995	NRHP
Toll House	Georgetown	12/18/1970	NRHP

Source: National Park Service, History Colorado

The National Environmental Policy Act (NEPA) and National Historic Preservation Act (NHPA) define any property over 50 years of age as a historic resource 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 and the NHPA regarding this key age period. In addition, by law under the NHPA, "members of the public have a voice when federal actions will affect properties that qualify for the National Register of Historic Places, the nation's official list of historic properties" (A Citizen's Guide to Section 106 Review, 2016). Structural mitigation projects are considered alterations for the purpose of these NEPA/NHPA regulations, if regarding historical properties and places.

In addition to the properties listed above, the downtown historic districts as well as numerous mines/mills throughout the County are rich with history and cultural significance.

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 wetland areas can protect sensitive habitat as well as attenuate and store floodwaters.

Wetlands are a valuable natural resource for communities due to their benefits to water quality, wildlife protection, recreation, and education, and play an important role in hazard mitigation. Wetlands provide natural floodplain protection 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 is vital (Wetland Functions and Values, 2016).

Endangered Species

To further understand natural resources that may be particularly vulnerable to a hazard event, as well as those that need consideration when implementing mitigation activities, it is important to identify at-risk species (endangered and threatened 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 a third category of plants and animals at risk, but these have been proposed as endangered or threatened but are not currently listed.

According to the U.S. Fish and Wildlife Service (USFW) Environmental Conservation Online System (ECOS), there were 17 federally endangered, threatened, or candidate/proposed/ under/other status review species in Clear Creek County (as of October 2020). These are listed in Table 4-18. Resolved Taxon refers to species for which a Not Warranted 12 month finding or Not Substantial 90-day finding has been published in the Federal Register, or which has been removed from the candidate list.

Table 4-18: Endangered Species in Clear Creek County

Group	Common Name	Scientific Name	Status
Insects	Monarch butterfly	*Danaus plexippus*	Candidate
Mammals	Preble's meadow jumping mouse	*Zapus hudsonius preblei*	Threatened
Mammals	American pika	*Ochotona princeps*	Resolved Taxon
Flowering Plants	Western prairie fringed Orchid	*Platanthera praeclara*	Threatened
Birds	Southern white-tailed ptarmigan	*Lagopus leucura altipetens*	Resolved Taxon
Amphibians	Northern leopard frog	*Rana pipiens*	Resolved Taxon
Mammals	North American wolverine	*Gulo luscus*	Resolved Taxon
Mammals	Long-eared myotis	*Myotis evotis*	Species of Concern
Amphibians	Boreal toad	*Anaxyrus boreas*	Resolved Taxon
Birds	Mexican spotted owl	*Strix occidentalis lucida*	Threatened
Birds	Swainson's hawk	*Buteo swainsoni*	Resolved Taxon

Group	Common Name	Scientific Name	Status
Birds	American peregrine falcon	*Falco peregrinus anatum*	Recovery
Mammals	Canada Lynx	*Lynx canadensis*	Threatened
Mammals	Long-legged myotis	*Myotis volans*	Species of Concern
Mammals	Little brown bat	*Myotis lucifugus*	Under Review
Fishes	Greenback Cutthroat trout	*Oncorhynchus clarkii stomias*	Threatened
Birds	Whooping crane	*Grus americana*	Experimental Population

Source: U.S. Fish & Wildlife Service Environmental Conservation Online System

4.3 Avalanche

AVALANCHE HAZARD RANKING	
Clear Creek County	Medium
City of Idaho Springs	Medium
Town of Empire	Medium
Town of Georgetown	Medium
Town of Silver Plume	High
Clear Creek Fire Authority	Medium

4.3.1 Description

Avalanches can occur whenever a sufficient depth of snow is deposited on slopes steeper than approximately 20 degrees, with the most dangerous coming from slopes in the 35- to 40-degree range. Avalanche-prone areas can be identified with some accuracy, since they typically follow the same paths year after year, leaving scarring on the paths. However, unusual weather conditions can produce new paths or cause avalanches to extend beyond their normal paths.

In the spring, warming of the snowpack occurs from below (from the warmer ground) and above (from warm air, rain, etc.). Warming can be enhanced near rocks or trees that transfer heat to the snowpack. The effects of a snowpack becoming weak may be enhanced in steeper terrain where the snowpack is shallow, and over smooth rock faces that may focus meltwater and produce "glide cracks." Such slopes may fail during conditions that encourage melt.

Wind can affect the transfer of heat into the snowpack and associated melt rates of near-surface snow. During moderate to strong winds, the moistening near-surface air in contact with the snow is constantly mixed with drier air above through turbulence. As a result, the air is continually drying out, which enhances evaporation from the snow surface rather than melt. Heat loss from the snow necessary to drive the evaporation process cools off near-surface snow and results in substantially less melt than otherwise might occur, even if temperatures are well above freezing.

When the snow surface becomes uneven in spring, air flow favors evaporation at the peaks, while calmer air in the valleys favors condensation there. Once the snow surface is wet, its ability to reflect solar energy drops

DEFINITIONS

Avalanche—Any mass of loosened snow or ice and/or earth that suddenly and rapidly breaks loose from a snowfield and slides down a mountain slope, often growing and accumulating additional material as it descends.

Slab avalanches—The most dangerous type of avalanche, occurring when a layer of coherent snow ruptures over a large area of a mountainside as a single mass. Like other avalanches, slab avalanches can be triggered by the wind, by vibration, or even by a loud noise, and will pull in surrounding rock, debris, and even trees.

Climax avalanches—An avalanche involving multiple layers of snow, usually with the ground as a bed surface.

Loose snow avalanches—An avalanche that occurs when loose, dry snow on a slope becomes unstable and slides. Loose snow avalanches start from a point and gather more snow as they descend, fanning out to fill the topography.

Powder snow avalanches—An avalanche that occurs when sliding snow has been pulverized into powder, either by rapid motion of low-density snow or by vigorous movement over rugged terrain.

Surface avalanches—An avalanche that occurs only in the uppermost snow layers.

Wet snow avalanche—An avalanche in wet snow, also referred to as a wet loose avalanche or a wet slab avalanche. Often the basal shear zone is a water-saturated layer that overlies an ice zone.

dramatically; this becomes a self-perpetuating process, so that the valleys deepen (favoring calmer air and more heat transfer), while more evaporation occurs near the peaks, increasing the differential between peaks and valleys. However, a warm wet storm can quickly flatten the peaks as their larger surface area exposed to warm air, rain or condensation hastens their melt over the sheltered valleys.

Avalanches can reach speeds of up to 200 miles per hour and can exert forces great enough to destroy structures and uproot or snap off large trees. Avalanche paths consist of a starting zone, a track, and a runout zone. The runout zone is often an attractive setting for development.

Avalanche hazards occur predominantly in the mountainous regions of Colorado above 8,000 feet. The majority of avalanches occur during and shortly after winter storms, during the winter and spring months between November and April. The most avalanche-prone months are, in order, February, March, and January. Avalanches caused by thaw occur most often in April (Colorado Avalanche Information Center). The avalanche danger increases with major snowstorms and periods of thaw. About 2,300 avalanches are reported to the Colorado Avalanche Information Center (CAIC) in an average winter. More than 80 percent of these occur during or just after large snowstorms.

According to the CAIC, avalanches have killed more people in Colorado since 1950 than any other natural hazard, and Colorado accounts for one-third of all avalanche deaths in the United States. Avalanche forecasts were first issued by the Colorado Avalanche Warning Center in 1973. The program was originally part of a federal research program but has been a part of the Colorado State government since 1983. The CAIC is now a program within the Colorado Department of Natural Resources (DNR), Executive Director's Office. The program is a partnership between the DNR, Colorado Department of Transportation (CDOT), and the Friends of the CAIC (FoCAIC) a 501(c)3 group. The mission of the CAIC is to provide avalanche information and education and to promote research for the protection of life, property, and the enhancement of the state's economy (CAIC no date).

4.3.2 Past Events

Clear Creek County is a relatively mountainous area and avalanches do occur frequently, occasionally resulting in death. There have been 33 recorded deaths attributable to avalanches in Clear Creek County between 1950 and February 2021. The fatalities occurred primarily in the western border of the county. All of the fatalities were from backcountry activities. Five backcountry skiers died in the Sheep's Creek Slide along Loveland Pass in April 2013; all were trained backcountry skiers and rescuers. That avalanche event is one of the deadliest backcountry skiing death events to occur in Colorado since January 21, 1962. The following is a list of past events in Clear Creek County from the CAIC database.

- **December 20, 1997** – Guanella Pass, Duck Lake. Two men were snowshoeing behind a cabin near Duck Lake, just over a mile south of Guanella Pass, when they triggered a slab avalanche. At about 1300 hours the men were crossing beneath a short but steep slope through a small area of willows when they heard "a thud". The snow under their feet collapsed, and like pulling out a log from the bottom of a wood pile, released the slab avalanche from above. The men were about 15 feet apart and the avalanche caught one but missed the other. The Clear Creek County Sheriff's Office was notified, and rescue teams were notified. The victim's friend and their wives quickly returned to the avalanche to look for the buried man. They knew basically where to look and started digging, unfortunately they were off by a few feet. After about 45 minutes the CCC Sheriff and another officer arrived. The sheriff took a ski pole and cut off the basket to fashion a probe pole. He started to show the others how to use the pole when he immediately probed the buried man. The 39-year-old California man was buried under 2 to 3 feet of snow near the toe (bottom) of the debris for nearly an hour. He was quickly dug out and

resuscitation efforts started. A Flight for Life helicopter from Denver soon arrived and advanced life support efforts were tried without luck.

- **April 1, 1998** – St. Mary's Glacier. Fatal incident. 1 hiker caught and buried. Hikers were along the steep left side of the glacier when one of the hikers slipped and slid down the steep snow-covered slope. At the bottom of the slope, they stood up and started to climb back to her friend. At this time, they triggered the avalanche as they started up the slope. The second hiker was some distance above and to the side was also caught. The slab avalanche swept both of them down. Hiker 2 was able to free themself quickly and started looking for hiker 1. The survivor searched for about 30 minutes before other hikers joined the search. After about 40+ minutes, word reached the Clear Creek County Sheriff's Office and a rescue effort started. Rescuers found the victim about two hours after the avalanche. An arm and leg were protruding from the snow.
- **April 6, 1999** – St. Mary's Glacier. 1 backcountry skier caught. A lucky backcountry skier survived a short burial at St. Mary's Glacier by the quick action of a couple of avalanche-savvy snowboarders. At about 10:30 AM two skiers stood above the steep slopes above St. Mary's Lake. The first skier ventured onto the slope and when he made his first turn, he triggered a shallow soft-slab avalanche.
- **December 22, 2005** – Kelso Mountain. At about 1230 hours Thursday afternoon two teenage hikers were caught in a hard slab avalanche on the east side of Kelso Mountain, a little over 3 miles south of Bakerville and about 1 mile east of the summit of Torreys Peak. One young man, an 18-year-old from Colorado Springs, was buried and killed.
- **March 3, 2007** – Echo lake, north of Mount Evans. Two snowshoers were hiking along Colorado Highway 5, south of Echo Lake. Around 2:30 pm, they reached a spot where a steep wind drift covered the road. The victim, a 53-year-old male, slipped off the trail and slid down hill. As he climbed back to the road, he triggered an avalanche. The avalanche swept him down about 250 vertical feet. Media reports said his dog found him very quickly, buried to his neck. The snowshoer's companion and a passing group dug him out and sent for rescuers. The snowshoer was alive when rescuers arrived but died during the evacuation.
- **December 12, 2010** – Near Jones Pass. The rider was moving very slowly on low angle terrain when he saw the cracks. He "pulled into [the] rocks, thought I was out of path and would watch it go by." The rider was hit by a "freightliner" of snow from above. He was instantly buried. He triggered his airbag and "floated to the surface as I heard the bag inflate." He was able to swim to the edge of the avalanche, and came to a stop after about 100 feet, partly buried under 6 to 18 inches of snow. "Below me was a [rocky area] that would have destroyed me, period." The avalanche continued over the rocks and to the valley bottom. There were "car...sized blocks" left in the starting zone, and debris piles deeper than the party's 3 m probes. The rider's sled was buried and found the following day.
- **April 20, 2013** – Sheep Creek north of Loveland Pass. The avalanche was quite large and engulfed the entire group from above at approximately 10:15am. The avalanche pushed all group members between 5 and 20 feet into the Sheep Creek gully. Five of the six members of the group were completely buried. The survivor was 3rd in line at the time of the accident and was partially buried in very close proximity (touching) to the two group members in the front of the line. The survivor came to rest in an upright semi-seated position with his lower left arm free, and his face very near the surface. He was able to clear the snow from his face, and at that point could breathe freely. He then began slowly moving snow away from his face and head and trying to free his right arm from the snow. The survivor continued to yell for help, but to no avail, as there was no one left unburied to hear him and no other people in the area. The survivor was stranded in this position for approximately 4 hours before rescuers arrived at the scene.

- **November 24, 2013** – St. Mary's Lake. Sunday morning November 24th a group of three climbers ascended towards St Mary's Lake northwest of Idaho Springs. Two of the climbers split off from the third climber and ascended gentle terrain to the north of the steep terrain above St Mary's Lake. At about 10:30 AM Climber 3 was ascending just to the climbers left of the central couloir above St Mary's Lake when he triggered a slab avalanche. The climber was nearing the top of the climb when the slab fractured and ran. The climber was carried for around 120 feet before they were able to self-arrest. The debris continued down the track another 500 to 600 vertical feet. Climber 3 did not have a beacon, probe, or shovel. Climber 1 was uninjured and was able to return to the trailhead under his own power.
- **December 27, 2013** - Skier 1 felt the snow collapse and drop, but only heard a gentle 'whoosh'. Skier 1 decided to head straight down the steeper slope they had planned to avoid in the hopes of outrunning the avalanche. The slab broke into "undulating blocks of different sizes going up and down at random like the keys on a player piano". Skier 1 rode on top of the slab for about 100 feet down slope. Then the avalanche hit a bench at the bottom of the path. Two backcountry skiers on the ridge witnessed the avalanche and called 911, which began a response by Flight for Life Helicopters. A backcountry tourer on a splitboard (Snowboarder 1) also saw the avalanche and headed over to do a search. Snowboarder 1 began a beacon search but could find no signal. He then visually followed Skier 1's track from the crown down slope along the estimated trajectory. Snowboarder 1 saw a black ski pole tip, sticking about a foot out of the snow. Snowboarder 1 began to dig an estimated 10 minutes after the avalanche occurred. He dug down the ski pole and saw a hand and continued digging until he reached Skier 1's head. Skier 1 was semi-conscious at this point and began to respond little by little. It took Snowboarder 1 about 30 minutes to excavate Skier 1. Skier 1 was able to ski to the highway on his own.
- **December 31, 2014** – Kelso Mountain. Climbers 1 and 2 stopped on the track to discuss their plan immediately before the track led directly under a steep, cross-loaded gully. They were increasing uncomfortable with their route and decided to cross the gully one at a time. Climber 1 used the skin track to pass under the avalanche path into a shallow area of snow on the far side. She turned around to spot Climber 2, who had already started to cross the path. Climber 2 was about a third of the way across the path when the avalanche released. Climber 1 watched as Climber 2 was washed downhill in the avalanche. Initially Climber 2 was on top of the debris, but then disappeared from view. Climber 1 turned her avalanche beacon to receive and began searching for Climber 2. She moved to the last place Climber 2 was visible. She yelled to Climber 3, who was about 300 feet away on the trail. Climber 1 followed the radio signal with her rescue beacon but could not get a reading below 4.9 m. Climbers 1 and 3 cleared some of the loose blocks of snow away from surface and continued searching. They used one shovel, probe pole, and their snowshoes to find Climber 2's arm and from there his head. They performed rescue breaths but could not revive him. The 911 call center alerted the Clear Creek County Sheriff's Office, who activated the Flight for Life and the Alpine Rescue Team.
- **January 16, 2016** – St. Mary's Lake. The climber arrived at the St Mary's trailhead around mid-day Saturday, January 16, 2016. A powerful winter storm had begun the day prior. Friends and family reported that the climber often visited the area in the winter. His usual route was up and down the access road, and he usually ascended a gully to south side of the lake (climber's left) for exercise. It is unknown exactly where the climber was at the time of the avalanche. The climber was found buried at the lake margin below a steep slope. Avalanche debris spread several hundred feet over the lake ice. Large chunks of ice were broken out and encased in avalanche debris. Friends reported the climber missing the evening of January 16, 2016, when he failed to return for dinner. The Clear Creek County Sheriff's office-initiated search and rescue efforts that evening. Weather prevented a safe search, and the rescue team aborted their attempt that night.

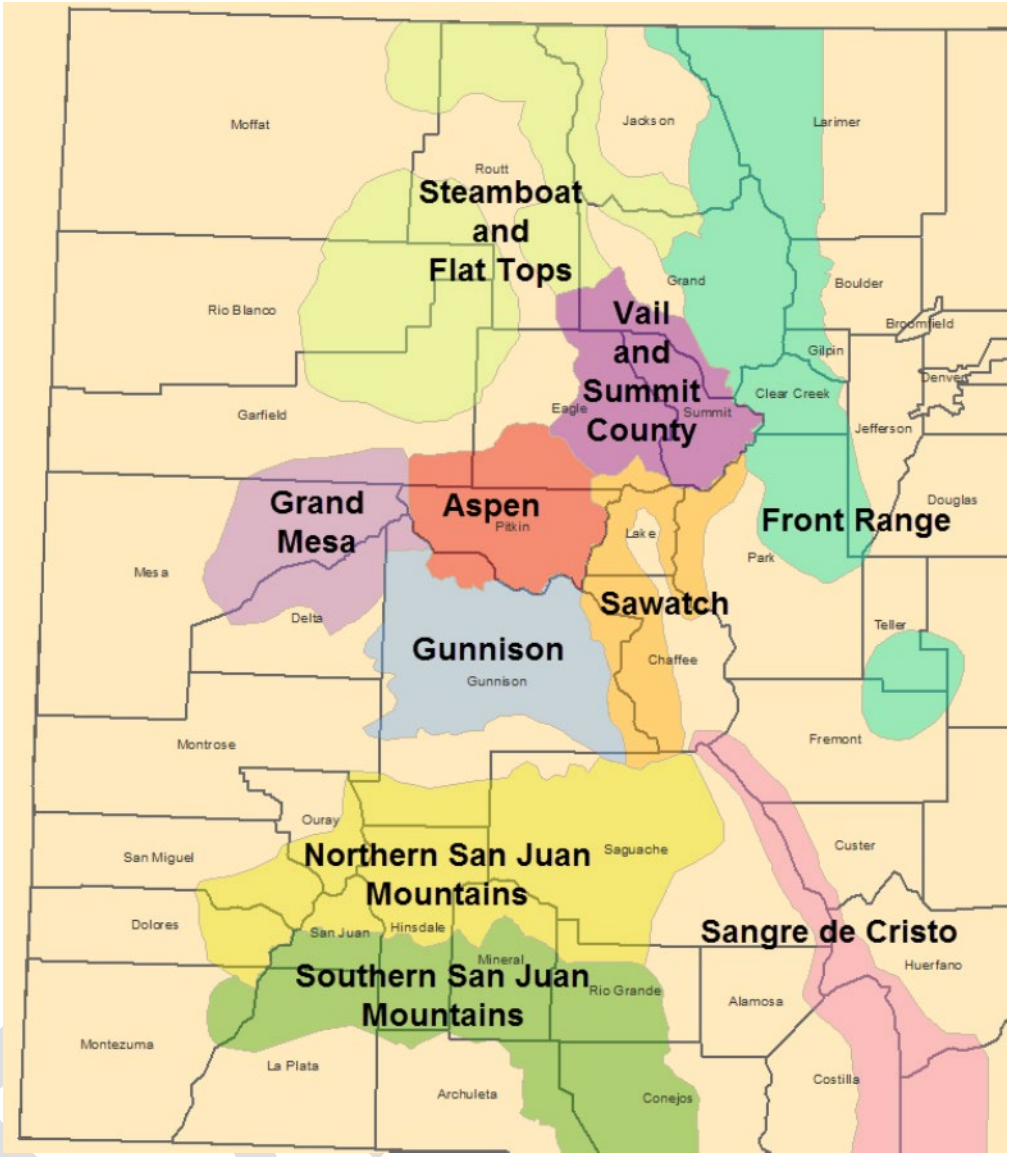
- **February 14, 2021** – Near Mount Trealease north of Loveland Pass. This avalanche occurred on a steep, east-facing, above-treeline slope on Mount Trelease, locally known as Pat's Knob. The slope angle of the bed surface was generally 35 degrees, but as steep as 42 degrees in places. This was a very large, hard-slab avalanche unintentionally triggered by a snowboarder. The avalanche was large relative to the path and produced enough destructive force to bury and destroy a car or destroy a wood frame house. The crown face of the avalanche was up to 20 feet deep and 850 feet wide. The debris ran 500 vertical feet. The avalanche broke in a layer of faceted snow about 2 feet from the ground before stepping down to the ground taking the entire season's snowpack with it.
- **June 6, 2021** – Torreys Peak. A group of six climbers were ascending as a single roped group in an area known Dead Dog Couloir when a section of rock on the climber's right ridge of the couloir detached. This led to the group being showered with rocks and releasing small loose-wet avalanche. Four of the climbers suffered minor injuries; one climber was hit by moving debris and traveled a short distance down the slope. Two other climbers were also struck by rocks. The Clear Creek County Sheriff's department and two Flight for Life helicopters responded to the incident.

4.3.3 Location

The greatest impact from an avalanche is in the western portion of Clear Creek County in the western Front Range Mountains. As noted in the past events above St. Mary's Glacier, Loveland pass, Guanella Pass and areas near Mount Kelso and Mount Evans are common locations for human caused avalanches. Interstate 70 and Highway 40 over Berthoud Pass are also exposed to avalanche risk, and would cause significant impacts, both economic and related to emergency services, to the entire county if a slide was to occur across the highway.

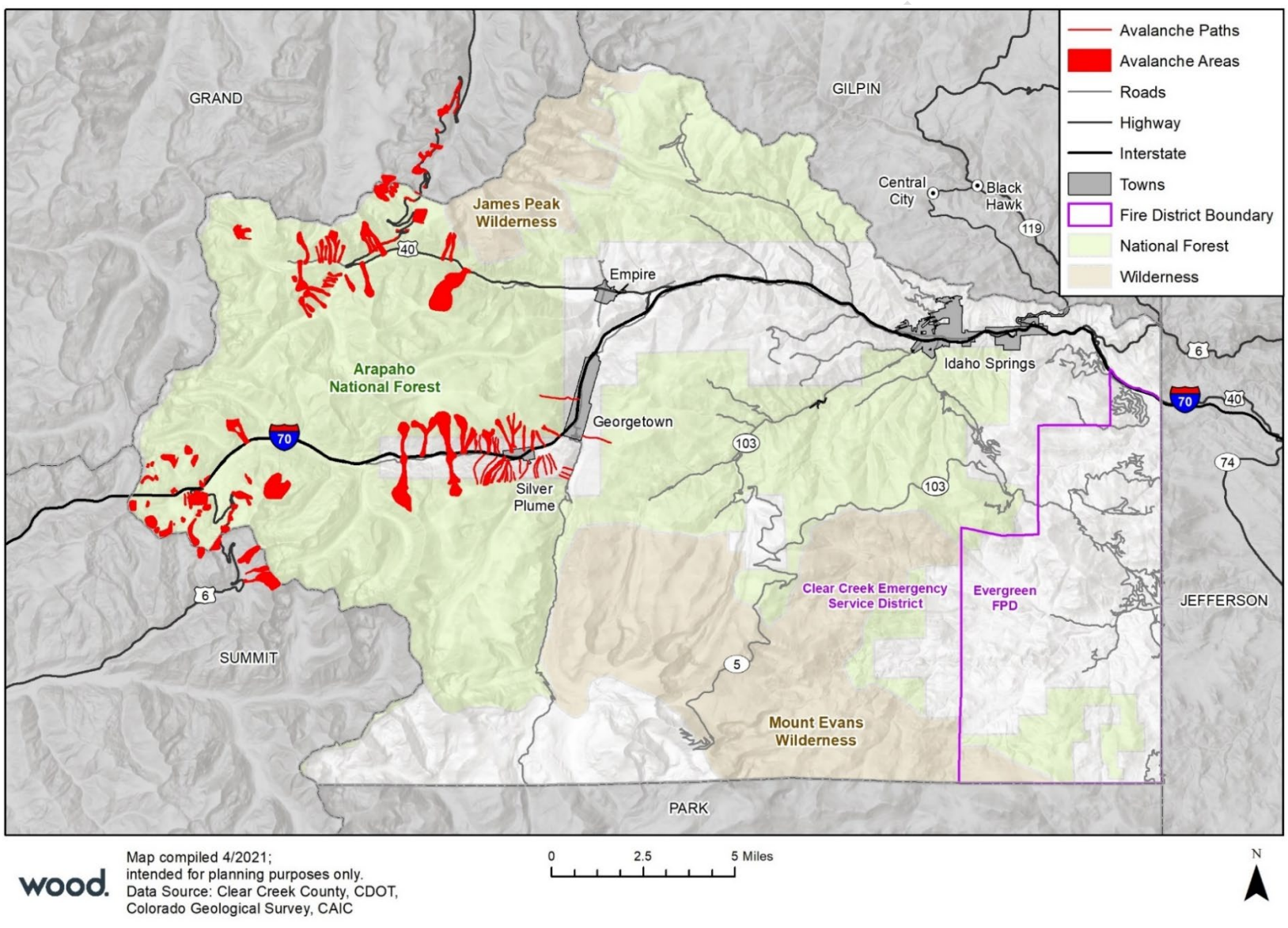
Figure 4-4 shows the CAIC forecast zones in Colorado and Figure 4-5 shows the historic avalanche paths and areas in the County, based on data provided by the CAIC. Note that this mapping is not all encompassing of all avalanche risk areas in the County but is used for planning purposes to give a general idea of risk near transportation corridors, populated areas, or areas frequented by backcountry users.

Figure 4-4: Avalanche Forecast Zones in Colorado



Source: Colorado Avalanche Information Center

Figure 4-5: Clear Creek Avalanche Areas



4.3.4 Magnitude and Severity

A number of weather and terrain factors determine avalanche severity and danger:

- Weather:
  - Storms—A large percentage of all snow avalanches occur during and shortly after storms.
  - Rate of snowfall—Snow falling at a rate of 1 inch or more per hour rapidly increases avalanche danger.
  - Temperature—Storms starting with low temperatures and dry snow, followed by rising temperatures and wetter snow, are more likely to cause avalanches than storms that start warm and then cool with snowfall.
  - Wet snow—Rainstorms or spring weather with warm, moist winds and cloudy nights can warm the snow cover, resulting in wet snow avalanches. Wet snow avalanches are more likely on sun-exposed terrain (south-facing slopes) and under exposed rocks or cliffs.
- Terrain:
  - Ground cover—Large rocks, trees, and heavy shrubs help anchor snow.
  - Slope profile—Dangerous slab avalanches are more likely to occur on convex slopes.
  - Slope aspect—Leeward slopes are dangerous because windblown snow adds depth and creates dense slabs. South-facing slopes are more dangerous in the springtime.
  - Slope steepness—Snow avalanches are most common on slopes of 30 to 45 degrees.

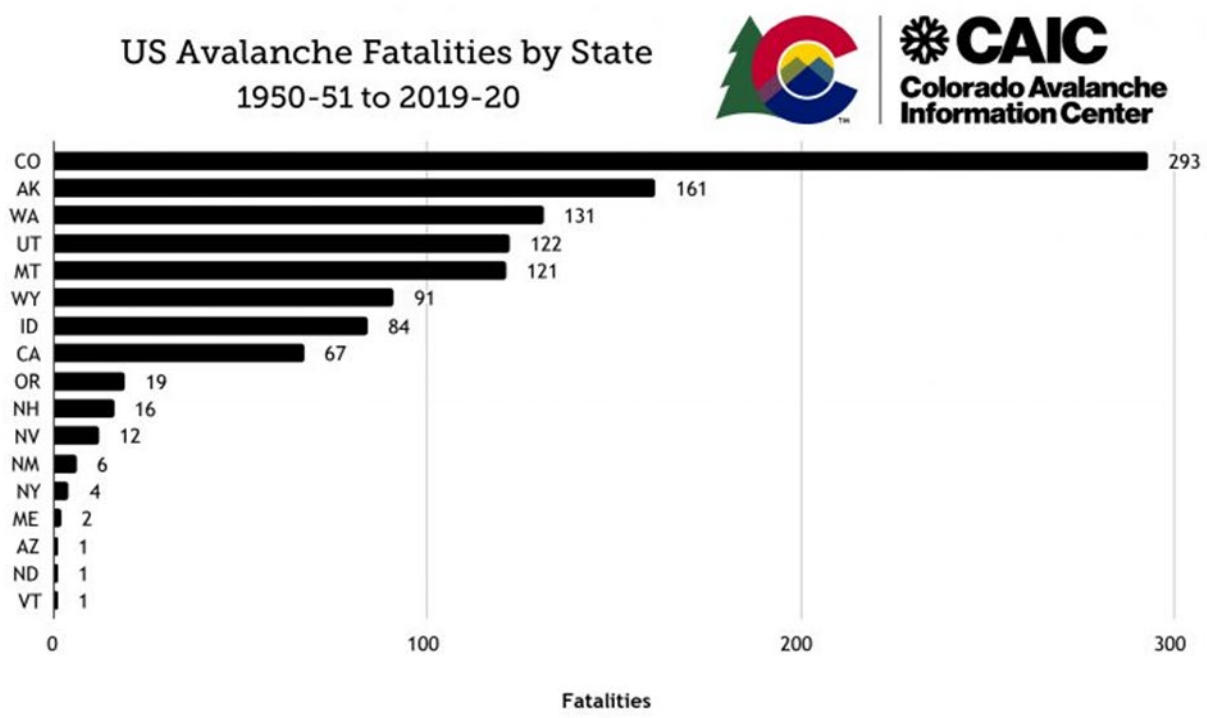
The common factors contributing to the avalanche hazard are old snow depth, old snow surface, new snow depth, new snow type, density, snowfall intensity, precipitation intensity, settlement, wind direction and speed, temperature, and subsurface snow crystal structure.

According to the CAIC, an average of 27 people have died each year in avalanches in the United States over the past 10 winters. Most fatal incidents are investigated and reported; however, non-fatal incidents are likely to go unreported (CAIC). Colorado has recorded the greatest number of fatalities due to avalanches of all states in the United States, total of 293 fatalities in the state since 1951. Colorado has recorded the greatest number of fatalities from avalanches of all states in the United States, as shown in Figure 4-6.

Avalanches can result in injury, death and limited property damage in the County. Closure of I-70 due to avalanche activity can result in serious transportation disruptions as well as limited emergency response capabilities due to the limited number of roads in the County and minimal personnel. Backcountry avalanche incidents involve search and rescue teams and resources, which can put these personnel in areas of risk.

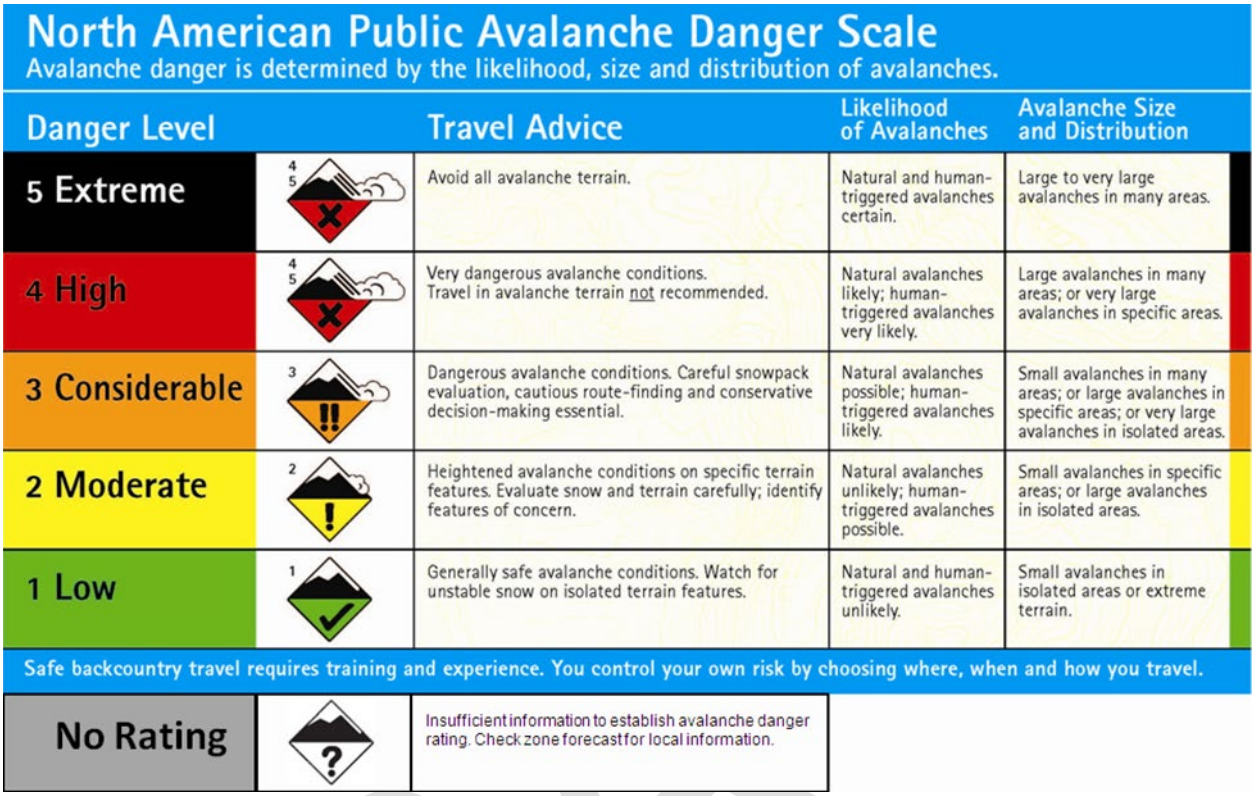
The severity of the avalanche hazard in the county is considered to be moderate with isolated deaths and injuries; minimal property damage that does not threaten structural stability; and or interruption of essential facilities and services for less than 24 hours. Based on the information in this hazard profile, the magnitude/severity of an avalanche, its overall significance is considered to have a high potential impact for the county. The magnitude/severity of an avalanche for the Town of Empire and City of Idaho Springs is minimal compared to the Town of Silver Plume, Town of Georgetown and unincorporated Clear Creek County.

Figure 4-6: Avalanche Fatalities by State, 1950-51 to 2019-20



Source: Colorado Avalanche Information Center Website (http://avalanche.state.co.us/accidents/statistics-and-reporting/)

Figure 4-7: Avalanche Danger Scale



North American Public Avalanche Danger Scale

Avalanche danger is determined by the likelihood, size and distribution of avalanches.

Danger Level	Travel Advice	Likelihood of Avalanches	Avalanche Size and Distribution
5 Extreme	Avoid all avalanche terrain.	Natural and human-triggered avalanches certain.	Large to very large avalanches in many areas.
4 High	Very dangerous avalanche conditions. Travel in avalanche terrain not recommended.	Natural avalanches likely; human-triggered avalanches very likely.	Large avalanches in many areas; or very large avalanches in specific areas.
3 Considerable	Dangerous avalanche conditions. Careful snowpack evaluation, cautious route-finding and conservative decision-making essential.	Natural avalanches possible; human-triggered avalanches likely.	Small avalanches in many areas; or large avalanches in specific areas; or very large avalanches in isolated areas.
2 Moderate	Heightened avalanche conditions on specific terrain features. Evaluate snow and terrain carefully; identify features of concern.	Natural avalanches unlikely; human-triggered avalanches possible.	Small avalanches in specific areas; or large avalanches in isolated areas.
1 Low	Generally safe avalanche conditions. Watch for unstable snow on isolated terrain features.	Natural and human-triggered avalanches unlikely.	Small avalanches in isolated areas or extreme terrain.

Safe backcountry travel requires training and experience. You control your own risk by choosing where, when and how you travel.

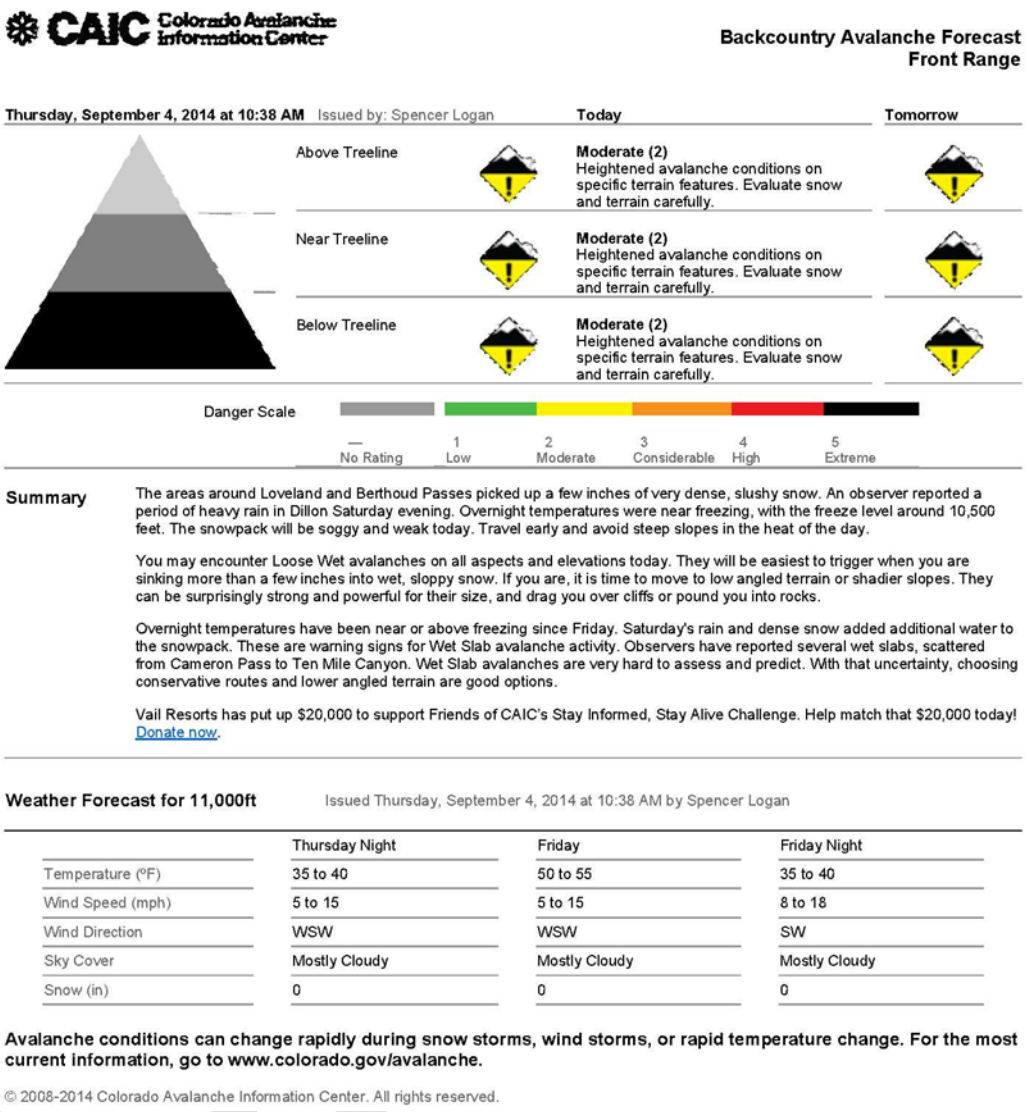
No Rating	Insufficient information to establish avalanche danger rating. Check zone forecast for local information.

Source: Colorado Avalanche Information Center Website (http://avalanche.state.co.us/wp-content/uploads/2013/09/ads.jpg.)

The time of an avalanche release depends on the condition of the snowpack, which can change rapidly during a day and particularly during rainfall. Although forecasts can provide information regarding when avalanches are more likely to occur, an avalanche can occur with little or no warning time.

CAIC issues watches and warnings by zone to communicate avalanche danger levels to those recreating in backcountry areas. The North American Danger Scale, which ranges from low to extreme danger is shown in Figure 4-7. An example of this forecast for the Front Range area is shown in Figure 4-8.

Figure 4-8: Sample Front Range Avalanche Danger Forecast



CAIC Colorado Avalanche Information Center

Backcountry Avalanche Forecast
Front Range

Thursday, September 4, 2014 at 10:38 AM Issued by: Spencer Logan

	Today	Tomorrow
Above Treeline	**Moderate (2)** Heightened avalanche conditions on specific terrain features. Evaluate snow and terrain carefully.	
Near Treeline	**Moderate (2)** Heightened avalanche conditions on specific terrain features. Evaluate snow and terrain carefully.	
Below Treeline	**Moderate (2)** Heightened avalanche conditions on specific terrain features. Evaluate snow and terrain carefully.	

Danger Scale: — No Rating; 1 Low; 2 Moderate; 3 Considerable; 4 High; 5 Extreme

Summary

The areas around Loveland and Berthoud Passes picked up a few inches of very dense, slushy snow. An observer reported a period of heavy rain in Dillon Saturday evening. Overnight temperatures were near freezing, with the freeze level around 10,500 feet. The snowpack will be soggy and weak today. Travel early and avoid steep slopes in the heat of the day.

You may encounter Loose Wet avalanches on all aspects and elevations today. They will be easiest to trigger when you are sinking more than a few inches into wet, sloppy snow. If you are, it is time to move to low angled terrain or shadier slopes. They can be surprisingly strong and powerful for their size, and drag you over cliffs or pound you into rocks.

Overnight temperatures have been near or above freezing since Friday. Saturday's rain and dense snow added additional water to the snowpack. These are warning signs for Wet Slab avalanche activity. Observers have reported several wet slabs, scattered from Cameron Pass to Ten Mile Canyon. Wet Slab avalanches are very hard to assess and predict. With that uncertainty, choosing conservative routes and lower angled terrain are good options.

Vail Resorts has put up $20,000 to support Friends of CAIC's Stay Informed, Stay Alive Challenge. Help match that $20,000 today! Donate now.

Weather Forecast for 11,000ft Issued Thursday, September 4, 2014 at 10:38 AM by Spencer Logan

	Thursday Night	Friday	Friday Night
Temperature (°F)	35 to 40	50 to 55	35 to 40
Wind Speed (mph)	5 to 15	5 to 15	8 to 18
Wind Direction	WSW	WSW	SW
Sky Cover	Mostly Cloudy	Mostly Cloudy	Mostly Cloudy
Snow (in)	0	0	0

Avalanche conditions can change rapidly during snow storms, wind storms, or rapid temperature change. For the most current information, go to www.colorado.gov/avalanche.

Source: Colorado Avalanche Information Center Website (http://avalanche.state.co.us/forecasts/backcountry-avalanche/front-range/)

4.3.5 Probability of Future Occurrence

Based on the information noted under subsection 4.3.2 Past Events, in the past 71 years there have been 33 fatalities in Clear Creek County due to avalanches. This suggests a probability of 46 percent of a fatal avalanche event happening each year, or a fatal avalanche event every 2.2 years. The probability of future occurrence that causes death, injury, or disrupts transportation for Clear Creek County is likely.

4.3.6 Climate Change Considerations

Unlike other phenomena such as tropical storms, snow avalanches are rarely used as indicators of climate change. The effects of climate change on avalanche frequency and magnitude are uncertain and will likely be dependent on local climate change impacts, such as changes in snow fall events and temperature series. Some studies have indicated that the types of avalanche events (wet or dry) may shift as a result of changes in snow cover (Martin et al. 2001). Avalanches, however, are not influenced by snow cover alone,

but several interrelated factors including forest structure, surface energy balance, melt water routing, precipitation, air temperature, and wind (Teich et al. 2012; Eckert 2009; and Lazar and Williams 2008).

Secondary and tertiary impacts of climate change may also alter avalanche events. For example, climate change may modify the distribution of arboreal species across mountain landscapes. Some case studies in the Swiss and French Alps indicate that climate change impacts may reduce the frequency or severity of such events, while other assessments indicate that events may occur more frequently in other mountain regions (Kohler 2009; Teich et al. 2012; and Eckert 2009). No studies assessing the relative frequency and severity of avalanches in the Colorado Rocky Mountain Range were located, but an analysis of wet avalanche hazards in an Aspen ski area indicated that such effects may occur more frequently under high emissions scenarios (Lazar and Williams 2008). Feedback loops affecting snow cover, forest structure, meteorological norms, and land use planning decisions are all likely to influence the future frequency and severity of impacts from avalanche events.

4.3.7 Vulnerability

People

Mountain communities are exposed to avalanche risk; however, the greatest exposure to the avalanche hazard is to persons participating in outdoor recreation in backcountry areas. The greatest impact from an avalanche is to backcountry enthusiasts in the Front Range Mountains of the County. Avalanche control by CDOT mitigates risk to travelers on the major transportation routes of Interstate 70 and Highway 40. The populations of Idaho Springs, Empire, Georgetown, and Silver Plume are always at a small level of avalanche risk, though that risk is minimal.

Property

Avalanche exposure of property in the county is minimal. Towns of Georgetown, Empire, and Silver Plume have the potential for property damage, but damage is still likely to be insignificant.

Critical Facilities and Infrastructure

It is unlikely that there are critical facilities exposed to avalanche hazards, although there may be some facilities exposed in the unincorporated mountain communities. The most critical infrastructure to be exposed to avalanche are Interstate 70 and US Highway 40. Disruption of transportation could cause major impacts to Clear Creek County, the State of Colorado, and potentially areas throughout the Country.

Government Services

Un-planned closure of Interstate 70 and US 40 due to an avalanche event can prevent emergency services vehicles from being able to reach people in need or be able to take them to hospital to receive medical help.

Economy

Avalanche activity inside or outside the county (along connecting roadways) can disrupt transportation in and out of the local communities, which could result in temporary economic impacts. Closures of transportation routes, in particular I-70 and US Hwy 40 into or out of the county could prevent the import and export of goods and services and economic losses for businesses, as well as disrupt tourism.

Historic, Cultural, and Natural Resources

Avalanches are a natural event, but they can negatively affect the environment. This includes trees located on steep slopes. A large avalanche can knock down many trees and kill the wildlife that live in them. In spring, this loss of vegetation on the mountains may weaken the soil, causing landslides and mudflows. If

significant woody debris reaches the valley bottoms this could cause a potential for ponding and flooding. The impact on historic or cultural resources in the County is unknown.

4.3.8 Development Trends

Future trends in development cannot be determined until the avalanche hazard areas are accurately mapped. The population of Clear Creek County is increasing and some of this new development may be occurring in avalanche hazard areas.

4.3.9 Risk Summary

- The overall significance of this hazard for the County is Medium.
- Since 1950 there have been 33 fatalities in the County.
- Backcountry recreationalists, road crews, and motorists along the main roadways are the most at risk to avalanche dangers. Human-caused avalanches are most common cause of events.
- I-70 and US Hwy 40 has been closed due to avalanches, or for avalanche mitigation work and poses some risk to the travelling public and economic impacts due to detours during closures.
- The Towns of Empire, Silver Plume and Georgetown have some limited avalanche exposure.
- Related hazards: Winter Storm, Severe Wind, Drought.

4.4 Dam Incident

DAM INCIDENT HAZARD RANKING	
Clear Creek County	Medium
City of Idaho Springs	Medium
Town of Empire	Medium
Town of Georgetown	Medium
Town of Silver Plume	Low
Clear Creek Fire Authority	Medium

4.4.1 Description

A dam is a barrier constructed across a watercourse that stores, controls, or diverts water. Dams are constructed for a variety of uses, including flood protection, power, agriculture/irrigation, water supply, and recreation. The water impounded behind a dam is referred to as the reservoir and is usually measured in acre-feet, with one acre-foot being the volume of water that covers one acre of land to a depth of one foot. Depending on local topography, even a small dam may have a reservoir containing many acre-feet of water. Dams serve many purposes, including irrigation control, providing recreation areas, electrical power generation, maintaining water levels, and flood control.

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.

Non-Failure Incidents

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.

Dam safety incidents are defined as situations at dams that require an immediate response by dam safety engineers.

Low Head Dams

DEFINITIONS

Dam—A man-made barrier, together with appurtenant structures, constructed above the natural surface of the ground for the purpose of impounding water. Flood control and storm runoff detention dams are included (2-CCR 402-1, Rule 4, Section 4.2.5).

Dam Failure—An uncontrolled release of impounded water due to structural deficiencies in dam.

Emergency Action Plan—A document that identifies potential emergency conditions at a dam and specifies actions to be followed to minimize property damage and loss of life. The plan specifies actions the dam owner should take to alleviate problems at a dam. It contains procedures and information to assist the dam owner in issuing early warning and notification messages to responsible downstream emergency management authorities of the emergency situation. It also contains inundation maps to show emergency management authorities the critical areas for action in case of an emergency. (FEMA 64)

High Hazard Dam—Dams where failure or operational error will probably cause loss of human life. (FEMA 333)

Significant Hazard Dam—Dams where failure or operational error will result in no probable loss of human life but can cause economic loss, environmental damage, or disruption of lifeline facilities, or can impact other concerns. Significant hazard dams are often located in rural or agricultural areas but could be located in areas with population and significant infrastructure. (FEMA 333)

Levee—A man-made structure, usually an earthen embankment or concrete floodwall, designed and constructed in accordance with sound engineering practices to contain, control, or divert the flow of water so as to provide reasonable assurance of excluding temporary flooding from the leveed area.

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 2 low head dams in the County, which are used as diversion or grade control structures. The location of each dam is shown in Figure 4-11.

Causes of Dam Failure

Dam failures in the United States typically occur in one of four ways:

- Overtopping of the primary dam structure, which accounts for 34% of all dam failures, can occur due to inadequate spillway design, settlement of the dam crest, blockage of spillways, and other factors.
- Foundation defects due to differential settlement, slides, slope instability, uplift pressures, and foundation seepage can also cause dam failure. These account for 30% of all dam failures.
- Failure due to piping and seepage accounts for 20% of all failures. These are caused by internal erosion due to piping and seepage, erosion along hydraulic structures such as spillways, erosion due to animal burrows, and cracks in the dam structure.
- Failure due to problems with conduits and valves, typically caused by the piping of embankment material into conduits through joints or cracks, constitutes 10% of all failures.

The remaining 6% of U.S. dam failures are due to miscellaneous causes. Many dam failures in the United States have been secondary results of other disasters. The prominent causes are earthquakes, landslides, extreme storms, massive snowmelt, equipment malfunction, structural damage, foundation failures, and sabotage.

Poor construction, lack of maintenance and repair, and deficient operational procedures are preventable or correctable by a program of regular inspections. Terrorism and vandalism are serious concerns that all operators of public facilities must plan for; these threats are under continuous review by public safety agencies.

Levees

The United States Multi-Hazard (HAZUS-MH) database and the U.S. Army Corp of Engineers (USACE) National Levee Database list no known levees in Clear Creek County.

Regulatory Oversight

The potential for catastrophic flooding due to dam failures led to passage of the National Dam Safety Act (Public Law 92-367). The National Dam Safety Program requires a periodic engineering analysis of every major dam in the country. The goal of this FEMA-monitored effort is to identify and mitigate the risk of dam failure so as to protect the lives and property of the public.

Colorado Rules and Regulations for Dam Safety and Dam Construction

The Colorado Rules and Regulations for Dam Safety and Dam Construction (2-CCR 402-1, January 1, 2007) apply to any dam constructed or used to store water in Colorado. These rules apply to applications for review and approval of plans for the construction, alteration, modification, repair, enlargement, and removal of dams and reservoirs, quality assurance of construction, acceptance of construction, non-jurisdictional dams, safety inspections, owner responsibilities, emergency action plans, fees, and restriction

of recreational facilities within reservoirs. Certain structures (defined in Rule 17) are exempt from these rules. The purpose of the rules is to provide for the public safety through the Colorado Safety of Dams Program by establishing reasonable standards and to create a public record for reviewing the performance of a dam.

U.S. Army Corps of Engineers Dam Safety Program

The USACE is responsible for safety inspections of some federal and non-federal dams in the United States that meet the size and storage limitations specified in the National Dam Safety Act. The USACE has inventoried dams; surveyed each state and federal agency's capabilities, practices, and regulations regarding design, construction, operation and maintenance of the dams; and developed guidelines for inspection and evaluation of dam safety (USACE 1997).

Federal Energy Regulatory Commission Dam Safety Program

The Federal Energy Regulatory Commission (FERC) cooperates with a large number of federal and state agencies to ensure and promote dam safety. More than 3,000 dams are part of regulated hydroelectric projects in the FERC program. Two-thirds of these are more than 50 years old. As dams age, concern about their safety and integrity grows, so oversight and regular inspection are important. FERC inspects hydroelectric projects on an unscheduled basis to investigate the following:

- Potential dam safety problems
- Complaints about constructing and operating a project
- Safety concerns related to natural disasters
- Issues concerning compliance with the terms and conditions of a license

Every 5 years, an independent engineer approved by the FERC must inspect and evaluate projects with dams higher than 32.8 feet (10 meters) or with a total storage capacity of more than 2,000 acre-feet.

FERC monitors and evaluates seismic research and applies it in investigating and performing structural analyses of hydroelectric projects. FERC also evaluates the effects of potential and actual large floods on the safety of dams. During and following floods, FERC visits dams and licensed projects, determines the extent of damage, if any, and directs any necessary studies or remedial measures the licensee must undertake. The FERC publication Engineering Guidelines for the Evaluation of Hydropower Projects guides the FERC engineering staff and licensees in evaluating dam safety. The publication is frequently revised to reflect current information and methodologies.

FERC requires licensees to prepare emergency action plans and conducts training sessions on how to develop and test these plans. The plans outline an early warning system if there is an actual or potential sudden release of water from a dam due to failure. The plans include operational procedures that may be used, such as reducing reservoir levels and reducing downstream flows, as well as procedures for notifying affected residents and agencies responsible for emergency management. These plans are frequently updated and tested to ensure that everyone knows what to do in emergency situations.

4.4.2 Past Events

According to the Association of State Dam Safety Officials, there have been no reported dam failures or incidents in Clear Creek County. Colorado does have a history of dam failure, with more than 130 known dam incidents since 1890. Many dam incidents don't involve a total failure, and according to the National Performance of Dams database from Stanford University there have been 179 total dam incidents in Colorado from 1890 to 2001.

4.4.3 Location

Dam data is from the Colorado Division of Water Resources (CDWR) Dam Safety Branch. The data lists 28 dams in the county and classifies dams based on the potential hazard to the downstream area resulting from failure or mis-operation of the dam or facilities:

- High Hazard Potential—Probable loss of life (one or more).
- Significant Hazard Potential—No probable loss of human life but can cause economic loss, environmental damage, disruption of lifeline facilities, or impact other concerns; often located in predominantly rural or agricultural areas but could be located in areas with population and significant infrastructure.
- Low Hazard Potential—No probable loss of human life and low economic or environmental losses; losses are principally limited to the owner's property.

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. Based on these classifications, there are 11 high hazard dams and 3 significant hazard dams in Clear Creek County. These dams are listed in Table 4-19 with their associated stream, downstream town, the distance to town, the normal storage capability of the dam, its hazard classification, and the date of their Emergency Action Plan as listed with CDWR.

Figure 4-9 and Figure 4-10 show the locations of dams throughout Clear Creek County and the potential inundation from dam incidents. Dam inundation areas were provided by the CDWR and include significant portions of the City of Idaho Springs.

Table 4-19: High and Significant-Hazard Dams in Clear Creek County

Name	Stream	Downstream Town	Town Distance (Miles)	Normal Storage (Acre-Feet)	Overall Conditions	Hazard Class	Date of EAP
Idaho Springs	Chicago Creek	Idaho Springs	9	230	Satisfactory	High	8/16/2018
Upper Cabin Creek	South Clear Creek	Georgetown	4	1,602	N/A*	High	6/21/2017
Lower Cabin Creek	South Clear Creek	Georgetown	3	1,988	N/A*	High	6/21/2017
Clear Lake	South Clear Creek	Georgetown	3	703	N/A*	High	6/21/2017
Upper Beaver Brook	Beaver Brook	Golden	14	397	Satisfactory	High	8/1/2017
Lower Beaver Brook	Beaver Brook	Golden	11	30	Conditionally Satisfactory	High	8/1/2017
Georgetown	South Clear Creek	Lawson	5	386	Satisfactory	High	6/1/2020
Guanella	West Fork of Clear Creek	Empire	0.5	1,340	Satisfactory	High	8/1/2019
Fall River	Fall River	Idaho Springs	8	890	Conditionally Satisfactory	High	10/1/2017
Lower Chinns	Fall River	Idaho Springs	10	108	Satisfactory	High	10/1/2017
Loch Lomond	Fall River	Idaho Springs	9	875	Conditionally Satisfactory	High	1/1/1997
Lower Urad	Woods Creek	Empire	7	252	Satisfactory	Significant	8/1/2019

Name	Stream	Downstream Town	Town Distance (Miles)	Normal Storage (Acre-Feet)	Overall Conditions	Hazard Class	Date of EAP
Green Lake	South Clear Creek	Georgetown	3	96	Satisfactory	Significant	8/21/2018
St. Mary's Lake	Silver Creek	Idaho Springs	9	38	Unsatisfactory	Significant	7/1/2018

Source: Colorado Division of Water Resources, Dam Safety
* Information not available

As of May 2021, the State Engineer has rated St. Mary's Lake Dam as unsatisfactory, meaning it has storage restrictions due to structural concerns. Three other dams – Lower Beaver Brook, Fall River, and Loch Lomond – are rated as conditionally satisfactory and also have storage restrictions.

There are an uncounted number of 'non-jurisdictional' dams on public and private lands in the county. These are small dams that normally do not store water but may impound water during heavy precipitation events. Because they are not monitored or maintained, there is potential for them to overtop or fail and cause flooding and property damage during a significant rainfall event. The extent and risk associated with these dams is not known.

The areas of the county most likely to be impacted by a dam failure are along Clear Creek. Eleven high and three significant-hazard dams could impact the Towns of Empire and Georgetown, and the City of Idaho Springs.

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 4-20. 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 4-20: Dams with Risk of Non-Failure Inundation

Name	Dam ID	Outlet Description	Max Outlet Release Capacity (cfs)	Ranking	Outlet Release Hazard Rating
Georgetown	070132	48" & 24" CMP	275	112	HIGH
Lower Cabin Creek	070110	21" & 36" gates in 6' CMPs(2)	549	14	HIGH
Fall River	070129	24" DIP	88	169	MODERATE

Name	Dam ID	Outlet Description	Max Outlet Release Capacity (cfs)	Ranking	Outlet Release Hazard Rating
Guanella	070318	54-inch diameter steel pipe encased in concrete - controlled by 24-inch square slide gate	73	183	MODERATE
Idaho Springs	070111	20" Steel	16	231	MODERATE
Clear Lake	070117	24" PVC conduit grouted inside 4' steel tunnel replaced 2- 16" section in 1997, upper and lower riveted steel sections are lined with InSituform	42	342	LOW
Loch Lomond	070210	21" Concrete	60	367	LOW
Lower Beaver Brook	070102	2-14" Steel in Rock Tunnel	50	362	LOW
Lower Chinns	070113	15" PVC	16	367	LOW
Upper Beaver Brook	070103	24" DIP	72	367	LOW
Upper Cabin Creek	070109	15FT Tunnel (penstock)	0.01	359	LOW

Source: Colorado Division of Water Resources, Dam Safety

Figure 4-9: Dams in Clear Creek County

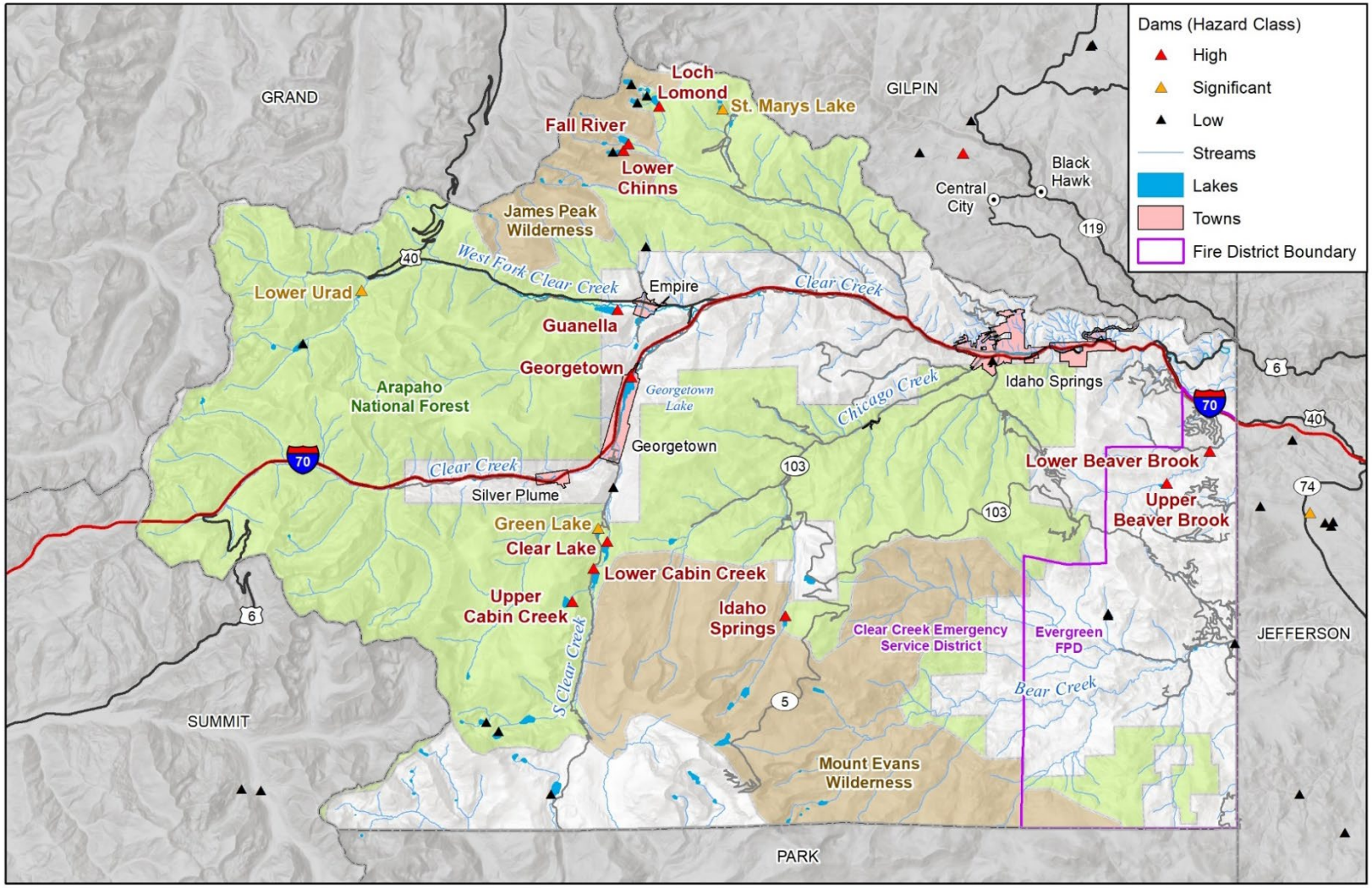


Figure 4-10: Dams with Inundation Areas within Clear Creek County

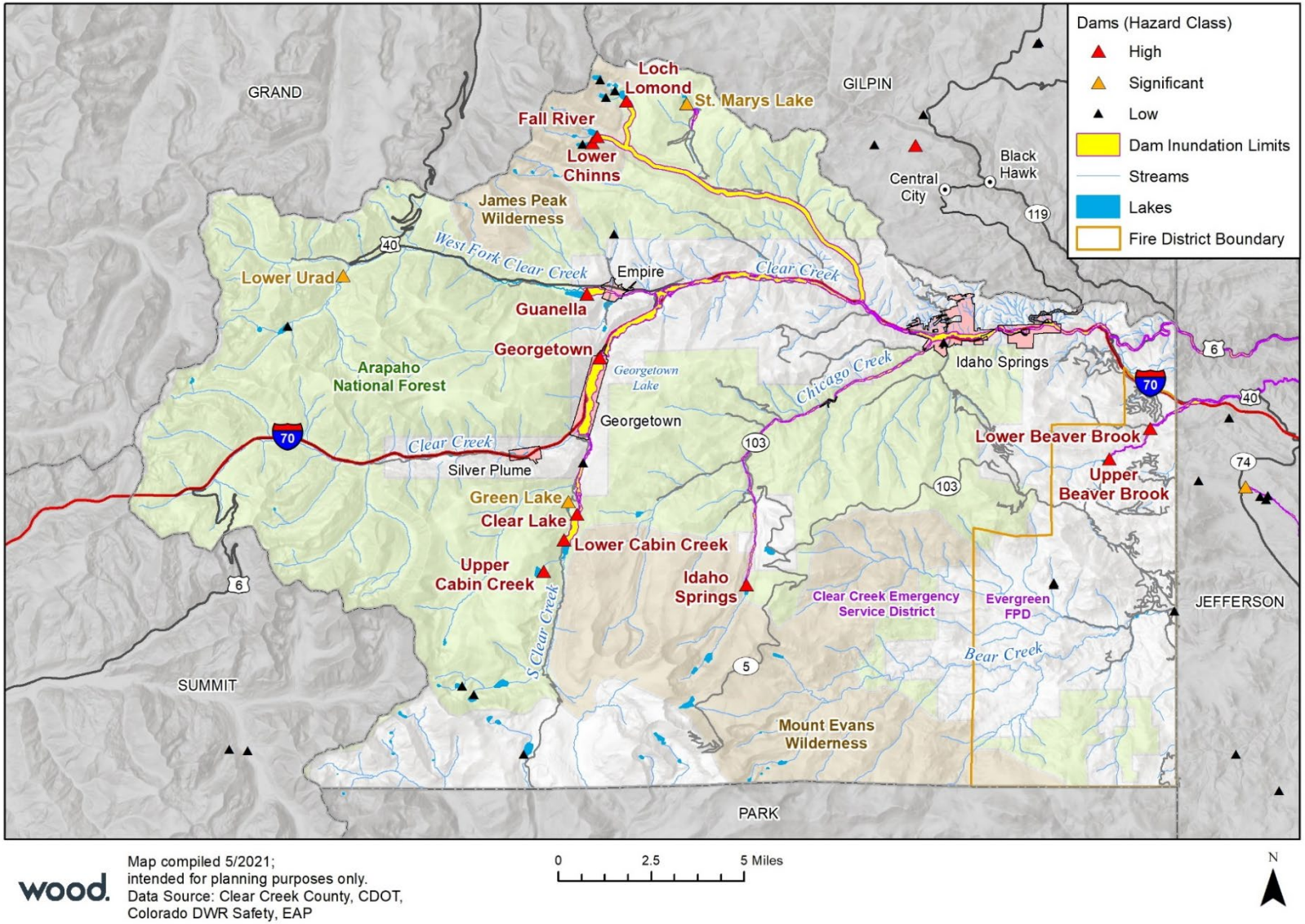
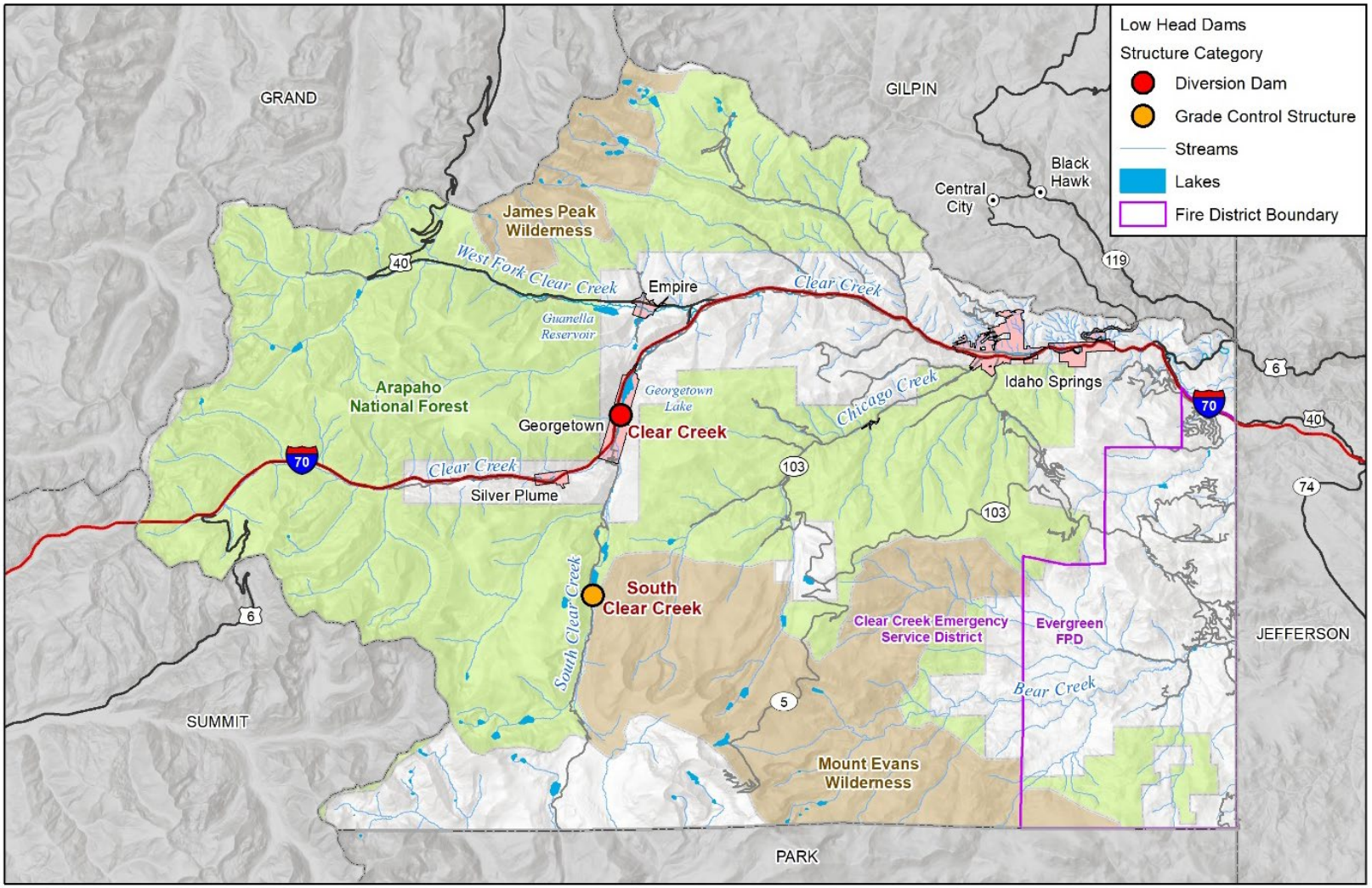


Figure 4-11: Low Head Dams in Clear Creek County



Map compiled 3/2021;
intended for planning purposes only.
Data Source: Clear Creek County, CDOT, Colorado Dept. of Natural Resources

4.4.4 Magnitude and Severity

As noted above, dams are classified as High Hazard Potential if failure is likely to result in loss of life, or Significant Hazard Potential if failure is likely to cause property damage, economic loss, environmental damage, or disruption of lifeline facilities.

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 Clear Creek 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.

There have been no recorded occurrences of dam failures in Clear Creek County in the past 80 years. According to the National Performance of Dams Program Database from Stanford University, there have been four non-failure dam incidents and high and significant hazard dams in Clear Creek County.

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). A failure of any dam in Clear Creek County would further impact the dams and cities of the Denver Metropolitan area located further downstream.

4.4.5 Probability of Future Occurrence

The probability of future occurrences is unlikely. There have been no dam failures recorded in Clear Creek County, and only four reported non-failure incidents over a 65-year period. This results in an approximate 6% chance of a dam incident in any given year. Therefore, the probability of a failure or incident in the future is minimal.

Warning time for dam failure varies depending on the cause of the failure. In events of extreme precipitation or massive snowmelt, evacuations can be planned with sufficient time. In the event of a structural failure due to earthquake, there may be no warning time. A dam's structural type also affects warning time. Earthen dams do not tend to fail completely or instantaneously. Once a breach is initiated discharging water erodes the breach until either the reservoir water is depleted, or the breach resists further erosion. Concrete gravity dams also tend to have a partial breach as one or more monolith sections are forced apart by escaping water. The time of breach formation ranges from a few minutes to a few hours (USACE 1997).

4.4.6 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.

With a potential for increases in extreme precipitation events due to climate change, dam failure and dam incidents could become a larger issue if increased rainfall events result in large floods that stress dam infrastructure. Dams are designed partly based on assumptions about a river's flow behavior, expressed as hydrographs. Changes in weather patterns can have significant effects on the hydrograph used for the

design of a dam. If the hydrograph changes, it is conceivable that the dam can lose some or all of its designed margin of safety, also known as freeboard. If freeboard is reduced, dam operators may be forced to release increased volumes earlier in a storm cycle in order to maintain the required margins of safety. Such early releases of increased volumes can increase flood potential downstream. Throughout the west, communities downstream of dams have historically experienced increases in stream flows from earlier dam releases.

4.4.7 Vulnerability

While dam failures are unlikely, a major failure could have severe consequences. Structures, aboveground infrastructure, critical facilities, and natural environments are all vulnerable to dam failure. Roads closed due to dam failure floods could result in serious transportation disruptions due to the limited number of roads in the county. Information for the exposure analysis provided in the sections below is based off dam inundation data provided by the state. These areas are indicated in Figure 4-10.

The most significant issue associated with dam failure involves the properties and populations in the inundation areas. Flooding as a result of a dam failure would significantly impact these areas. There is often limited warning time for dam failure. These events are frequently associated with other natural hazard events such as earthquakes, landslides or severe weather, which limits their predictability and compounds the hazard.

Population

The population impacted by dam failure was estimated using the structure count of buildings within the dam inundation area and applying the U.S. Census value of 2.23 persons per household for Clear Creek County. A significant portion of the City of Idaho Springs, and Towns of Empire and Georgetown are within dam inundation zones. Approximately 2,505 people are exposed within the dam inundation areas in the county.

Vulnerable populations are all populations downstream from dam failures that are incapable of escaping the area within the allowable timeframe. This population includes the elderly and young who may be unable to get themselves out of the inundation area. The vulnerable population also includes those who would not have adequate warning from a television or radio emergency warning system.

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 dam's 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 and number of visitors increases in Colorado and in Clear Creek County there is the potential for increased fatalities from low head dams.

Property

Vulnerable properties are those within and close to the dam inundation area. These properties would experience the largest, most destructive surge of water. Low-lying areas are also vulnerable since they are where the dam waters would collect.

Communities located below a high or significant hazard dam and along a waterway are potentially exposed to the impacts of a dam failure. High hazard dams threaten lives and property, while significant hazard dams threaten property only. Inundation maps that identify anticipated flooded areas (which may not

coincide with known floodplains) are produced for many high hazard dams. Six of the high or significant hazard dams contained dam inundation extents in spatial form that were analyzed to quantify risk across the planning area. Table 4-21 displays the number of structures in dam inundation areas within the county and their values. Total building exposure numbers were based off 2021 county assessor data.

Table 4-21: Clear Creek County Structures Within Dam Inundation Areas, By Jurisdiction and Property Types

Jurisdiction	Property Type	Improved Parcels	Building Count	Improved Value	Content Value	Total Value
Empire	Mining	1	1	$150	$150	$300
	Residential	11	11	$339,780	$169,890	$509,670
	Total	**11**	**11**	**$339,780**	**$169,890**	**$509,670**
Georgetown	Commercial	29	34	$1,216,510	$1,216,510	$2,433,020
	Exempt	22	29	$1,350,690	$1,350,690	$2,701,380
	Residential	494	553	$31,202,810	$15,601,405	$46,804,215
	Improved Vacant	15	15	$497,450	$497,450	$994,900
	Total	**560**	**631**	**$34,267,460**	**$18,666,055**	**$52,933,515**
Idaho Springs	Commercial	67	87	$4,370,340	$4,370,340	$8,740,680
	Exempt	39	43	$2,412,920	$2,412,920	$4,825,840
	Industrial	1	1	$7,040	$10,560	$17,600
	Mining	1	1	$30	$30	$60
	Residential	270	324	$11,810,750	$5,905,375	$17,716,125
	Improved Vacant	5	7	$101,030	$101,030	$202,060
	Total	**383**	**463**	**$18,702,110**	**$12,800,255**	**$31,502,365**
Unincorporated	Commercial	15	21	$2,033,730	$2,033,730	$4,067,460
	Exempt	30	51	$5,540,570	$5,540,570	$11,081,140
	Mining	10	11	$4,139,860	$4,139,860	$8,279,720
	Residential	263	338	$13,590,930	$6,795,465	$20,386,395
	Improved Vacant	9	10	$175,820	$175,820	$351,640
	Total	**327**	**431**	**$25,480,910**	**$18,685,445**	**$44,166,355**
	Grand Total	**1,281**	**1,536**	**$78,790,260**	**$50,321,645**	**$129,111,905**

Source: Clear Creek County Assessor, DWR, EAP, Wood Analysis

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. Transportation routes are vulnerable to dam inundation and have the potential to be wiped out, creating isolation issues. Roads closed due to floods caused by dam failure or incident could result in serious transportation disruptions due to the limited number of roads in the county. Those that are most vulnerable are those that are already in poor condition and would not be able to withstand a large water surge. Utilities such as overhead power lines, cable and phone lines could also be vulnerable. Loss of these utilities could create additional isolation issues for the inundation 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 4-22: Dam Inundation Exposure in Clear Creek County by Jurisdiction, Lifeline & Facility Type

Jurisdiction	FEMA Lifeline	Facility Type	Count
Georgetown	Communications	Communications	4
	Energy	Substation Power Plant	1
	Food, Water, Shelter	Community Center	1
		Wastewater Treatment Facility	1
	Hazardous Material	Hazmat	4
		Tier II	1
	Health and Medical	Emergency Air Transportation	1
	Safety and Security	EOC	1
		Fire Station	1
		Government Building	3
		Police	1
		School	1
		Sheriff	1
	Transportation	Bridge	6
		Total	**27**
Idaho Springs	Communications	Communications	2
	Food, Water, Shelter	Recreation Center	1
		Water Facility	2
	Hazardous Material	Hazmat	5
		Tier II	1
	Health and Medical	Clinic	1
		Emergency Air Transportation	1
		EMS	2
		Health Clinic	1
	Safety and Security	Government Building	2
		Police	1
		School	1
	Transportation	Bridge	16
		Total	**36**
Unincorporated	Communications	Communications	1
	Energy	Water Electric Plant	2
	Food, Water, Shelter	Wastewater Treatment Facility	2
	Health and Medical	Emergency Air Transportation	4
		EMS	1
	Safety and Security	Fire Station	1
		Government Building	1
	Transportation	Bridge	30

Jurisdiction	FEMA Lifeline	Facility Type	Count
		Total	42
		Grand Total	105

Source: Clear Creek County, National Inventory of Dams, HIFLD, DWR, EAP, Wood Analysis

Government Services

Impacts to transportation corridors and communications lines resulting from a dam incident could affect first responders' ability to effectively respond. Isolated areas cutoff from the rest of the County due to transportation route impacts could make search and rescue efforts difficult. Damage to facilities/personnel in incident area may require temporary relocation of some operations. Regulatory waivers may be needed locally. Fulfillment of some contracts may be difficult. The public may question local government's ability to respond and recover if planning, response, and recovery are not timely and effective, regardless of the dam owner.

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. 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. A dam failure can have long lasting economic impacts and could deter visitors for a period of time.

Historic, Cultural, and Natural Resources

Reservoirs held behind dams affect many ecological aspects of a river. River topography and dynamics depend on a wide range of flows, but rivers below dams often experience long periods of very stable flow conditions or saw-tooth flow patterns caused by releases followed by no releases. Water releases from dams usually contain very little suspended sediment; this can lead to scouring of riverbeds and banks.

The environment would be vulnerable to a number of risks in the event of dam failure. The inundation could introduce many foreign elements into local waterways, potentially causing the destruction of downstream habitats.

4.4.8 Development Trends

The vulnerability to dam failure could increase if development occurs in inundation areas downstream of dams. Often these inundation areas are not shown on plat or planning maps or NFIP maps and thus are not regulated. This type of development can change the designation of a dam from low to high hazard. Guiding future land use and growth through the county and municipal comprehensive plans and zoning ordinances may help reduce future risk and exposure. Flood-related policies in the comprehensive plans will help to reduce the risk associated with the dam failure hazard for all future development in the planning area.

4.4.9 Risk Summary

The most significant issue associated with dam failure involves the properties and populations in the inundation areas. Flooding as a result of a dam failure would significantly impact these areas. There is often limited warning time for dam failure. These events are frequently associated with other natural hazard events such as earthquakes, landslides, or severe weather, which limits their predictability and compounds the hazard. Important issues associated with dam failure hazards include the following:

- The overall significance of this hazard for the County is Medium.

- While an incident or failure is a low probability, the presence of eleven high hazard and three significant hazard dams in the County do pose a risk.
- Approximately 2,505 people are exposed within the dam inundation areas in the County.
- Approximately 1,536 buildings are exposed within the dam inundation areas in the County.
- A dam failure and loss of water from a critical reservoir or structure could include direct and indirect business and industry damages or disruption of the local economy and key county resources (e.g. potable water).
- Related hazards: Flooding, Earthquake, Landslide, Erosion

4.5 Drought and Extreme Heat

DROUGHT AND EXTREME HEAT HAZARD RANKING		
	Drought	Extreme Heat
Clear Creek County	Medium	Low
City of Idaho Springs	Medium	Low
Town of Empire	High	Low
Town of Georgetown	Medium	No Exposure
Town of Silver Plume	Medium	Low
Clear Creek Fire Authority	Medium	Low

DEFINITIONS

Drought—The cumulative impacts of several dry years on water users. It can include deficiencies in surface and subsurface water supplies and generally impacts health, well-being, and quality of life.

Extreme Heat— Summertime weather that is substantially hotter or more humid than average for a location at that time of year.

4.5.1 Description

Drought

Drought is a normal phase in the climatic cycle of most geographical areas. According to the National Drought Mitigation Center (NDMC), drought originates from a deficiency of precipitation over an extended period, usually a season or more. This results in a water shortage for some activity, group, or environmental sector. Drought is the result of a significant decrease in water supply relative to what is "normal" in a given location. Unlike most disasters, droughts normally occur slowly but last a long time. There are four generally accepted operational definitions of drought (National Drought Mitigation Center 2006):

- **Meteorological** drought is an expression of precipitation's departure from normal over some period of time. Meteorological measurements are the first indicators of drought. Definitions are usually region-specific and based on an understanding of regional climatology. A definition of drought developed in one part of the world may not apply to another, given the wide range of meteorological definitions.
- **Agricultural** drought occurs when there is not enough soil moisture to meet the needs of a particular crop at a particular time. Agricultural drought happens after meteorological drought but before hydrological drought. Agriculture is usually the first economic sector to be affected by drought.
- **Hydrological** drought refers to deficiencies in surface and subsurface water supplies. It is measured as stream flow and as lake, reservoir, and groundwater levels. There is a time lag between lack of rain and less water in streams, rivers, lakes, and reservoirs, so hydrological measurements are not the earliest indicators of drought. After precipitation has been reduced or deficient over an extended period of time, this shortage is reflected in declining surface and subsurface water levels. Water supply is controlled not only by precipitation, but also by other factors, including evaporation (which is increased by higher than normal heat and winds), transpiration (the use of water by plants), and human use.
- **Socioeconomic** drought occurs when a physical water shortage starts to affect people, individually and collectively. Most socioeconomic definitions of drought associate it with the supply and demand of an economic good.

Droughts originate from a deficiency of precipitation resulting from an unusual weather pattern. If the weather pattern lasts a short time (a few weeks or a couple months), the drought is considered short-term. If the weather pattern becomes entrenched and the precipitation deficits last for several months or years, the drought is considered to be long-term. It is possible for a region to experience a long-term circulation pattern that produces drought, and to have short-term changes in this long-term pattern that result in short-

term wet spells. Likewise, it is possible for a long-term wet circulation pattern to be interrupted by short-term weather spells that result in short-term drought.

Precipitation, as snowmelt runoff, is the main source of Colorado's water supply. Annual precipitation in the populated areas of the planning area is approximately 11 to 15 inches per year. According to the 2018 Colorado State Drought Mitigation and Response Plan, "there are no major rivers that flow into Colorado (McKee et al. 1999). There are several major river basins originating in the Colorado Rockies, which flow out of the state, providing water to much of the southwestern United States, and contributing to the Missouri and Mississippi Rivers as well. Thus, Colorado earns its title as "the Mother of Rivers" (CWCB 2013). This supply is stored in five forms throughout the state: snowpack, streamflow, reservoir water, soil moisture, and groundwater (McKee and others 2000).

Defining when drought begins is a function of the impacts of drought on water users and includes consideration of the supplies available to local water users as well as the stored water they may have available in surface reservoirs or groundwater basins. Different local water agencies have different criteria for defining drought conditions in their jurisdictions. Some agencies issue a drought watch or drought warning announcements to their customers. Determinations of regional or statewide drought conditions are usually based on a combination of hydrologic and water supply factors.

Droughts are climatic patterns that occur over long periods of time. Only generalized warnings can take place due to the numerous variables that affect drought conditions. Scientists do not currently know how to predict drought more than a month in advance for most locations, with predictions relying on the ability to forecast precipitation and temperature. Anomalies of precipitation and temperature may last from several months to several decades. How long they last depends on interactions between the atmosphere and the oceans, soil moisture and land surface processes, topography, internal dynamics, and the accumulated influence of weather systems on the global scale. Although the ability to predict drought in advance is limited, drought conditions can be monitored through these variables, and the slow-onset nature of drought allows ample time to issue warnings and water restrictions if needed as drought severity increases.

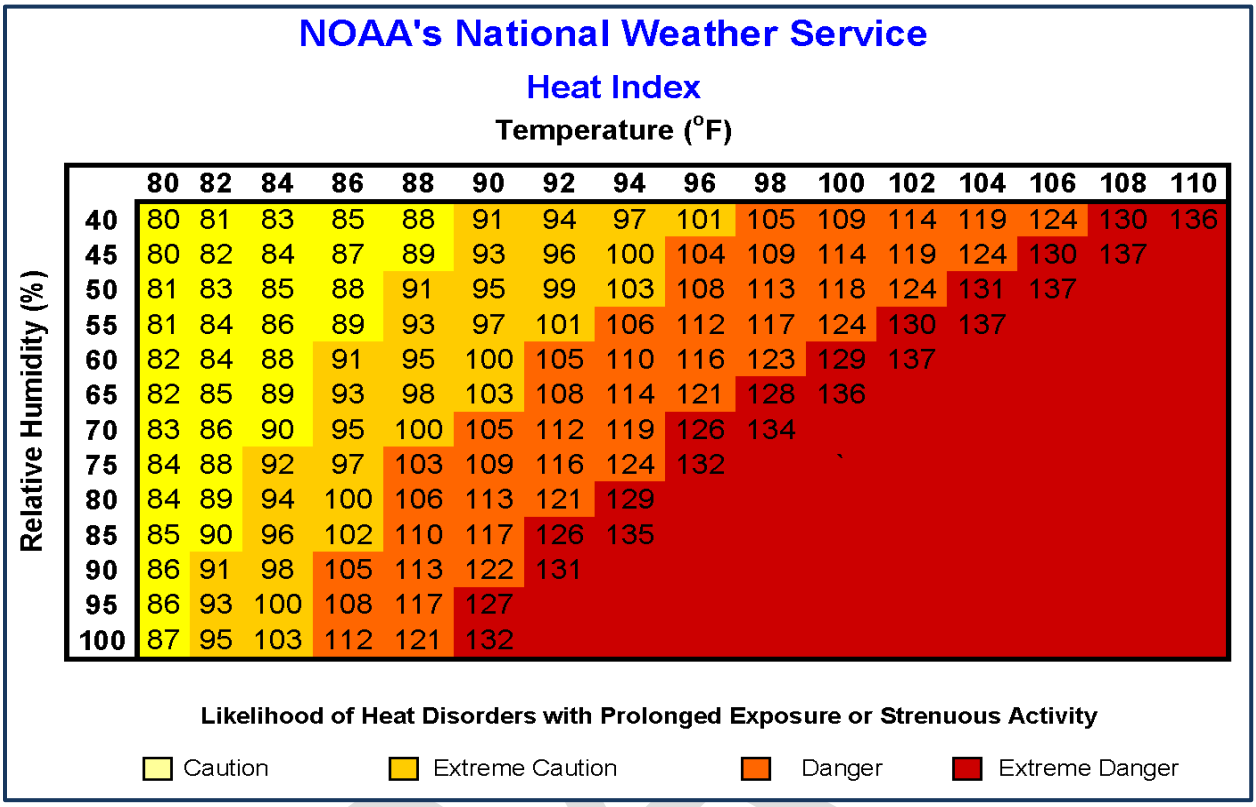
Colorado is semi-arid; thus, drought is a regular and natural occurrence in the state. The main source of water supply in the state is precipitation and much of this occurs in the winter as snowfall. Although drought conditions are difficult to predict, low levels of winter snowpack may act as an indicator that drought conditions are occurring.

Extreme Heat

Extreme heat events are defined by the Colorado State Hazard Mitigation Plan 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." Criteria that define an excessive heat event may differ among jurisdictions and in the same jurisdiction depending on the time of year. Extreme heat events are often a result of more than just ambient air temperature. Heat index tables (see Figure 4-12) provide information about how hot it feels based on the interactions between temperature and relative humidity. Since heat index values were devised for shady, light wind conditions, exposure to full sunshine can increase heat index values by up to 15 degrees Fahrenheit (°F). Also, strong winds, particularly with very hot, dry air, can be extremely hazardous.

NOAA and the National Weather Service issue watch, warning and advisory information for extreme heat. Meteorologists can often forecast extreme heat days.

Figure 4-12: Heat Index Table



The National Weather Service (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.

4.5.2 Past Events

Drought

Colorado has experienced multiple severe droughts. Colorado has experienced drought in 2020, 2018, 2011-2013, 2006-2004, 1996, 1994, 1990, 1989, 1975-1979, 1963-1965, 1951-1957, 1931-1941, and 1893-1905 (Colorado Drought Mitigation and Response Plan, 2018). The most significant are listed in Table 4-23. Although drought conditions can vary across the state, it is likely that Clear Creek County was affected during these dry periods.

Table 4-23: 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

Date	Dry	Wet	Duration (years)
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
2011-2013*	X		2
2018-2019**	X		2

Notes:
Source: McKee, et al. 1999
*modified for 2018 State of Colorado Drought Mitigation and Response Plan Update based on input from the Colorado Climate Center
**Modified for 2021 Clear Creek HMP update

From 2012 to 2021, Clear Creek County received six USDA Disaster Declarations for drought, with designations as a primary County in 2012, 2019, and 2021 and designations as a contiguous County in 2013, 2018, and 2020.

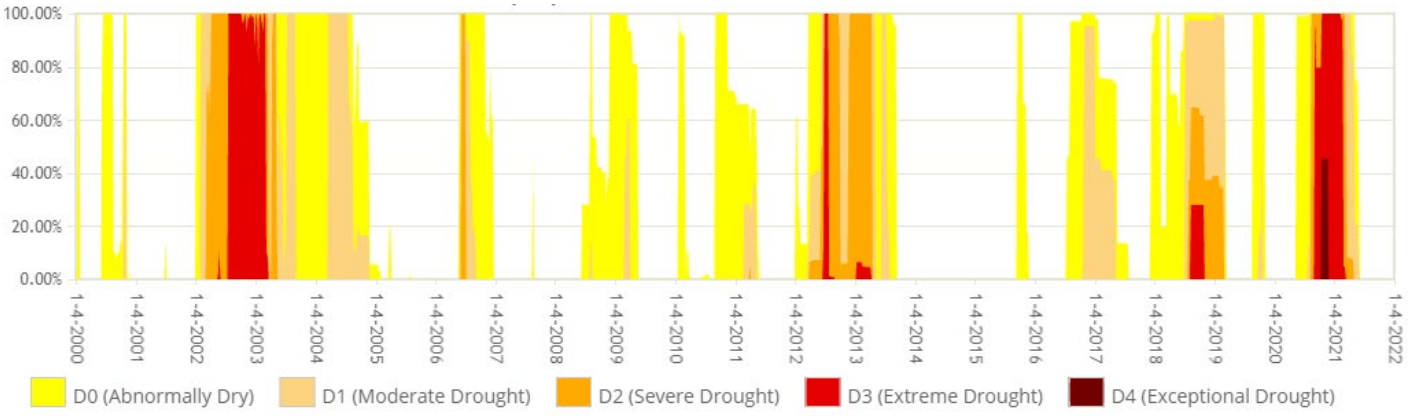
Drought is a regular and widespread occurrence in the State of Colorado. According to the U.S. Drought Monitor records for Clear Creek County, in the 1,095-week period from January 1, 2000 through December 31, 2020, the county spent 596 weeks (54% of the time) in some level of drought, defined as Abnormally 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 4-24 and shown in time series in Figure 4-13.

Table 4-24: Clear Creek County Weeks in Drought by Intensity, 2000-2020

Category	Description	Palmer Drought Severity Index (PDSI)	Standardized Precipitation Index (SPI)	Clear Creek County Weeks in Drought, 2000-Jan. 4, 2021
D0	Abnormally Dry	-1.0 to -1.9	-0.5 to -0.7	596
D1	Moderate Drought	-2.0 to -2.9	-0.8 to -1.2	344
D2	Severe Drought	-3.0 to -3.9	-1.3 to -1.5	174
D3	Extreme Drought	-4.0 to -4.9	-1.6 to -1.9	91
D4	Exceptional Drought	-5.0 or less	-2.0 or less	6

Source: U.S. Drought Monitor

Figure 4-13: Clear Creek County Drought Intensity, 2000-2020



Source: U.S. Drought Monitor

The NDMC developed the Drought Impact Reporter in response to the need for a national drought impact database for the United States. Information comes from a variety of sources: on-line, drought-related news stories and scientific publications, members of the public who visit the website and submit a drought-related impact for their region, members of the media, and members of relevant government agencies. The database is being populated beginning with the most recent impacts and working backward in time. The Drought Impact Reporter contains information on 148 impacts from droughts that affected the entire State of Colorado and 26 impacts for Clear Creek County for the 20-year period from January 2001 through December 2020. Table 4-25 summarized the drought impacts reported by category and years reported for Clear Creek County. Note that some impacts are assigned to more than one category.

Table 4-25: Reported Drought Impacts in Clear Creek County, 2001-2020

Drought Impact Category	Count of Impacts	Years Reported
Agriculture	4	2020, 2013, 2012
Business & Industry	3	2018, 2017, 2010
Fire	9	2020, 2019, 2018, 2015, 2012
Plants & Wildlife	6	2020, 2018, 2012, 2010
Relief, Response & Restrictions	15	2020, 2019, 2018, 2015, 2013, 2012, 2008, 2006
Society & Public Health	3	2012
Tourism & Recreation	5	2018, 2017, 2012
Water Supply & Quality	5	2020, 2018, 2012

Source: National Drought Mitigation Center Drought Impact Reporter

Based on these NDMC records, Clear Creek County experienced impacts of drought in 10 of the last 20 years. NOAA's NCEI database also records four incidents of drought from 2000 through 2020; however, these records are all related to wildfire events partially precipitated by drought.

Extreme Heat

According to data from the Western Regional Climate Center for the Georgetown, CO weather station (053261) for the period of record from 1983-2016, the extreme maximum temperature in June and July is 92°F and the average number of days above 90°F is 0.1 in June and July. From 1995 through 2020, no days with temperatures above 90°F were recorded. Thus, the temperature in the county rarely exceeds 90°F. Table 4-26 summarizes temperature data related to extreme heat for the station.

Table 4-26: Temperature Data at Clear Creek Weather Station (Georgetown, CO 053261) (1893-2016)

	Jan.	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Temperature (degrees Fahrenheit)												
Average Maximum Temperature	36.4	37.8	42.7	50.6	60.9	72.1	77.9	75.2	68.6	57.8	44.9	36.6
Average Minimum Temperature	15.6	15.9	19.6	26.4	34.6	42.1	48.7	46.8	39.7	31.5	22.6	16.3
Average Temperature	26.2	26.8	31.6	38.2	47.6	57.4	63.3	61.0	54.4	44.5	34.0	26.5
Extreme Temperatures (degrees Fahrenheit)												
Extreme Maximum Temperature	60	62	68	76	83	92	92	89	86	81	70	60
Average Number of Days												
Maximum Temperature above 90 degrees Fahrenheit	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.0	0.0	0.0	0.0	0.0

Source: Western Regional Climate Center

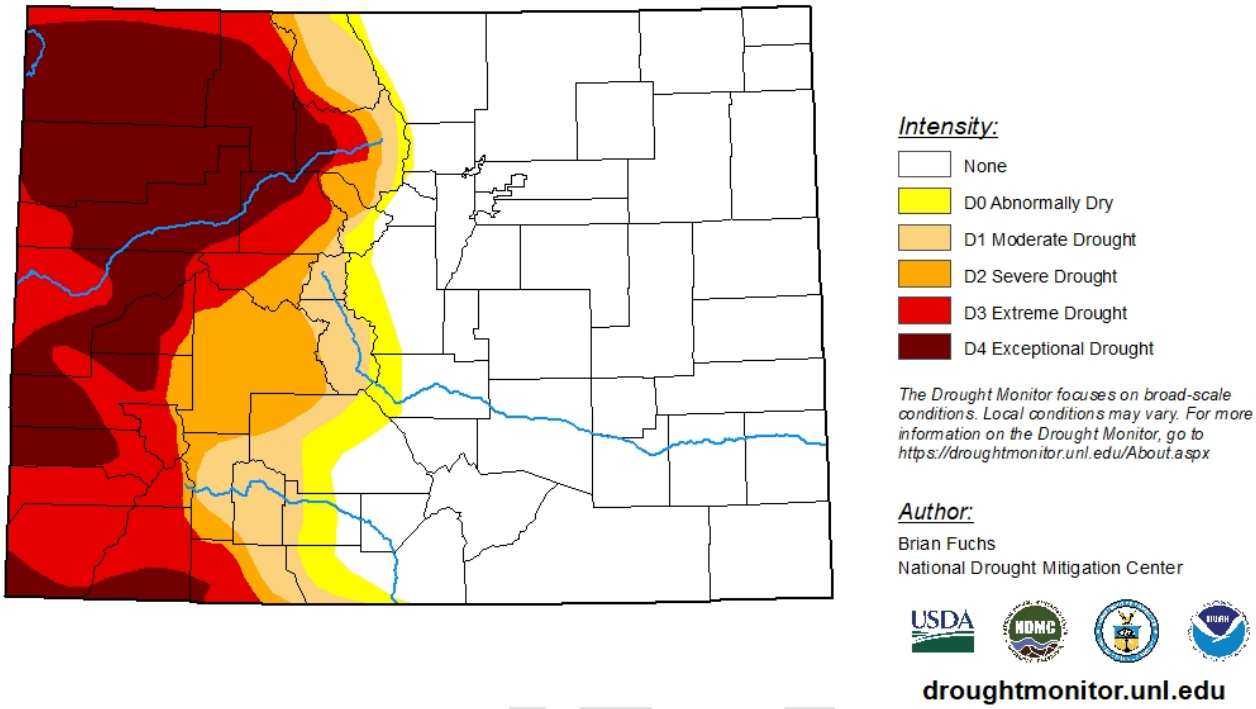
4.5.3 Location

Drought

The National Oceanic and Atmospheric Administration (NOAA) has developed several indices to measure drought impacts and severity and to map their extent and locations:

- The Palmer Crop Moisture Index measures short-term drought on a weekly scale and is used to quantify drought's impacts on agriculture during the growing season.
- The Palmer Z Index measures short-term drought on a monthly scale.
- The Palmer Drought Index (PDI) measures the duration and intensity of long-term, drought-inducing circulation patterns. Long-term drought is cumulative, so the intensity of drought during a given month is dependent on the current weather patterns plus the cumulative patterns of previous months. Weather patterns can change quickly from a long-term drought pattern to a long-term wet pattern, and the PDI can respond fairly rapidly.
- The hydrological impacts of drought (e.g., reservoir levels, groundwater levels, etc.) take longer to develop and it takes longer to recover from them. The Palmer Hydrological Drought Index (PHDI), another long-term index, was developed to quantify hydrological effects. The PHDI responds more slowly to changing conditions than the PDI.
- While the Palmer indices consider precipitation, evapotranspiration and runoff, the Standardized Precipitation Index (SPI) considers only precipitation. In the SPI, an index of zero indicates the median precipitation amount; the index is negative for drought and positive for wet conditions. The SPI is computed for time scales ranging from 1 to 24 months.
- U.S. Drought Monitor releases maps every Thursday showing the areas of the United States that are in drought. Five classifications areas used: abnormally dry, areas that may be going into or coming out of drought, and then four levels of drought, moderate, severe, extreme and exceptional. The Drought Monitor is a collaborative effort between NDMC, USDA, and NOAA. Figure 4-14 shows the U.S. Drought Monitor for Colorado as of June 8, 2021, illustrating the regional nature of drought.

Figure 4-14: U.S. Drought Monitor, As of June 8, 2021



In Colorado, drought is a natural but unpredictable occurrence. Because of 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 portions of the state are quite common.

The entire county is at risk to drought conditions, and drought can increase the vulnerability to wildfires interfacing with the city and towns. Drought is one of the few hazards that has the potential to impact every person directly or indirectly in the county as well as adversely affect the local economy.

Extreme Heat

Most of the county is low risk to extreme heat events because of the high elevation, proximity to the continental divide, and mountainous geography. This is even the case in the County's more urban areas, such as Idaho Springs. Extreme heat events are even less likely at higher elevations in Clear Creek County because average temperatures tend to decrease with increases in elevation, roughly 4°F per 1,000 feet above mean sea level.

4.5.4 Magnitude and Severity

Drought

Drought impacts are wide-reaching and may be economic, environmental, 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. An ongoing drought that severely inhibits natural plant growth cycles may impact critical wildlife habitats or may leave an area more prone to beetle kill and associated wildfires. Drought conditions can also cause soil to compact, increasing an area's susceptibility to flooding, and reduce vegetation cover, which exposes soil to wind and erosion. A reduction of electric power generation and water quality deterioration are also

potential problems. Drought impacts increase with the length of a drought, as carry-over supplies in reservoirs are depleted and water levels in streams and groundwater decline.

The severity of a drought depends on the degree of moisture deficiency, the duration, and the size and location of the affected area. The longer the duration of the drought and the larger the area impacted, the more severe the potential impacts. Droughts are not usually associated with direct impacts on people or property, but they can have significant impacts on agriculture, which can impact people indirectly. The U.S. Drought Monitor provides a drought classification scheme (shown in Figure 4-15) used to monitor drought nationwide. The figure below shows historical impacts by drought category, which can be used as a measure of the magnitude of drought.

Figure 4-15: Historically Observed Impacts by Drought Monitor Category in Colorado

Category	Historically observed impacts
D0	Hay production decreases; rangeland is dry
	Irrigation begins sooner
D1	Rangeland growth is stunted; very little hay is available
	Dryland crops suffer
	Wildfires increase
	Pheasant population declines; ski season is limited
D2	CRP lands suffer
	Farmers reduce planting; producers sell cattle
	Fire season is extended
	Snowpack is low; surface water levels are low; river flow is reduced
D3	Pasture conditions worsen
	City landscapes are dying
	Large fires develop
	Rafting, fishing, hunting, skiing are reduced; fish kills occur
	Grasshopper and insect infestation are noted
	Reservoirs are extremely low; mandatory water restrictions are implemented; water temperature increases
D4	Dust storms and topsoil removal are widespread
	Agricultural and recreational economic losses are large

The 2018 State of Colorado Drought Mitigation and Response Plan evaluated the vulnerability of different sectors to drought for all counties in Colorado. (The evaluation excluded the Municipal and Industrial sector because that sector did not follow standard methodology.) The sector vulnerability scores for Clear Creek County are shown in Table 4-27. A score of 3.0 or above means that sector is vulnerable to drought. While none of the sectors in Clear Creek County score above 3.0, the socioeconomic sector has a score of 2.80 and is vulnerable to an increase. This is largely due to the County's lack of economic diversity and tourism economy base. This includes vulnerability to secondary economic impacts, behavioral health impacts and public health concerns specific to drought.

Table 4-27: Drought Vulnerability Scores by Sector

Sector	Clear Creek County Score
Recreation	2.12
Energy	1.00
Agriculture	1.00
State Assets	1.98
Socioeconomic	2.80
Environment	1.36
Average Overall Vulnerability	1.71

Source: 2018 State of Colorado Drought Mitigation and Response Plan

Extreme Heat

Extreme heat can threaten health and safety, and in severe cases can cause damage to infrastructure. According to the National Weather Service (NWS), young children and infants, older adults, people with chronic medical conditions, and pregnant women are all particularly vulnerable to extreme heat. Outdoor workers are also at higher risk due to greater exposure to heat. As a measure of the magnitude of heat, the NWS Heat Index Program provides a measure of the extent of health impacts of exposure to heat by heat index temperatures, shown in Table 4-28.

Table 4-28: 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

Based on the past event data in this hazard profile, the magnitude/severity of extreme heat is considered minimal for the Clear Creek County, including the City of Idaho Springs and the Towns of Empire, and Silver Plume. The Town of Georgetown has no exposure.

4.5.5 Probability of Future Occurrence

Drought

The probability of a future drought in Clear Creek County is considered likely, with a recurrence interval of 10 years or less. Droughts typically occur as short durations in Clear Creek County but can last for multiple years. According to a study cited in the 2018 Colorado Drought Mitigation and Response Plan, droughts occur somewhere in Colorado in nearly 9 out of every 10 years. (McKee and others 2000).

Extreme Heat

There are no recorded instances of extreme heat or heat events in Clear Creek County from 1996 to 2020 in the National Centers for Environmental Information's Storm Events Database. In addition, weather station data shows that temperatures in the county rarely exceed 90°F. Therefore, extreme heat is considered unlikely to occur in the future.

4.5.6 Climate Change Considerations

The long-term effects of climate change on regional water resources are not fully understood, but global water resources are already experiencing the following stresses non-climate:

- Growing populations
- Increased competition for available water
- Poor water quality
- Environmental claims
- Uncertain reserved water rights
- Groundwater overdraft
- Aging urban water infrastructure

Per the 2018 Colorado Drought Mitigation and Response Plan, regional studies commissioned by the Colorado Water Conservation Board (CWCB) suggest a reduction in the total water supply in Colorado by the mid-21st century. Projections show a decline in snowpack across western Colorado by the mid-21st century, including severe declines at lower elevations and modest declines at high elevations. Additionally, warming temperatures have been resulting in earlier onset of streamflow from melting snow, which may cause a reduction in late summer flows.

The Fourth National Climate Assessment reports that throughout the Southwest region, increased temperatures are resulting in decreases in snowpack and its water content, earlier peak of snow-fed streamflow, and increases in the proportion of rain to snow, all of which exacerbate hydrological drought. Additionally, drought risk is being exacerbated by the depletion of groundwater.

With a warmer climate, droughts could become more frequent, more severe, and longer lasting. From 1987 to 1989, losses from drought in the U.S. totaled $39 billion (Congressional Office of Technology Assessment [OTA] 1993). More frequent extreme events such as droughts could end up being more cause for concern than the long-term change in temperature and precipitation averages.

The best advice to water resource managers regarding climate change is to start addressing current stresses on water supplies and build flexibility and robustness into any system. Flexibility helps to ensure a quick response to changing conditions, and robustness helps people prepare for and survive the worst conditions. With this approach to planning, water system managers will be better able to adapt to the impacts of climate change.

4.5.7 Vulnerability

All people, property, and environments in the planning area would be exposed to some degree to the impacts of moderate to extreme drought conditions. Drought produces a complex web of impacts that spans many sectors of the economy and reaches well beyond the area experiencing physical drought. This complexity exists because water is integral to the ability to produce goods and provide services. Drought can affect a wide range of economic, environmental, and social activities. The vulnerability of an activity to the effects of drought usually depends on its water demand, how the demand is met, and what water supplies are available to meet the demand. Extreme heat can exacerbate the effects of drought.

Population

The planning partnership has the ability to minimize any impacts on residents and water consumers in the county should several consecutive dry years occur. No significant life or health impacts are anticipated as a result of drought within the planning area.

According to the EPA, the individuals with the following combinations or characteristics are typically at greater risk to the adverse effects of excessive heat events: individuals with physical or mobility constraints, cognitive impairments, economic constraints, and social isolation. Populations living in densely populated urban areas are likely to be more exposed to extreme heat events; however, these events are rare and low magnitude. People who live at higher elevations would be less susceptible to heat events.

Property

No structures will be directly affected by drought conditions, though some structures may become vulnerable to wildfires, which are more likely following years of drought. Droughts can also have significant impacts on landscapes, which could cause a financial burden to property owners. However, these impacts are not considered critical in planning for impacts from the drought hazard.

Typically, the only impact extreme heat has on general building stock is increased demand on air conditioning equipment, which in turn may cause strain on electrical systems. Excessive heat events can cause failure of motorized systems such as ventilation systems used to control temperatures inside buildings.

Critical Facilities and Infrastructure

Critical facilities as defined for this plan will continue to be operational during a drought. Critical facility elements such as landscaping may not be maintained due to limited resources, but the risk to the planning area's critical facilities inventory will be largely aesthetic. For example, when water conservation measures are in place, landscaped areas will not be watered and may die. These aesthetic impacts are not considered significant. Regional power outages may occur as a result of extreme heat events.

Government Services

Periods of prolonged and/or severe drought can diminish the County's water supply and force the County to initiate water usage restrictions. The County may need to balance competing demands from water users, which may affect public confidence in local governance.

Economy

According to the USDA Census of Agriculture, the market value of agricultural products sold in Clear Creek County was $174,000 in 2017, down 49 percent from the 2012 Census of Agriculture. Livestock accounted for 70 percent of sales and crops accounted for 30 percent. Therefore, overall agriculture exposure in the county is decreasing. However, drought and extreme heat may impact all crops grown in Clear Creek County and the pastureland used to sustain private livestock. Agricultural damages may result from direct impacts or water usage restrictions that limit irrigation.

In addition to agriculture, economic exposure is largely associated with industries that use water or depend on water for their business. For example, landscaping businesses were affected in the droughts of the past as the demand for service significantly declined because landscaping was not watered. Recreation and tourism industries, including rafting, angling, and ski resorts, have experienced past losses due to low flows and/or low snowpack; these businesses continue be exposed to drought impacts. Refer to Table 4-27 above for the results of the section vulnerability analysis from the 2018 State of Colorado Drought Mitigation and Response Plan. The County's Strategic Water Plan aims to encourage economic development by placing water resources to beneficial use. Growing dependency on water resources may make the County more vulnerable to drought in the future.

The Colorado Water Conservation board (CWCB) maintains a Future Avoided Cost Explorer (FACE) tool, which estimates annual damages from drought. According to FACE analysis (detailed in Table 4-29), Clear

Creek County could experience an average annual loss of $1.4 million due to drought conditions under current population and climate scenarios.

Historic, Cultural, and Natural Resources

Environmental losses from drought are associated with damage to plants, animals, wildlife habitat, and air and water quality; forest and range fires; degradation of landscape quality; loss of biodiversity; and soil erosion. Some of the effects are short-term and conditions quickly return to normal following the end of the drought. Other environmental effects linger for some time or may even become permanent. Wildlife habitat, for example, may be degraded through the loss of wetlands, lakes, and vegetation. However, many species will eventually recover from this temporary aberration. The degradation of landscape quality, including increased soil erosion, may lead to a more permanent loss of biological productivity. Although environmental losses are difficult to quantify, growing public awareness and concern for environmental quality has forced public officials to focus greater attention and resources on these effects.

Drought can also increase risk of wildfire. A prolonged lack of precipitation dries out vegetation, which becomes increasingly susceptible to ignition as the duration of the drought extends. A drought may also increase the speed at which dead and fallen trees dry out and become more potent fuel sources for wildfires. Drought may also weaken trees in areas already affected by mountain pine beetle infestations, causing more extensive damage to trees and increasing wildfire risk, at least temporarily (CWCB 2018).

Drought conditions can also cause soil to compact, decreasing its ability to absorb water, making an area more susceptible to flash flooding and erosion (CWCB 2018).

4.5.8 Development Trends

Each municipal planning partner in this effort has an established comprehensive plan that includes policies directing land use and dealing with issues of water supply and the protection of water resources. These plans provide the capability at the local municipal level to protect future development from the impacts of drought. All planning partners reviewed their general plans under the capability assessments performed for this effort. Deficiencies identified by these reviews can be identified as mitigation initiatives to increase the capability to deal with future trends in development. Vulnerability to drought will increase as population growth increases, putting more demands on existing water supplies. Future water use planning should consider increases in population as well as potential impacts of climate change.

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 Clear Creek County due to drought events for each of the climate and population scenarios.

Table 4-29: Potential Future Economic Losses from Drought in Clear Creek County

Climate Scenarios	Population Scenarios		
	Low Growth (~10,600)	Medium Growth (~12,400)	High Growth (~14,400)
Current Conditions	Total damages: $2.6M	Total damages: $2.7M	Total damages: $2.7M
	Total damages per person: $240	Total damages per person: $210	Total damages per person: $180

Climate Scenarios	Population Scenarios		
	Low Growth (~10,600)	Medium Growth (~12,400)	High Growth (~14,400)
Moderately Warmer Climate by 2050	Total damages: $9.1M	Total damages: $9.1M	Total damages: $10M
	Total damages per person: $850	Total damages per person: $730	Total damages per person: $700
Severely Warmer Climate by 2050	Total damages: $11M	Total damages: $12M	Total damages: $12M
	Total damages per person: $1000	Total damages per person: $970	Total damages per person: $840

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

Extreme heat is unlikely to impact future development since its typically does not affect structures. However, growth may add to stress on the electric grid, which could increase the possibility of power outages when demand is high during periods of extreme heat.

4.5.9 Risk Summary

- The overall significance of extreme heat is low; the overall significance of drought is Medium.
- Drought vulnerability may increase over time as demand for water from different sectors increases and as the County plans for economic development around the use of water resources
- Climate change may result in an increase in an increase in the frequency and severity of drought which could lead to impacts to the recreation and tourism industry in the County.
- Extreme heat events are unlikely throughout the County, and the magnitude of heat events is low.
- Related hazards: Wildfire, Erosion

4.6 Earthquake

EARTHQUAKE HAZARD RANKING	
Clear Creek County	Low
City of Idaho Springs	Low
Town of Empire	Low
Town of Georgetown	Low
Town of Silver Plume	Low
Clear Creek Fire Authority	Low

DEFINITIONS

Earthquake—The shaking of the ground caused by an abrupt shift of rock along a fracture in the earth or a contact zone between tectonic plates.

Epicenter—The point on the earth's surface directly above the hypocenter of an earthquake. The location of an earthquake is commonly described by the geographic position of its epicenter and by its focal depth.

Fault—A fracture in the earth's crust along which two blocks of the crust have slipped with respect to each other.

Focal Depth—The depth from the earth's surface to the hypocenter.

Hypocenter—The region underground where an earthquake's energy originates.

Liquefaction—Loosely packed, water-logged sediments losing their strength in response to strong shaking, causing major damage during earthquakes.

4.6.1 Description

How Earthquakes Happen

An earthquake is the vibration of the earth's surface following a release of energy in the earth's crust. This energy can be generated by a sudden dislocation of the crust or by a volcanic eruption. Most destructive quakes are caused by dislocations of the crust. The crust may first bend and then, when the stress exceeds the strength of the rocks, break and snap to a new position. In the process of breaking, vibrations called "seismic waves" are generated. These waves travel outward from the source of the earthquake at varying speeds.

Earthquakes can last from a few seconds to over five minutes; they may also occur as a series of tremors over several days. The actual movement of the ground in an earthquake is seldom the direct cause of injury or death. Casualties generally result from falling objects and debris, because the shocks shake, damage, or demolish buildings and other structures. Disruption of communications, electrical power supplies and gas, sewer, and water lines should be expected. Earthquakes may trigger fires, dam failures, landslides, or releases of hazardous material, compounding their disastrous effects.

Earthquakes tend to reoccur along faults, which are zones of weakness in the crust. Even if a fault zone has recently experienced an earthquake, there is no guarantee that all the stress has been relieved. Another earthquake could still occur.

Small, local faults produce lower magnitude quakes, but ground shaking can be strong, and damage can be significant in areas close to the fault. In contrast, large regional faults can generate earthquakes of great magnitudes but, because of their distance and depth, they may result in only moderate shaking in an area.

Geologists classify faults by their relative hazards. Active faults, which represent the highest hazard, are those that have ruptured to the ground surface during the Holocene period (about the last 11,000 years). Potentially active faults are those that displaced layers of rock from the Quaternary period (the last 1,800,000 years). Determining if a fault is "active" or "potentially active" depends on geologic evidence, which may not be available for every fault. Although there are probably still some unrecognized active

faults, nearly all the movement between the two plates, and therefore the majority of the seismic hazards, are on the well-known active faults.

Faults are more likely to have earthquakes on them if they have more rapid rates of movement, have had recent earthquakes along them, experience greater total displacements, and are aligned so that movement can relieve accumulating tectonic stresses. A direct relationship exists between a fault's length and location and its ability to generate damaging ground motion at a given site. In some areas, smaller, local faults produce lower magnitude quakes, but ground shaking can be strong, and damage can be significant as a result of the fault's proximity to the area. In contrast, large regional faults can generate great magnitudes but, because of their distance and depth, may result in only moderate shaking in the area.

Earthquake Classifications

Earthquakes are typically classified in one of two ways: By the amount of energy released, measured as magnitude; or by the impact on people and structures, measured as intensity.

Magnitude

Currently the most commonly used magnitude scale is the moment magnitude (Mw) scale, with the following classifications of magnitude:

- Great—Mw > 8
- Major—Mw = 7.0 - 7.9
- Strong—Mw = 6.0 - 6.9
- Moderate—Mw = 5.0 - 5.9
- Light—Mw = 4.0 - 4.9
- Minor—Mw = 3.0 - 3.9
- Micro—Mw < 3

Estimates of Mw scale roughly match the local magnitude scale (ML) commonly called the Richter scale. One advantage of the Mw scale is that, unlike other magnitude scales, it does not saturate at the upper end. That is, there is no value beyond which all large earthquakes have about the same magnitude. For this reason, Mw scale is now the most often used estimate of large earthquake magnitudes.

Intensity

Currently the most commonly used intensity scale is the modified Mercalli intensity scale, with ratings defined as follows (U.S. Geological Survey [USGS] 1989) based on felt effects:

Table 4-30: 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

Magnitude	Mercalli Intensity	Effects	Frequency
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 epicenter 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

Ground Motion

Earthquake hazard assessment is also based on expected ground motion. This involves determining the annual probability that certain ground motion accelerations will be exceeded, then summing the annual probabilities over the time period of interest. The most commonly mapped ground motion parameters are the horizontal and vertical peak ground accelerations (PGA) for a given soil or rock type. Instruments called accelerographs record levels of ground motion due to earthquakes at stations throughout a region. These readings are recorded by state and federal agencies that monitor and predict seismic activity.

Maps of PGA values form the basis of seismic zone maps that are included in building codes such as the International Building Code. Building codes that include seismic provisions specify the horizontal force due to lateral acceleration that a building should be able to withstand during an earthquake. PGA values are directly related to these lateral forces that could damage "short period structures" (e.g., single-family dwellings). Longer period response components create the lateral forces that damage larger structures with longer natural periods (apartment buildings, factories, high-rises, bridges). Table 4-31 lists damage potential and perceived shaking by PGA factors, compared to the modified Mercalli scale.

Table 4-31: Mercalli Scale and Peak Ground Acceleration Comparison

Modified		Potential Structure Damage		Estimated PGA[a]
Mercalli Scale	Perceived Shaking	Resistant Buildings	Vulnerable Buildings	(%g)
I	Not Felt	None	None	<0.17%
II-III	Weak	None	None	0.17% - 1.4%
IV	Light	None	None	1.4% - 3.9%
V	Moderate	Very Light	Light	3.9% - 9.2%
VI	Strong	Light	Moderate	9.2% - 18%
VII	Very Strong	Moderate	Moderate/Heavy	18% - 34%
VIII	Severe	Moderate/Heavy	Heavy	34% - 65%

Modified Mercalli Scale	Perceived Shaking	Potential Structure Damage		Estimated PGA[a] (%g)
		Resistant Buildings	Vulnerable Buildings	
IX	Violent	Heavy	Very Heavy	65% - 124%
X - XII	Extreme	Very Heavy	Very Heavy	>124%

a. Peak Ground Acceleration (PGA) measured in percent of g (%g), where g is the acceleration of gravity
b. Sources: USGS 2008; USGS 2010

Effect of Soil Types

The impact of an earthquake on structures and infrastructure is largely a function of ground shaking, distance from the source of the earthquake, and liquefaction, a secondary effect of an earthquake in which soils lose their shear strength and flow or behave as liquid, thereby damaging structures that derive their support from the soil. Liquefaction generally occurs in soft, unconsolidated sedimentary soils. A program called the National Earthquake Hazard Reduction Program (NEHRP) creates maps based on soil characteristics to help identify locations subject to liquefaction. Table 4-32 summarizes NEHRP soil classifications. NEHRP Soils B and C typically can sustain ground shaking without much effect, dependent on the earthquake magnitude. The areas that are commonly most affected by ground shaking have NEHRP Soils D, E, and F. In general, these areas are also most susceptible to liquefaction.

Table 4-32: NEHRP Soil Classification System

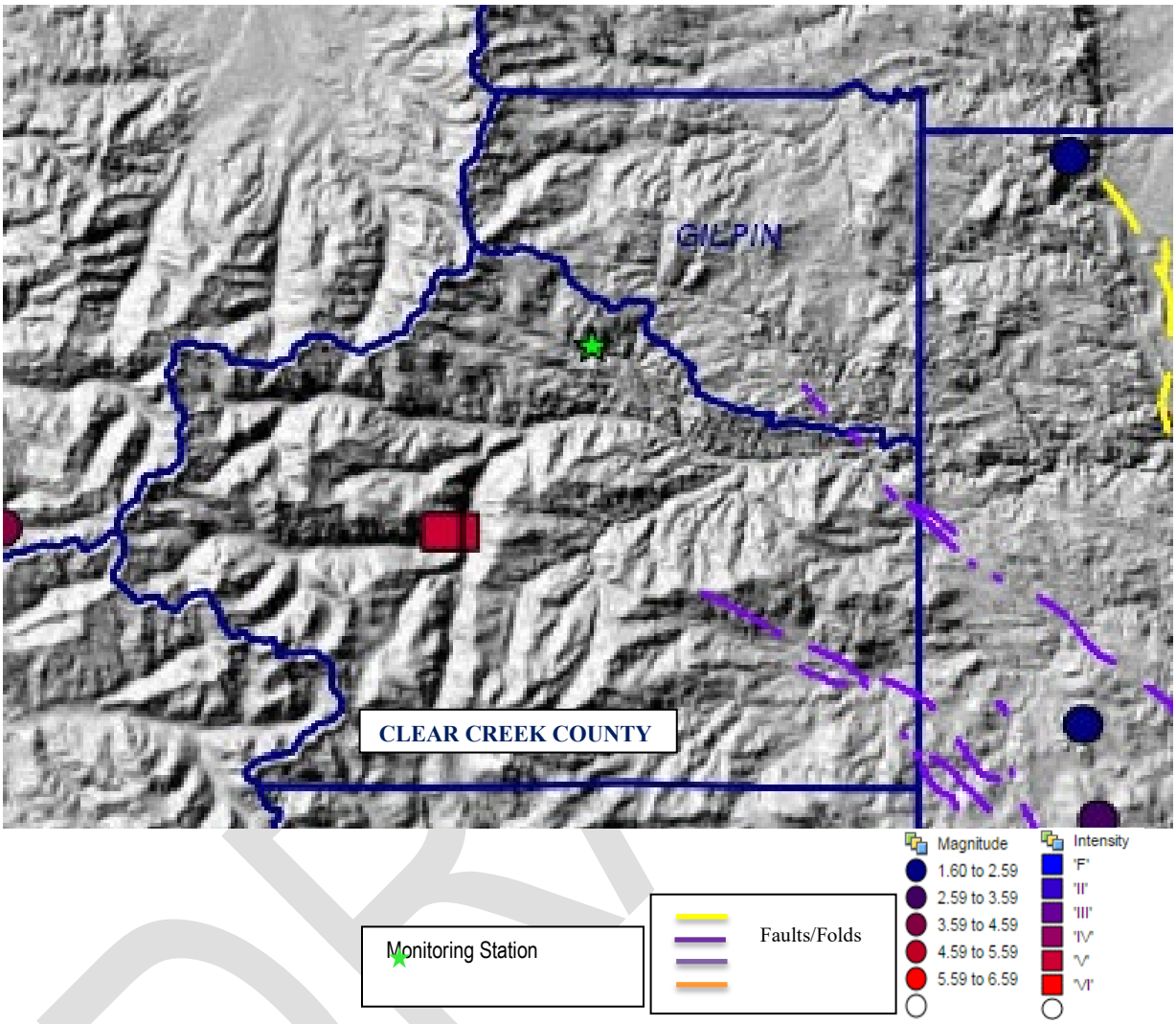
NEHRP Soil Type	Description	Mean Shear Velocity to 30 m (m/s)
A	Hard Rock	1,500
B	Firm to Hard Rock	760-1,500
C	Dense Soil/Soft Rock	360-760
D	Stiff Soil	180-360
E	Soft Clays	< 180
F	Special Study Soils (liquefiable soils, sensitive clays, organic soils, soft clays >36 m thick)	

Notes:
m Meters
m/s Meters per second

4.6.2 Past Events

Colorado has a relatively short period of historical records for earthquakes. An earthquake and fault map developed by the Colorado Geological Survey depicts the location of historical epicenters and potentially active faults in that state. Figure 4-16 shows the faults and recorded earthquakes for Clear Creek County and vicinity. The map indicates that there are two recorded earthquake events which occurred in Clear Creek County. Both are historical events that were mentioned in a newspaper, one from 1871 and the second from 1894. The November 1882 earthquake was the largest felt earthquake in the state and was likely felt in Clear Creek County, as the epicenter was suspected to be near Estes Park. Figure 4-16 also shows the location of a monitoring station located in Clear Creek County. According to the USGS earthquake catalog, another minor earthquake occurred within the county on October 24th, 2020. This event epicenter was located approximately 2 kilometers east/southeast of Georgetown and was a magnitude 2.5 event.

Figure 4-16: Earthquake Faults and 1870 – 2020 Recorded Epicenters Map for Clear Creek County and Vicinity

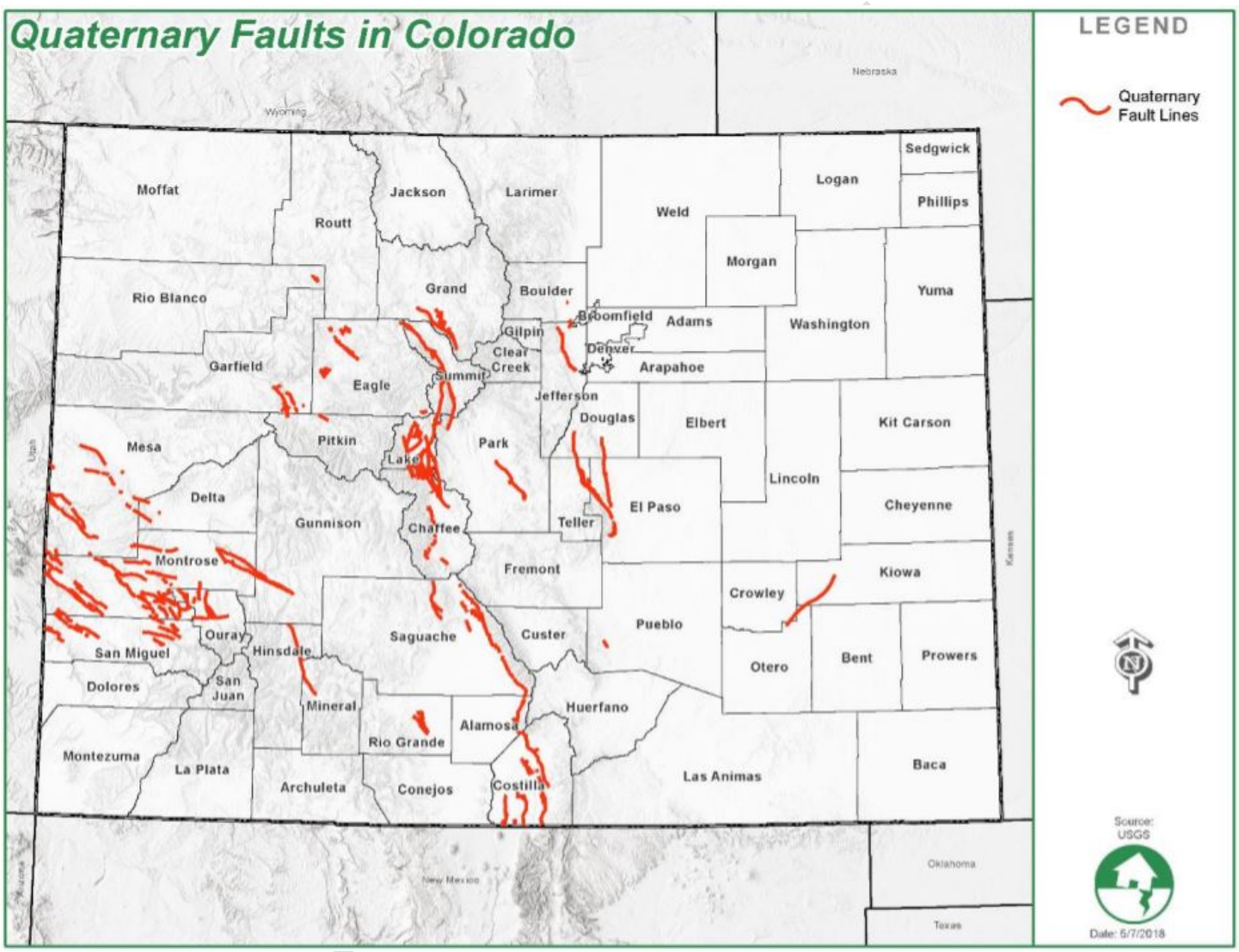


Source: Colorado Geological Survey (http://dnrwebmapgdev.state.co.us/cgsonline/)

4.6.3 Location

Geological research indicates that faults capable of producing earthquakes are prevalent in Colorado. There are approximately 90 potentially active faults in Colorado with documented movement within the last 1.6 million years. Clear Creek County has two major faults that run on the eastern portion of the county. Floyd Hill Fault is the more northern fault that runs through only a small portion of the county. The Kennedy Gulch Fault is larger and runs through more of the central and eastern portion of the county. Parts of the Kennedy Gulch Fault are not represented on Figure 4-17, but portions of the fault run just southeast of Georgetown. Figure 4-17 shows other potentially active faults near Clear Creek County and in all of Colorado. More than 700 earthquake tremors of magnitude 2.5 or higher have been recorded in Colorado since 1867. This is considered relatively infrequent for a western state, but instrument recording of earthquakes did not begin in Colorado until the 1960s so the data may be incomplete.

Figure 4-17: Colorado Quaternary Fault Map



Source: State of Colorado 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 to 130,000 years)
- MLQ—Middle to Late Quaternary (130,000 to 750,000 years)
- Q—Quaternary (approximately past 2 million years)
- LC—Late Cenozoic (approximately past 23.7 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). While the record of past occurrences does not indicate many earthquakes have originated from within Clear Creek County, when earthquakes do occur, they are very often felt across large geographic areas, with impacts and potential damage possible miles away from the epicenter. This means that there is potential for impacts to the County from an event that originated elsewhere in the region.

4.6.4 Magnitude and Severity

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. Damage and life loss can be particularly devastating in communities where buildings were not designed to withstand seismic forces (e.g., historic structures). Other damage-causing effects of earthquakes include surface rupture, fissuring, settlement, and permanent horizontal and vertical shifting of the ground. Secondary impacts can include landslides, rock falls, liquefaction, fires, dam failure, and hazardous materials (HAZMAT) incidents.

The severity of an earthquake can be expressed in terms of intensity or magnitude. Intensity represents the observed effects of ground shaking on people, buildings, and natural features. According to FEMA's *2006 Homebuilder's Guide to Earthquake Resistant Design and Construction*, the International Residential Code designates the level of potential seismic hazard for dwellings by assigning a house to a Seismic Design Category based on its location. Clear Creek County is in category B and has the potential of moderate ground shaking.

As described above in Section 4.6.1, earthquake magnitude is related to the amount of seismic energy released at the hypocenter of an earthquake. It is calculated based on the amplitude of the earthquake waves recorded on instruments. Whereas intensity varies depending on location with respect to the earthquake epicenter, magnitude is represented by a single, instrumentally measured value for each earthquake event.

In simplistic terms, the severity of an earthquake event can be measured in the following terms:

- How hard did the ground shake?
- How did the ground move? (horizontally or vertically)
- How stable was the soil?
- What is the fragility of the built environment in the area of impact?

Probabilistic hazard mapping was used to assess the risk of earthquakes within the planning area. One probabilistic scenario and was selected for this plan:

2,500-Year Probabilistic Scenario—This is a HAZUS-MH Probabilistic Event scenario, which allows the user to generate estimates of damage and loss based on the seismic hazard with a 2% probability of exceedance in 50 years return period.

4.6.5 Probability of Future Occurrence

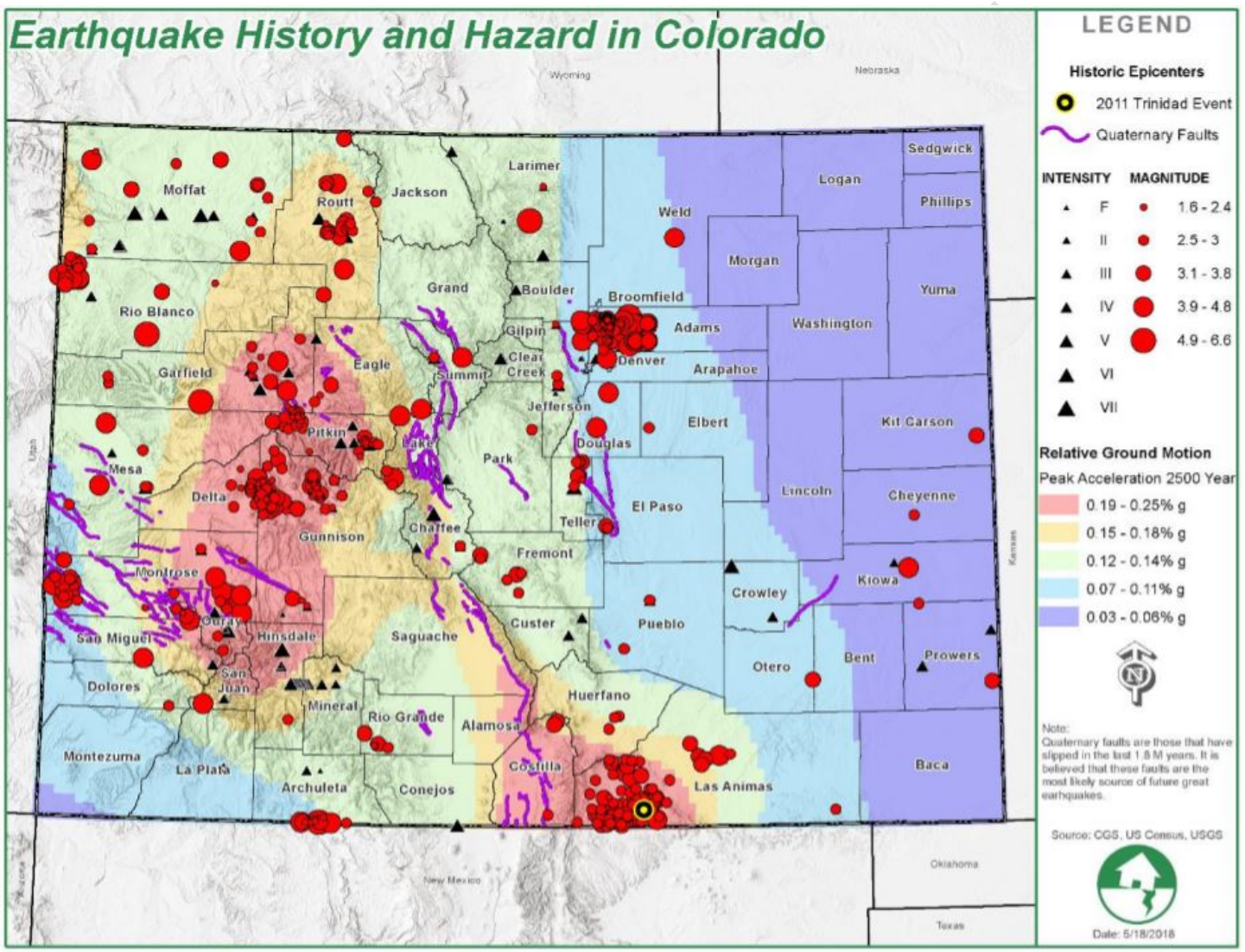
Research based on Colorado's earthquake history suggests that an earthquake of magnitude 6.3 or larger has a 1% probability of occurring each year somewhere in Colorado (Charlie, Doehring, Oaks Colorado Earthquake Hazard Reduction Program Open File Report 93-01 1993).

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 4-18 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 4-18 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, Clear Creek County lies in the range of 0.12-0.14 percent peak acceleration. Ground motions become structurally damaging when average peak accelerations reach 0.10 to 0.15 peak ground acceleration, 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 of an earthquake causing significant damage is **unlikely**, with less than a 1 percent chance of occurrence over the next 100-year period.

Figure 4-18: Colorado Seismic Hazard Map – 2% Probability of Exceedance in 50 Years



Source: Colorado State Hazard Mitigation Plan, 2018

Part of what makes earthquakes so destructive is that they generally occur without warning. The main shock of an earthquake can usually be measured in seconds, and rarely lasts for more than a minute. Aftershocks can occur within the days, weeks, and even months following a major earthquake.

By studying the geologic characteristics of faults, geoscientists can often estimate when the fault last moved and estimate the magnitude of the earthquake that produced the last movement. Because the occurrence of earthquakes is relatively infrequent in Colorado and the historical earthquake record is short, accurate estimations of magnitude, timing, or location of future dangerous earthquakes in Colorado are difficult to estimate.

There is currently no reliable way to predict the day or month that an earthquake will occur at any given location. Research is being done with warning systems that use the low energy waves that precede major earthquakes. These potential warning systems give approximately 40 seconds notice that a major earthquake is about to occur. The warning time is very short, but it could allow for someone to get under a desk, step away from a hazardous material they are working with, or shut down a computer system.

4.6.6 Climate Change Considerations

The impacts of global climate change on earthquake intensity and probability are largely unknown but there is not expected to be a direct correlation.

4.6.7 Vulnerability

Earthquake vulnerability data was generated during the 2021 update using a Level 1 HAZUS-MH analysis. HAZUS-MH estimates the intensity of the ground shaking, the number of buildings damaged, the number of casualties, the damage to transportation systems and utilities, the number of people displaced from their homes, and the estimated cost of repair and clean up.

Population

The entire population of Clear Creek County is potentially exposed to direct and indirect impacts from earthquakes. The degree of exposure is dependent on many factors, including the age and construction type of the structures people live in, the soil type their homes are constructed on, their proximity to fault location, etc. Whether impacted directly or indirectly, the entire population will have to deal with the consequences of earthquakes to some degree. Business interruption could keep people from working, road closures could isolate populations, and loss of functions of utilities could impact populations that suffered no direct damage from an event itself.

Three population groups are particularly vulnerable to earthquake hazards:

- **Linguistically Isolated Populations**—Approximately 1.6% of the planning area population over 5 years old speaks English “less than very well.” Problems arise when there is an urgent need to inform non-English speaking residents of an earthquake event. They are vulnerable because of difficulties in understanding hazard-related information from predominantly English-speaking media and government agencies.
- **Population below Poverty Level**—Families with incomes below the poverty level in 2019 made up 4.1% of the total county population. These families may lack the financial resources to improve their homes to prevent or mitigate earthquake damage. Poorer residents are also less likely to have insurance to compensate for losses in earthquakes.
- **Population over 65 Years Old**—Approximately 19.4% of the residents in Clear Creek County are over 65 years old. This population group is vulnerable because they are more likely to need special medical attention, which may not be available due to isolation caused by earthquakes. Elderly residents also

have more difficulty leaving their homes during earthquake events and could be stranded in dangerous situations

Impacts on persons and households in the planning area were estimated for the 2,500-Year Probabilistic Earthquake. Table 4-33 summarizes the results. Further impacts to the population as estimated by Hazus are detailed in Table 4-36. It is estimated in a 2 p.m. time of occurrence scenario, which is likely to be a worst case scenario, that there would be nine injuries across the county, one of which would require hospitalization. There could also be increased risk of damage or injury from rock fall to travelers, hikers, and others recreating outdoors at the time of the earthquake.

Table 4-33: Estimated Earthquake Impact on Persons and Households

	Number of Displaced Households	Number of Persons Requiring Short-Term Shelter
2,500-Year Earthquake	17	8

Source: HAZUS-MH Global Summary Report, Wood analysis

Property

The HAZUS analysis estimates that there are 5,000 buildings in the planning area, with a total replacement value of $1.34 billion. Because all structures in the planning area are susceptible to earthquake impacts to varying degrees, this total represents the countywide property exposure to seismic events. Most of the buildings (91%) and most of the associated building value (81%) are residential. According to the model about 599 buildings will be at least moderately damaged. A summary of these damage estimates is included in Table 4-34 below:

Table 4-34: Estimated Building Damage by Occupancy

	None		Slight		Moderate		Extensive		Complete	
	Count	(%)	Count	(%)	Count	(%)	Count	(%)	Count	(%)
Agriculture	8.00	0.19	1.97	0.21	1.53	0.32	0.46	0.42	0.04	0.51
Commercial	194.73	4.71	64.26	6.89	53.84	11.19	15.81	14.27	1.37	18.22
Education	7.72	0.19	2.05	0.22	1.70	0.35	0.48	0.44	0.04	0.52
Government	7.63	0.18	2.47	0.26	2.22	0.46	0.63	0.57	0.05	0.73
Industrial	60.27	1.46	20.40	2.19	18.22	3.79	5.66	5.11	0.46	6.06
Other Residential	263.38	6.37	110.64	11.86	108.28	22.51	23.77	21.46	1.93	25.63
Religion	16.03	0.39	4.37	0.47	3.55	0.74	0.97	0.88	0.08	1.05
Single Family	3577.66	86.51	727.03	77.91	291.80	60.65	62.96	56.86	3.55	47.29
Total	**4,135**		**933**		**481**		**111**		**8**	

Source: HAZUS-MH Global Summary Report, Wood analysis

Property losses were estimated through the Level 1 HAZUS-MH analysis for a 2,500-year probabilistic earthquake. The figure below is an excerpt from the HAZUS global summary report and shows the results for two types of building loss:

- Direct building losses, representing damage to building structures.
- Business interruption losses.

For the 2,500-year probabilistic earthquake scenario the estimated damage potential is $54.5 million.

Table 4-35: HAZUS Building Related Economic Loss Estimates for 2,500 Year Scenario

Category	Area	Single Family	Other Residential	Commercial	Industrial	Others	Total
Income Losses							
	Wage	0.0000	0.2294	1.9990	0.0458	0.1106	2.3848
	Capital-Related	0.0000	0.0979	2.3598	0.0398	0.0248	2.5223
	Rental	0.7439	0.4059	0.8715	0.0223	0.0463	2.0899
	Relocation	2.6556	0.3488	1.1938	0.1685	0.4024	4.7691
	Subtotal	**3.3995**	**1.0820**	**6.4241**	**0.2764**	**0.5841**	**11.7661**
Capital Stock Losses							
	Structural	3.8840	0.6345	1.5003	0.4046	0.3970	6.8204
	Non_Structural	15.0932	2.8746	4.2048	1.2805	1.1083	24.5614
	Content	6.4572	0.7891	2.3311	0.8656	0.6682	11.1112
	Inventory	0.0000	0.0000	0.0576	0.1309	0.0040	0.1925
	Subtotal	**25.4344**	**4.2982**	**8.0938**	**2.6816**	**2.1775**	**42.6855**
	Total	**28.83**	**5.38**	**14.52**	**2.96**	**2.76**	**54.45**

Source: HAZUS-MH Global Summary Report, Wood analysis; values shown are in millions of dollars.

The HAZUS analysis also estimated the amount of earthquake-caused debris in the planning area for the 2,500-Year probabilistic earthquake scenario event is estimated to be 15,000 tons.

Critical Facilities and Infrastructure

All critical facilities and infrastructure in the planning area are exposed to the earthquake hazard. HAZMAT releases can occur during an earthquake from fixed facilities or transportation-related incidents. Transportation corridors can be disrupted during an earthquake, leading to the release of materials to the surrounding environment. Facilities holding HAZMAT are of particular concern because of possible isolation of neighborhoods surrounding them. During an earthquake, structures storing these materials could rupture and leak into the surrounding area or an adjacent waterway, having a disastrous effect on the environment.

HAZUS-MH classifies the vulnerability of critical facilities to earthquake damage in two categories: at least moderate damage or complete damage. The analysis did not indicate any damages in these categories to specific facilities. The model also estimates lifeline damages to linear networks such as transportation and utilities. Damage to the transportation system is estimated at $5.9 million and utility lifelines at $233.9 million. The steep terrain in the County adjacent to the highway and road corridors would likely create multiple rockslides that could damage roadways and disrupt traffic.

Government Services

Damage impacts to transportation corridors and communications lines could affect first responders' ability to effectively respond in the aftermath of an earthquake. Damage to government facilities/personnel in incident area may require temporary relocation of some operations. Regulatory waivers may be needed locally. The public may question local government's ability to respond and recover if planning, response, and recovery are not timely and effective. A significant earthquake may require disaster declarations and aid programs. These needs may impact funding or administrative resources for other regular operations or may necessitate changes to existing operating procedures.

Economy

HAZUS-MH models total economic losses that includes building and lifeline related losses previously described. Total earthquake scenario loss estimates are summarized in below.

Table 4-36: HAZUS-MH Earthquake Loss Estimation 2,500-Year Scenario Results

Type of Impact	Impacts to County
Total Buildings Damaged	Slight: 933 Moderate: 481 Extensive: 111 Complete: 8
Building and Income Related Losses	$54.5 million 63% of damage related to residential structures 22% of loss due to business interruption
Total Economic Losses (includes building, income, and lifeline losses)	$294.3 Million Building: $54.5 Million Income: $11.8 Million Transportation/Utility: $239.8 Million
Casualties (based on 2 a.m. time of occurrence)	Without requiring hospitalization: 5 Requiring hospitalization: 1 Life threatening: 0 Fatalities: 0
Casualties (based on 2 p.m. time of occurrence)	Without requiring hospitalization: 8 Requiring hospitalization: 1 Life threatening: 0 Fatalities: 0
Casualties (based on 5 p.m. time of occurrence)	Without requiring hospitalization: 6 Requiring hospitalization: 1 Life threatening: 0 Fatalities: 0
Fire Following Earthquake	0 Ignitions
Debris Generation	15,000 tons of debris generated 600 truckloads
Displaced Households	17
Shelter Requirements	8

Source: HAZUS-MH 4.2

Historic, Cultural, and Natural Resources

Secondary hazards associated with earthquakes will likely have some of the most damaging effects on the environment. Earthquake-induced landslides can significantly impact surrounding habitat. Streams can be rerouted after an earthquake. This can change the water quality, possibly damaging habitat and feeding

areas. There is a possibility of streams fed by groundwater drying up because of changes in underlying geology. Historic building stock is commonly made of unreinforced masonry which is vulnerable to damage from earthquakes, which are present in Idaho Springs and Georgetown.

4.6.8 Development Trends

Land use in the planning area will be directed by the comprehensive plans adopted by the county and its planning partners as well as local permitting departments and zoning maps. Development in the planning area will be regulated through building standards and performance measures so that the degree of risk will be reduced with modern code adoption and enforcement.

4.6.9 Risk Summary

Earthquakes represent a high consequence but low probability hazard; due to the low probability the overall significance is considered low.

- The overall significance of extreme heat is low; the overall significance of drought is Low.
- Colorado has much lower seismic activity compared to other Western states.
- Resulting damages to building stock and utility lifelines, and income related losses could equate to millions of dollars based on HAZUS-MH modeling.
- Light casualties are anticipated.
- Earthquake risk is relatively the same across all participating jurisdictions, though impacts could be greater in areas with historic buildings and concentrations of people, such as Idaho Springs and Georgetown.
- The cost of retrofitting buildings to meet earthquake seismicity standards may be cost-prohibitive, but low cost non-structural measures can reduce property loss and prevent injury.
- Earthquakes could produce damaging and disruptive rockfalls that could damage roads and block access/egress.
- Related hazards: Landslide and rockfall

4.7 Erosion and Deposition, Expansive Soil, and Subsidence

EROSION AND DEPOSITION, EXPANSIVE SOIL, AND SUBSIDENCE HAZARD RANKING			
	Erosion and Deposition	**Expansive Soil**	**Subsidence**
Clear Creek County	Low	Low	Low
City of Idaho Springs	Low	Low	High
Town of Empire	Medium	Low	Low
Town of Georgetown	Medium	Low	Low
Town of Silver Plume	Low	Low	Low
Clear Creek Fire Authority	Low	Low	Low

4.7.1 Description

Erosion and Deposition

Erosion is the removal and transport of earth materials from one location to another by water, wind, waves, or moving ice. Deposition is the placing of eroded material in a new location. All material that is eroded is later deposited in another location. Both erosion and deposition are continually occurring phenomenon, although the rate of erosion and deposition varies tremendously and can be affected by a variety of factors including rate of scour, type of material being eroded, and the presence or absence of vegetation.

DEFINITIONS

Soil Erosion— Soil erosion is the removal and simultaneous transportation of earth materials from one location to another by water, wind, waves, or moving ice.

Deposition— Deposition is the placing of eroded material in a new location.

Expansive Soil – Expansive or swelling soils are made up of layers of clay and can expand up to 20% by volume when exposed to water causing more property damage than any other natural hazard.

Ground Subsidence— Ground subsidence is the sinking of land over human-caused or natural underground voids and the settlement of native low density soils.

Expansive Soil

Expansive and collapsible soils are some of the most widely distributed and costly geologic hazards. Collapsible soils are a group of soils that can rapidly settle or collapse the ground. They are also known as metastable soils and are unsaturated soils that undergo changes in volume and settlement in response to wetting and drying, often resulting in severe damage to structures. The sudden and usually large volume change could cause considerable structural damage.

Expansive soil and rock are characterized by clayey material that shrinks as it dries or swells as it becomes wet. In addition, trees and shrubs placed closely to a structure can lead to soil drying and subsequent shrinkage. The parent (source) rock most associated with expansive soils is shale.

Subsidence and Sinkholes

Ground subsidence is the sinking of land over human caused or natural underground voids and the settlement of native low-density soils). The Colorado Geological Survey defines land subsidence as the sinking of the land over manmade or natural underground voids. Subsidence can occur gradually over time or virtually instantaneously. Subsidence can occur gradually over time or virtually instantaneously. There are many different types of subsidence; however, in Colorado, there are three types of subsidence that

warrant the most concern: settlement related to collapsing soils, sinkholes in karst areas, and the ground subsidence over abandoned mine workings.

Collapsible Soils

Collapsible soils consist of loose, dry, low-density materials that collapse and compact under the addition of water or excessive loading. Soil collapse occurs when the land surface is saturated at depths greater than those reached by typical rain events. This saturation eliminates the clay bonds holding the soil grains together. Similar to expansive soils, collapsible soils result in structural damage such as cracking of the foundation, floors, and walls in response to settlement.

Collapsible soils are a group of soils that can rapidly settle or collapse the ground. The most common type of collapsible soil is hydrocompactive soil. According to the CGS, hydrocompactive soils form in semi- arid to arid climates in the western U.S. and large parts of Colorado in specific depositional environments. These soils are low in density and in moisture content and are loosely packed together. Agents that bind these loosely packed particles together, such as clay and silk buttresses, are water sensitive. When water is introduced to these soils, the binding agents may quickly break down, soften, disperse, or dissolve.

This results in a reorganization of the soil particles in a denser arrangement, which in turn results in a net volume loss indicated by resettlement or subsidence at the surface. Volume loss can be between 10 to 15 percent, which can result in several feet of surface-level displacement.

Abandoned Mine Workings

The underground removal of minerals and rock can undermine underground support systems and lead to void spaces. These voids can then be affected by natural and man-made processes such as caving, changes in flowage, or changes in overlying rock and soil material resulting in collapse or subsidence. Hazards from these abandoned sites are complicated by the fact that many “final mine maps” are inaccurate or incomplete (Colorado Geological Survey 2014). Mines operating after August 1997 were required by federal and state law to take potential surface subsidence into account; however, mining has been an activity in the state since the 1860s (Colorado Geological Survey 2001). There are some mapped, known mine hazard areas in Colorado and in Clear Creek County. Three mapped road-mine sinkholes are documented in the vicinity of Idaho Springs.

4.7.2 Past Events

Erosion and Deposition

Soil erosion and deposition occur in all parts of the County. Point sources of erosion often occur in areas where humans interact with exposed areas of the earth’s surface, such as construction sites. Waterways are continually involved in erosion and deposition processes. Erosion and deposition may be exacerbated in areas where wildfires have occurred. As a fire burns, it destroys plant material and the layers of litter that blanket the floor of an ecosystem. These materials, as well as trees, grasses, and shrubs, buffer and stabilize the soil from intense rainstorms. The plant materials slow runoff to give rainwater time to percolate into the ground. When fire destroys this protective later, rain and wind wash over the unprotected soil and erosion occurs. Areas in Clear Creek County that were recently burned are more susceptible to exacerbated erosion and deposition. Additionally, areas with high slopes and mountainous regions have a higher susceptibility to soil erosion.

Expansive Soil

The planning area is exposed to a minimal risk from expansive soil since this mountainous county has very little underlay of clay soils.

Subsidence and Sinkholes

The occurrence of subsidence is an on-going process resulting from natural and human induced causes. There have been five known events of subsidence and sinkhole events that have occurred within Clear Creek County and according to the USGS, primarily along the Interstate 70 corridor. Three road-mine sinkholes occurred and are mapped, one July 19, 2012, one April 14, 2006, and one August 27, 2004. Additional sinkhole details are below along with two additional sinkhole occurrences in 2015 and 2016.

- March 22, 2016 – A car-size sinkhole opened up near an Interstate 70 off-ramp in Idaho Springs according to CDOT spokeswoman. CDOT crews filled the hole and then traffic was able to continue moving.
- July 26, 2015 – A small 2-foot-wide sinkhole opened on the westbound side of Interstate 70 on the Loveland Bridge near Georgetown. There were no reported cost estimates or reported injuries associated with the sinkhole. CDOT blamed a "joint failure" for the sinkhole and said it was not caused by a mine shaft (source: CDOT news release, https://www.codot.gov/news/dailyclips/july-2015-clips/july-29-2015).
- July 19, 2012 – CDOT was notified about a sinkhole 15 feet-deep and 14 feet-wide that opened up on Interstate 70 near Idaho Springs as shown in Figure 4-19. The sinkhole is believed to have opened up due to a couple of mine shafts weakening underneath the highway. There were no injuries and no vehicles damaged due to the sinkhole (source: CDOT news release, https://www.codot.gov/news/2012-news-releases/07-2012/i-70-sinkhole-in-idaho-springs-area).

Figure 4-19: Sinkhole on Interstate 70 near Idaho Springs, Colorado, July 19, 2012

Source: Channel 9 News, http://legacy.9news.com/story/news/local/4-pm-show/2014/02/22/1807844/, Photo KUSA

4.7.3 Location

Erosion and Deposition

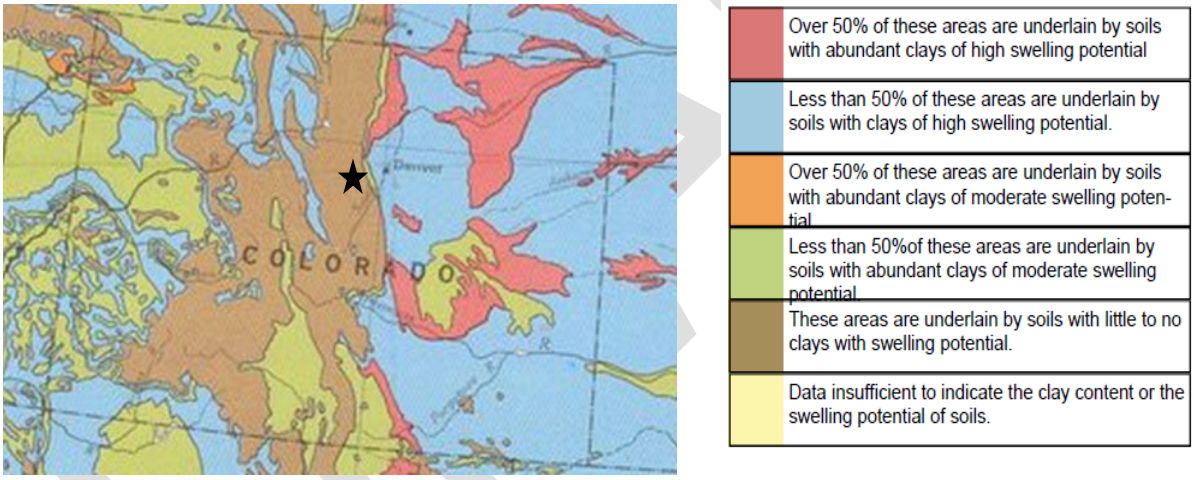
Soil erosion and deposition are ongoing events that can be affected by both natural and human-induced processes. Soil erosion and deposition events are continually occurring throughout the county. Portions of the county vary between highly erodible land to not highly erodible land. The majority of the highly erodible land is in higher sloped and mountainous areas.

Recently, the Colorado Water Conservation Board (CWCB) developed a Relative Elevation Model (REM) tool that provides data on narrow streams where erosion occurs (UCCWA 2021). The REM provides relative elevation along multiple streams including Clear Creek at Georgetown and Leavenworth Creek in addition to data for stream restoration and stream corridor preservation risk scores.

Expansive Soil

Clear Creek County soils are mostly underlain by soils with less than 50% of clays with high swelling potential, with some areas, primarily the Front Range Mountains that are areas underlain by soils with little to no clays with swelling potential (Figure 4-20). Because most of the county is in mountainous terrain, there is little to no clay, resulting in minimal swelling potential.

Figure 4-20: Expansive Soils in the State of Colorado



★ Clear Creek County

Source: USGS. http://ngmdb.usgs.gov/Prodesc/proddesc_10014.htm

Subsidence and Sinkholes

According to the Colorado Geological Survey, "Most catalogued sinkholes of Colorado lie on surficial deposits such as flat-lying glacial outwash terraces, recent valley side sediments, or older deposits on pediment slopes overlying the evaporite bedrock. The highest density of sinkholes that are manifested at the surface in Colorado occur in the Garfield County, Eagle County, Rio Blanco County, and Park County" (Colorado Geological Survey 2001). There are five known sinkhole hole events that have occurred in the county, as described in Section 4.7.2. Most of the sinkholes are a result of old, unmapped mines. There have been documented areas of road-mine sinkholes in the vicinity of Idaho Springs.

4.7.4 Magnitude / Severity

Erosion and Deposition

Erosion and deposition, subsidence, and sinkholes are occurring continuously throughout the county and the probability is likely to continue in the future. Soil erosion and deposition generally occurs gradually over time; however, these processes may be intensified as a result of natural or human-induced activities. Large precipitation events as well as human activity may influence the frequency of these events. Such events can cause property damage as well as loss of life; however, events may also occur in remote areas of the county where there is little to no impact to people or property.

Erosion can cause undercutting that can result in an increase in landslide or rockfall hazards. Deposition can have impacts that aggravate flooding, bury crops, or reduce capacities of water reservoirs.

The Towns of Empire and Georgetown have a moderate potential impact for erosion and deposition. The City of Idaho Springs and Town of Silver Plume have a low potential impact for erosion and deposition.

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

Expansive Soil

Expansive soils are not likely to occur in the county, although large precipitation events as well as human activity may influence the frequency of these events. While fiscal damage from widespread expansive soils could be significant, the overall severity and impacts of the hazard are readily mitigated, reducing the overall impacts. All participating jurisdictions have a low potential impact for expansive soils.

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

Subsidence and Sinkholes

Subsidence and sinkholes have occurred throughout the county and the probability is likely to continue in the future. Large precipitation events as well as human activity may influence the frequency of these events. Such events can cause property damage as well as loss of life; however, events may also occur in remote areas of the county where there is little to no impact to people or property. According to the Colorado Geological Survey, “In general, the type and severity of surface subsidence is governed by the amount of ground surface and the location of removal or compression, and the geological conditions of a particular site” (Colorado Geological Survey 2014).

Subsidence can happen suddenly and without warning or can occur gradually over time. 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.

Unmapped and abandoned mining locations can cause a serious issue for Clear Creek County with the threat of soil collapse. There is historically a good deal of mining that has occurred in Clear Creek County. Though there are no marked areas of immediate concern, more research is needed to identify locations of past mining locations.

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 are five events of record for the County related to subsidence since

2004. The developed areas with the greatest vulnerability to known subsidence areas is along the I-70 Interstate corridor, near Idaho Springs, and Georgetown and other abandoned mine areas.

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.

The City of Idaho Springs has a high potential impact for subsidence based on past road-mine sinkhole events. The Towns of Empire, Georgetown, and Silver Plume have a low potential for subsidence.

Based on these factors, the magnitude severity ratings for subsidence are considered **limited**, based on the dollar amount of property damage incurred.

4.7.5 Probability of Future Occurrences

Erosion and Deposition

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 1952, there have been eight fire incidents in Clear Creek County that have burned 10 or more acres, giving a probability of erosion occurring as a result of severe wildfire in any given year is 11.6%. This corresponds to a probability of future occurrences rating of **likely**.

Expansive Soil

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 should prevent the likelihood of the hazard having damaging impacts. The probability rating for this hazard is considered as **occasional.**

Subsidence and Sinkholes

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 have been five reported incidents in Clear Creek County that caused property damage since 2004. The methodology for calculating the probability of future occurrences is described in Section 4-4. This formula evaluates that the probability of subsidence occurring in any given year is 29.4%. This corresponds to a probability of future occurrences rating of **likely**.

4.7.6 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, from regional erosion and deposition, 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.

Changes in precipitation events and the hydrological cycle may result in changes in the rate of subsidence and soil erosion.

4.7.7 Vulnerability

People

The risk of injury or fatalities as a result of these hazards are limited, but possible. Spontaneous collapse and opening of voids are rare, but still may occur resulting in death or injury to any people in the area at the time. It is likely that any such injuries would be highly localized to the area directly impacted by an event. Erosion can adversely impact populations who have respiratory issues by reducing air quality, so those with existing respiratory issues are likely to be more vulnerable.

Residents of the county living or travelling in areas prone to subsidence and erosion are exposed to the hazard. Population exposure estimates are unavailable. The majority of the population is not exposed to subsidence. Interstate 70 is a major transportation route that transects Colorado and is a major national east-west highway that has experienced sinkholes. Disruption of transportation could cause major impacts to Clear Creek County, the State of Colorado, and potentially areas throughout the country.

General Property

Property exposed to subsidence and erosion can sustain minor damages or can result in complete destruction. According to Colorado Geological Survey, merely an inch of differential subsidence beneath a residential structure can cause several thousand dollars of damage. Structures may be condemned as a result of this damage resulting in large losses. FEMA estimates that there are over $125 million in losses in the U.S. annually as a result of subsidence. Structures exposed to erosion hazard areas may be undermined, resulting in damages. This may also result in the condemnation of a structure. Additionally, physical loss land area may occur as a result of erosion. Lack of data makes it difficult to pinpoint exposure and risk, and any damage would likely be sporadic.

Structures and other improvements located in areas prone to subsistence or soil erosion are exposed to risk from these hazards, particularly structures located along streams and other waterways. Additionally, deposition may result in damage to structures and property.

Critical Facilities and Infrastructure

Subsidence can result in serious structural damage to critical facilities and infrastructure such as, roads, irrigation ditches, underground utilities and pipelines. Large ground displacements caused by collapsing soils can damage roads and structures and alter surface drainage. Minor cracking and distress may result as the improvements respond to small adjustments in the ground beneath them. Erosion can also impact structures such as bridges and roads by undermining their foundations. Structures and underground utilities found in areas prone to subsidence or soil erosion can suffer from distress. The shifting and settling of the structure can be seen in a number of ways:

- Settlement, cracking and tilting of concrete slabs and foundations,
- Displacement and cracking in door jams, window frames, and interior walls, or
- Offset cracking and separation in rigid walls such as brick, cinderblock, and mortared rock (Colorado Geological Survey 2001).

Critical facilities or infrastructure located along streams and waterways are exposed to risk from the hazard. Deposition may result in additional exposure to facilities and infrastructure, including dams, bridges, and roads.

Economy

Subsidence and sinkhole events along I-70 corridor have caused minor repair costs and delays. In addition to the repair costs of roadways, these events delays tourist to Clear Creek County.

Wildfires often result in increased erosion, and there have been eight fires in Clear Creek County since 1952. Response and recovery costs to address erosion problems from the Buffalo Creek fire have cost Denver Water alone over $24 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.

Historic, Cultural and Natural Resources

Ecosystems that are exposed to increased sedimentation as a result of erosion and deposition degrades habitat. However, some erosion and disposition is required for healthful ecosystem functioning. Ecosystems that are already exposed to other pressures, such as encroaching development, may be more vulnerable to impacts from these hazards.

Subsidence, erosion and deposition, and expansive soils are all naturally occurring processes, but can still cause damage to the natural environment. Environments located in areas prone to subsidence and deposition are exposed. Additionally, areas where sediments are deposited are also exposed.

4.7.8 Development Trends

The County is seeing continued, limited single-family residential development on existing parcels and mining claims; mostly on the east side of the County. Future growth areas are anticipated in the I-70 corridor with additional limited growth in St. Mary's and the east side of the County where vacant parcels still exist.

According to the 2016 State of Colorado Hazard Mitigation Plan:

Future development will potentially intersect subsidence hazard areas. As Colorado's population continues to grow and the need for additional housing increases, more people and property may be affected by subsidence. Local land use planning agencies should consult federal and state sources including CGS, the US Forest Service, the Bureau of Land Management, and the Colorado Division of Reclamation, Mining, and Safety (DRMS) to identify known abandoned mine lands and other subsidence hazards before beginning development projects. Engineering geology and geotechnical investigations can help in identification of hazards and mitigation strategies. Avoidance is generally the best mitigation solution where subsidence features are properly identified. Many older sinkholes may be hidden. Only subsurface inspections, either by investigative trenching, a series of investigative borings, geophysical means, and/or observations made during overlot grading or utility installation, can ascertain whether sinkholes exist within a development area. Ground-modification and structural solutions can help mitigate the threat of localized subsidence. Drainage issues and proper water management are also important. In Colorado's semi-arid climate, additional increases of fresh water may accelerate dissolution and further destabilize certain subsidence areas.

Jurisdictions in the planning area should ensure that known hazard areas are regulated under their planning and zoning programs. In areas where hazards may be present, permitting processes should require geotechnical investigations to access risk and vulnerability to hazard areas. Erosion issues generally do not impact land use except along river channels. Issues pertaining to land use in these areas are likely addressed through jurisdictional floodplain ordinances and regulations. For further information regarding best management practices related to erosion, see the Clear Creek County Best Management Practices Manual, amended in 2012.

4.7.9 Risk Summary

- Overall significance of this hazard is **Low**, except the subsidence hazard is **High** for Idaho Springs, and erosion /deposition hazard is **Medium** for Empire and Georgetown.
- Human activities greatly influence the rate and extent of erosion and deposition. Activities should be evaluated before proceeding with them.
- Riverine erosion can reduce water quality and impact aquatic habitat as well as impacting private property and critical infrastructure. Human activities that affect waterways and sediment movement greatly influence the rate and extent of erosion and deposition.
- Onset of actual or observed subsidence in many cases is related to changes in land use. Land uses permitted in known hazard areas should be carefully evaluated.
- Abandoned mine information is incomplete. There are likely to be hazardous areas in addition to known locations.
- Some housing developments have had subsidence hazard investigations completed before development. This practice should be expanded.
- Homeowners within an undermined area that were built before 1989 are eligible to participate in the Mine Subsidence Protection Program, a federal program operated by the Mined Land Reclamation Board of the Division of Minerals and Geology. Homes built after 1989 are not covered.
- Many older sinkholes have been covered with recent soil infilling and are completely concealed at the surface.
- More detailed analysis should be conducted for critical facilities and infrastructure exposed to hazard areas. This analysis should address how potential structural issues were addressed in facility design and construction.
- Related hazards: Drought, flood, landslide, wildfire.

4.8 Flood

FLOOD HAZARD RANKING	
Clear Creek County	High
City of Idaho Springs	High
Town of Empire	High
Town of Georgetown	High
Town of Silver Plume	High
Clear Creek Fire Authority	High

DEFINITIONS

Flood—The inundation of normally dry land resulting from the rising and overflowing of a body of water.

Floodplain—The land area along the sides of a river that becomes inundated with water during a flood.

100-Year Floodplain—The area flooded by a flood that has a 1% chance of being equaled or exceeded each year. This is a statistical average only; a 100-year flood can occur more than once in a short period of time. The 1% annual chance flood is the standard used by most federal and state agencies.

Riparian Zone—The area along the banks of a natural watercourse.

4.8.1 Description

Flood

The following section is excerpted from the 2018 State of Colorado Flood Mitigation Plan.

A flood is a general and temporary condition of partial or complete inundation of normally dry land areas from:

- The overflow of stream banks,
- The unusual and rapid accumulation of runoff of surface waters from any source, or
- Mudflows or the sudden collapse of shoreline land.

Flooding results when the flow of water is greater than the normal carrying capacity of the stream channel. Rate of rise, magnitude (or peak discharge), duration, and frequency of floods are a function of specific physiographic characteristics. Generally, the rise in water surface elevation is quite rapid on small (and steep gradient) streams and slow in large (and flat sloped) streams.

The causes of floods relate directly to the accumulation of water from precipitation, rapid snowmelt, or the failure of man-made structures, such as dams or levees. Floods caused by precipitation are further classified as coming from: rain in a general storm system, rain in a localized intense thunderstorm, melting snow, rain on melting snow, and ice jams.

The potential for flooding can change and increase through various land use changes and changes to land surface. A change in environment can create localized flooding problems inside and outside of natural floodplains by altering or confining watersheds or natural drainage channels. These changes are commonly created by human activities (e.g., development). These changes can also be created by other events such as wildfires. Wildfires create hydrophobic soils, a hardening or “glazing” of the earth’s surface that prevents rainfall from being absorbed into the ground, thereby increasing runoff, erosion, and downstream sedimentation of channels.

Clear Creek County is susceptible to flooding, particularly in the jurisdictions that are located in river valleys. Snowmelt and rainfall tend to travel off the mountains and enter the towns below. Additionally, Clear Creek and its tributaries all flow through the jurisdictions in Clear Creek County.

Potential flood impacts include loss of life, injuries, and property damage. Floods can also affect infrastructure (water, gas, sewer, and power utilities), transportation, jobs, tourism, the environment, and ultimately local and regional economies.

General Rain Floods

General rain floods can result from moderate to heavy rainfall occurring over a wide geographic area lasting several days. They are characterized by a slow steady rise in stream stage and a peak flood of long duration. As various minor streams empty into larger and larger channels, the peak discharge on the mainstream channel may progress upstream or downstream (or remain stationary) over a considerable length of river. General rain floods can result in considerably large volumes of water. The general rain flood season is historically from the beginning of May through October.

Thunderstorm or Flash Floods

Damaging thunderstorm floods are caused by intense rain over basins of relatively small area. They are characterized by a sudden rise in stream level, short duration, and a relatively small volume of runoff. These floods often result by overwhelming the capacity of the stormwater drainage system in the area, leading to localized flooding. Because there is little or no warning time, the term flash flood is often used to describe thunderstorm floods. The average number of thunderstorm days per year in Colorado varies from less than 40 near the western boundary to over 70 in the mountains along the Front Range. The thunderstorm flood season in Colorado is from the middle of July through October.

Snowmelt Floods

Snowmelt floods result from melting of winter snowpack in the high mountain areas. Snowmelt floods typically begin as spring runoff appears, after the first spring warming trend. If the warming trend continues up to eight to ten consecutive days in a basin where the snowpack has a water content more than about 150% of average, serious flooding can develop. The total duration of snowmelt floods is usually over a period of weeks rather than days, and they yield a larger total volume in comparison to other types of floods in Colorado. Peak flows, however, are generally not as high as flows for the other types. A single cold day or cold front can interrupt a melting cycle causing the rising water to decline and stabilize until the cycle can begin again. Once snowmelt floods have peaked, the daily decreases are moderate, but fairly constant. Snowmelt flooding usually occurs in May, June, and early July.

Rain on Snowmelt Floods

Rain on snow flooding occurs most often in Colorado during the month of May. It is at this time of year that large general rainstorms occur over western Colorado. These rainstorms are most often caused when warm moist air from the Gulf of Mexico begins pushing far enough north that it begins to affect western weather. In combination with this movement of air mass is the continued possibility of cold fronts moving into Colorado from the Pacific Northwest. When these weather phenomena collide, long lasting general rainstorms can often occur. Rain on snowmelt exacerbates an already tenuous situation as snowmelt waters rush down heavily incised stream channels. Any abnormal increase in flow from other sources usually causes streams to leave their banks.

During the summer months of May and June when rivers are running high, there is a potential for flooding due to rain falling on melting snow. Usually such rain is over a small part of a basin, and the resulting flood is of short duration and may often go unnoticed in the lower reaches of a large drainage basin. To some extent, the cloud cover associated with the rain system can slow the melting cycle and offset the compound effect. In some cases, however, rainfall may be heavy and widespread enough to noticeably affect peak flows throughout the basin.

Ice Jam Floods

Ice jam floods can occur by two phenomena. In the mountain floodplains during extended cold periods of 20 to 40 degrees below zero, the streams ice over. The channels are frozen solid and overbank flow occurs, which results in ice inundation in the floodplains. Ice jam floods can occur when frozen water in the upper reaches of a stream abruptly begins to melt due to warm Chinook winds. Blocks of ice floating downstream can become lodged at constrictions and form a jam. The jam can force water to be diverted from the stream channel causing a flood. An ice jam can also break up, suddenly causing a surge of water as the "reservoir" that was formed behind it is suddenly released. Ice jamming occurs in slow moving streams where prolonged periods of cold weather are experienced. Sometimes the ice jams are dynamited, allowing a controlled release of the backed-up water to flow downstream.

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

A floodplain is the area adjacent to a river, creek, or lake that becomes inundated during a flood. Floodplains may be broad, as when a river crosses an extensive flat landscape, or narrow, as when a river is confined in a canyon.

When floodwaters recede after a flood event, they leave behind layers of rock and mud. These gradually build up to create a new floor of the floodplain. Floodplains generally contain unconsolidated sediments (accumulations of sand, gravel, loam, silt, or clay), often extending below the bed of the stream. These sediments provide a natural filtering system, with water percolating back into the ground and replenishing groundwater. These are often important aquifers, the water drawn from them being filtered compared to the water in the stream. Fertile, flat reclaimed floodplain lands are commonly used for agriculture, commerce, and residential development.

Connections between a river and its floodplain are most apparent during and after major flood events. These areas form a complex physical and biological system that not only supports a variety of natural resources but also provides natural flood and erosion control. When a river is separated from its floodplain with levees and other flood control facilities, natural, built-in benefits can be lost, altered, or significantly reduced.

Measuring Floods and Floodplains

The frequency and severity of flooding are measured using a discharge probability, which is the probability that a certain river discharge (flow) level will be equaled or exceeded in a given year. Flood studies use historical records to estimate the probability of occurrence for the different discharge levels. The flood frequency equals 100 divided by the discharge probability. For example, the 1% annual chance flood, also referred to as the base flood or 100-year flood, is a flood scenario that has a 1% chance of being equaled

or exceeded in any given year. The "annual flood" is the greatest flood event expected to occur in a typical year. These measurements reflect statistical averages only; it is possible for two or more floods with a 1% annual occurrence or higher recurrence interval to occur in a short time period. The same flood can have different recurrence intervals at different points on a river.

The extent of flooding associated with a 1% annual probability of occurrence is used as the regulatory boundary by many agencies. Also referred to as the special flood hazard area (SFHA), this boundary is a convenient tool for assessing vulnerability and risk in flood-prone communities. Many communities have maps that show the extent and likely depth of flooding for the base flood. Corresponding water-surface elevations describe the elevation of water that will result from a given discharge level, which is one of the most important factors used in estimating flood damage.

Floodplain Ecosystems

Floodplains can support ecosystems that are rich in plant and animal species. A floodplain can contain 100 or even 1,000 times as many species as a river. Wetting of the floodplain soil releases an immediate surge of nutrients: those left over from the last flood, and those that result from the rapid decomposition of organic matter that has accumulated since then. Microscopic organisms thrive and larger species enter a rapid breeding cycle. Opportunistic feeders (particularly birds) move in to take advantage. The production of nutrients peaks and falls away quickly, but the surge of new growth endures for some time. This makes floodplains valuable for agriculture. Species growing in floodplains are markedly different from those that grow outside floodplains. For instance, riparian trees (trees that grow in floodplains) tend to be very tolerant of root disturbance and very quick growing compared to non-riparian trees.

Effects of Human Activities

Because they border water bodies, floodplains have historically been popular sites to establish settlements. Human activities tend to concentrate in floodplains for a number of reasons: water is readily available; land is fertile and suitable for farming; transportation by water is easily accessible; and land is flatter and easier to develop. But human activity in floodplains frequently interferes with the natural function of floodplains. It can affect the distribution and timing of drainage, thereby increasing flood problems. Human development can create local flooding problems by altering or confining drainage channels. This increases flood potential in two ways: it reduces the stream's capacity to contain flows, and it increases flow rates or velocities downstream during all stages of a flood event. Human activities can interface effectively with a floodplain as long as steps are taken to mitigate the activities' adverse impacts on floodplain functions.

National Flood Insurance Program

The NFIP makes federally backed flood insurance available to homeowners, renters, and business owners in participating communities. For most participating communities, FEMA has prepared a detailed Flood Insurance Study (FIS). The study presents water surface elevations for floods of various magnitudes, including the 1% annual chance flood (the 100-year flood) and the 0.2% annual chance flood (the 500-year flood). Base flood elevations and the boundaries of the 1% and 0.2% floodplains are shown on Flood Insurance Rate Maps (FIRM), which are the principal tools for identifying the extent and location of the flood hazard. FIRMs are the most detailed and consistent data source available, and for many communities they represent the minimum area of oversight under their floodplain management program.

Participants in the NFIP must, at a minimum, regulate development in floodplain areas in accordance with NFIP criteria. Before issuing a permit to build in a floodplain, participating jurisdictions must ensure that three criteria are met:

- New buildings and those undergoing substantial improvements must, at a minimum, be elevated to protect against damage by the 100-year flood.
- New floodplain development must not aggravate existing flood problems or increase damage to other properties.
- New floodplain development must exercise a reasonable and prudent effort to reduce its adverse impacts on threatened salmonid species.

Clear Creek County and all of the participating jurisdictional communities participate in the NFIP program. Structures permitted or built in the county before then are called "pre-FIRM" structures, and structures built afterwards are called "post-FIRM." The insurance rate is different for the two types of structures. The effective date for the current countywide DFIRM (Digital Flood Insurance Rate Map) is July 17, 2012 and the National Flood Hazard Layer (NFHL) was last updated on 12/20/2019. FEMA now utilizes the NFHL, which is a geospatial database containing Letter of Map Revision (LOMR) updates and current effect flood hazard data used to support the NFIP. According to FEMA, NFHL data covers over 90 percent of the U.S. population, with new and revised data being continuously added. The county and participating communities, with the exception of Empire, are currently in good standing with the provisions of the NFIP. Compliance is monitored by FEMA regional staff. Maintaining compliance under the NFIP is an important component of flood risk reduction.

4.8.2 Past Events

The National Centers for Environmental Information Storm Events Database includes flood events that happened in Clear Creek County between 1998 and 2020, as listed in Table 4-37. Only one incident in September 2013 resulted in recorded property damage and a fatality.

Table 4-37: Clear Creek County Flood Events (1998-2020)

			Estimated Damage Cost	
Location	Date	Event Type	Property	Crops
Idaho Springs	7/25/1998	Flash Flood	$0	$0
Idaho Springs	9/3/2003	Flash Flood	$0	$0
Idaho Springs	7/16/2004	Flash Flood	$0	$0
Idaho Springs	7/18/2004	Flash Flood	$0	$0
Idaho Springs	7/19/2004	Flash Flood	$0	$0
North Central Portion	8/5/2004	Flash Flood	$0	$0
Idaho Springs	9/12/2013	Flood	$0	$0
Idaho Springs	9/14/2013	Flash Flood	$256,000	$0

Source: National Centers for Environmental Information, Storm Events Database

Notable flood incidents causing damages in Clear Creek County are described below:

- **July 1998** – Flooding occurred after a month of above-average precipitation and in areas where the ground was already fully saturated. In Idaho Springs, the rains caused a flash flood in Virginia Canyon and rainwater flooding in the town. At its peak, there was over 2 inches of rainfall in less than 1 hour.
- **September 2003** – According to the 2019 Flood Insurance Study for Clear Creek County there has been a history of flash flooding throughout the county. The study states that "Flooding in Georgetown,

Idaho Springs, and Silver Plume is primarily caused by either spring snowmelt or snowmelt in conjunction with rainfall". One instance of flash flooding specifically referenced in the study occurred in September 2003. These flash floods caused mud slides down Virginia Canyon and flooded numerous basements in Idaho Springs. There were also several instances during the summer of 2004 where local heavy rains caused washouts along the Virginia Canyon Road.

- **September 2013** – FEMA-EM-3365 and FEMA-DR-4145. A deep southerly flow over Colorado, ahead of a near stationary low-pressure system over the Great Basin, pumped monsoonal moisture into the area. In addition, a weak stationary front stretched along the Front Range Foothills and Palmer Divide. As a result, a prolonged period of moderate to heavy rain developed across the Front Range Foothills, Palmer Divide, and Urban Corridor. By September 14, storm totals ranged from 6 to 18 inches. Houses were flooded along Soda Creek Road south of Idaho Springs, and roads were impassable near Upper Bear Creek, stranding numerous residents. Clear Creek County schools were closed, and motorists were stuck for hours at various times in traffic that moved very slowly for miles. One Idaho Springs' man died when Clear Creek water level rose above normal and the bank collapsed under his feet. The victim was an 83-year old man. The flooding was some of the worst the county has experienced (see photos in Figure 4-21 and Figure 4-22). According to FEMA, 113 households in the county were impacted by flooding. FEMA-DR-4145 approved over $61 million for individual assistance and over $354 million for public assistance aid statewide for the affected communities of this federal disaster (Source: FEMA, https://www.fema.gov/disaster/4145).

Figure 4-21: Photos of Flood Damage in Clear Creek County, September 2013

Source: Clear Creek Office of Emergency Management

Figure 4-22: Photos of Flood Damage along Juno Trail in Clear Creek County, September 2013

Source: Clear Creek Office of Emergency Management

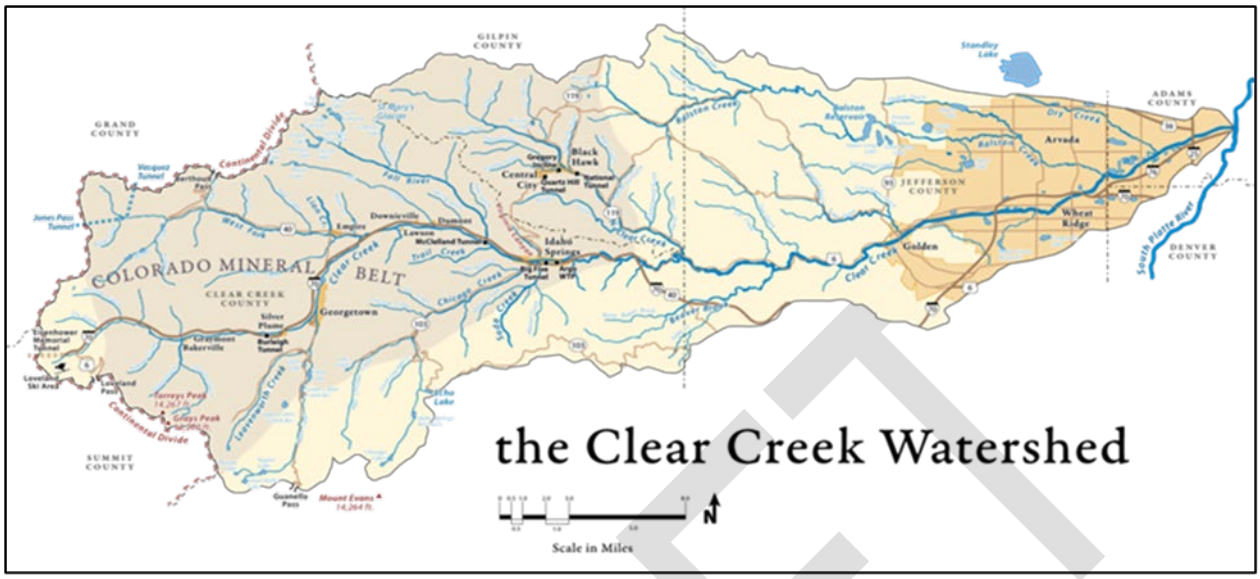
4.8.3 Location

Clear Creek County is a very mountainous county with elevations above 7,500 feet and bounded on the west by the continental divide. Clear Creek and its tributaries divide the county. Most of the towns in the county are located directly on Clear Creek and its tributaries, contributing to a high overall significance of flood hazards.

Clear Creek is a tributary of the South Platte River and is approximately 66 miles long. The Clear Creek Watershed is approximately 575 square miles and spans from 14,000-foot mountain peaks at its western edge on the Continental Divide in Clear Creek County down to the urbanized plains at its confluence with the South Platte River just north of Denver. The main stem of Clear Creek flows eastward along the Interstate 70 corridor through several mountain communities, along approximately 12 miles of the Highway 6 corridor through Clear Creek Canyon, and then back along the Interstate 70 corridor through several Denver Front Range Communities. Clear Creek converges with the South Platte River near Commerce City. The Clear Creek Watershed is shown below in Figure 4-23.

Clear Creek and its tributaries serve as the primary water supply source for several upper-watershed communities including the Towns of Silver Plume, Georgetown, Empire, and the City of Idaho Springs.

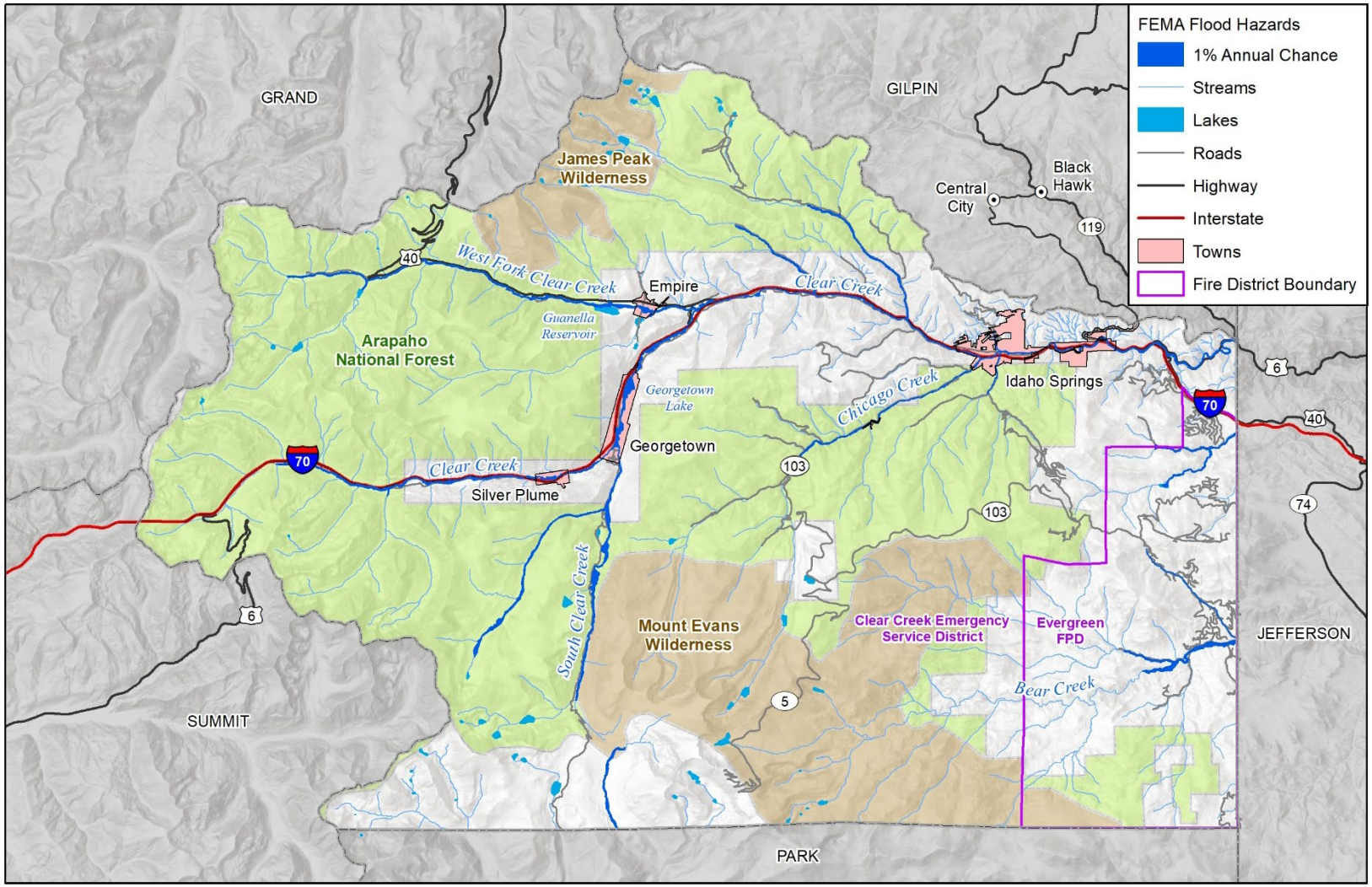
Figure 4-23: Clear Creek Watershed



Source: Clear Creek Watershed Foundation (https://www.coloradowater.org/clear-creek-watershed-foundation)

Figure 4-24 below highlights the extent of the 100-year floodplain countywide in the planning area. The effective date for the current countywide FIRM is July 17, 2012 with the NFHL's date as December 20, 2019. Figure 4-25 through Figure 4-28 focus on the city of Idaho Springs and towns of Georgetown, Empire, and Silver Plume, and highlight the locations of exposed properties in the 100-year and 500-year floodplain.

Figure 4-24: Clear Creek County FEMA Flood Hazards, 1% Annual Chance Floodplain



Map compiled 6/2021;
intended for planning purposes only.
Data Source: Clear Creek County, CDOT,
FEMA NFHL 12/20/2019, Effective Date 7/17/2012

Figure 4-25: City of Idaho Springs FEMA Flood Hazards and Exposed Properties, 1% Annual Chance Floodplain

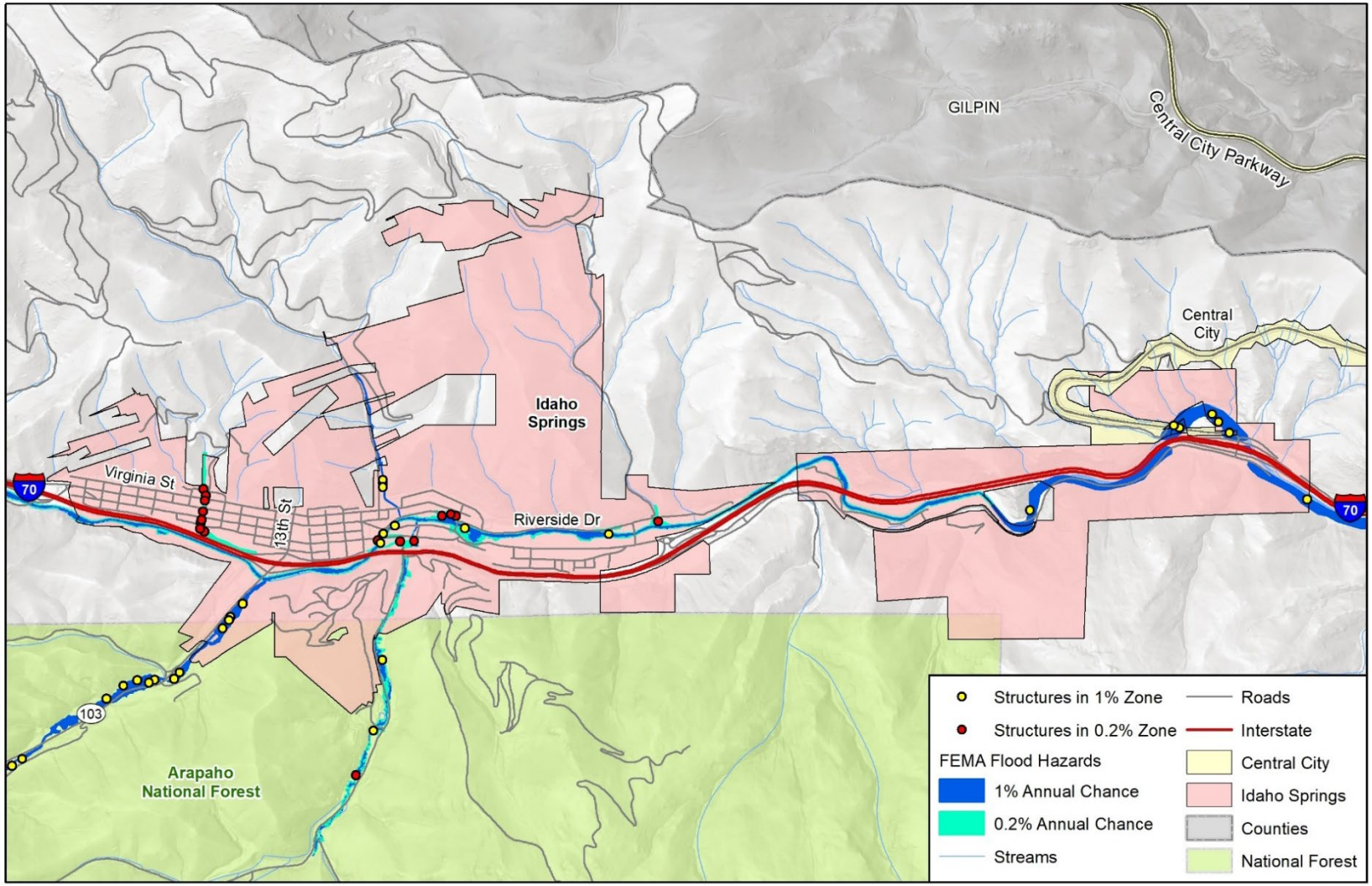


Figure 4-26: Town of Georgetown FEMA Flood Hazards, 1% Annual Chance Floodplain

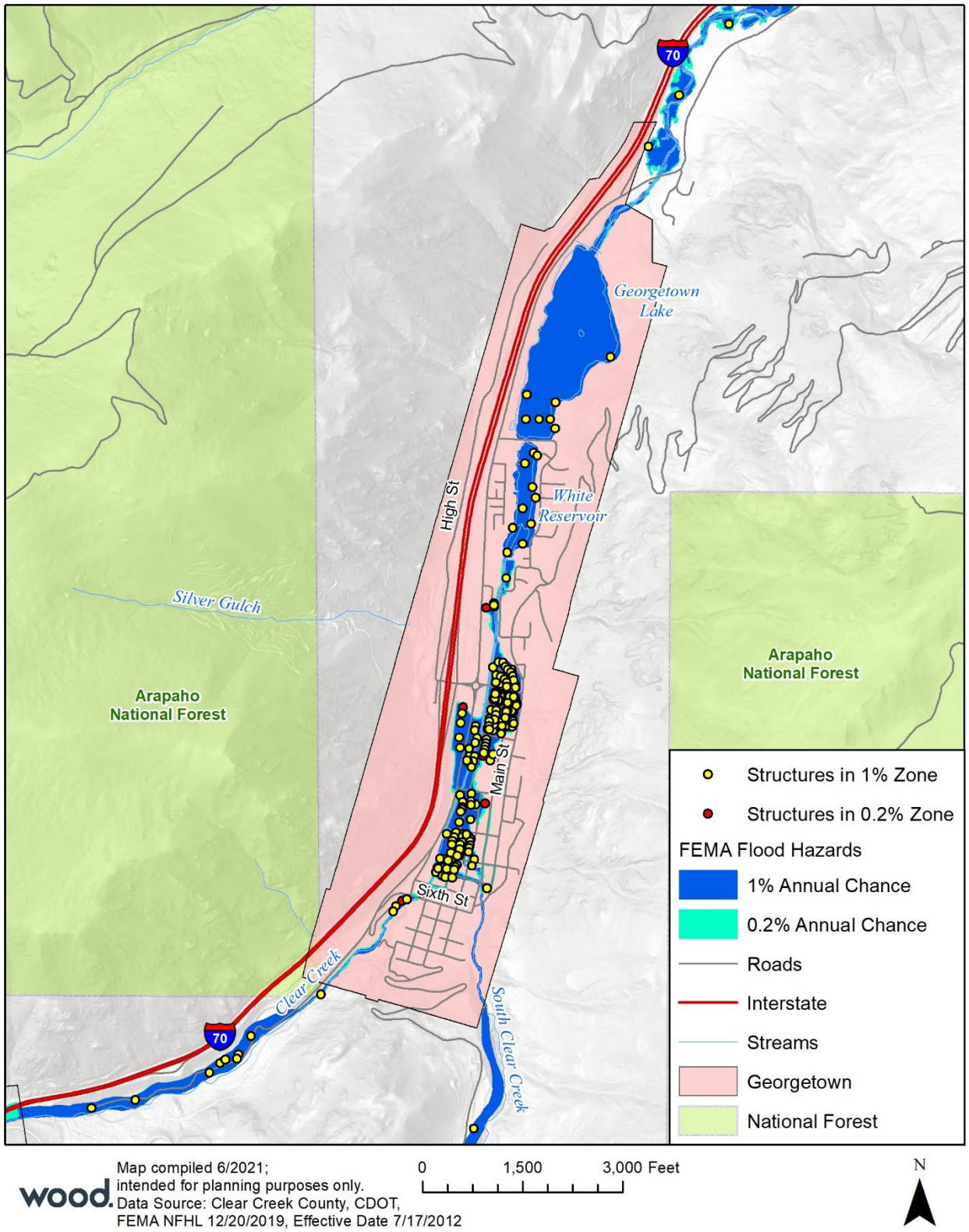


Figure 4-27: Town of Silver Plume FEMA Flood Hazards, 1% Annual Chance Floodplain

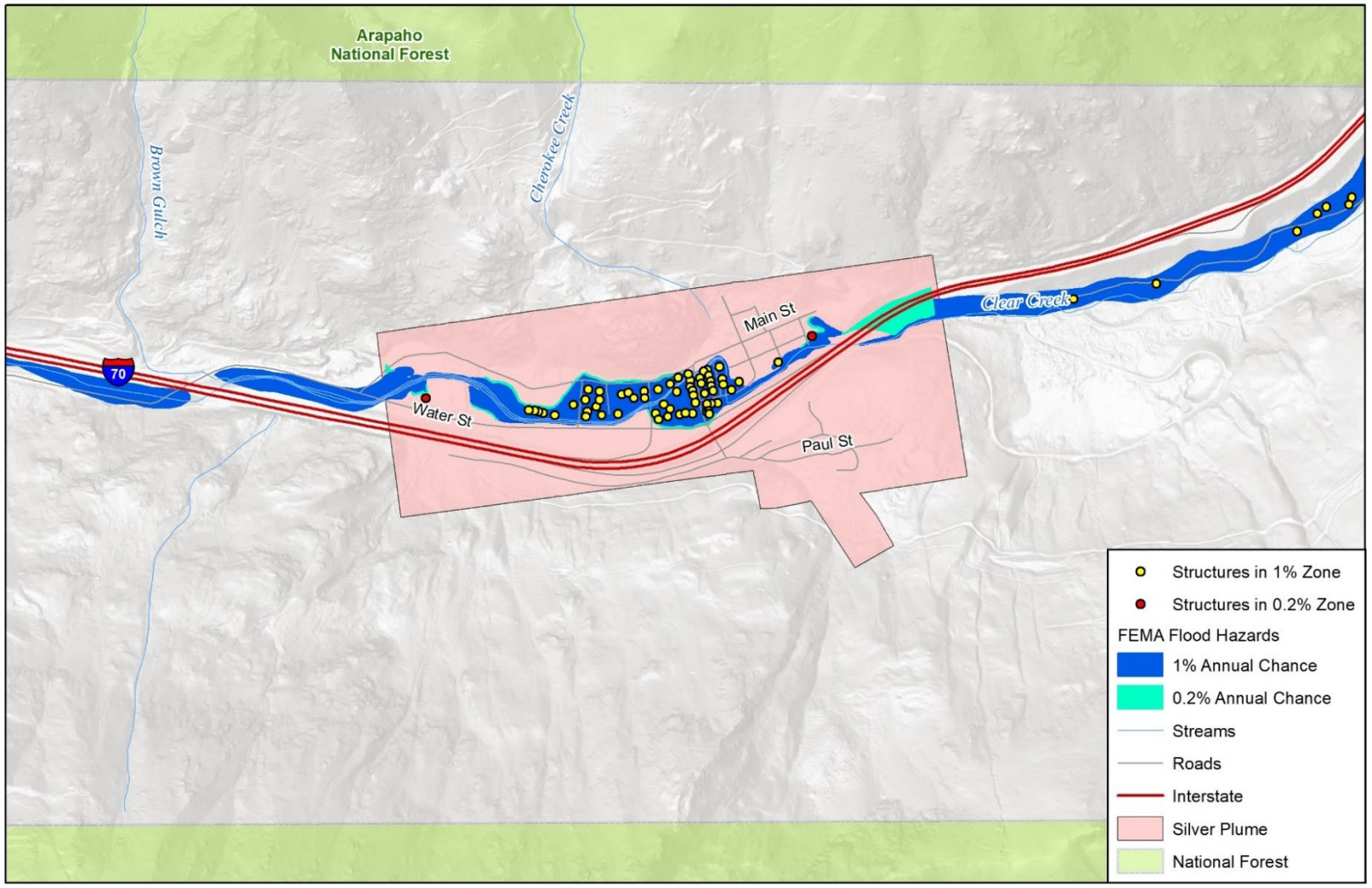
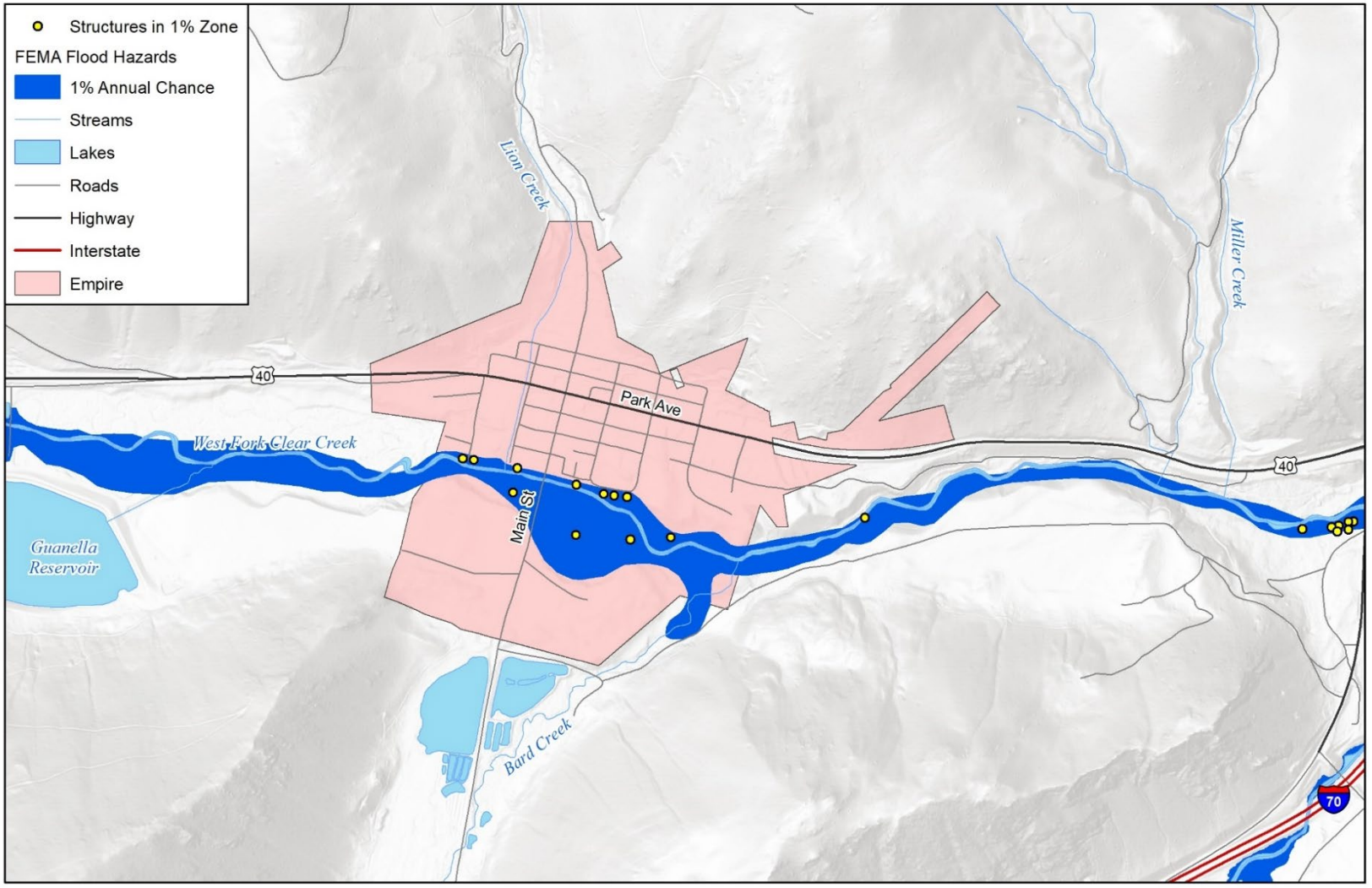


Figure 4-28: Town of Empire FEMA Flood Hazards, 1% Annual Chance Floodplain



4.8.4 Magnitude and Severity

Magnitude and severity can be described or evaluated by a combination of different levels of impact 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.

Based on the information in this hazard profile, the magnitude/severity of flooding is moderate to high, for all the planning partners. The loss potential is the highest for the unincorporated county and the Town of Georgetown (see Table 4-36). This is reflected in the flood hazard maps shown previously and quantified in the vulnerability sub-section.

4.8.5 Probability of Future Occurrences

Periodic flooding of lands adjacent to rivers and streams is a natural occurrence in the county and can be expected to take place based upon established flood recurrence intervals.

A 100-year flood, which has a 1% chance (1 in 100) of occurring in a given year, is a regulatory standard used by federal agencies, states, and NFIP- participating communities to administer and enforce floodplain management programs, as well as set insurance requirements nationwide.

The 500-year flood event, which has a 0.2% chance (1 in 500) chance of occurring in a given year, is another commonly mapped and studied event by FEMA flood related programs and efforts.

The most recent FEMA special flood hazard areas mapped, which contain the 1% and 0.2% events and hence where riverine flooding is expected to primarily occur in the future, are shown in Figure 4-24 through Figure 4-28 under the Hazard Location subsection of this chapter.

Seasonal flooding in Clear Creek County has been decreasing through time due to the increased attention to water management issues. Flash floods and floods, however, are still considered to be likely to occur, with approximately 36% chance of occurrence in any given year. This probability is based on the historical record of 8 events occurring over the 22 years reported in the National Centers for Environmental Information Storm Events Database (Table 4-37). This corresponds to a probability of future occurrences rating of likely.

4.8.6 Climate Change Considerations

Use of historical hydrologic data has long been the standard of practice for designing and operating water supply and flood protection projects. For example, historical data are used for flood forecasting models and to forecast snowmelt runoff for water supply. This method of forecasting assumes that the climate of the future will be similar to that of the period of historical record. However, the hydrologic record cannot be used to predict changes in frequency and severity of extreme climate events such as floods. Going forward, model calibration or statistical relation development must happen more frequently, new forecast-based tools must be developed, and a standard of practice that explicitly considers climate change must be adopted. Climate change is already impacting water resources, and resource managers have observed the following:

- Historical hydrologic patterns can no longer be solely relied upon to forecast the water future.
- Precipitation and runoff patterns are changing, increasing the uncertainty for water supply and quality, flood management, and ecosystem functions.
- Extreme climatic events will become more frequent, necessitating improvement in flood protection, drought preparedness, and emergency response.

The amount of snow is critical for water supply and environmental needs, but so is the timing of snowmelt runoff into rivers and streams. Rising snowlines caused by climate change will allow more mountain area to contribute to peak storm runoff. As hydrology changes, what is currently considered a 100-year flood may strike more often, leaving many communities at greater risk. High frequency flood events (e.g., 10-year floods) in particular will likely increase with a changing climate. Additionally, scientists predict greater storm intensity, resulting in more direct runoff and flooding. As stream flows and velocities change, erosion patterns will also change, altering channel shapes and depths. With potential increases in the frequency and intensity of wildfires due to climate change, there is potential for more floods following fire, which in turn increase sediment loads and water quality impacts.

4.8.7 Vulnerability

This section describes vulnerabilities in terms of population, property, infrastructure, and environment. The vulnerability analysis was performed at the parcel level using GIS during the 2021 update. This methodology improves upon the census-block level Hazus analysis done previously, which likely overestimated impacts from both the modelled 100-year and 500-year flood events as it is assumed that both structures and the population are evenly spread throughout census block. This section describes vulnerabilities in terms of population, property, infrastructure, and environment. Results of the analysis for each vulnerability subject are presented in the following sections.

Population

Injuries or fatalities typically result if people are caught off guard by the flood event, more commonly associated with flash floods. Most fatalities occur when people attempt to drive across flooded areas.

Population counts of those living in the floodplain in the planning area were generated by analyzing tax assessor data and building locations that intersect with the 100-year and 500-year floodplains identified on FIRMs. Since both floodplains are nearly identical spatially (that is, the 100-year and 500-year floodplains overlap), they contain similar numbers of structures and therefore have similar population distributions. Total populations were estimated by multiplying the number of residential properties exposed to the 100-year floodplain by the average Clear Creek County household size of the respective communities (ranging from 1.73 to 2.23 persons per household).

Using this approach, it was estimated that the exposed population for the entire county is 720 within the 100-year floodplain, and an additional 39 in the 500-year floodplain. For the unincorporated portions of the county, it is estimated that the exposed population is 404 within the 100-year floodplain. For the City of Idaho Springs, Town of Georgetown, Town of Empire, and the Town of Silver Plume, it is estimated the exposed population to the 100-year floodplain are 4, 225, 7, and 81, respectively.

Property

Figure 4-27 summarizes the total number of improved parcels and number of structures in the 100-year floodplains by municipality and unincorporated county. Table 4-39 summarizes the total number of improved parcels and number of structures in the 500-year floodplain by municipality and unincorporated areas. The analysis determined that there are an estimated 401 structures within the 100-year floodplain total. Approximately 53.3% of these structures are in unincorporated areas. Approximately 85% of the structures are residential. The parcel analysis revealed there are significantly fewer structures in the 500-year floodplain, with a grand total of 21 structures. The analysis does not account for those structures that might have been more recently constructed in accordance with local floodplain management regulations, and thus are not prone to 1% annual chance flooding.

Table 4-38: Property and Estimated Values in the 1% Annual Chance Flood Hazard

Jurisdiction	Property Type	Improved Parcels	Building Count	Improved Value	Content Value	Total Value	Estimated Loss
Empire	Mining	1	1	$150	$150	$300	$75
	Residential	4	4	$251,670	$125,835	$377,505	$94,376
	Total	**5**	**5**	**$251,820**	**$125,985**	**$377,805**	**$94,451**
Georgetown	Commercial	6	8	$374,640	$374,640	$749,280	$187,320
	Exempt	2	2	$211,510	$211,510	$423,020	$105,755
	Improved Vacant Land	2	2	$41,640	$41,640	$83,280	$20,820
	Residential	106	117	$7,434,760	$3,717,380	$11,152,140	$2,788,035
	Total	**116**	**129**	**$8,062,550**	**$4,345,170**	**$12,407,720**	**$3,101,930**
Idaho Springs	Commercial	2	2	$498,750	$498,750	$997,500	$249,375
	Exempt	3	5	$318,130	$318,130	$636,260	$159,065
	Residential	2	2	$54,460	$27,230	$81,690	$20,423
	Total	**7**	**9**	**$871,340**	**$844,110**	**$1,715,450**	**$428,863**
Silver Plume	Commercial	1	1	$31,350	$31,350	$62,700	$15,675
	Exempt	1	1	$36,420	$36,420	$72,840	$18,210
	Improved Vacant Land	2	2	$21,000	$21,000	$42,000	$10,500
	Residential	37	40	$1,473,880	$736,940	$2,210,820	$552,705
	Total	**41**	**44**	**$1,562,650**	**$825,710**	**$2,388,360**	**$597,090**
Unincorporated	Agriculture	3	6	$3,190	$3,190	$6,380	$1,595
	Exempt	13	14	$5,601,930	$5,601,930	$11,203,860	$2,800,965
	Mining	10	13	$428,700	$428,700	$857,400	$214,350
	Residential	141	181	$11,154,760	$5,577,380	$16,732,140	$4,183,035
	Total	**167**	**214**	**$17,188,580**	**$11,611,200**	**$28,799,780**	**$7,199,945**
Grand Total		**336**	**401**	**$27,936,940**	**$17,752,175**	**$45,689,115**	**$11,422,279**

Source: Clear Creek Assessor, FEMA NFHL 12/20/2019, Wood GIS Analysis

Table 4-39: Property and Estimated Values in the 0.2% Annual Chance Flood Hazard

Jurisdiction	Property Type	Improved Parcels	Building Count	Improved Value	Content Value	Total Value	Estimated Loss
Georgetown	Residential	3	3	$299,450	$149,725	$449,175	$112,294
	Total	**3**	**3**	**$299,450**	**$149,725**	**$449,175**	**$112,294**
Idaho Springs	Exempt	1	1	$170,760	$170,760	$341,520	$85,380
	Residential	11	11	$233,130	$116,565	$349,695	$87,424
	Improved Vacant Land	1	1	$10,680	$10,680	$21,360	$5,340
	Total	**13**	**13**	**$414,570**	**$298,005**	**$712,575**	**$178,144**
Silver Plume	Residential	1	1	$41,920	$20,960	$62,880	$15,720
	Total	**1**	**1**	**$41,920**	**$20,960**	**$62,880**	**$15,720**
Unincorporated	Residential	4	4	$154,620	$77,310	$231,930	$57,983
	Total	**4**	**4**	**$154,620**	**$77,310**	**$231,930**	**$57,983**
Grand Total		**21**	**21**	**$910,560**	**$546,000**	**$1,456,560**	**$364,140**

Source: Clear Creek Assessor, FEMA NFHL 12/20/2019, Wood GIS Analysis

National Flood Insurance Program

Table 4-40 lists flood insurance statistics that help identify vulnerability in the planning area. Clear Creek County, the City of Idaho Springs, and the Towns of Georgetown and Silver Plume all participate in the NFIP. The Town of Empire does not participate in the NFIP and is currently sanctioned, which means residents cannot obtain flood insurance.

Table 4-40: National Flood Insurance Program Statistics

	Initial FIRM Effective Date	Claims (11/1978 to 5/1/2021)	Value of Claims Paid (11/1978 to 5/1/2021)
Georgetown	06/05/1989	8	$11,886
Idaho Springs	11/15/1978	4	$369
Silver Plume	01/17/1979	2	$1,460
Rest of County	03/11/1980	12	$28,995
Total	**--**	**26**	**$42,710**

Note: FIRM = Flood Insurance Rate Map

Properties constructed after a FIRM has been adopted are eligible for reduced flood insurance rates. Such structures are less vulnerable to flooding since they were constructed after regulations and codes were adopted to decrease vulnerability. Properties built before a FIRM is adopted are more vulnerable to flooding because they do not meet code or are located in hazardous areas.

The following information from flood insurance statistics is relevant to reducing flood risk:

- The use of flood insurance in the planning area is below the national average.
- The average claim paid in the planning area is below the national average.

Repetitive Loss

A repetitive loss property is defined by FEMA and FY2016 Flood Mitigation Assistance as an NFIP-insured property that has experienced any of the following since 1978, regardless of any changes in ownership:

- Four or more paid losses in excess of $1,000
- Two paid losses in excess of $1,000 within any rolling 10-year period
- Three or more paid losses that equal or exceed the current value of the insured property.

Clear Creek County, the City of Idaho Springs and the Towns of Empire, Georgetown, and Silver Plume have no repetitive loss or severe repetitive loss properties according to the FEMA definition.

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 4-41. Critical facilities at-risk to the 0.2% annual chance flood are shown in Table 4-42.

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.

Table 4-41: Critical Facilities in 1% Annual Chance Flood Hazard Areas

Jurisdiction	FEMA Lifeline	Facility Type	Count
Georgetown	Safety and Security	Government Building	1
	Transportation	Bridge	3
		Total	**4**
Idaho Springs	Food, Water, Shelter	Water Facility	1
	Health and Medical	EMS	1
	Transportation	Bridge	10
		Total	**12**
Silver Plume	Transportation	Bridge	2
		Total	**2**
Unincorporated	Communications	Communications	1
	Energy	Substation Power Plant	1
	Health and Medical	Emergency Air Transportation	2
	Transportation	Bridge	11
		Total	**15**
		Grand Total	**33**

Source: HIFLD, FEMA NFHL 12/20/2019, Wood GIS Analysis

Table 4-42: Critical Facilities in 0.2% Annual Chance Flood Hazard Areas

Jurisdiction	FEMA Lifeline	Facility Type	Count
Georgetown	Transportation	Bridge	1
		Total	**1**
Idaho Springs	Communications	Communications	1
	Hazardous Material	Hazmat	1

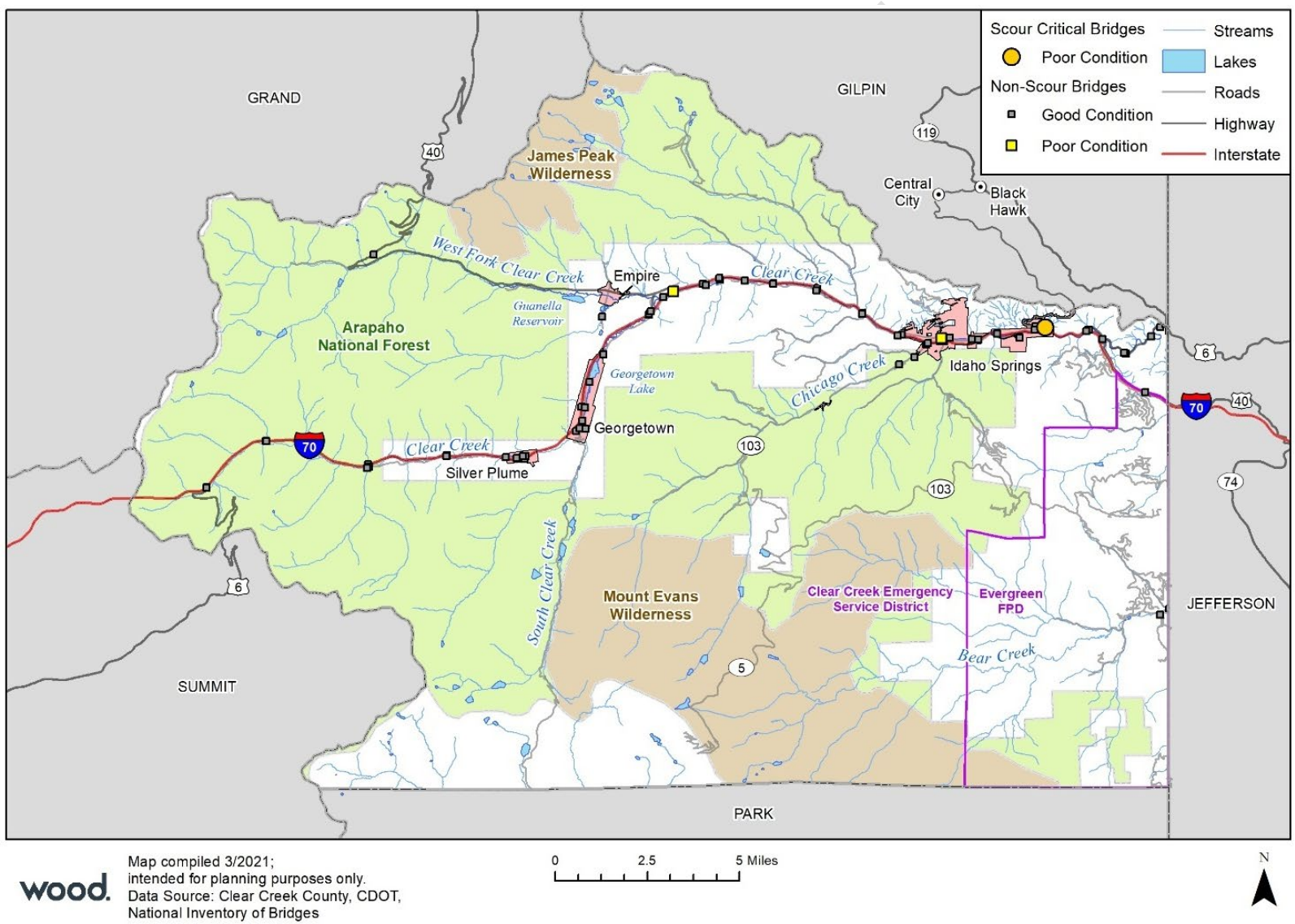
Jurisdiction	FEMA Lifeline	Facility Type	Count
	Health and Medical	Health Clinic	1
		Total	**3**
Unincorporated	Transportation	Bridge	1
		Total	**1**
		Grand Total	**5**

Source: HIFLD, FEMA NFHL 12/20/2019, Wood GIS Analysis

Transportation routes could be cut off due to floodwaters, isolating portions of the planning area. These impacts may last after the floodwater recedes as flash floods in the area have been known to cause extensive damage to roadway infrastructure.

Clear Creek 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 3 bridges that fall within these categories, all of which are located across Clear Creek. Figure 4-29 shows the locations for each bridge listed above.

Figure 4-29: Clear Creek County Bridges



Government Services

Publicly owned facilities are a key component of daily life for all citizens of the county. Public buildings are of particular importance during flood events because they house critical assets for government response and recovery activities. Damage to public water and sewer systems, transportation networks, flood control facilities, emergency facilities, and offices can hinder the ability of the government to deliver services. Loss of power and communications can be expected. Drinking water and wastewater treatment facilities may be temporarily out of operation.

Flooding can have various impacts to responders in terms of response time and the personal safety of first responders. Flooded roadways can block emergency vehicles from crossing certain areas, delaying response times.

Public confidence in government services may be hindered if warnings and alerts prior to the flood event are not communicated effectively. The government's ability to respond and recover may be questioned and challenged by the public if planning, response, and recovery is not timely and effective, particularly in areas that have repeated flooding.

Economy

Flooding can have a major negative impact on the economy. Based on the flood loss analysis, there are 11 commercial structures worth an estimated $1.8 million in total value directly at risk to flooding in the 1% annual chance zone. Based on the loss analysis this could result in approximately $452,370 in direct losses. This does not account for other indirect losses such as business interruption, reduced tourism and visitation, lost wages, and other downtime costs.

These indirect losses can also have a significant economic cost. Flood events can cut off customer access to a business as well as close a business for repairs or permanently. A quick response to the needs of businesses affected by flood events can help a community maintain economic vitality in the face of flood damage. Responses to business damages can include funding to assist owners in elevating or relocating flood-prone business structures.

Historic, Cultural, and Natural Resources

Flooding is a natural event, and floodplains provide many natural and beneficial functions. Nonetheless, with human development factored in, flooding can impact the environment in negative ways. Pollution from roads, such as oil, and hazardous materials can wash into rivers and streams. During floods, these can settle onto normally dry soils, polluting them for agricultural uses. Human development such as bridge abutments can increase stream bank erosion, causing rivers and streams to migrate into non-natural courses.

4.8.8 Development Trends

Clear Creek County and its planning partners regulate growth within flood hazard areas. All municipal planning partners, except for the Town of Empire, are participants in the NFIP and have adopted flood damage prevention ordinances in response to its requirements. All municipal planning partners have committed to maintaining their good standing under the NFIP through initiatives identified in this plan.

Urban flooding issues that contribute to flash floods are also a concern in Clear Creek County. Jurisdictions in the county incorporate stormwater design requirements and rely on the State of Colorado's stormwater permitting program as mandated by the National Pollutant Discharge Elimination System. This program helps jurisdictions apply effective mitigation measures for stormwater runoff.

4.8.9 Risk Summary

- The overall significance rating for flood in the County is High.
- Countywide an estimated $11.4 million in property losses is at risk to a 1% annual chance flood hazard. The unincorporated areas of the county together make up the majority of this risk, with an estimated $7.2 million in losses.
- Of the municipalities in the County, Georgetown is at the highest risk with $3.1 million in estimated losses in a 1% annual chance flood; Silver Plume has 41 structures in the 1% flood hazard area which is a significant portion of the Town's building inventory.
- Idaho Springs has less exposure to the 1% annual chance flood, but the analysis shows risk to a water and an EMS facility; the clinic and a hazardous materials facility are within the 0.2% annual chance zone.
- Flash flooding that occurs with little or no warning will continue to impact the planning area.
- Flooding may be exacerbated by other hazards, such as wildfires.
- Flooding may also bring other related hazards, such as erosion.
- Damages resulting from flood may impact tourism, which may have significant impacts on the local economy.
- Continued compliance with the NFIP and the promotion of flood insurance as a means of protecting private property owners from the economic impacts of frequent flood events should continue.

4.9 Hail, Lightning, and Severe Wind

HAIL, LIGHTNING, AND SEVERE WIND HAZARD RANKING			
	Hail	**Lightning**	**Severe Wind**
Clear Creek County	Medium	Medium	Medium
City of Idaho Springs	High	High	High
Town of Empire	Low	Low	High
Town of Georgetown	Low	Low	High
Town of Silver Plume	Low	Low	High
Clear Creek Fire Authority	Medium	Medium	Medium

4.9.1 Description

A thunderstorm is a rain event that includes thunder and lightning. A thunderstorm is classified as "severe" when it contains one or more of the following: hail with a diameter of three-quarter inch or greater, winds gusting in excess of 50 knots (57.5 mph), or tornado.

Three factors cause thunderstorms to form: moisture, rising unstable air (air that keeps rising when disturbed), and a lifting mechanism to provide the disturbance. Thunderstorms have three stages (see Figure 4-30):

- The developing stage of a thunderstorm is marked by a cumulus cloud that is being pushed upward by a rising column of air (updraft). The developing stage lasts about 10 minutes.
- The thunderstorm enters the mature stage when the updraft continues to feed the storm, but precipitation begins to fall out of the storm, and a downdraft begins. The mature stage is the most likely time for hail, heavy rain, frequent lightning, strong winds, and tornadoes.
- Eventually, a large amount of precipitation is produced, and the updraft is overcome by the downdraft beginning the dissipating stage. At the ground, the gust front moves out a long distance from the storm and cuts off the warm moist air that was feeding the thunderstorm. Rainfall decreases in intensity, but lightning remains a danger.

DEFINITIONS

Severe Local Storm—Small-scale atmospheric systems, including tornadoes, thunderstorms, windstorms, ice storms, and snowstorms. These storms may cause a great deal of destruction and even death, but their impact is generally confined to a small area. Typical impacts are on transportation infrastructure and utilities.

Thunderstorm—A storm featuring heavy rains, strong winds, thunder, and lightning, typically about 15 miles in diameter and lasting about 30 minutes. Hail and tornadoes are also dangers associated with thunderstorms. Lightning is a serious threat to human life. Heavy rains over a small area in a short time can lead to flash flooding.

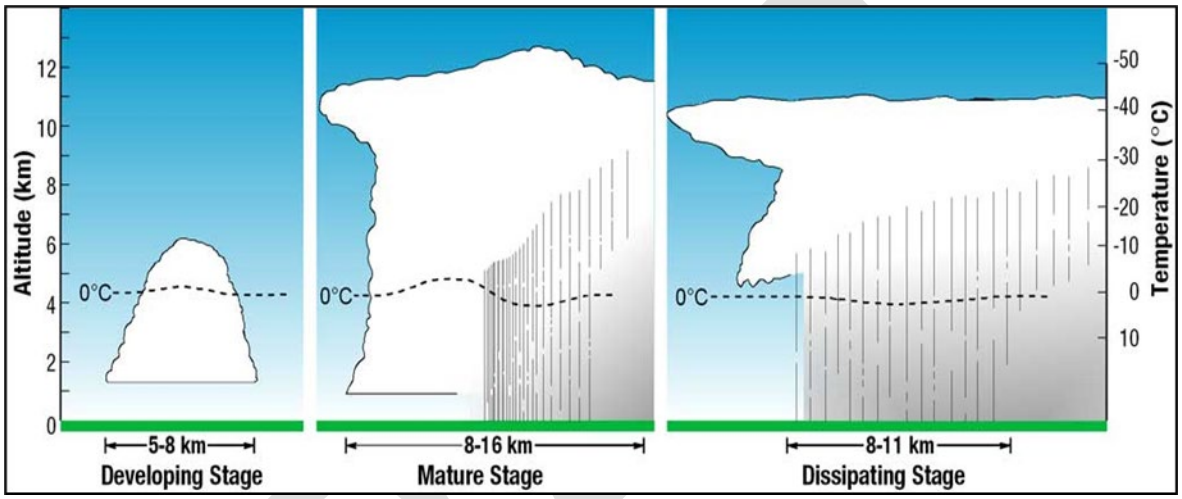
Windstorm—A storm featuring violent winds. Windstorms tend to damage ridgelines that face into the winds.

There are four types of thunderstorms:

- **Single-Cell Thunderstorms**—Single-cell thunderstorms usually last 20 to 30 minutes. A true single-cell storm is rare, because the gust front of one cell often triggers the growth of another. Most single-cell storms are not usually severe, but a single-cell storm can produce a brief severe weather event.
- **Multi-Cell Cluster Storm**—A multi-cell cluster is the most common type of thunderstorm and is usually more intense than a single cell storm. The multi-cell cluster consists of a group of cells, moving as one unit, with each cell in a different phase of the thunderstorm life cycle.

- **Multi-Cell Squall Line**—A multi-cell line storm, or squall line, consists of a long line of storms with a continuous well-developed gust front at the leading edge. Squall lines can produce hail up to golf-ball size, heavy rainfall, and weak tornadoes, but they are best known as the producers of strong downdrafts.
- **Super-Cell Storm**—A super-cell is a highly organized thunderstorm that poses a high threat to life and property. It is similar to a single-cell storm in that it has one main updraft, but the updraft is extremely strong, reaching speeds of 150 to 175 miles per hour. Super-cells are rare. The rotating updraft of a super-cell (also called a mesocyclone) can produce extreme weather events, such as giant hail, strong downbursts of 80 mph or more, and tornadoes.

Figure 4-30: Thunderstorm Life Cycle



Source: National Weather Service

Hail

Hail occurs when updrafts in thunderstorms carry raindrops upward into extremely cold areas of the atmosphere where they freeze into ice. Recent studies suggest that super-cooled water may accumulate on frozen particles near the backside of a storm as they are pushed forward across and above the updraft by the prevailing winds near the top of the storm. Eventually, the hailstones encounter downdraft air and fall to the ground.

Hailstones grow two ways: by wet growth or dry growth. In wet growth, a tiny piece of ice is in an area where the air temperature is below freezing, but not super cold. When the tiny piece of ice collides with a super-cooled drop, the water does not freeze on the ice immediately. Instead, liquid water spreads across tumbling hailstones and slowly freezes. Since the process is slow, air bubbles can escape, resulting in a layer of clear ice. Dry growth hailstones grow when the air temperature is well below freezing and the water droplet freezes immediately as it collides with the ice particle. The air bubbles are "frozen" in place, leaving cloudy ice. Hailstones can have layers like an onion if they travel up and down in an updraft, or they can have few or no layers if they are "balanced" in an updraft. One can tell how many times a hailstone traveled to the top of the storm by counting its layers. Hailstones can begin to melt and then re-freeze together, forming large and very irregularly shaped hail.

The NWS classifies hail as non-severe and severe based on hail diameter size. Descriptions and diameter sizes are provided in Table 4-46. According to the NWS Storm Prediction Center, Clear Creek County experiences an average of 4 to 5 severe hail days a year.

Lightning

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 strokes per flash. The length and duration of each lightning stroke vary, but typically average about 30 microseconds.

Lightning is one of the more dangerous and unpredictable weather hazards in the United States and in Colorado. 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 as well as deaths and injuries to livestock and other animals. According to the National Fire Protection Association (NFPA), between 2007 and 2011 local fire departments in the U.S. responded to an average of 22,600 structural fires per year due to lightning. On average the Rocky Mountain region has a report of 1,395 lighting-caused fires. On average the number of acres burned due to lightning-caused fires is nine times (402 acres) higher than the average acres burned for human-caused fires (45 acres) (NFPA 2013). The National Lightning Safety Institute estimates property damage, increased operating costs, production delays, and lost revenue from lightning and secondary effects to be in excess of $8-10 billion per year. People or objects can be directly struck, or damage can occur indirectly when the current passes through or near it.

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 can be visible for many miles.

Although not as common, cloud-to-ground lightning is the most damaging and dangerous form of lightning. Most flashes originate near the lower-negative charge center and deliver negative charge to earth. However, a minority of 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. It can strike as far as 5 or 10 miles from the storm in areas that most people do not consider to be a threat. Positive lightning also has a longer duration, so fires are more easily ignited. And, when positive lightning strikes, it usually carries a high peak electrical current, potentially resulting in greater damage. On average, Clear Creek County experiences 3,100 cloud-to-ground lightning flashes annually (NWS).

The ratio of cloud-to-ground and intra-cloud lightning can vary significantly from storm to storm. Depending upon cloud height above ground and changes in electric field strength between cloud and earth, the discharge 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, NOAA monitors a yearly average of 25 million strokes of lightning from the cloud-to-ground. Figure 4-31 shows the lightning flash density for the nation. Clear Creek County experiences 8-12 lightning events per square kilometer per year.

Data from the National Lightning Detection Network ranks Colorado 20th in the nation (excluding Alaska and Hawaii) with respect to the number of lighting counts, cloud-to-ground strokes plus cloud pulse, with an average number of more than 3,704,799 lightning counts per year. U.S. lightning statistics compiled by NOAA between 1959 and 1994 indicate that most lightning incidents occur during the summer months of June, July, and August, and during the afternoon hours from between 2 p.m. and 6 p.m. In the Rocky Mountains of Colorado, it is common for afternoon thunderstorms during the summer months to occur with lightning strikes at the higher elevations.

Figure 4-31: Average U.S. Total Lightning Density Per County, 2015-2019

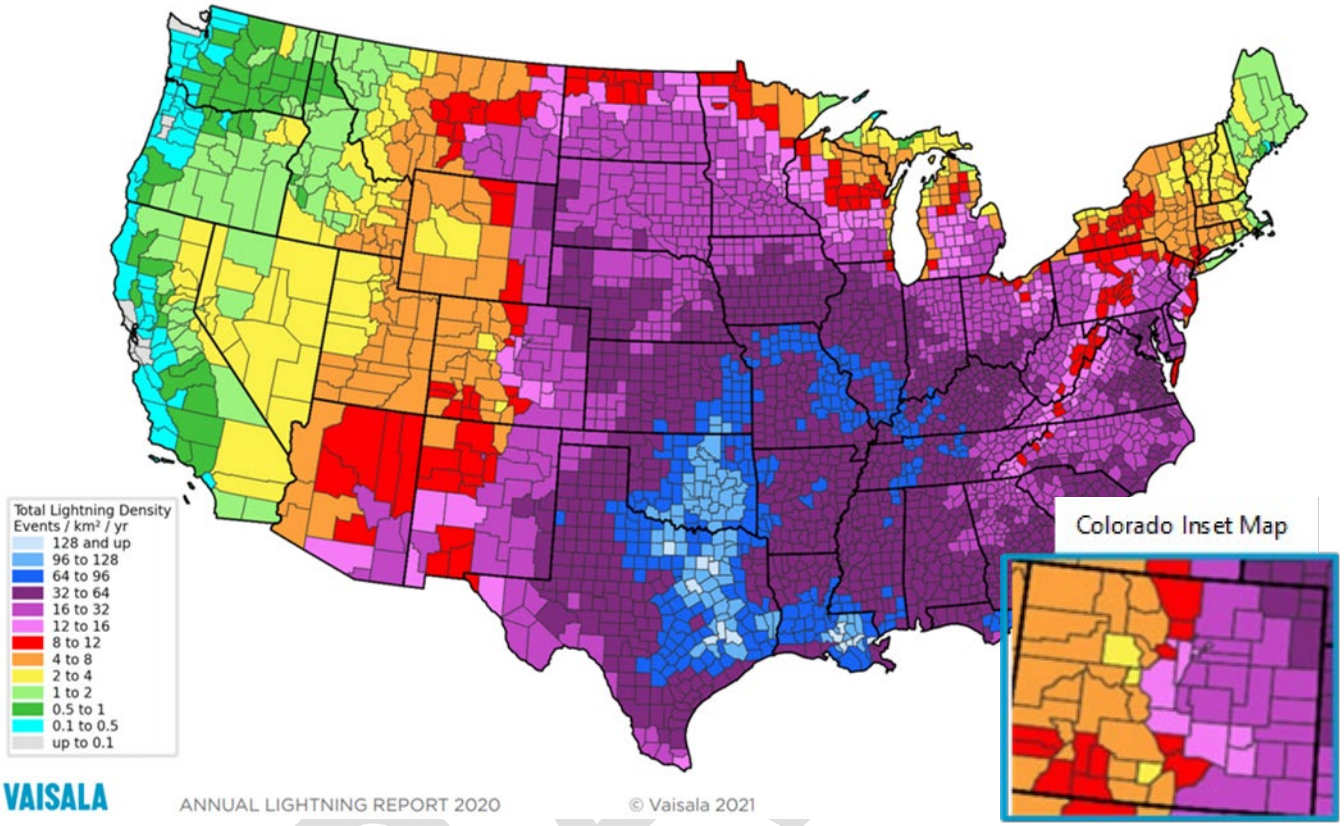
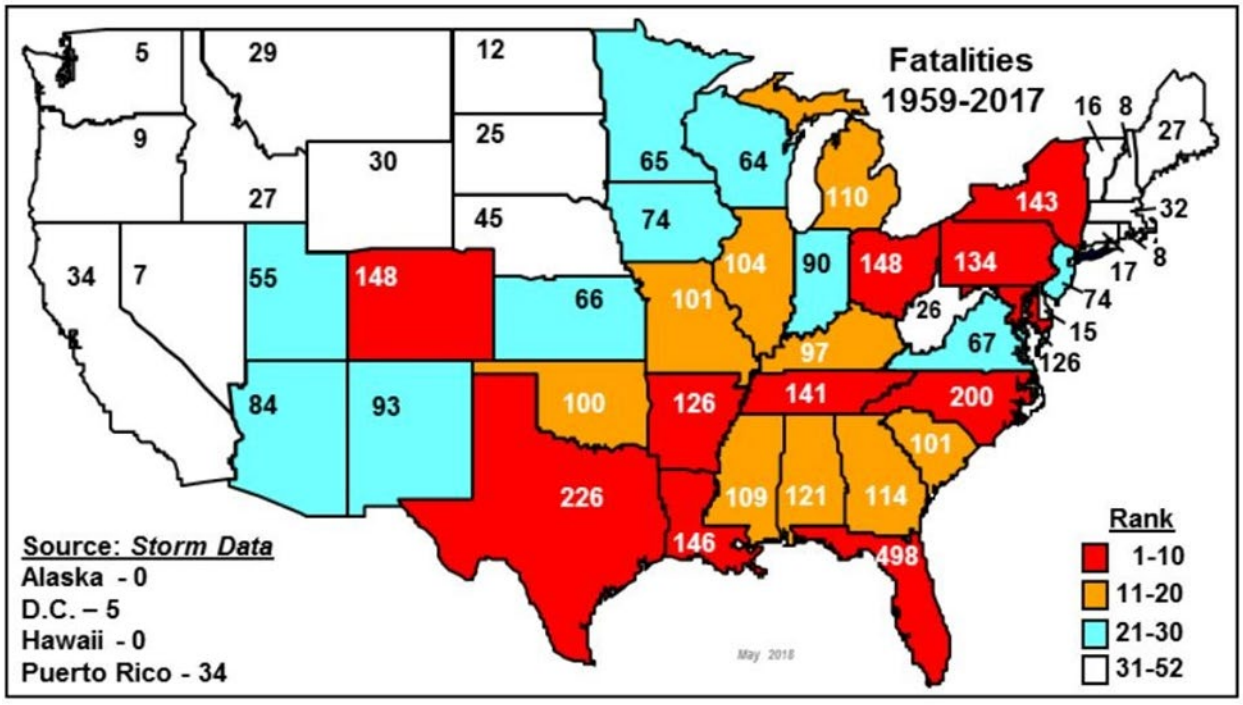


Figure 4-32: Lightning Fatalities in the United States (1959-2017)



Source: National Weather Service, http://www.lightningsafety.noaa.gov/media.shtml

Figure 4-32 shows state-by-state lightning deaths from 20141959-2017. Colorado ranks fourth for the number of deaths at 148. Florida (498), Texas (226), and North Carolina (200) were ranked higher. Based on National Weather Service data since 1980 an average of 3 people are killed and 12 are injured in Colorado annually In the Rocky Mountains of Colorado, it is common for afternoon thunderstorms during the summer months to occur with lightning strikes at the higher elevations.

Severe Winds

Damaging winds are classified as those exceeding 60 mph. Damage from such winds accounts for half of all severe weather reports in the lower 48 states and is more common than damage from tornadoes. Wind speeds can reach up to 100 mph and can produce a damage path extending for hundreds of miles. 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.

The most significant secondary hazards associated with severe local hail and wind storms are floods, falling and downed trees, landslides, and downed power lines. Fires can occur as a result of lightning strikes. Many locations in the region have minimal vegetative ground cover and the high winds can create a large dust storm, which becomes a hazard for travelers and a disruption for local services. High winds in

the winter can turn small amount of snow into a complete whiteout and create drifts in roadways. Debris carried by high winds can also result in injury or damage to property. A wildland fire can be accelerated and rendered unpredictable by high winds, which makes a dangerous environment for firefighters.

4.9.2 Past Events

Hail

The National Centers for Environmental Information's (NCEI) Storm Events Database lists 12 hail events in Clear Creek County between 1971 and 2019. These events are noted in Table 4-43.

Table 4-43: Clear Creek County Hail Events (1971-2019)

Location	Date	Maximum Hail Size (inches)
Clear Creek County	7/25/1971	1.75
Clear Creek County	7/21/1973	0.75
Clear Creek County	9/7/1988	1.75
Clear Creek County	6/9/1991	2.00
Idaho Springs	7/31/1998	1.75
Idaho Springs	8/29/2006	0.88
Idaho Springs	7/3/2007	1.75
Idaho Springs	6/11/2010	1.00
Dumont	6/28/2013	1.75
Idaho Springs	5/28/2018	1
Idaho Springs	9/6/2019	1

Source: National Centers for Environmental Information

While the NCEI database does not capture property damage in any of the past events listed in the table above, the HMPC noted that a severe hail event in the Floyd Hill area near the Central City Parkway did result in significant property damages.

Lightning

According to the National Centers for Environmental Information's Storm Events Database, four lightning events occurred in the Clear Creek County between 2000 and 2020. The National Weather Service also collects information on lightning casualties in Colorado and notes an additional event that resulted in an injury in the 1982 but does not list the specific location. Neither database has records of lighting events causing impacts since 2015. The events are noted in Table 4-44. No lightning events resulted in reported property damage or fatalities. On June 28, 2015, there was a reported lightning strike on Mount Bierstadt along Guanella Pass, which injured 8 people in an unusual pre-noon storm.

Table 4-44: Clear Creek County Lightning Events (1982-2020)

Location	Date	Deaths	Injuries	Property Damage
Unknown	8/6/1982*	0	1	$0
Idaho Springs	7/8/2000	0	2	$0
Idaho Springs	7/16/2000	0	2	$0

Location	Date	Deaths	Injuries	Property Damage
Georgetown	8/16/2003	0	1	$0
Guanella Pass	6/28/2015	0	8	$0
	Total	**0**	**14**	**$0**

Source: National Centers for Environmental Information *National Weather Service

Severe Winds

High winds can occur year-round in Clear Creek County. In the spring and summer, high winds often accompany severe thunderstorms. The varying topography in the area has the potential for continuous and sudden gusting of high winds. According to the State of Colorado Plan, Chinook winds are a fairly common wintertime phenomena in Colorado. These winds develop in well-defined areas and can be quite strong. Atmospheric conditions are expected to continue unchanged with windstorms remaining a perennial occurrence. The areas within the county that have the highest wind potential are located in the Front Range Mountains and in the valleys that funnel the wind. The entire county is susceptible to severe wind events.

Historical severe weather data from the National Centers for Environmental Information Storm Events Database includes 131 high wind events and 1 thunderstorm wind events in Clear Creek County between 1996 and 2020. As shown in Table 4-45, wind-related events caused over $16,825,000 in damages to property. There was no crop damage, but there were 10 injuries between three events.

Table 4-45: Clear Creek County Damage or Injury Wind-Related Events (1996-2020)

Location	Date	Event Type	Peak Wind Speed (knots)	Estimated Property Damage	Injuries
Jefferson and W Douglas Counties above 6000 feet/Gilpin/Clear Creek/ NE Park Counties Below 9000 feet	10/29/1996	High Wind	88	$0	5
Jefferson and W Douglas Counties above 6000 feet/Gilpin/Clear Creek/ NE Park Counties Below 9000 feet	1/21/1997	High Wind	NA	$0	2
Southern Front Range Foothills/ Clear Creek Basin	2/2/1999	High Wind	110	$3,000,000	0
Southern Front Range Foothills/ Clear Creek Basin	4/9/1999	High Wind	85	$13,800,000	0
Jefferson and W Douglas Counties above 6000 feet/Gilpin/Clear Creek/ NE Park Counties Below 9000 feet	1/7/2009	High Wind	80	$25,000	0
Jefferson and W Douglas Counties above 6000 feet/Gilpin/Clear Creek/ NE Park Counties Below 9000 feet	11/12/2011	High Wind	71	$0	3

Source: National Centers for Environmental Information
NA Not Applicable

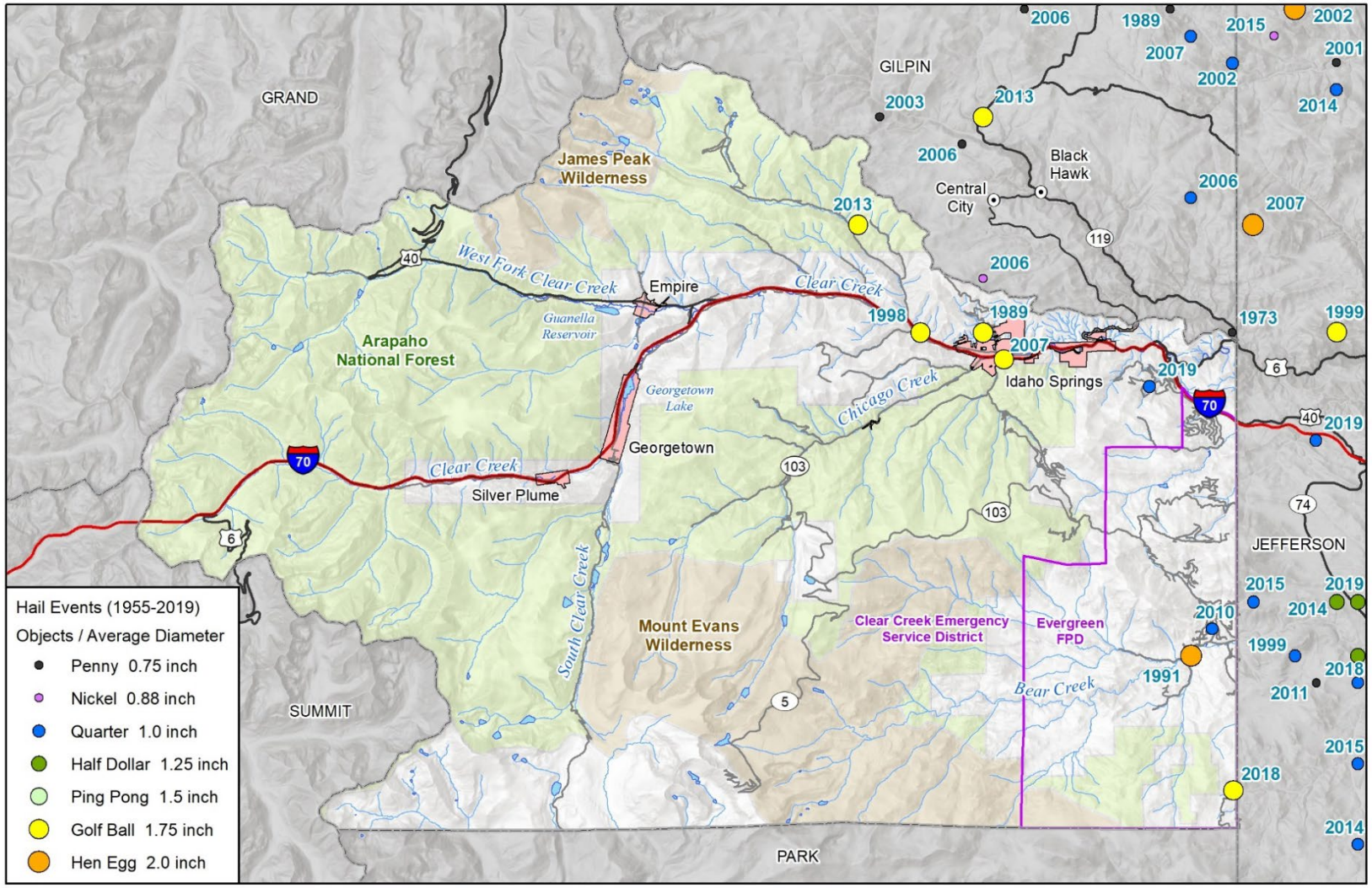
4.9.3 Location

Severe hail, wind, and lightning events have the potential to happen anywhere in the planning area. Thunderstorms are generally expansive in size. The entire county is susceptible to any of the effects of a severe thunderstorm, including hail, heavy rain, and high winds.

Hail

While all of Clear Creek County is potentially exposed to hail, most reported hailstorms occur in the eastern portion of the county, close to the City of Idaho Springs. Previous instances of hail events in the county are shown in Figure 4-33.

Figure 4-33: Hail Events in Clear Creek County



Lightning

The entire extent of Clear Creek County is exposed to some degree of lightning hazard, though exposed points of high elevation have significantly higher frequency of occurrence. Since lightning accompanies thunderstorms, it can be assumed that lightning occurs more often than damages are reported.

Severe Winds

Windstorms could occur anywhere in Clear Creek County. They have the ability to cause damage over 100 miles from the center of storm activity. Higher elevations could experience the most significant wind speeds, but these areas are generally not developed or populated. Wind events are most damaging to areas that are heavily wooded. Winds impacting walls, doors, windows, and roofs, may cause structural components to fail. The locations of previous occurrences of damaging high winds are not mapped because high wind events are likely to occur throughout the county, with high mountainous areas and valleys being the primary locations.

4.9.4 Magnitude and Severity

The nation has experienced severe storms (wind, lightning, hail) that are occurring with more intensity and affecting more areas of the country. While scientists debate why these storms occur, no one argues with their effects—extensive property damage and, many times, loss of life. The property damage can be as minimal as a few broken shingles to total destruction of buildings.

Hail

Severe hailstorms can be quite destructive to property and crops. Vehicles, roofs of buildings and homes, and landscaping are the other things most commonly damaged by hail. Hail has been known to cause injury to humans and occasionally has been fatal.

Colorado's severe hail season is between mid-April to mid-September and an average of 119 days per year (NICB 2020). According to the Rocky Mountain Insurance Information Association, hailstorms in the last 10 years have caused more than $5 billion in insured damaged in Colorado. The May 2017 event alone caused $3.6 billion in damage (NICB 2020). The costliest hailstorms have been centered in the Denver Metropolitan Area and Colorado Front Range.

According to the National Insurance Crime Bureau (NICB) April 2020 Hail Report, Colorado was second in the number of hail claims from 2017 to 2019 with 380,066 claims. Texas had the highest number of claims every year except 2018, where Colorado topped the states with 191,679 claims that year. The National Weather Service (NWS) classifies hail by diameter size, and corresponding everyday objects to help relay scope and severity to the population. Table 4-46 indicates the hailstone measurements utilized by the NWS.

There is no clear distinction between storms that do and do not produce hailstones. Nearly all severe thunderstorms probably produce hail aloft, though it may melt before reaching the ground. Multi-cell thunderstorms produce many hailstones, but not usually the largest hailstones. In the life cycle of the multi-cell thunderstorm, the mature stage is relatively short so there is not much time for growth of the hailstone. Supercell thunderstorms have sustained updrafts that support large hail formation by repeatedly lifting the hailstones into the very cold air at the top of the thunderstorm cloud. In general, hail 2 inches (5 cm) or larger in diameter is associated with supercells (a little larger than golf ball size which the NWS considers to be 1.75 inch.). Non-supercell storms are capable of producing golf ball size hail.

The largest hailstone recorded in the NCEI database for Clear Creek County was 2 inches on June 9, 1991 and the most recorded hailstone size is 1.75 inches. Refer to Table 4-43 for a summary of recorded hail

events in Clear Creek County. Based on the information in this hazard profile, the overall significance of hail events is moderate.

Table 4-46: National Weather Service Hail Severity

Severity	Description	Hail Diameter Size (in inches)
Non-Severe Hail Does not typically cause damage and does not warrant severe thunderstorm warning from NWS.	Pea	1/4"
	Marble/mothball	1/2"
	Penny	3/4"
	Nickel	7/8"
Severe Hail Research has shown that damage occurs after hail reaches around 1" in diameter and larger. Hail of this size will trigger a severe thunderstorm warning from NWS.	Quarter	1" (severe)
	Half Dollar	1 1/4"
	Walnut/Ping Pong Ball	1 1/2"
	Golf Ball	1 3/4"
	Hen Egg	2"
	Tennis Ball	2 1/2"
	Baseball	2 3/4"
	Teacup	3"
	Grapefruit	4"
	Softball	4 1/2"

Source: National Weather Service

Lightning

Lightning is measured by the Lightning Activity Level (LAL) scale, created by the National Weather Service to define lightning activity into a specific categorical scale. The LAL is a common parameter that is part of fire weather forecasts nationwide. Due to the high elevation and varied topography of the County, Clear Creek is at risk to experience lightning in any of these categories. The LAL is reproduced in Table 4-47.

Table 4-47: Lightning Activity Level Scale

Lightning Activity Level	
LAL 1	No thunderstorms
LAL 2	Isolated thunderstorms. Light rain will occasionally reach the ground. Lightning is very infrequent, 1 to 5 cloud to ground strikes in a five-minute period
LAL 3	Widely scattered thunderstorms. Light to moderate rain will reach the ground. Lightning is infrequent, 6 to 10 cloud to ground strikes in a five-minute period.

Lightning Activity Level	
LAL 4	Scattered thunderstorms. Moderate rain is commonly produced. Lightning is frequent, 11 to 15 cloud to ground strikes in a five-minute period.
LAL 5	Numerous thunderstorms. Rainfall is moderate to heavy. Lightning is frequent and intense, greater than 15 cloud to ground strikes in a five-minute period.
LAL 6	Dry lightning (same as LAL 3 but without rain). This type of lightning has the potential for extreme fire activity and is normally highlighted in fire weather forecasts with a Red Flag warning.

Source: National Weather Service

The number of reported injuries from lightning is likely to be low, and county infrastructure losses equate to tens of thousands of dollars each year. The relationship of lightning to wildfire ignitions in the county increases the significance of this hazard. Based on the information in this hazard profile, the overall significance of lightning events is moderate for Clear Creek County but high in the City of Idaho Springs and low in the Towns of Empire, Georgetown, and Silver Plume. Caution does have to be taken on high mountainous peaks where lightning strikes are likely to occur.

Severe Winds

High winds, often accompanying severe thunderstorms, can cause significant property and crop damage, threaten public safety, and have adverse economic impacts from business closures and power loss. Windstorms in Clear Creek County are rarely life-threatening, but do disrupt daily activities, cause damage to buildings, and structures, and increase the potential for other hazards, such as wildfire. Winter winds can also cause damage, close highways (blowing snow), and induce avalanches. Winds can also cause trees to fall, particularly those killed by pine beetles or wildfire, creating a hazard to property or those outdoors.

Damaging wind is measured using the Beaufort Wind Scale as shown in Table 4-48. This scale only reflects land-based effects and does not take into consideration the effects of wind over water.

Table 4-48: Beaufort Wind Scale

Beaufort Number	Description	Windspeed (MPH)	Land Conditions
0	Calm	<1	Calm. Smoke rises vertically.
1	Light air	1 – 3	Wind motion visible in smoke.
2	Light breeze	3 – 7	Wind felt on exposed skin. Leaves rustle.
3	Gentle breeze	8 – 12	Leaves and smaller twigs in constant motion.
4	Moderate breeze	13 – 17	Dust and loose paper raised. Small branches begin to move.

Beaufort Number	Description	Windspeed (MPH)	Land Conditions
5	Fresh breeze	18 – 24	Branches of a moderate size move. Small trees begin to sway.
6	Strong breeze	25 – 30	Large branches in motion. Whistling heard in overhead wires. Umbrella use becomes difficult. Empty plastic garbage cans tip over.
7	High wind, Moderate gale, Near gale	31 – 38	Whole trees in motion. Effort needed to walk against the wind. Swaying of skyscrapers may be felt, especially by people on upper floors.
8	Gale, Fresh gale	39 – 46	Some twigs broken from trees. Cars veer on road. Progress on foot is seriously impeded.
9	Strong gale	47 – 54	Some branches break off trees, and some small trees blow over. Construction/temporary signs and barricades blow over. Damage to circus tents and canopies.
10	Storm, Whole gale	55 – 63	Trees are broken off or uprooted, saplings bent and deformed. Poorly attached asphalt shingles and shingles in poor condition peel off roofs.
11	Violent storm	64 – 72	Widespread vegetation damage. Many roofing surfaces are damaged; asphalt tiles that have curled up and/or fractured due to age may break away completely.
12	Hurricane	≥ 73	Very widespread damage to vegetation. Some windows may break; mobile homes and poorly constructed sheds and barns are damaged. Debris may be hurled about.

Source: National Oceanographic and Atmospheric Association

Between 2005 and 2020 there were 129 watches, advisories and warnings issued by the National Weather Service in Clear Creek County for high winds (Table 4-49).

Table 4-49: Number of Wind Advisories, Watches and Warnings, 2005-2020

Type	Count
High Wind Watch	6
Wind Advisory	109
High Wind Warning	14
Total	**129**

Source: NWS

The following describes how high wind watches, warnings and advisories are defined by the National Weather Service.

- **High Wind Watch** - is issued when high wind conditions are expected to develop in the next 12 to 36 hours. Sometimes it will be issued late in the first forecast period...6 to 12 hours...if the potential for high wind exists. There is some uncertainty.
- **High Wind Warning** - Sustained winds of 50 mph for at least 1 hour or gusts to 75 mph for any duration in the mountains and foothills.
- **Wind Advisory** - Issued when the following conditions are expected:
  - 1) sustained winds of 31 to 39 mph for an hour or more. And/or

- 2) wind gusts of 46 to 57 mph for any duration.

Based on the information in this hazard profile, the magnitude/severity of severe winds is considered moderate to high. Overall significance of the hazard is considered to have a moderate to high potential impact because of the high mountainous terrain found throughout the county.

4.9.5 Probability of Future Occurrences

Severe thunderstorm events that include lightning, hail and/ or high winds can be predicted with a reasonable level of certainty. By identifying and tracking various indicators of weather systems, warning time for snowstorms can be as much as a week in advance. Understanding the historical frequency, duration, and spatial extent of severe winter weather assists in determining the likelihood and potential severity of future occurrences. The characteristics of past severe thunderstorm events provide benchmarks for projecting similar conditions into the future. Based on historical records and frequencies there is nearly a 100% chance of this type of event will occur somewhere in Clear Creek at least once every year.

4.9.6 Climate Change Considerations

As the atmosphere warms further due to climate change, the increased heat in the atmosphere provides more energy for severe storms. The frequency of severe weather events has increased steadily over the last century. The number of weather- related disasters during the 1990s was four times that of the 1950s, and cost 14 times as much in economic losses. Historical data shows that the probability for severe weather events increases in a warmer climate. The changing hydrograph caused by climate change could have a significant impact on the intensity, duration and frequency of storm events. All of these impacts could have significant economic consequences.

4.9.7 Vulnerability

People

It can be assumed that the entire planning area is exposed to some extent to thunderstorm, lightning high wind, and hail 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, while populations in low-lying areas are at risk for possible flooding. It is not uncommon for residents living in more remote areas of the county to be isolated after such events.

Vulnerable populations are 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 Clear Creek County, 11% of Medicare Beneficiaries (760 of 6,961 total Beneficiaries) rely on electricity to live independently in their homes. Isolation of these populations is a significant concern. Isolation of these populations is a significant concern. Isolation of these populations is a significant concern. These populations face isolation and exposure during thunderstorm, wind, and hail events and could suffer more secondary effects of the hazard. Hikers and climbers in the area may also be more vulnerable to severe weather events. Visitors to the area may not be aware of how quickly a thunderstorm can build in the mountains.

Property

All property is vulnerable during lightning, high wind, and hail 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.

Older building stock in the planning area may be built to low code standards or none at all. These structures could be highly vulnerable to severe weather events such as windstorms. 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.

All of these buildings are considered to be exposed to the thunderstorm hazards, but structures in poor condition or in particularly vulnerable locations (located on hilltops or exposed open areas) may risk the most damage. The frequency and degree of damage will depend on specific locations.

Hail

A total of 12 hail events have taken place in Clear Creek County between 1971 and 2019. Loss estimates cannot be made because the events did not result in any reported damages in the county or any of the jurisdictions, though they likely incurred insured losses.

Lightning

A total of 5 reported lightning events have taken place in Clear Creek County between 1996 and 2020. Loss estimates cannot be made because the events did not result in any reported damages in the county or any of the jurisdictions.

Severe Winds

A total of 131 severe wind events have taken place in Clear Creek County between 1996 and 2020. Only three of the events results in reported damages. The loss estimates for severe wind events in the county are listed in Table 4-50.

Table 4-50: Loss Estimates for Severe Wind Events in Clear Creek County

Community	Annual Rate of Occurrence	Average Loss Expectancy	Annualized Loss
Clear Creek County	5 events/year	$150,223/event	$901,338

Note: Loss estimates based on historical record of 131 wind-related events.
Source: NOAA - National Centers for Environmental Information 1996 - 2020

Critical Facilities and Infrastructure

Power, communication, and transportation infrastructure can be vulnerable to lightning, wind, and hail, mostly associated with secondary hazards. Landslides caused by heavy prolonged rains can block roads. 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. Prolonged obstruction of major routes due to landslides, debris, or floodwaters can disrupt the shipment of goods and other commerce. Large, prolonged storms can have negative economic impacts for an entire region. 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. Lightning events in the county can have destructive effects on power and information systems. Failure of these systems would have cascading effects throughout the county and could possibly disrupt critical facility functions.

Facilities on higher ground may also be exposed to wind damage or damage from falling trees. The most common problems associated with these weather events are loss of utilities. Downed power lines can cause blackouts, leaving large areas isolated. Phone, water, and sewer systems may not function. Roads may become impassable due to secondary hazards such as landslides. Lightning and wind can impact communications infrastructure, damaging towers or temporarily disrupting services.

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, and flooding (refer to the Wildfire and Flood sections). In general, all severe thunderstorms pose a risk to the tourism economy in the county. These events can disrupt travel into and out of all areas of the county and create perilous conditions for residents, tourists and nature alike.

Historic, Cultural and Natural Resources

The environment is highly exposed to lightning, winds, and hail. Natural resources such as trees and other vegetation risk potential damage and destruction. Prolonged rains can saturate soils and lead to slope failure. Flooding events can produce river channel migration or damage riparian habitat. Large swaths of tree blowdowns can occur, particularly in the beetle-killed forests prevalent in the county.

4.9.8 Development Trends

All future development will be affected by severe storms. The ability to withstand impacts lies in sound land use practices and consistent enforcement of codes and regulations for new construction. The planning partners have adopted the International Building Code. This code is equipped to deal with the impacts of severe weather events. Land use policies identified in master plans and enforced through zoning code and the permitting process also address many of the secondary impacts (flood and landslide) of the severe weather hazard. With these tools, the planning partnership is well equipped to deal with future growth and the associated impacts of severe weather.

4.9.9 Risk Summary

- Hail, lightning and severe wind events have an overall significance of **Medium** for the County as a whole, although the risk varies from location to location.
- There have been 148 recorded hail, lightning and severe wind events in Clear Creek County since 1972, resulting in over $16,825,000 in property damages. All from severe wind events.
- Lightning events have caused 14 injuries since 1982. With an event along Guanella Pass injuring 8 people in 2015.
- 11% of Medicare Beneficiaries in the County rely on electricity dependent medical equipment to live independently in their own homes making them vulnerable to lightning and severe wind events that may result in power outages.
- Related hazards: Flood; Wildfire; Avalanche; Landslide, Mud/Debris Flow

4.10 Landslide, Mud/Debris Flow, and Rockfall

LANDSLIDE, MUD/DEBRIS FLOW, ROCKFALL HAZARD RANKING	
Clear Creek County	Medium
City of Idaho Springs	High
Town of Empire	High
Town of Georgetown	Medium
Town of Silver Plume	High
Clear Creek Fire Authority	Medium

DEFINITIONS

Landslide—The sliding movement of masses of loosened rock and soil down a hillside or slope. Such failures occur when the strength of the soils forming the slope is exceeded by the pressure, such as weight or saturation, acting upon them.

Mass Movement—A collective term for landslides, debris flows, falls and sinkholes.

Mudslide (or Mudflow or Debris Flow)—A river of rock, earth, organic matter and other materials saturated with water.

Rockfall—A detached mass of rock falling from a cliff or down a very steep slope.

4.10.1 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.

A landslide is a general term for a variety of mass-movement processes that generate a downslope movement of soil, rock, and vegetation under gravitational influence. Some of the natural causes of ground instability are stream and lakeshore erosion, heavy rainfall, and poor-quality natural materials. In addition, many human activities tend to make the earth materials less stable and, thus, increase the chance of ground failure. Human activities contribute to soil instability through grading of steep slopes or overloading them with artificial fill, by extensive irrigation, construction of impermeable surfaces, excessive groundwater withdrawal, and removal of stabilizing vegetation. Landslides typically have a slower onset and can be predicted to some extent by monitoring soil moisture levels and ground cracking or slumping in areas of previous landslide activity.

Landslides are caused by one or a combination of the following factors: change in slope of the terrain, increased load on the land, shocks and vibrations, change in water content, groundwater movement, frost action, weathering of rocks, and removing or changing the type of vegetation covering slopes. In general, landslide hazard areas are where the land has characteristics that contribute to the risk of the downhill movement of material, such as the following:

- A slope greater than 30%.
- A history of landslide activity or movement during the last 10,000 years.
- Stream or wave activity, which has caused erosion, undercut a bank, or cut into a bank to cause the surrounding land to be unstable.
- The presence or potential for snow avalanches.
- The presence of an alluvial fan, indicating vulnerability to the flow of debris or sediments.
- The presence of impermeable soils, such as silt or clay, which are mixed with granular soils such as sand and gravel.

Flows and slides are commonly categorized by the form of initial ground failure. Figure 4-34 through Figure 4-37 show common types of slides. The most common is the shallow colluvial slide, occurring particularly in response to intense, short-duration storms. The largest and most destructive are deep-seated slides, although they are less common than other types.

Figure 4-34: Deep Seated Slide

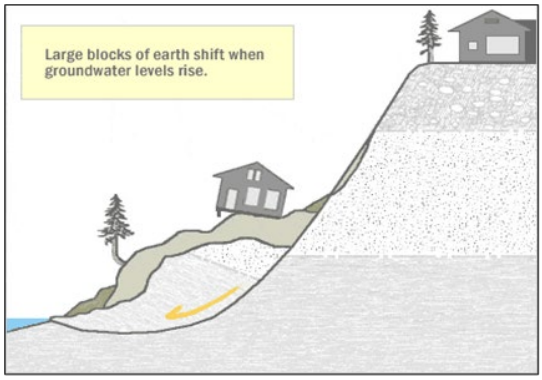


Figure 4-36: Bench Slide

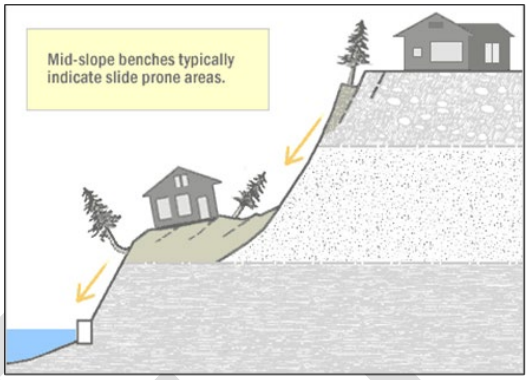


Figure 4-35: Shallow Colluvial Slide

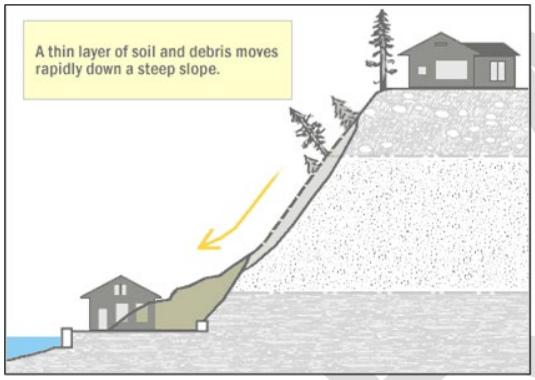
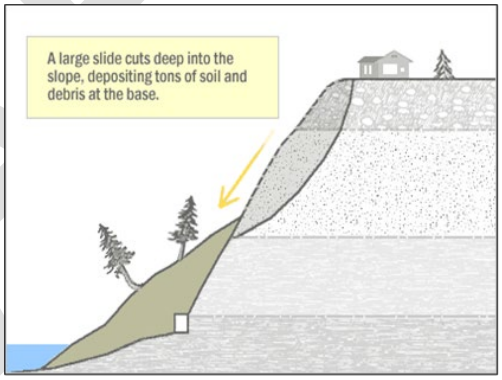


Figure 4-37: Large Slide



Slides and earth flows can pose serious hazard to property in hillside terrain. They tend to move slowly and thus rarely threaten life directly. When they move—in response to such changes as increased water content, earthquake shaking, addition of load, or removal of downslope support—they deform and tilt the ground surface. The result can be destruction of foundations, offset of roads, breaking of underground pipes, or overriding of downslope property and structures.

Mud and Debris Flow

A mudslide is a mass of water and fine-grained earth that flows down a stream, ravine, canyon, arroyo, or gulch. If more than half of the solids in the mass are larger than sand grains (rocks, stones, boulders), the event is called a debris flow. A debris fan is a conical landform produced by successive mud and debris flow deposits, and the likely spot for a future event. Mud and debris flow problems can be exacerbated by wildfires that remove vegetation that serves to stabilize soil from erosion. Heavy rains on the denuded landscape can lead to rapid development of destructive mudflows.

Rockfall

A rockfall is the falling of a detached mass of rock from a cliff or down a very steep slope. 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. Weathering and decomposition of

geological materials produce conditions favorable to rockfalls. Rockfalls are caused by the loss of support from underneath through erosion or triggered by ice wedging, root growth, or ground shaking. Changes to an area or slope such as cutting and filling activities can also increase the risk of a rockfall. Rocks in a rockfall can be of any dimension, from the size of baseballs to houses. Rockfalls can threaten human life, impact transportation corridors and communication systems and result in other property damage. Spring is typically the landslide/rockfall season in Colorado as snow melts and saturates soils and temperatures enter into freeze/thaw cycles. Rockfalls and landslides are influenced by seasonal patterns, precipitation and temperature patterns. Earthquakes could trigger rockfalls and landslides too.

4.10.2 Past Events

Based on available GIS data, there have been 286 and 3 landslide events in Clear Creek County, according to USGS and NASA's Global Landslide Catalog respectively, the majority of the events are focused on high mountainous areas in the western portion of the county. Several events have occurred in Silver Plume, Georgetown, and Empire. There have been no reported landslide events in Idaho Springs. Landslides are a major issue for the Interstate 70 corridor. Landslides can cause road closures and vehicles accidents. The Interstate 70 corridor is a major east/west route across the county and provides goods and materials across the country.

Since landslides, debris flows, and rockfalls have a high level of prevalence in Colorado, and a moderate level of prevalence in Clear Creek County, the most useful previous occurrences to examine are those which caused 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 Clear Creek County.

Since the 2016 HMP, three landslide/rockfall events have occurred. These types of incidents occur frequently along I-70 and parallel side roads during periods of heavy rain and spring thaw (OEM CCC 2021).

- **April 4, 2017** – A rockfall closed the right lane I-70 near Dumont triggered by thaw (NCCS NASA 2021).
- **September 6, 2019** - A rockslide occurred at the bottom of Floyd Hill on I-70. This event caused an I-70 closure and traffic detour. This rockslide also caused road damage needing repair. No injuries or other damage was reported.
- **November 29, 2019** - Rockslide on I-70 between Beaver Brook and Dumont causing a closure for 6 and 4 hours on westbound and eastbound lanes, respectively. No injuries were reported, however there was damage to the I-70 roadbed.

Georgetown Lake is partially a natural lake formed by an ancient landslide event, enhanced with a dam to store more water.

4.10.3 Location

According to the 2013 State of Colorado Hazard Mitigation Plan, "Many of Colorado's landslides occur along transportation networks because soil and rock along the transportation corridor has been disturbed by roadway construction. Construction along roads can occur with or without proper landslide hazard mitigation procedures. The cost to maintain, cleanup, monitor, and repair roads and highways from landslide activity is difficult to assess, but the best records come from CDOT, which is responsible for maintaining Colorado roads and highways" (Colorado Division of Emergency Management 2015).

The best available predictor of where movement of slides and earth flows might occur is the location of past movements. Past landslides can be recognized by their distinctive topographic shapes, which can remain in place for thousands of years. Most landslides recognizable in this fashion range from a few acres to several square miles. Most show no evidence of recent movement and are not currently active. A small proportion of them may become active in any given year, with movements concentrated within all or part of the landslide masses or around their edges.

The recognition of ancient dormant mass movement sites is important in the identification of areas susceptible to flows and slides because they can be reactivated by earthquakes or by exceptionally wet weather. Also, because they consist of broken materials and frequently involve disruption of groundwater flow, these dormant sites are vulnerable to construction-triggered sliding.

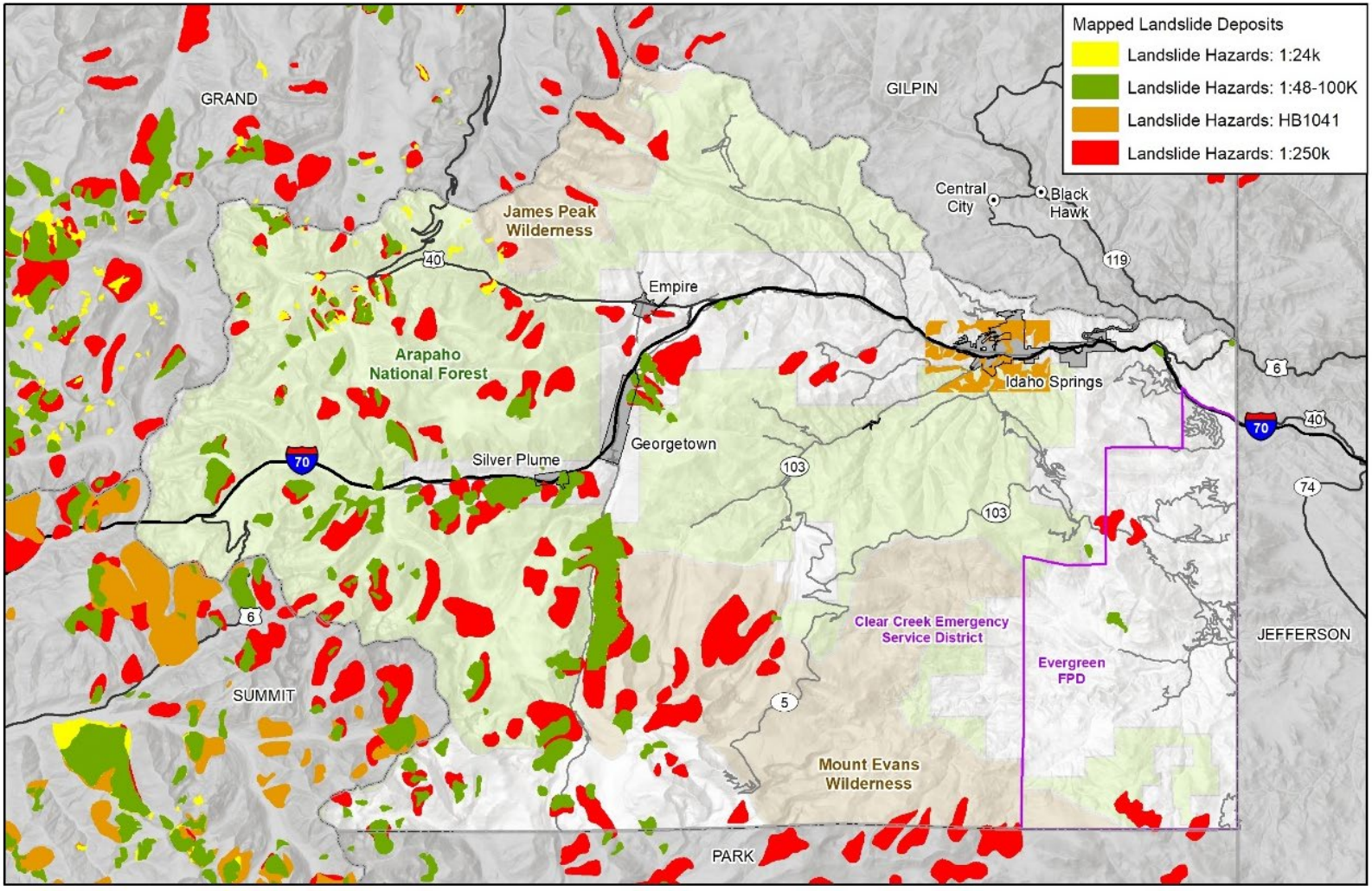
The geographic location of landslides and rockfalls throughout Clear Creek County is isolated. Figure 4-38 shows landslide deposits from various geologic mapping studies performed at different scales available on the Colorado Geological Survey's online map portal. Generally the larger scale mapping (1:24,000) can be considered more accurate and hazard areas are more generalized in smaller scale maps (e.g. 1:250,000). Primarily, the area with likely landslides is in the western and high mountainous areas of the county in the Front Range Mountains. Along I-70 landslide deposits are most predominant near Silver Plume and on the north side of Georgetown, and in and around Idaho Springs. According to the USGS, the Towns of Empire, Georgetown, and Silver Plume are located within an area with high susceptibility to landslides and a moderate incidence rate. Debris fans are formed where steep slopes meet valley floors and are periodically impacted by debris flows. The fans are located in and around Georgetown.

Landslide events have occurred in Silver Plume, Georgetown, and Empire. There have been no reported landslide events in Idaho Springs.

Figure 4-39 shows mapped rockfall areas within the county. Along I-70, this includes Silver Plume to Georgetown and Idaho Springs.

There is a high potential for landslides, mud/debris flows, and rockfalls along I-70 that could severely disrupt traffic along the highway.

Figure 4-38: Landslide Deposits in Clear Creek County



wood.

Map compiled 3/2021;
intended for planning purposes only.
Data Source: Clear Creek County, CDOT, Colorado Geological Survey, USGS

Figure 4-39: Rockfall Areas in Clear Creek County

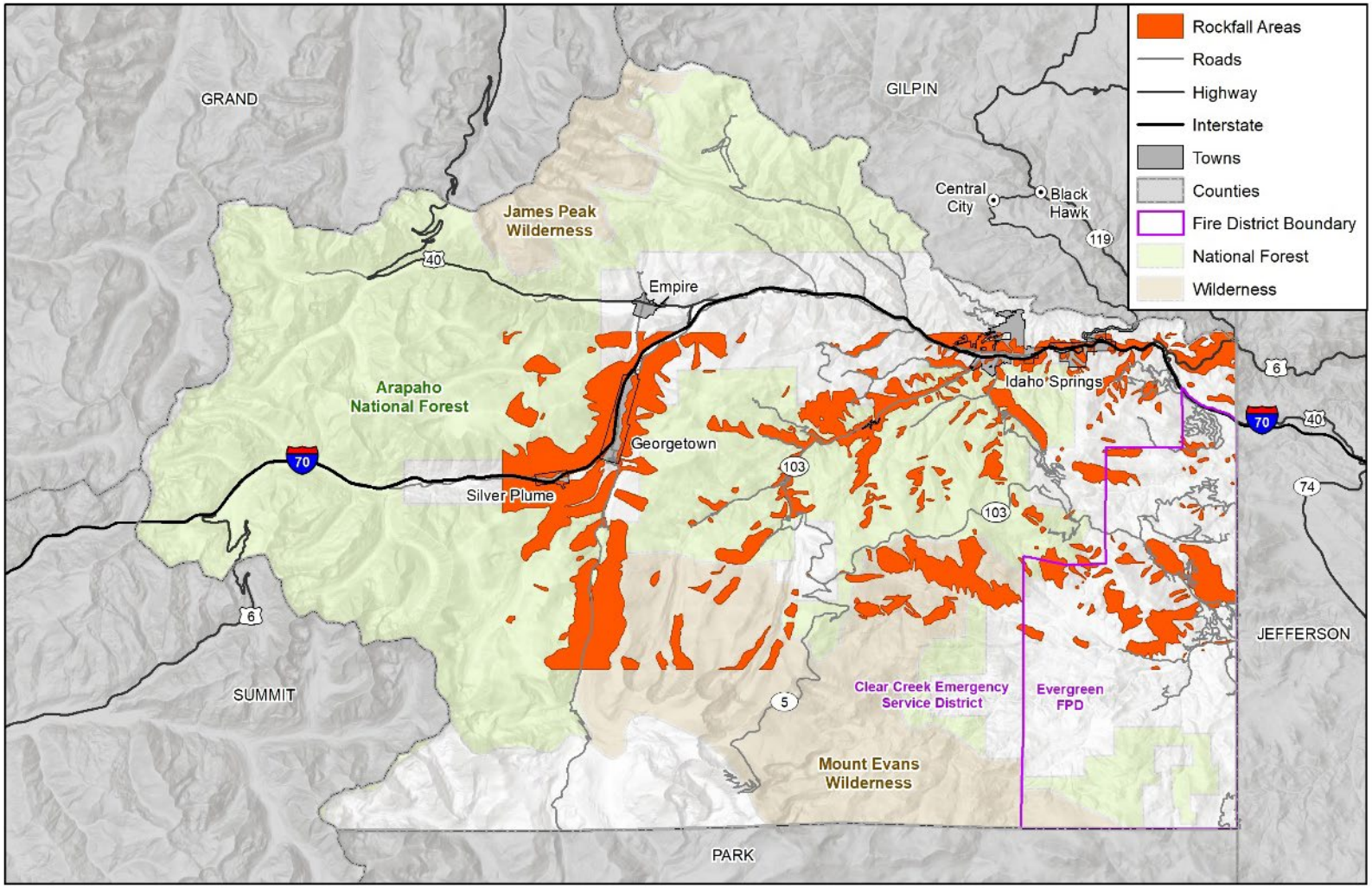
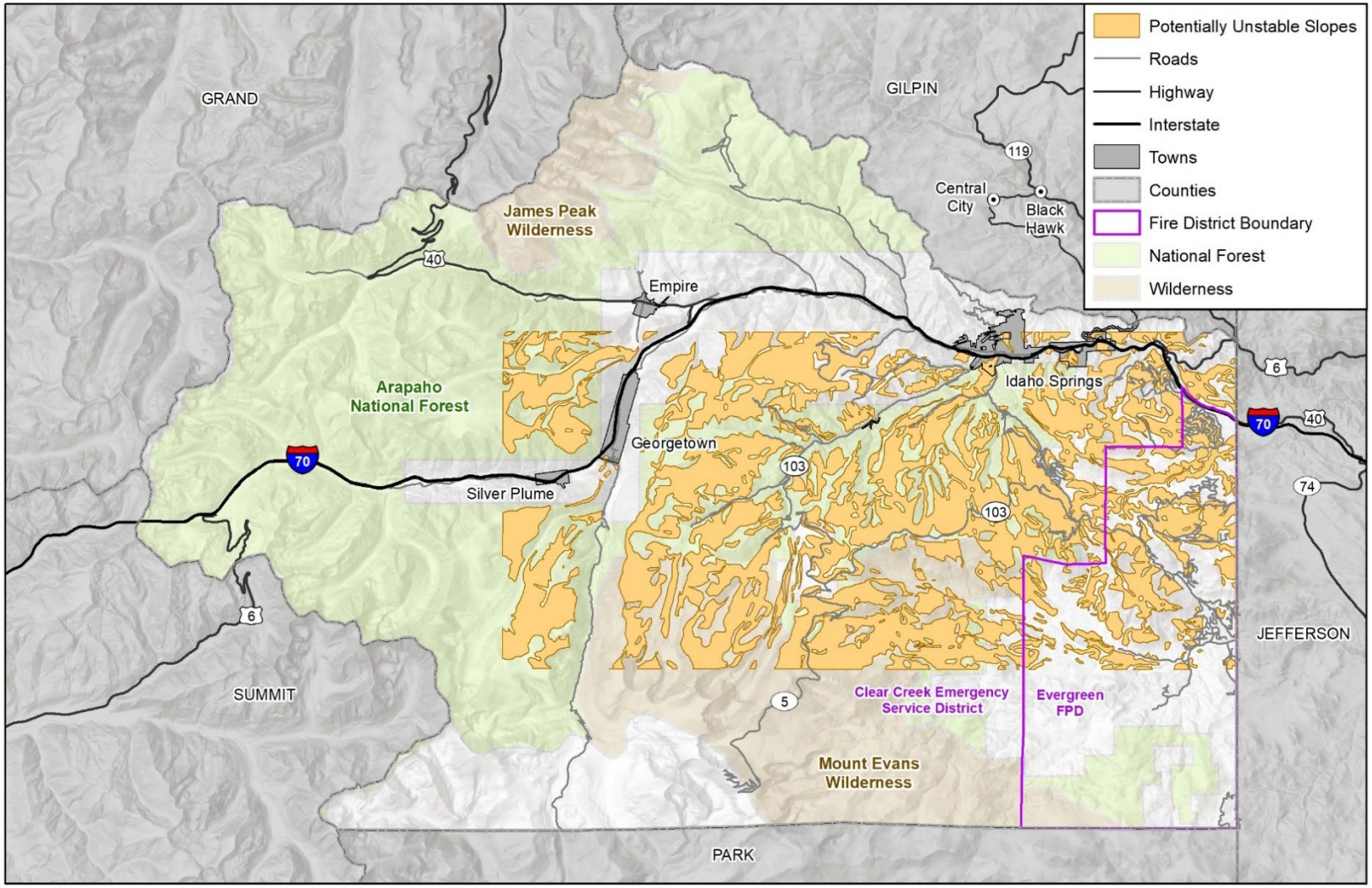


Figure 4-40: Potentially Unstable Slopes in Clear Creek County



4.10.4 Magnitude and Severity

Property damages from these hazards has 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 I-70 corridor. By a combination of mitigation efforts and luck there has not been documented deaths from rockfall in Clear Creek County, but the potential remains. Based on these factors and primarily because of the impact it could have on I-70 corridor, the magnitude severity ratings for landslide, debris flow, and rockfall are considered **critical**.

Mass movements can occur suddenly or slowly. The velocity of movement may range from a slow creep of inches per year to many feet per second, depending on slope angle, material and water content. Some methods used to monitor mass movements can provide an idea of the type of movement and the amount of time prior to failure. It is also possible to identify what areas are at risk during general time periods. Assessing the geology, vegetation, and amount of predicted precipitation for an area can help in these predictions. However, there is no practical warning system for individual landslides. The current standard operating procedure is to monitor situations on a case-by-case basis and respond after the event has occurred. Generally accepted warning signs for landslide activity include:

- Springs, seeps, or saturated ground in areas that have not typically been wet before.
- New cracks or unusual bulges in the ground, street pavements, or sidewalks.
- Soil moving away from foundations.
- Ancillary structures such as decks and patios tilting or moving relative to the main house.
- Tilting or cracking of concrete floors and foundations.
- Broken water lines and other underground utilities.
- Leaning telephone poles, trees, retaining walls, or fences.
- Offset fence lines.
- Sunken or down-dropped roadbeds.
- Rapid increase in creek water levels, possibly accompanied by increased soil content.
- Sudden decrease in creek water levels though rain is still falling or just recently stopped.
- Sticking doors and windows and visible gaps indicating jambs and frames out of plumb.
- A faint rumbling sound that increases in volume as the landslide nears.
- Unusual sounds, such as trees cracking or boulders knocking together.

4.10.5 Probability of Future Occurrences

Mitigation efforts have been taken to decrease probability of future occurrences. 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. Based on the history of landslides, debris flow incidents, and rockfalls in Clear Creek County including most recently the 3 incidents over 4 years along I-70, this formula evaluates that the probability of a damaging landslide-type event occurring in any given year is 75%. This corresponds to a probability of future occurrences rating of **likely**.

4.10.6 Climate Change Considerations

Climate change may impact storm patterns, increasing the probability of more frequent, intense storms with varying duration. Increases in global temperature could affect the snowpack and its ability to hold and store water. Warming temperatures also could increase the occurrence and duration of droughts, which would

increase the probability of wildfire, reducing the vegetation that helps to support steep slopes. All of these factors would increase the probability for landslide occurrences.

4.10.7 Vulnerability

Population

While past landslide, debris flow, or rockfall events in Clear Creek County have not resulted in any fatalities or serious injuries, the potential for both exists. As shown in Table 4-51, several thousand people live in areas at risk of these hazards. These estimates were calculated by taking the number of residential parcels exposed (see Table 4-52) multiplied by the average household for each community.

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.

Table 4-51: Population Exposed to Landslide, Rockfall, or Slope Failure

Jurisdiction	Landslide	Rockfall	Unstable Slopes
Empire	0	0	0
Georgetown	21	428	0
Idaho Springs	93	733	54
Silver Plume	46	83	0
Unincorporated	230	765	1,521
Total	**390**	**2,009**	**1,575**

Source: Wood analysis of Clear Creek GIS and Assessor's Data

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.

General Property

GIS was used to create a risk assessment for geological hazards in Clear Creek County. Landslide, rockfall, slope failure and subsidence hazard data were overlaid on Clear Creek 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 4-52. The greatest exposure is to rockfall.

Table 4-52: Buildings Exposed to Landslide, Rockfall, or Slope Failure

Jurisdiction	Property Type	Landslide	Rockfall	Unstable Slopes
Empire	Exempt	1		
	Total	**1**		

Jurisdiction	Property Type	Landslide	Rockfall	Unstable Slopes
Georgetown	Commercial		1	
	Exempt	1	5	
	Mining		1	
	Residential	1	223	
	Vacant Land		4	
	Total	**12**	**234**	
Idaho Springs	Commercial	2	5	1
	Exempt	1	20	
	Residential	45	354	26
	Vacant Land	2	8	3
	Total	**50**	**387**	**30**
Silver Plume	Commercial		4	
	Exempt	4	4	
	Residential	23	41	
	Total	**27**	**49**	
Unincorporated	Agriculture			2
	Commercial	2	2	9
	Exempt	12	19	20
	Mining	29	12	16
	Residential	103	343	682
	Vacant Land	15	8	17
	Total	**161**	**384**	**746**
Grand Total		**251**	**1,054**	**776**

Source: Wood analysis of Clear Creek GIS and Assessor's Data

Property exposure to landslide hazard areas is be moderate. As stated previously, the Towns of Empire, Georgetown, and Silver Plume all have known occurrences of landslide events. The City of Idaho Springs has known occurrences of sinkholes from old/unmapped mines as mentioned in Section 0. Interstate 70 is most likely to be at risk of damage.

Critical Facilities and Infrastructure

Critical facilities exposed to landslide, rockfall, and unstable slopes are shown in the following tables. All Lifeline categories have some exposure to one or more of these hazards, with the greatest risk being in the unincorporated County.

Table 4-53: Critical Facilities at Risk to Landslide Deposits by Jurisdiction and Lifeline

Jurisdiction	FEMA Lifeline	Facility Type	Count
Idaho Springs	Hazardous Material	Hazardous Waste Facility	1
Unincorporated	Communications	Communications	1
	Health and Medical	Emergency Air Transportation	3
Total			**5**

Source: Wood analysis of HIFLD and CERC Data

Table 4-54: Critical Facilities at Risk to Rockfall Areas by Jurisdiction and Lifeline

Jurisdiction	FEMA Lifeline	Facility Type	Count
Idaho Springs	Food, Water, Shelter	Water Facility	1
	Hazardous Material	Hazardous Waste Facility	1
Silver Plume	Safety and Security	Fire Station	1
Unincorporated	Communications	Communications	2
	Energy	Substation Power Plant	1
	Energy	Water Electric Plant	1
	Hazardous Material	Tier II	1
	Transportation	Bridge	9
Total			**17**

Source: Wood analysis of HIFLD and CERC Data

Table 4-55: Critical Facilities at Risk to Unstable Slope Areas by Jurisdiction and Lifeline

Jurisdiction	FEMA Lifeline	Facility Type	Count
Unincorporated	Communications	Communications	5
	Health and Medical	Emergency Air Transportation	2
	Safety and Security	School	1
Total			**8**

Source: Wood analysis of HIFLD and CERC Data

Economy

Landslides can block access to roads, which can isolate residents and businesses and delay commercial, public, and private transportation. This could result in economic losses for businesses. Rockfall impacts on Clear Creek County highways and I-70 have the potential to cause significant indirect economic loss. The most significant road that could be impacted by rockfall and related road closures is I-70. Economic losses from this road closure and resulting detours could be estimated with traffic counts and detour mileage.

Historic, Cultural and Natural Resources

Landslides/rockslides are a natural environmental process. Environmental impacts can include the removal of vegetation, soil, and rock. Landslides that fall into streams may significantly impact fish and wildlife habitat, as well as affecting water quality. Hillsides that provide wildlife habitat can be lost for prolonged periods of time. Additionally, rockfalls to rivers can cause blockages causing flooding, damage rivers or streams, potentially harming water quality, fisheries, and spawning habitat.

4.10.8 Development Trends

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 recreational activity grows in nearby counties, the amount of traffic within Clear Creek County, especially the I-70 corridor, will continue to 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.

4.10.9 Risk Summary

- The overall significance of extreme heat is low; the overall significance of drought is Medium.
- Landslides, debris flow, and rockfall do occur with some regularity in Clear Creek County. The direct effect on the populace is low, but there is potential for severe injury or death from rockfall.
- The secondary effect of closed roads is a more likely threat, especially if the closed roads cut off emergency personnel from those who need assistance.
- There are numerous homes, businesses, and critical facilities exposed throughout the County. The degree of vulnerability of these structures depends on the codes and standards the structures were constructed to. Information to this level of detail is not currently available.
- As incidents of wildfires increase and hillsides are void of vegetation, rain-soaked hillsides are more likely to slide resulting in increased damage countywide.
- Future development could lead to more homes in landslide risk areas and debris fans.
- Mapping and assessment of landslide hazards are constantly evolving. As new data and science become available, assessments of landslide risk should be reevaluated.
- Climate change may cause warming temperatures, more frequent storms, more droughts, and more wildfires reducing vegetation on steep slopes which would all contribute to increase probability for landslide occurrences.
- Landslides may cause negative environmental consequences, including water quality degradation.
- The risk associated with the landslide hazard overlaps the risk associated with other hazards such as earthquake, flood, and wildfire. This provides an opportunity to seek mitigation alternatives with multiple objectives that can reduce risk for multiple hazards.

4.11 Space Weather

SPACE WEATHER RANKING	
Clear Creek County	Low
City of Idaho Springs	Low
Town of Empire	Low
Town of Georgetown	Low
Town of Silver Plume	Low
Clear Creek Fire Authority	Low

DEFINITIONS

Space Weather—FEMA's Ready.gov site defines space weather as the variable conditions on the sun and in space that can influence the performance of technology used on Earth.

4.11.1 Description

The NOAA Space Weather Prediction Center states that all weather on Earth, from the surface of the planet out into space, begins with the Sun. Space weather and terrestrial weather (the weather we feel at the surface) are influenced by the small changes the Sun undergoes during its solar cycle. Extreme space weather could potentially cause damage to critical infrastructure – especially the electric grid – highlighting the importance of being prepared.

The sun is the main source of space weather. Sudden bursts of plasma and magnetic field structures from the Sun's atmosphere called coronal mass ejections (CME) together with sudden bursts of radiation, or solar flares, all cause space weather effects here on Earth.

Space weather can produce electromagnetic fields that induce extreme currents in wires, disrupting power lines, and even causing wide-spread blackouts. Severe space weather also produces solar energetic particles, which can damage satellites used for commercial communications, global positioning, intelligence gathering, and weather forecasting.

The most important impact the Sun has on Earth is from the brightness or irradiance of the Sun itself. The Sun produces energy in the form of photons of light. The variability of the Sun's output is wavelength dependent; different wavelengths have higher variability than others. Most of the energy from the Sun is emitted in the visible wavelengths (approximately 400 – 800 nanometers [nm]). The output from the Sun in these wavelengths is nearly constant and changes by only one part in a thousand (0.1%) over the course of the 11-year solar cycle.

At ultraviolet or UV wavelengths (120 – 400 nm), the solar irradiance variability is larger over the course of the solar cycle, with changes up to 15%. This has a significant impact on the absorption of energy by ozone and in the stratosphere. At shorter wavelengths, like the extreme ultraviolet (EUV), the Sun changes by 30% to 300% over very short timescales (i.e. minutes). These wavelengths are absorbed in the upper atmosphere so they have minimal impact on the climate of Earth. At the other end of the light spectrum, at infrared (IR) wavelengths (800 to 10,000 nm), the Sun is very stable and only changes by a percent or less over the solar cycle.

There are other types of space weather that can impact the atmosphere. Energetic particles penetrate into the atmosphere and change the chemical constituents. These changes in minor species such as nitrous oxide (NO) can have long lasting consequences in the upper and middle atmosphere, however it has not been determined if these have a major impact on the Earth's climate.

The March 2019 National Space Weather Strategy and Action Plan developed by the National Science and Technology Council established objectives to plan and prepare for the impacts of space weather on a national scale. This plan includes the following 3 objectives:

- Enhance the Protection of National Security, Homeland Security, and Commercial Assets and Operations against the Effects of Space Weather
- Develop and Disseminate Accurate and Timely Space Weather Characterization and Forecasts
- Establish Plans and Procedures for Responding to and Recovering from Space Weather Events

It should be noted that these objectives are for the most part, outside the control of Clear Creek County and its jurisdictions.

4.11.2 Past Events

Table 4-56 lists documented events associated with Space Weather worldwide since the 1700s. No events have been documented as impacting Colorado including Clear Creek County. The largest geomagnetic storm on record occurred in September 1859; known as the Carrington Event, it resulted in larger than normal auroral displays visible at tropical latitudes and significant impacts to telegraph systems.

Table 4-56: Global Space Weather Events Since 1700

Date	Event	Location	Impacts to Clear Creek County
July 1, 1770	Lexell's comet	International	None
September 1, 1859	Solar Flare	International	None
February 5, 1905	Meteorite	The Arabian Peninsula	None
June 30, 1908	Meteorite	Russia	None
May 1, 1921	Geomagnetic storm	International	None
February 12,1947	Bolide Event	Russia	None
September 17, 1966	Bolide Event	Lake Huron	None
February 8, 1969	Meteorites	Pueblito de Allende, Mexico	None
August 4, 1972	Solar Flare	Illinois	None
August 10, 1972	Meteorites	Western US and Canada	None
January 1, 1978	Soviet Satellite, Cosmos 954	International	None
July 11, 1979	Skylab Space Station	International	None
March 13, 1989	Geomagnetic Storms	Canada and Eastern US	None
October 9, 1992	Peekskill Meteorite	New York	None
January 1, 1994	Space Weather	Canada	None
July 15 - 24, 1994	Comet Schoemaker	International	None
March 19, 1996	Asteroid	International	None
January 11, 1997	Satellite Failure	International	None
September 1, 1997	Meteorite Explosions	Michigan	None
April-May 1998	Satellite Failure	International	None
June 14, 2002	Asteroid	International	None
February 1, 2003	Space Shuttle Columbia	United States	None
March 26, 2003	Meteorite Shower	Park Forest, Suburban Chicago	None
December 1, 2005	Geomagnetic storms	International	None
December 6, 2006	Solar Burst	International	None
September 20, 2007	Meteorite Impact	Southern Peru	None

Date	Event	Location	Impacts to Clear Creek County
February 4, 2011	Asteroid	International	None
June 27, 2011	Asteroid	International	None
October 31, 2015	Halloween Asteroid	International	None
January 5, 2016	Geomagnetic storms	International	None

Source: 2016 Clear Creek County Hazard Mitigation Plan

In the event that a space weather occurrence should happen, FEMA's Ready.gov website states that residents should:

- Follow energy conservation measures to keep the use of electricity as low as possible, which can help power companies avoid imposing rolling blackouts during periods when the power grid is compromised.
- Follow the Emergency Alert System instructions carefully.
- Disconnect electrical appliances if instructed to do so by local officials.
- Do not use the telephone unless absolutely necessary. During emergency situations keeping lines open for emergency personnel can improve response.

Such an event would likely have substantial negative effects on the local economy.

4.11.3 Location

The entirety of the County is potentially exposed to space weather events, which typically occur on a regional scale.

4.11.4 Magnitude and Severity

Space weather prediction services in the United States are provided primarily by NOAA's Space Weather Prediction Center and the U.S. Air Force's Weather Agency, which work closely together to address the needs of their civilian and military user communities. The Space Weather Prediction Center draws on a variety of data sources, both space and ground-based, to provide forecasts, watches, warnings, alerts, and summaries as well as operational space weather products to civilian and commercial users.

Data from NOAA's Space Weather Prediction Center has developed Space Weather Scales. NOAA studies have determined that different types of space weather may occur separately. Descriptions of all three general classifications of space weather as documented by NOAA are included in Figure 4-40. These include geomagnetic storms, solar radiation storms, and radio blackouts.

Figure 4-41: NOAA Space Weather Scales

NOAA Space Weather Scales

NOTE: Each type of space weather may occur separately. Descriptions of all three types of space weather warnings are here combined into one table merely to conserve space.

HF means high frequency (radio waves), but other radio frequencies may also be affected by these events. LF means low frequency (radio waves). F: refers to event frequency.

Category Labels	Geomagnetic Storms (effect & frequency)	Solar Radiation Storms (effect & frequency)	Radio Blackouts (effect & frequency)
Minor G1 S1 R1	G1 events can cause weak power grid fluctuations, minor impacts on satellite operations, effects on migratory animals, and widely visible auroras seen in Northern Michigan. F: about 900 days per solar cycle.	S1 events result in minor impacts on HF radio in polar regions. F: about 50 such events per solar cycle, each of which can last more than 1 day.	R1 events cause weak or minor degradation of HF radio communication on the sunlit side of Earth, and occasional loss of radio contact. LF navigation signals used by maritime and general aviation systems may be degraded for brief intervals. F: about 950 days per solar cycle.
Moderate G2 S2 R2	G2 events can cause high-latitude power systems to experience voltage alarms. Long-duration storms may cause transformer damage. Corrections to satellite orientation and orbital drag prediction may be required. HF radio propagation can fade at higher latitudes. Auroras may be visible throughout Michigan. F: about 360 days per solar cycle.	S2 events may expose persons in high-flying aircraft to an elevated radiation risk* in areas of high latitude. Infrequent single-event upsets of satellite operations are possible. Possible effects on HF propagation and navigation through polar regions. F: about 25 events per solar cycle, each of which can last more than 1 day.	R2 events cause a limited blackout of HF radio communications on the sunlit side of Earth, and loss of radio contact for tens of minutes. LF navigation signals may also be degraded for tens of minutes. F: about 300 days per solar cycle.
Strong G3 S3 R3	G3 events may require voltage corrections at power systems and may trigger false alarms on their protection devices. Satellite orientation problems may need correction. Increased atmospheric drag and component surface charging may occur. Intermittent LF radio navigation problems may occur. F: 130 days per solar cycle.	S3 events can expose persons in high-flying aircraft to a radiation risk* in areas of high latitude. Satellite operations may experience single-event upsets, imaging system noise, and slight solar panel inefficiencies. Degraded HF radio propagation in polar regions. Navigation position errors are likely. F: about 10 events per cycle (each can exceed 1 day).	R3 events cause a wide area blackout of HF radio communication and loss of radio contact for about an hour on the sunlit side of Earth. LF navigation signals may be degraded for about an hour. F: about 140 days per solar cycle.
Severe G4 S4 R4	G4 events may cause widespread voltage control problems for power systems, and mistaken exclusion of key assets from a power grid by some protective systems. Satellites may experience surface charging, tracking and orientation problems that may need correction. Pipelines may experience induced currents. HF radio propagation sporadic. LF radio disrupted. Satellite-based navigation may be degraded for hours. F: about 60 days per solar cycle.	S4 events can expose persons in high-flying aircraft to a radiation risk* in areas of high latitude. Satellites may experience memory device problems, imaging systems noise, orientation problems, and degraded solar panel efficiency. A blackout of HF radio communications is likely through the polar regions. Increased navigation errors over several days are likely. F: about 3 events per solar cycle (each can exceed 1 day).	R4 events cause an HF radio communication blackout on most of the sunlit side of Earth for 1 to 2 hours, with HF radio contact lost during this time. LF navigation signals cause increased errors in positioning for 1 to 2 hours. Minor disruptions of satellite navigation are possible on the sunlit side of Earth. F: about 8 days per solar cycle.
Extreme G5 S5 R5	G5 events may cause widespread voltage control and protective system problems in power systems, with some grid systems completely blacking out or collapsing, and possible damage to transformers. Satellites may experience extensive surface charging, orientation, tracking, and linkage problems. Pipelines may receive induced currents reaching hundreds of amps. HF radio may be out for 1 to 2 days in many areas. LF may be out for hours. Satellite-based navigation may be degraded for days. Bright auroral lights visible at night. F: about 4 days per solar cycle.	S5 events can expose persons in high-flying aircraft to a radiation risk* in areas of high latitude. Satellites may be rendered useless, may receive permanent solar panel damage, or may experience memory problems, loss of control, serious imaging data noise, and navigation problems. Complete HF radio communications blackouts are possible throughout the polar regions. Navigation operations will be extremely difficult and error-laden. F: less than 1 event per solar cycle should occur, although an event may exceed 1 day in duration.	R5 events cause a complete HF radio blackout on the entire sunlit side of Earth for a number of hours. No HF radio contact with mariners and aviators in this sector. LF navigation signals experience outages for many hours on the sunlit side of Earth, causing loss in positioning. Satellite navigation errors in positioning increase for several hours on the sunlit side and may spread into the night side of the Earth. F: fewer than 1 event per cycle.

*** Pregnant women are particularly susceptible to radiation risk.**

Source: National Weather Service

The most likely secondary impacts of Space Weather to residents and visitors to Clear Creek County could be impacts to the electric power grid, and consequently the power to homes and businesses which could be disrupted by space weather.

Space weather can have an impact on advanced technologies which has a direct impact on daily life. The main area of concern is most likely the nation's electric power grid. Northern territories are more vulnerable to these effects than areas farther south. Generally, power outages due to space weather are very rare events, but evidence suggests that significant effects could occur. These power outages may have cascading effects, causing:

- Loss of water and wastewater distribution systems
- Loss of perishable foods and medications

- Loss of heating/air conditioning and electrical lighting systems
- Loss of computer systems, telephone systems, and communications systems (including disruptions in airline flights, satellite networks and global positioning system services)
- Loss of public transportation systems
- Loss of fuel distribution systems and fuel pipelines
- Loss of all electrical systems that do not have back-up power

Given the global rise in technological presence and dependence, if another event of a similar magnitude to the 1859 Carrington Event were to occur, the results would be widespread electrical disruptions and blackouts, disruptions to global communication networks, and damage due to extended power outages. No space weather events have been documented as having occurred in Colorado nor more specifically in Clear Creek County. Thus, the probability of future events affecting the planning area is minimal.

4.11.5 Probability of Future Occurrence

The activity on the surface of the sun which triggers space weather events occurs constantly and is always impacting the conditions and weather we experience on Earth. Stronger events which could negatively impact Earth and cause damage occur far less frequently. Because of the rarity of these large events, they are difficult to study and predict their probability of future occurrence. According to a 2012 study by the American Geophysical Union, the likelihood of another event of the same scale as the 1859 Carrington Event occurring over the past decade was approximately 12%. While it is difficult to predict whether an event like this could specifically impact Clear Creek County, the growing global dependence on technology and telecommunications could mean an increasing likelihood of negative impacts in the future.

4.11.6 Climate Change Considerations

NOAA states that the duration of solar minimum may also have an impact on Earth's climate. During solar minimum the cosmic rays are at a maximum. Cosmic rays are high energy particles whose source is outside our solar system, reaching Earth. There is a theory that cosmic rays can create nucleation sites in the atmosphere which seed cloud formation and create cloudier conditions. If this were true, then there would be a significant impact on climate, which would be modulated by the 11-year solar cycle.

4.11.7 Vulnerability

Population

Vulnerable populations are the elderly, low income or linguistically isolated populations, people with life-threatening illnesses, those that are electricity dependent, and residents living in areas that are isolated from major population centers. Power outages can be life-threatening to those dependent on electricity for life support. According to the US Department of Health and Human Services, there are 760 electricity-dependent Medicare beneficiaries in Clear Creek County. Isolation of these populations is a significant concern.

Property

All property would be equally vulnerable to space weather. It is unlikely that the impacts of space weather would have a negative impact on the structures themselves.

Critical Facilities and Infrastructure

Space weather occurrences could cause disruption in power and communications potentially incapacitating transportation, isolating population, and disrupting ingress and egress. Of particular concern are critical facilities. The reduction of the planning area's vulnerability could be best achieved through the hardening of electrical systems and redundancy in power supplies and backups.

Government Services

Disruptions to the electrical grid and communications lines could affect first responders' ability to effectively respond in the aftermath of a space weather event. The potential for a long-lasting blackout following a space weather event may significantly hinder the ability to provide basic and essential services. The public may question local government's ability to respond and recover if planning, response, and recovery are not timely and effective.

Economy

Impacts to the economy resulting from a space weather event will likely be the result of disruptions to the power grid, satellite and GPS networks, and communications lines, and the numerous cascading impacts of disruptions to those lifelines. These disruptions could impact supply chains and transportation networks, which in turn may hinder economic activity.

Historic, Cultural, and Natural Resources

Environmental vulnerability will typically be the same as exposure.

4.11.8 Development Trends

All future development of communications and power systems should consider redundancy. All critical facilities should consider the inclusion of backup power and communication systems.

4.11.9 Risk Summary

- The overall significance of extreme heat is low; the overall significance of drought is Low.
- The processes which trigger space weather are continuously occurring on the surface of the sun.
- NOAA monitors solar activities and issues advisories, watches, and warnings accordingly in the event of larger space weather events.
- Impacts from the various types of space weather often include power outages, electrical disruptions, disruptions to global communications networks, satellites, and GPS systems.
- While space weather events occur frequently, events which impact Earth and specifically Clear Creek County occur far less frequently.
- The rarity of severe events makes it difficult to study and quantify the probability for future occurrences.
- Redundancy in power sources and hardening of electrical systems could increase the County's resilience with regards to space weather.

4.12 Tornado

TORNADO RANKING	
Clear Creek County	Low
City of Idaho Springs	Low
Town of Empire	Low
Town of Georgetown	Low
Town of Silver Plume	Low
Clear Creek Fire Authority	Low

DEFINITIONS

Tornado—Funnel clouds that generate winds up to 500 miles per hour. They can affect an area up to three-quarters of a mile wide, with a path of varying length. Tornadoes can come from lines of cumulonimbus clouds or from a single storm cloud. They are measured using the Enhanced Fujita Scale.

4.12.1 Description

A tornado is a narrow, violently rotating column of air that extends from the base of a cumulonimbus cloud to the ground. The visible sign of a tornado is the dust and debris that is caught in the rotating column made up of water droplets. Tornadoes are the most violent of all atmospheric storms. The following are common ingredients for tornado formation:

- Very strong winds in the mid and upper levels of the atmosphere
- Clockwise turning of the wind with height (i.e., from southeast at the surface to west aloft)
- Increasing wind speed in the lowest 10,000 feet of the atmosphere (i.e., 20 mph at the surface and 50 mph at 7,000 feet)
- Very warm, moist air near the ground with unusually cooler air aloft
- A forcing mechanism such as a cold front or leftover weather boundary from previous shower or thunderstorm activity

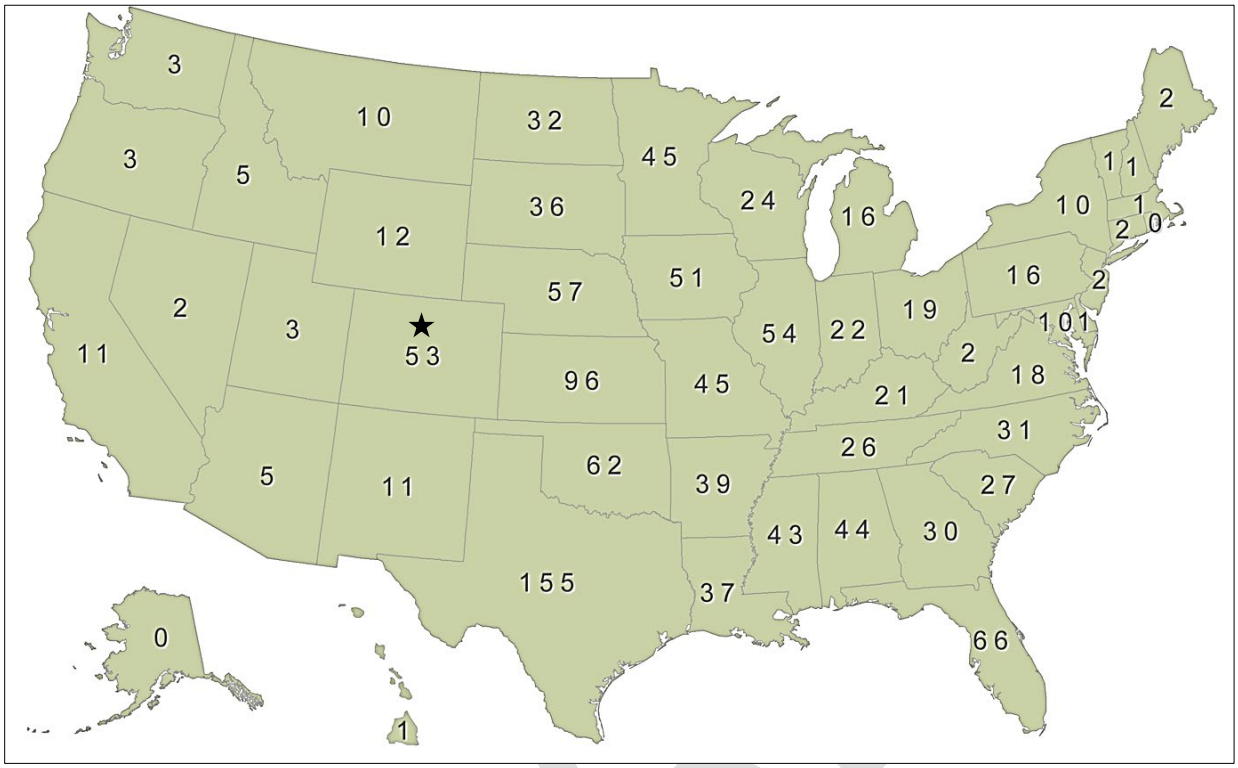
Tornadoes can form from individual cells within severe thunderstorm squall lines. They also can form from an isolated super-cell thunderstorm. Weak tornadoes can sometimes occur from air that is converging and spinning upward, with little more than a rain shower occurring in the vicinity.

The U.S. experiences more tornadoes than any other country. In a typical year, approximately 1,000 tornadoes affect the U.S. The peak of the tornado season is April through June, with the highest concentration of tornadoes in the central U.S. Figure 4-42 shows the annual average number of tornadoes between 1991 and 2010. Colorado experienced an average of 53 tornado events annually in that period. Colorado ranks 9th among the 50 states in frequency of tornadoes, but 38th for the number of deaths. Nationwide, Colorado ranks 31st for injuries and 30th for the cost of repairing the damages due to tornadoes. When these statistics are compared to other states by the frequency per square mile, Colorado ranks 28th for injuries per area and 37th for costs per area.

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.

Figure 4-42: Annual Average Number of Tornadoes in the U.S. (1991 – 2010)



★ Clear Creek County

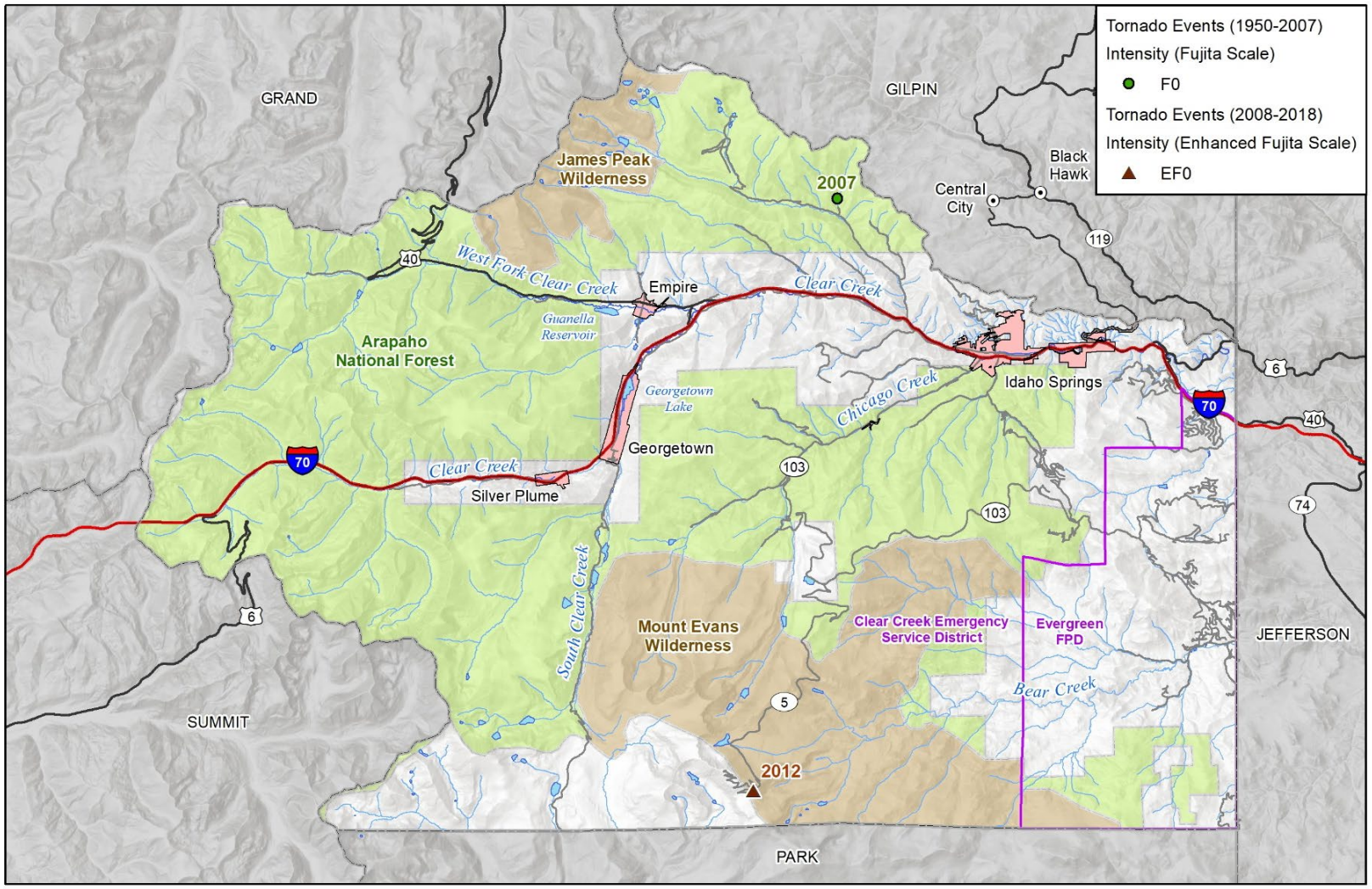
4.12.2 Past Events

There have been two recorded tornadoes in Clear Creek County in 2007 and 2012, each rated an F0/EF0. There were no known injuries, fatalities, or property damage from these two tornadoes. The 2012 tornado with an estimated elevation of 11,900 feet is one of the highest recorded tornado events in the U.S. (CBS). The tornado touched down briefly at the southeast corner of Mount Evans.

4.12.3 Location

Recorded tornadoes in the planning area are typically small and short-lived. They are more likely in flatter parts of the county, though they are generally unlikely to occur because of the mountainous terrain in the county. Figure 4-43 shows the location of previous tornado events in the county.

Figure 4-43: Tornado Locations in Clear Creek County



4.12.4 Magnitude and Severity

In 2007, the NWS began rating tornadoes using the Enhanced Fujita Scale (EF-scale). The EF-scale is a set of wind estimates (not measurements) based on damage. Its uses three-second gusts estimated at the point of damage based on a judgment of 8 levels of damage to the 28 indicators listed in Table 4-57. These estimates vary with height and exposure. Standard measurements are taken by weather stations in open exposures. Table 4-58 describes the EF-scale ratings versus the previous Fujita Scale used prior to 2007 (NOAA 2007). Visual examples of the degree of damage which could be expected with each EF rating are shown in Figure 4-44 below.

Table 4-57: Enhanced Fujita Scale Damage Indicators

No.	Damage Indicator	No.	Damage Indicator
1	Small barns, farm outbuildings	15	School – 1-story elementary (interior or exterior halls)
2	One or two-family residences	16	School – junior or senior high school
3	Single-wide mobile home	17	Low-rise (1-4 story) building
4	Double-wide mobile home	18	Mid-rise (5-20) building
5	Apt, condo, townhouse (3 stories or less)	19	High-rise (over 20 stories) building
6	Motel	20	Institutional bldg. (hospital, govt. or university)
7	Masonry apt. or motel	21	Metal building system
8	Small retail building (fast food)	22	Service station canopy
9	Small professional (doctor office, bank)	23	Warehouse (tilt-up walls or heavy timber)
10	Strip mall	24	Transmission line tower
11	Large shopping mall	25	Free-standing tower
12	Large, isolated (big box) retail building	26	Free standing pole (light, flag, luminary)
13	Automobile showroom	27	Tree – hardwood
14	Automobile service building	28	Tree – softwood

Source: National Weather Service

Table 4-58: The Fujita Scale and Enhanced Fujita Scale

Fujita Scale			Derived		Operational EF Scale	
F Number	Fastest ¼ mile (mph)	3-second gust (mph)	EF Number	3-second gust (mph)	EF Number	3-second gusts (mph)
0	40-72	45-78	0	65-85	0	65-85
1	73-112	79-117	1	86-109	1	86-110
2	113-157	118-161	2	110-137	2	111-135
3	158-207	162-209	3	138-167	3	136-165
4	208-260	210-261	4	168-199	4	166-200
5	261-318	262-317	5	200-234	5	Over 200

Source: National Weather Service
Notes: EF: Enhanced Fujita, F: Fujita, mph: Miles per Hour

Figure 4-44: Potential Damage Impacts from a Tornado

Source: National Oceanic and Atmospheric Administration

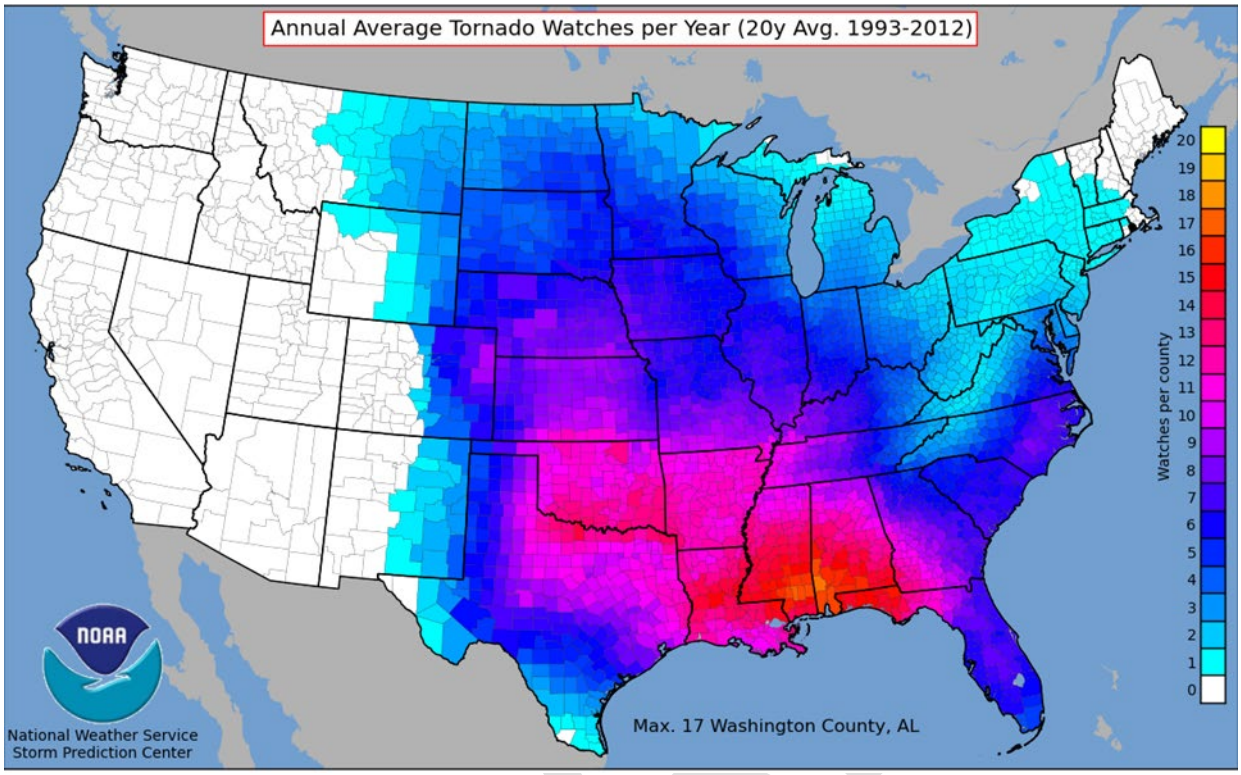
Tornadoes are potentially the most dangerous of local storms. If a major tornado were to strike within the populated areas of Clear Creek County, damage could be widespread. Businesses could be forced to close for an extended period or permanently, fatalities could be high, many people could be homeless for an extended period, and routine services such as telephone or power could be disrupted. Buildings may be damaged or destroyed.

The NOAA's storm prediction center issues tornado watches and warnings for Clear Creek County:

- Tornado Watch—Tornadoes are possible. Remain alert for approaching storms. Watch the sky and stay tuned to NOAA Weather Radio, commercial radio, or television for information.
- Tornado Warning—A tornado has been sighted or indicated by weather radar. Take shelter immediately.

A study from NOAA's National Severe Storms Laboratory used historical data to estimate the daily probability of tornado occurrences across the U.S., regardless of tornado magnitude. Figure 4-42 shows the estimates. The density per 25 square miles in the map's legend indicates the probable number of tornadoes for each 25 square mile cell within the contoured zone that can be expected over a similar period of record. It should be noted that the density number does NOT indicate the number of events that can be expected across the entire zone on the map.

Figure 4-45: Total Annual Tornado Watches in the U.S. (1993-2012)



Source: NOAA

Historically, tornadoes have not typically been severe or caused damage in the planning area; the reported tornadoes have only been listed as F0/EF0, the lowest rating for a tornado. Based on the information in this hazard profile, the overall significance of tornadoes in Clear Creek County is minimal.

4.12.5 Probability of Future Occurrences

Tornadoes have been reported 9 months of the year in Colorado, with peak occurrences between May and August. Statewide, June is by far the month with the most recorded tornadoes. There have been two recorded tornadoes between 1970 and 2014, therefore, an average of 0.05 tornadoes occur each year in Clear Creek County.

4.12.6 Climate Change Considerations

Climate change impacts on the frequency and severity of tornadoes are unclear. NASA's Earth Observatory has conducted studies which aim to understand the interaction between climate change and 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. The level of significance of this hazard should be revisited over time.

4.12.7 Vulnerability

People

It can be assumed that the entire planning area is exposed to some extent to tornadoes. Certain areas are more exposed due to geographic location and local weather patterns. Likelihood of injuries and fatalities

would increase if warning time was limited before the event or if residents were unable to find adequate shelter.

Vulnerable populations are 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. Isolation of these populations is a significant concern. These populations face isolation and exposure after tornado events and could suffer more secondary effects of the hazard. As noted in in the Hail, Lightning and Severe Wind vulnerability assessment section 4.9, 11% of Medicare Beneficiaries in the County rely on electricity-dependent medical equipment to be able to live independently in their homes. These populations face isolation and exposure after tornado events and could suffer more secondary effects of the hazard. These populations face isolation and exposure after tornado events and could suffer more secondary effects of the hazard.

Individuals caught in the path of a tornado who are unable to seek appropriate shelter are especially vulnerable. This may include individuals who are out in the open, in cars, or who do not have access to basements, cellars, or safe rooms.

Property

All property is vulnerable during tornado events, but properties in poor condition or in particularly vulnerable locations may risk the most damage. Mobile homes are more vulnerable to the impacts of a tornado event compared to housing types due to methods of construction. Statewide, mobile homes represent about 4% of total housing. While in Clear Creek County, 5.5% of total housing stock is mobile homes and 3.2% in both the Town Empire and Town of Georgetown. If an EF3 or higher tornado were to hit populated areas of the county substantial damage to property would be likely.

Tornadoes occur very infrequently in Clear Creek County. The two reported events occurred outside the jurisdiction areas. There is no loss expectancy from a tornado in the county based on the lack of property damage from the previous reported tornadoes.

Critical Facilities and Infrastructure

All critical facilities and infrastructure are likely exposed to tornadoes, though the likelihood of damage to any critical facilities or infrastructures from a tornado is extremely limited. The most common problems associated with this hazard are utility losses. Downed power lines can cause blackouts, leaving large areas isolated. Phone, water, and sewer systems may not function. Roads may become impassable due to downed trees or other debris.

Tornadoes 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. Any facility that is in the path of a tornado is likely to sustain damage.

Additionally, fires may result from damages to natural gas infrastructure. Hazardous materials may be released if a structure is damaged that houses such materials or if such a material is in transport.

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.

Historic, Cultural, and Natural Resources

Environmental features are exposed to tornado risk, although damages are generally localized to the path of the tornado however, if tornadoes impact facilities that store HAZMAT areas impacted by material releases may be especially vulnerable. Historic buildings built prior to modern building codes would be more prone to damage

4.12.8 Development Trends

All future development will be affected by tornadoes, particularly development that occurs at lower elevations. Development regulations that require safe rooms, basements, or other structures that reduce risk to people would decrease vulnerability. Tornadoes that cause damage are uncommon in the county, so mandatory regulations may not be cost-effective.

4.12.9 Risk Summary

- The overall significance of extreme heat is low; the overall significance of tornado is Low.
- There have been 2 recorded tornado events in the County since 1950. Neither resulted in property damage or injuries.
- Elderly and individuals who depend on electricity for medical needs are vulnerable to power outages caused by a tornado. 11% of Medicare Beneficiaries in the County rely on electricity-dependent equipment.
- All property is potentially vulnerable during tornado events, but mobile homes are disproportionately at risk due to the design of the homes. 5.5% of total housing in the County are mobile homes.
- Due to the low probability and generally low intensity, tornadoes are considered a low significance hazard.
- Related Hazards: Severe Wind

4.13 Wildfire

WILDFIRE HAZARD RANKING	
Clear Creek County	High
City of Idaho Springs	High
Town of Empire	High
Town of Georgetown	High
Town of Silver Plume	High
Clear Creek Fire Authority	High

DEFINITIONS

Conflagration—A fire that grows beyond its original source area to engulf adjoining regions. Wind, extremely dry or hazardous weather conditions, excessive fuel buildup, and explosions are usually the elements behind a wildfire conflagration.

Wildland Urban Interface (WUI) Area—An area susceptible to wildfires and where wildland vegetation and urban or suburban development occur together. An example would be smaller urban areas and dispersed rural housing in forested areas.

Wildfire—Fires that result in uncontrolled destruction of forests, brush, field crops, grasslands, and real and personal property in non-urban areas. Because of their distance from firefighting resources, they can be difficult to contain and can cause a great deal of destruction.

4.13.1 Description

A wildfire is any uncontrolled fire occurring on undeveloped land that requires fire suppression. Wildfires can be ignited by lightning or by human activity such as smoking, campfires, equipment use, and arson.

Fire hazards present a considerable risk to vegetation and wildlife habitats. Short-term loss caused by a wildfire can include the destruction of timber, wildlife habitat, scenic vistas, and watersheds. Long-term effects include smaller timber harvests, reduced access to affected recreational areas, and destruction of cultural and economic resources and community infrastructure. Vulnerability to flooding increases due to the destruction of watersheds. The potential for significant damage to life and property exists in areas designated as wildland urban interface (WUI) areas, where development is adjacent to densely vegetated areas.

Generally, there are three major factors that sustain wildfires and predict 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, leaves, twigs, and branches to dead standing trees, live trees, brush, and cured grasses. 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 treetops. 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 parts of the planning area are extremely vulnerable to wildfires, as a result of dense vegetation combined with urban interface living. Non-native species have become invasive in the area, specifically, Tamarisk and Russian Olive. These species burn readily and pose a threat to homes and other structures in the lower reaches of the county and into municipalities.
- **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 wildfire vulnerability and susceptibility. During periods of drought, low fuel moisture and lack of precipitation increase the threat of wildfire. 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.

Wildfires are of significant concern throughout Colorado. According to the Colorado State Forest Service, vegetation fires occur on an annual basis; most are controlled and contained early with limited damage. For those ignitions that are not readily contained and become wildfires, damage can be extensive. According to the 2018 State of Colorado Hazard Mitigation Plan, a century of aggressive fire suppression combined with cycles of drought and changing land management practices has left many of Colorado's forests, including those in Clear Creek County, unnaturally dense and ready to burn. Further, the threat of wildfire and potential losses is constantly increasing as human development and population increases and the Wildland Urban Interface (WUI) expands. Another contributing factor to fuel loads in the forest are standing trees killed by pine bark beetles, which have been affecting the forests of Colorado since 2002, becoming more widespread and a serious concern. According to the 2021 Clear Creek County Hazard Mitigation Community Survey (see Appendix C), Clear Creek County residents believe that wildfire is the greatest threat to their safety.

Fire Protection in Clear Creek County

Fire protection in Clear Creek County is divided between the Clear Creek Fire Authority (CCFA), the Evergreen Fire Protection District (EFPD), and the USDA Forest Service. CCFA maintains eight fire stations across the County, staffed by 4 paid fulltime employees and approximately 60 volunteers. Multiple community wildfire protection plans are in place under the umbrella of the 2008 Community Wildfire Protection Plan for Clear Creek County, as discussed in Section 2.10.

Vegetation Classes in Clear Creek County

General vegetation for Clear Creek County is described in Table 4-59. The most common land cover classes in the county are open water, spruce-fir, and ponderosa pine comprising over 65% of the acreage in the county.

Table 4-59: Vegetation Classes in Clear Creek County

Class	Acres	Percent (%)
Grassland	593	0.2
Shrubland	40,899	11.1
Aspen	46,473	12.6
Lodgepole Pine	0	0.0
Ponderosa Pine	52,577	14.2

Class	Acres	Percent (%)
Spruce-Fir	65,640	17.8
Mixed Conifer	339	0.1
Oak Shrubland	887	0.2
Pinyon-Juniper	268	0.1
Riparian	14,783	4.0
Introduced Riparian	2,820	0.8
Agriculture	14,895	4.0
Open Water	127,592	34.5
Urban and Community	1,900	0.5
Total	**2,185,797**	**100.0**

Source: Clear Creek County Wildfire Risk Summary Report

4.13.2 Past Events

The following wildfires were reported in Clear Creek County between 2002 and 2020 (see Table 4-60). Most of the wildfires had an acre or less burned.

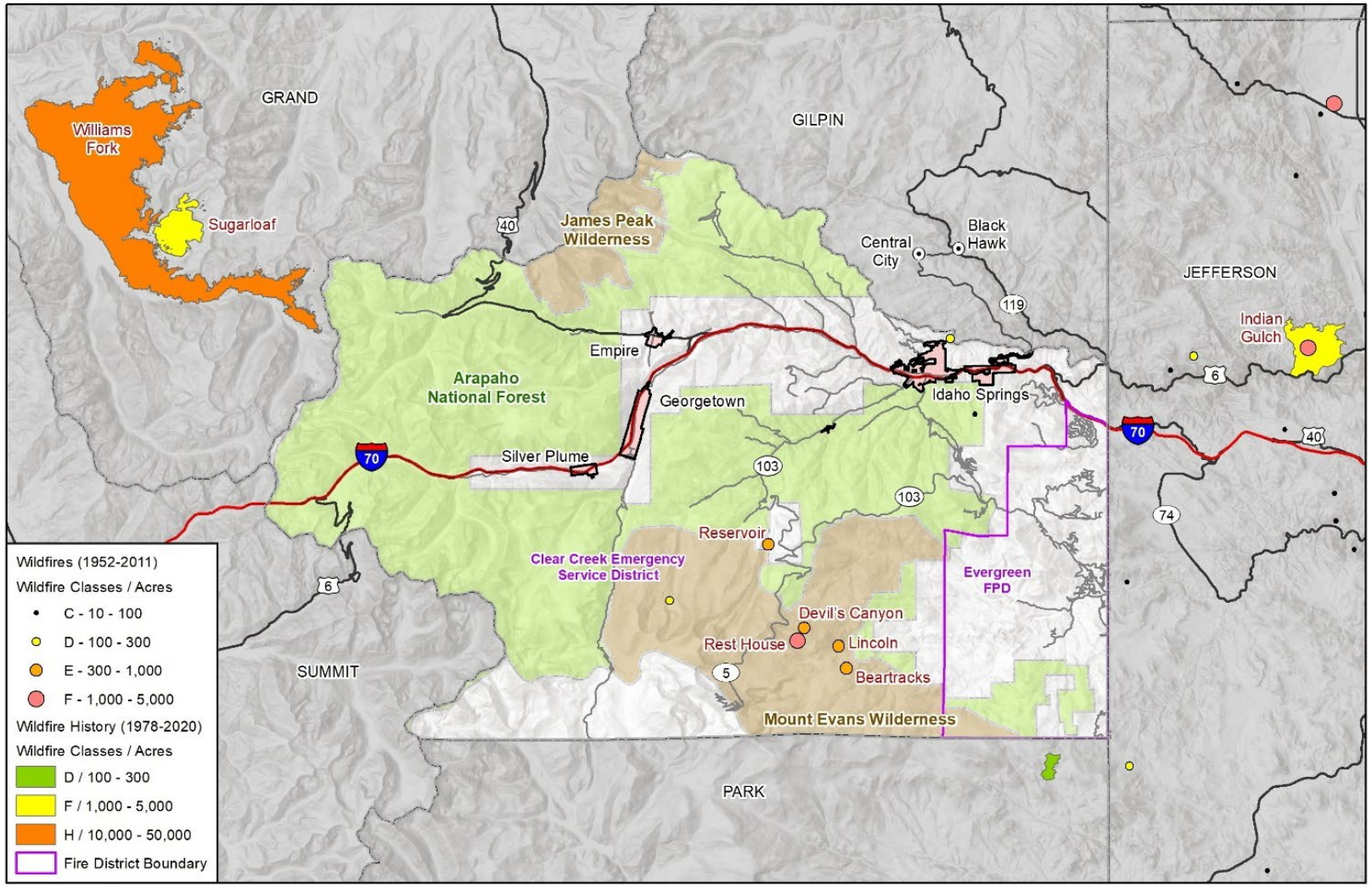
Table 4-60: Clear Creek County OEM Fire Records

Fire	Month/Year	Acres Burned	Comments
North Spring Fire	June 2002	9	
Fox Gulch Fire	May 2004	1.5	
Benchmark 263 Fire	June 2004	5	USFS Lands
Closet Fire	August 2004	<1	
Hidden Valley Fire	August 2004	<1	
Naylor Lake Fire	July 2005	1	
Three Valley Tree Fire	August 2005	<1	
Dumont East Fire	September 2005	<1	
Devil's Gate Fire	June 2006	<1	
Hwy 103 MM 12 Fire	June 2006	<1	
York Gulch Road Fire	June 2006	<1	
Devil's Tongue Fire	July 2006	<1	
Standley 236 Fire	September 2007	<1	
Alvarado Fire	November 2007	25	
Devil's Canyon	June 2008	14	
Red Elephant Fire	June 2019	10	

Note: OEM - Office of Emergency Management
Source: 2008 Community Wildfire Protection Plan for Clear Creek County, CO Forest Atlas

According to NOAA, two wildfire events occurred outside the county in 2012 (March 26 and April 1). The two wildfires were identified as the Lower North Fork Fire (in Jefferson County), which resulted in three deaths and over $20 million in damages. Fire history in the County from 1952-2020 is highlighted below in Figure 4-46.

Figure 4-46: Clear Creek County Fire History, 1952-2020



4.13.3 Location

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. 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. Colorado overall is one of the fastest growing states in the nation and much of this growth is occurring in the WUI area, where structures and other human improvements meet and mix with undeveloped wildland or vegetative fuels. Population growth within the WUI substantially increases the risk from wildfires. Figure 4-47 shows the Clear Creek County housing density within the WUI.

The Colorado State Forest Service's Colorado Wildfire Risk Assessment Portal (CO-WRAP) report for Clear Creek County maps the WUI Risk Index, which is a rating of the potential impact of a wildfire on people and their homes. The key input reflects housing density (Figure 4-47). The CO-WRAP report states that the location of people living in the WUI and rural areas is essential for defining potential wildfire impacts to people and homes. Figure 4-48 shows the WUI Risk Index for Clear Creek County.

Wildfire risk represents the possibility of loss or harm occurring from a wildfire. Risk is derived by combining the wildfire threat and the fire effects assessment outputs. It identifies areas with the greatest potential impacts from a wildfire. Wildfire risk combines the likelihood of a fire occurring (threat) with those areas of most concern that are adversely impacted by fire to derive a single overall measure of wildfire risk. Figure 4-49 shows the more general wildfire risks for areas within Clear Creek County, not specifically incorporating WUI locations. Figure 4-50 through Figure 4-53 below show the wildfire risk for the City of Idaho Springs and towns of Georgetown, Silver Plume, and Empire.

Figure 4-47: Clear Creek County Housing Density within the Wildland Urban Interface

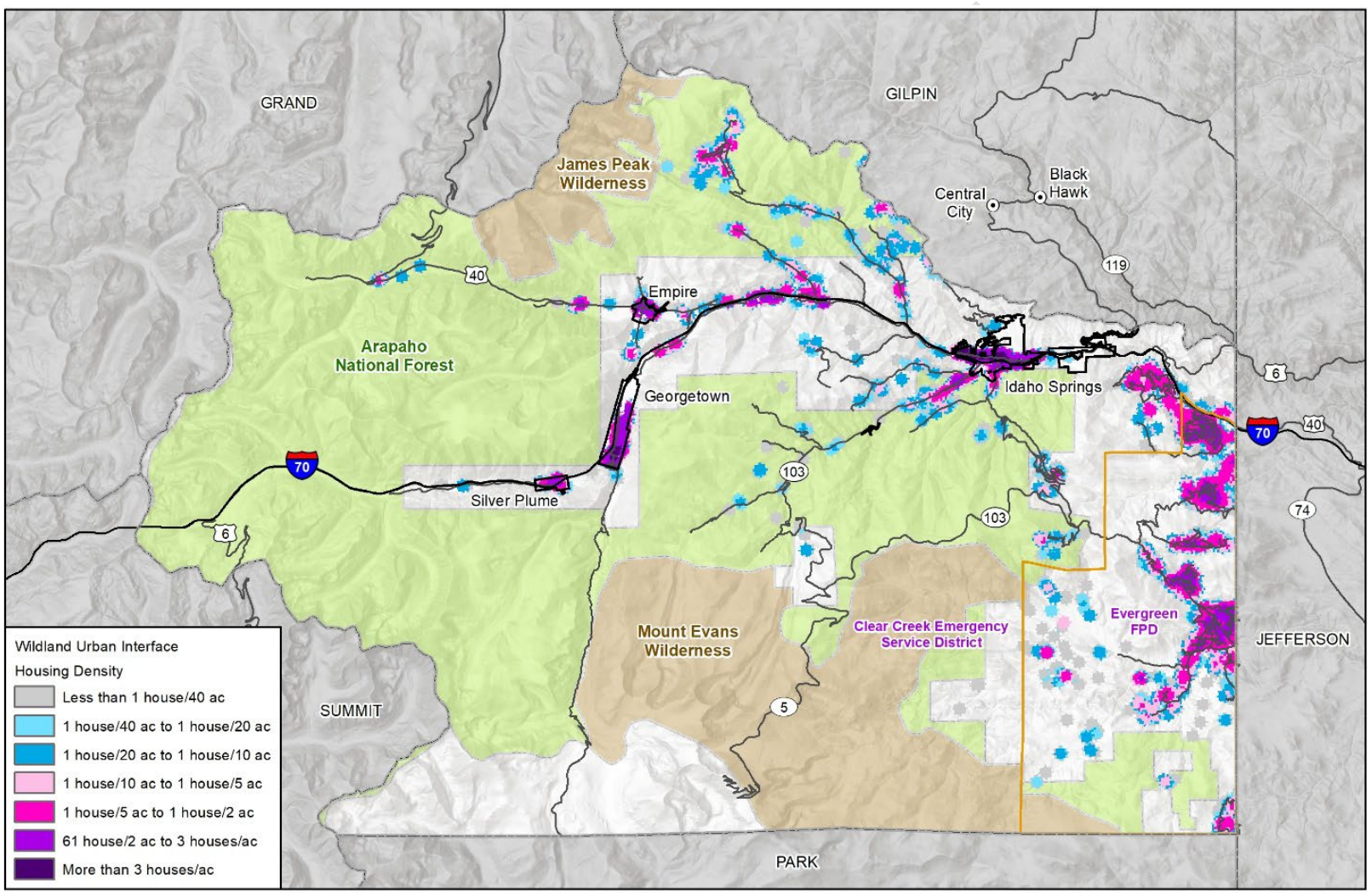


Figure 4-48: Wildland Urban Interface Risk Index for Clear Creek County

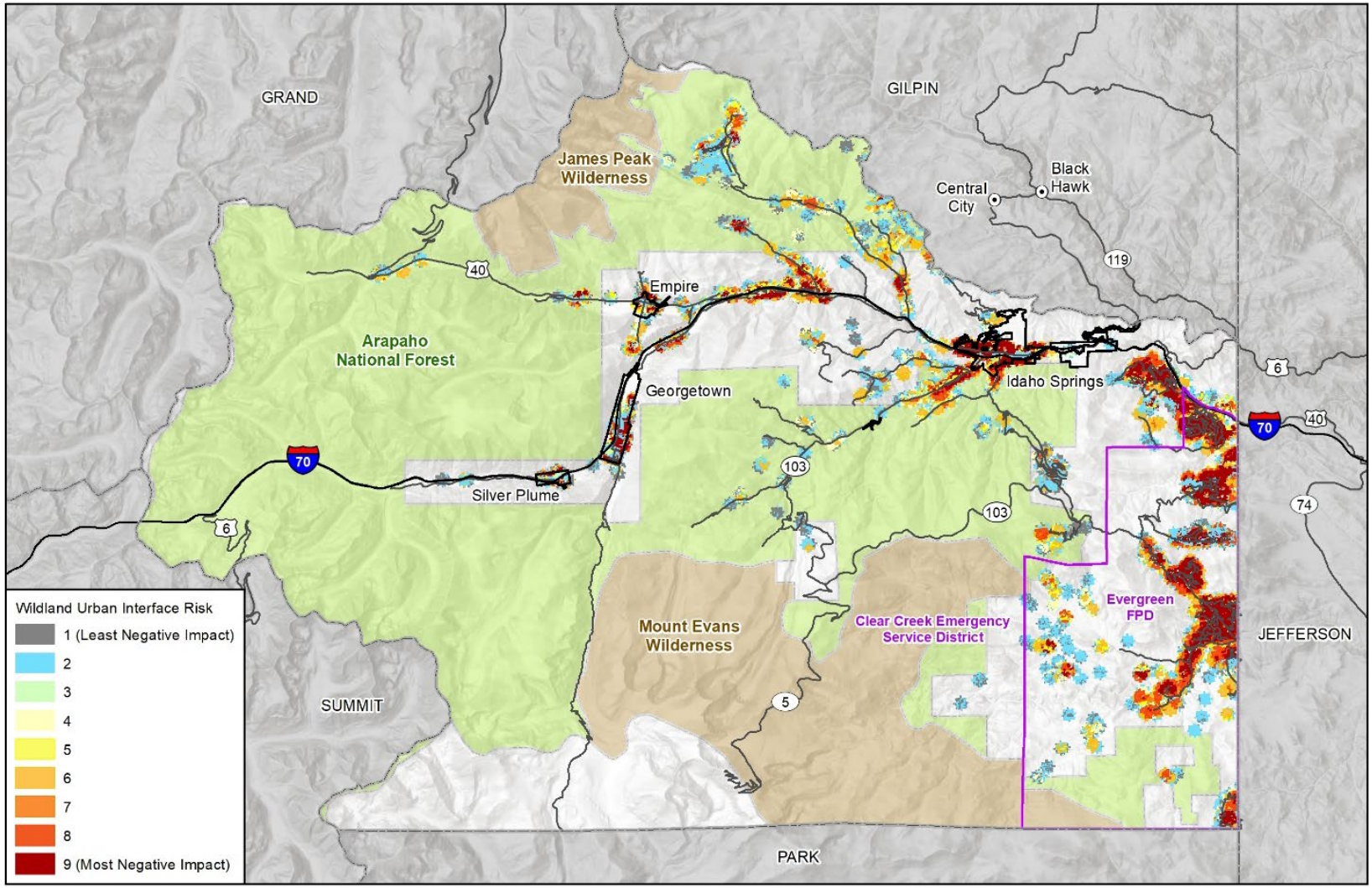


Figure 4-49: Wildfire Risks for Areas in Clear Creek County

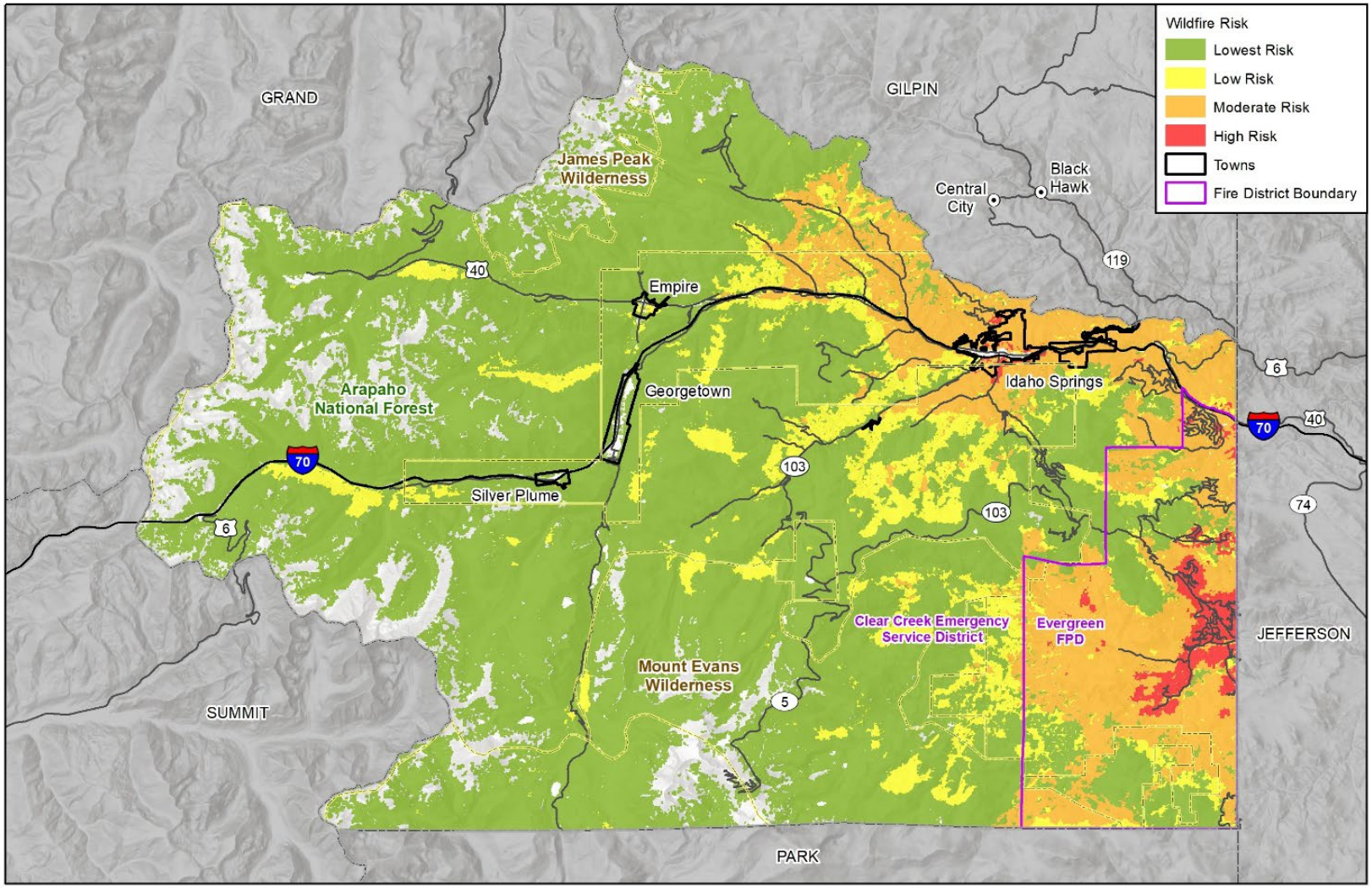


Figure 4-50: Wildfire Risks for the City of Idaho Springs

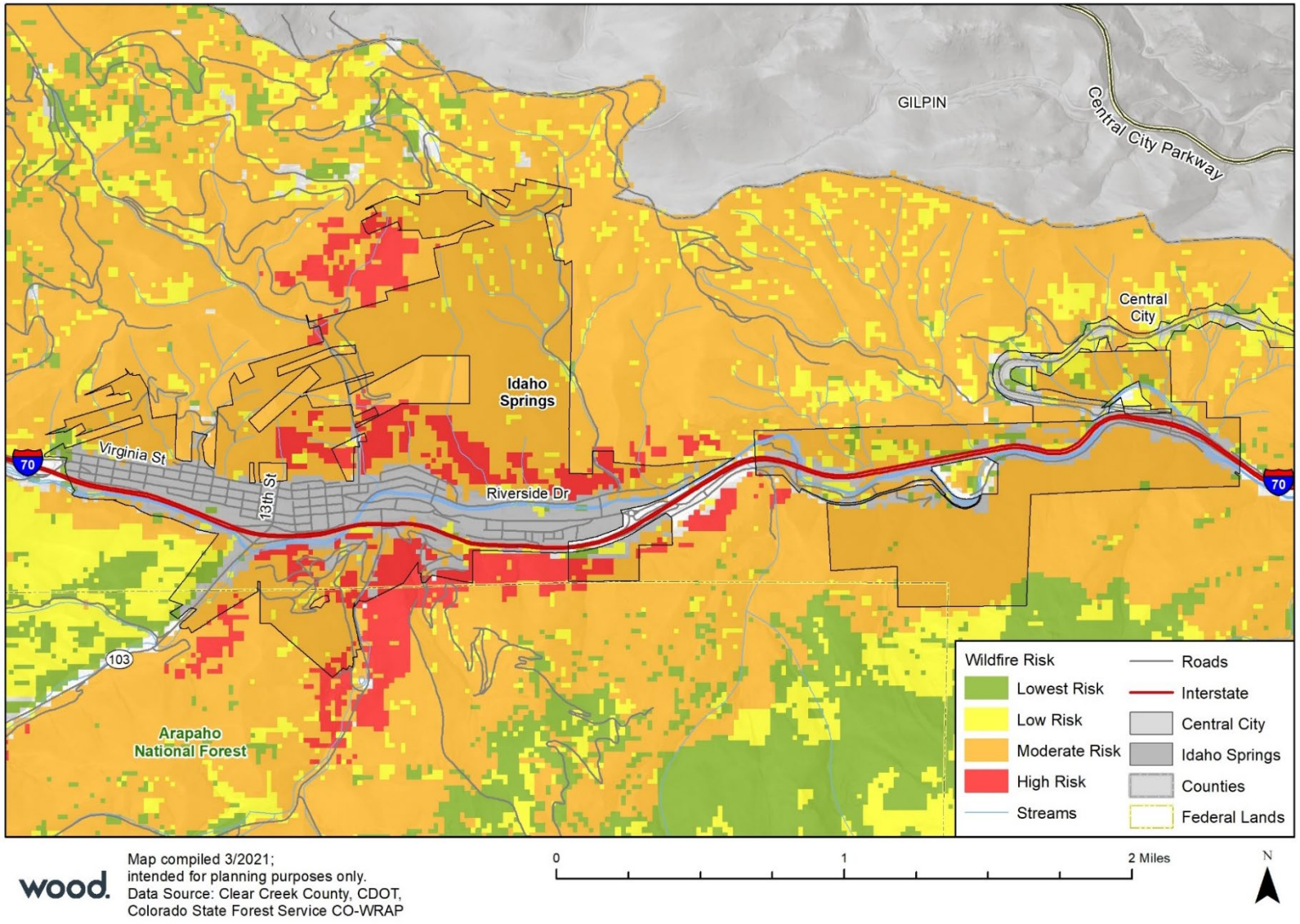


Figure 4-51: Wildfire Risks for the Town of Georgetown

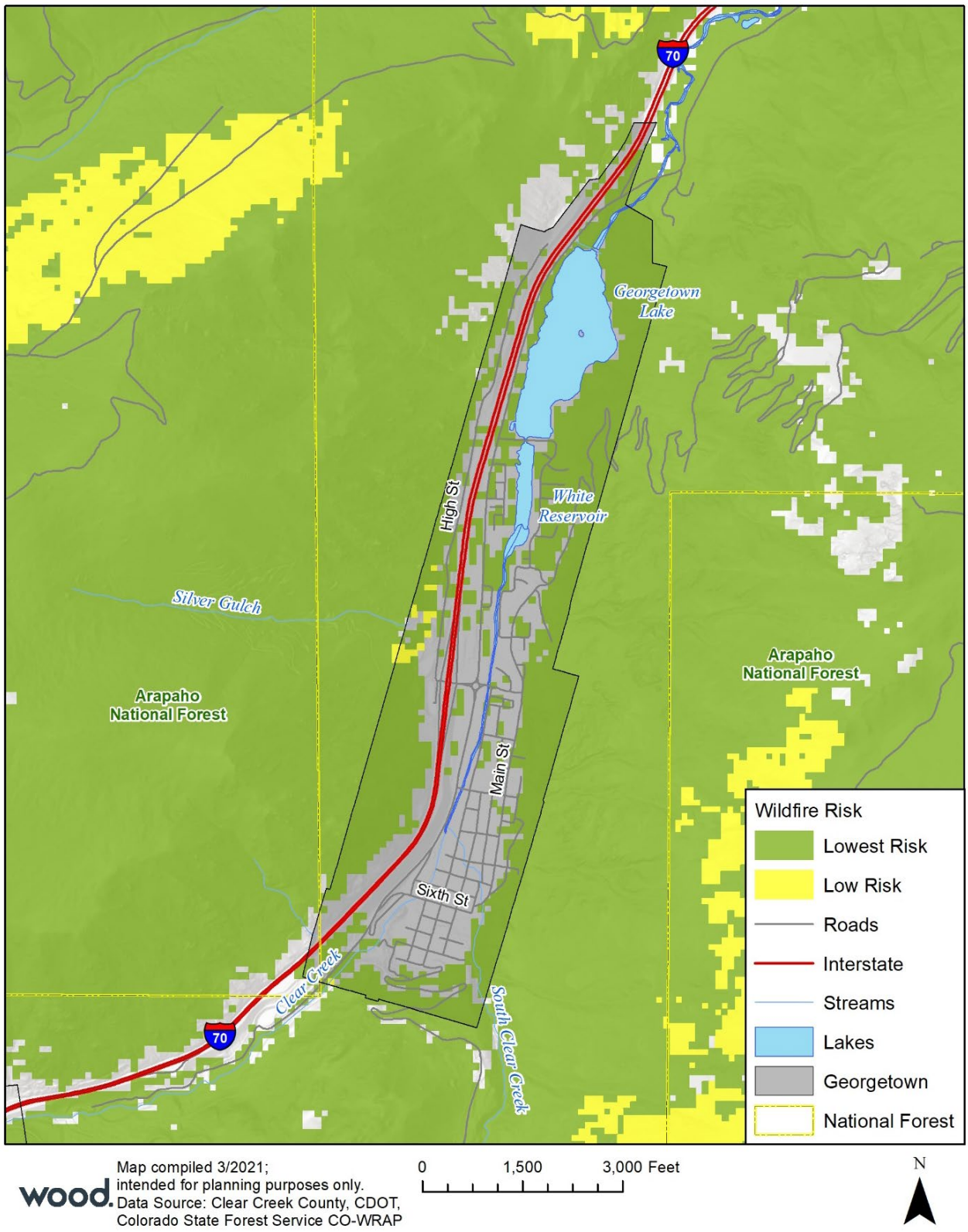


Figure 4-52: Wildfire Risks for the Town of Sliver Plume

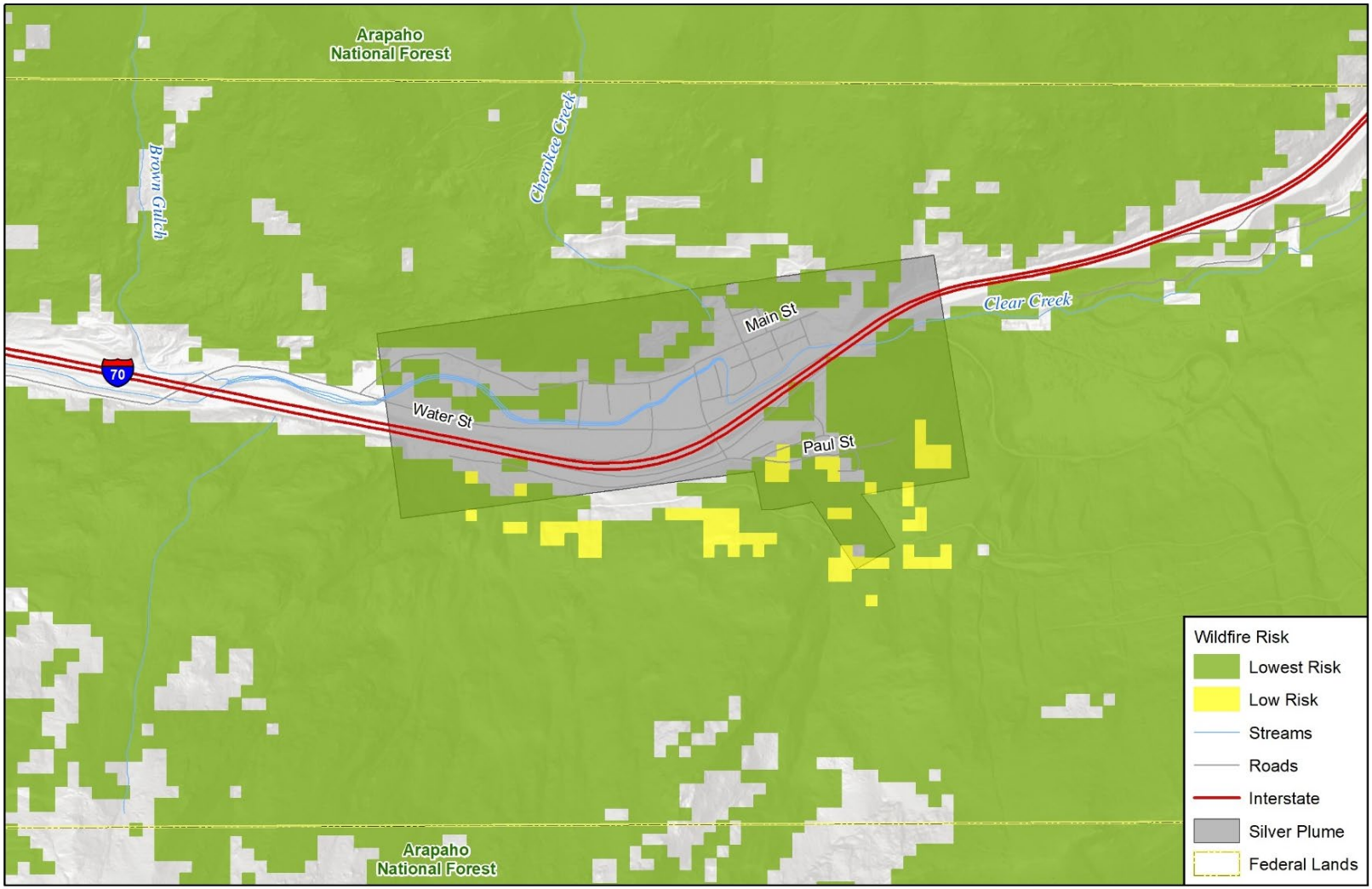


Figure 4-53: Wildfire Risks for the Town of Empire

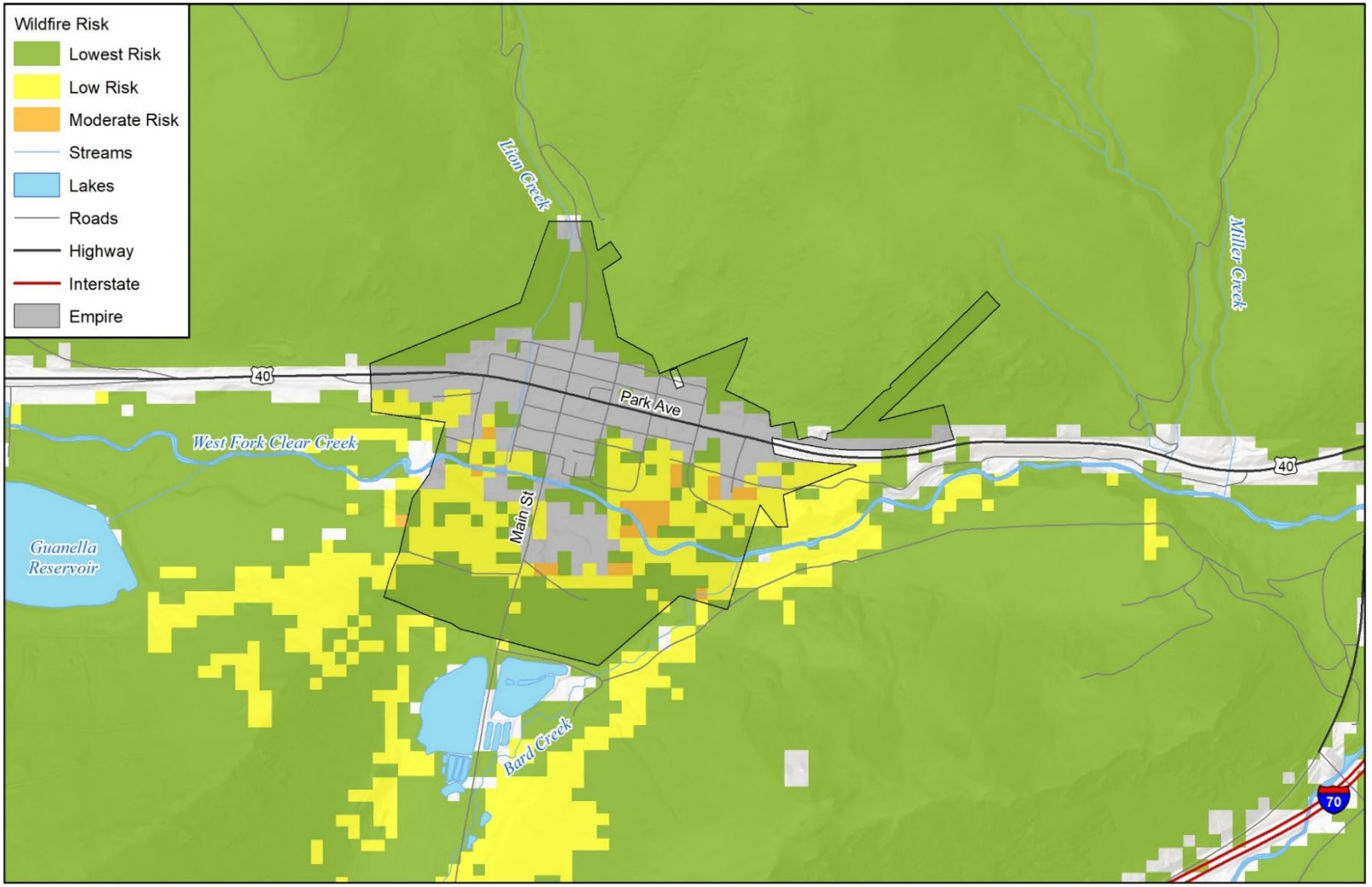
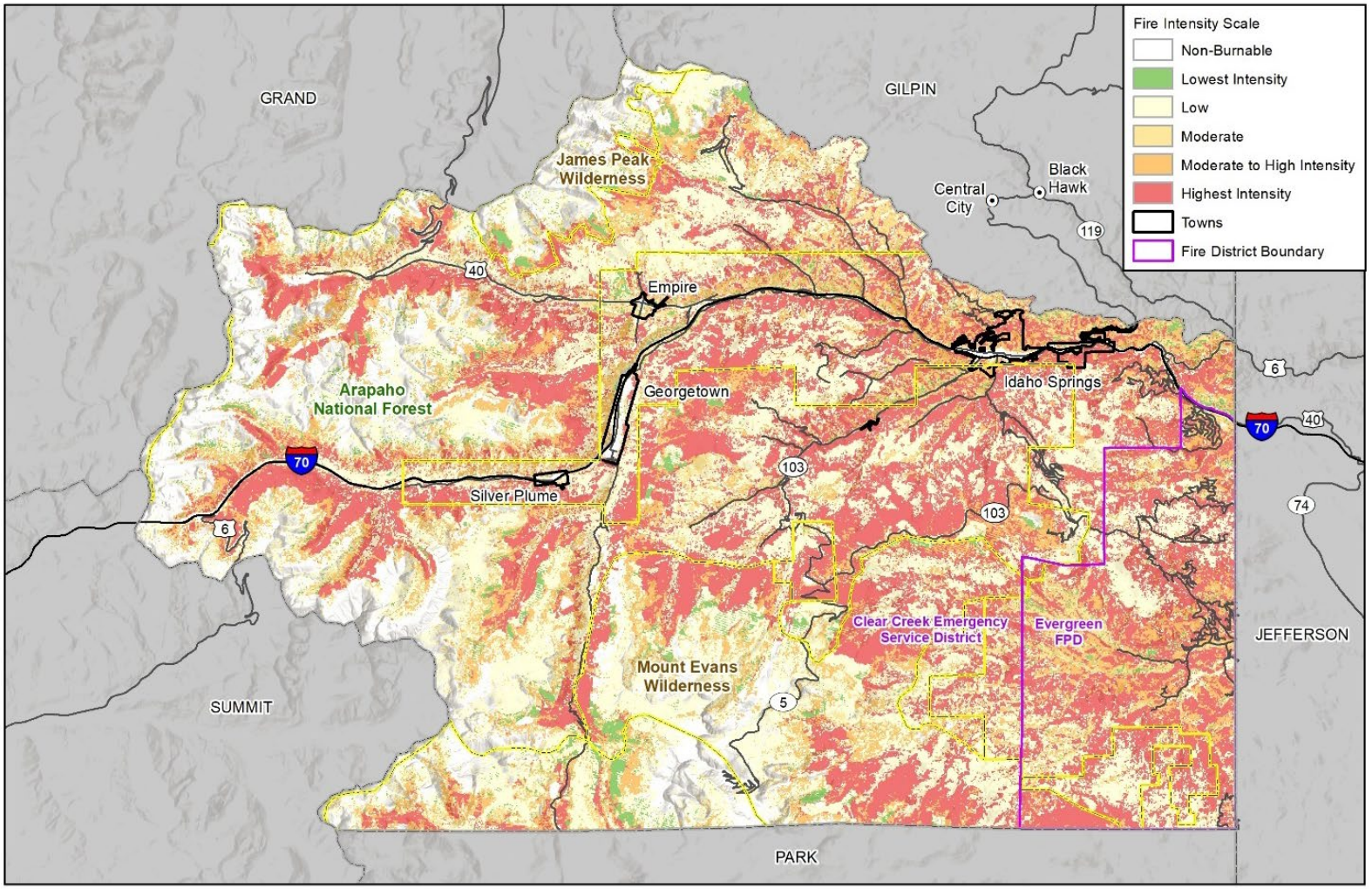


Figure 4-54: Clear Creek County Fire Intensity Scale Map



4.13.4 Magnitude and Severity

Wildfires occur naturally and are an important component of the Montane and Subalpine ecosystems that dominate much of Clear Creek County. The typical fire season of the study area is defined as June through September when 84% of the fires occur, although wildfires in Colorado can and have occurred in every month. While only 36% of fires in these districts were caused by lightning, over 64% were caused by non-natural ignitions. However, it should be noted that while lightning strikes do occur and start fires, many do not get reported.

The Colorado Forest Atlas 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. Each classification in wildfire intensity is ten times the intensity of the previous class. 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 in the central and eastern portions of the County, see Figure 4-54. This map highlights the potential intensity that could be observed throughout the County in the event of a wildfire.

Another factor of the impact of wildfires is the ability to warn and prepare residents ahead of time. Wildfires are often caused by humans, intentionally or accidentally. Because fireworks often cause brush fires, extra diligence is warranted around the Fourth of July when the use of fireworks is highest. Dry seasons and droughts are factors that greatly increase fire likelihood. Dry lightning may trigger wildfires. Severe weather can be predicted, so special attention can be paid during weather events that may include lightning. Reliable NWS lightning warnings are available on average 24 to 48 hours before a significant electrical storm.

If a fire does break out and spreads rapidly, residents may need to evacuate within days or hours. A fire's peak burning period generally is between 1 p.m. and 6 p.m. Once a fire has started, fire alerting is reasonably rapid in most cases. The rapid expansion of cellular and two-way radio communications in recent years has further contributed to a significant improvement in warning time.

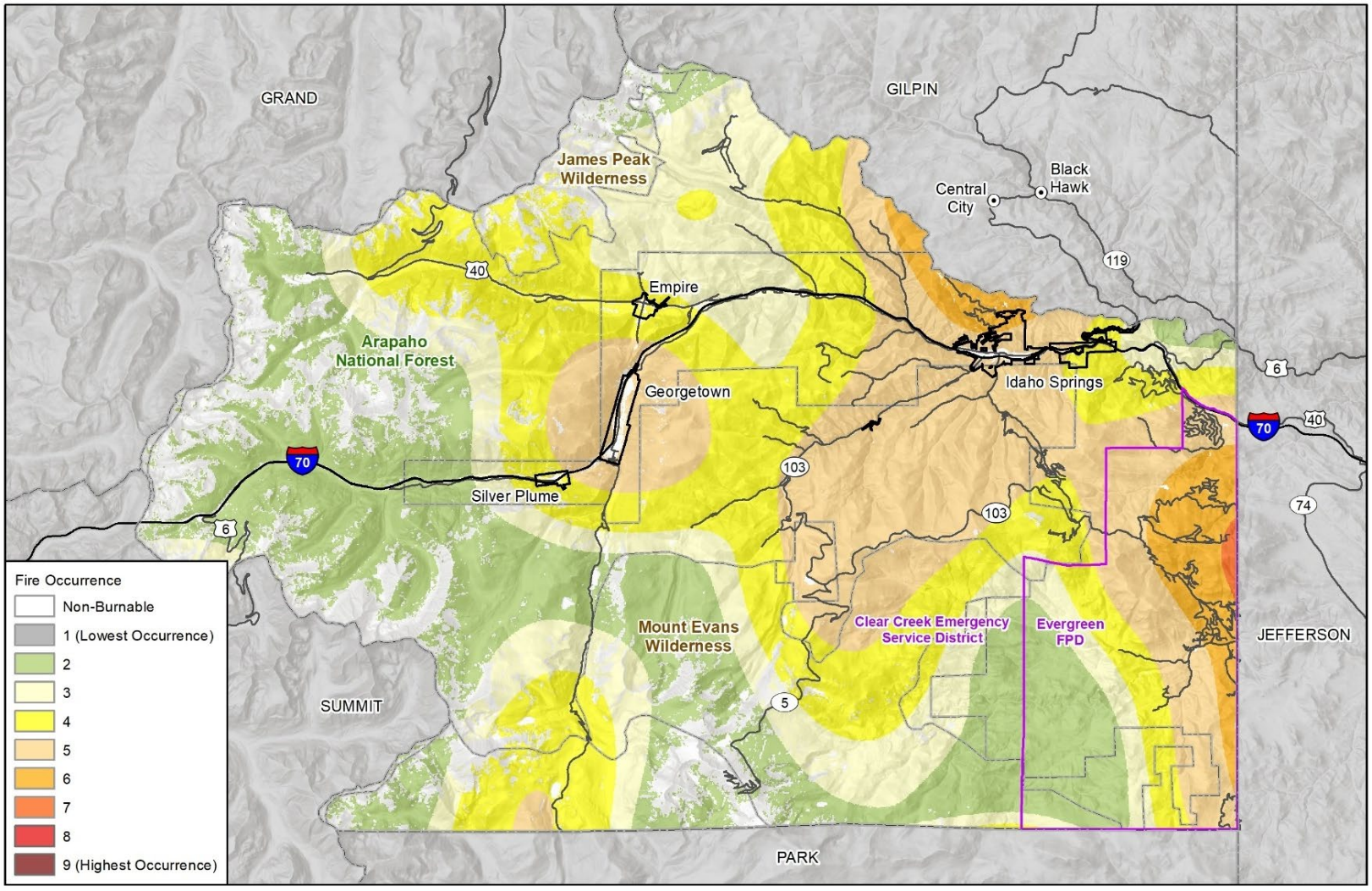
Based on the information in this hazard profile and the potential widespread impacts, the magnitude of severe wildfires is considered critical, causing isolated deaths and multiple injuries; major or long-term property damage that threatens structural stability; or interruption of essential facilities and services for 24 to 72 hours—as well as longer duration economic impact due to interrupted tourism, which plays a major part in the economy of Clear Creek and the planning partners. Overall significance of the hazard is considered High.

4.13.5 Probability of Future Occurrences

Based on the data provided by CFIRS, with 15 events from 2002 to 2020, there is roughly an 83% chance of a wildfire in Clear Creek County each year.

Additionally, fire occurrence, as provided by CO-WRAP, has been calculated for the county as the annual probability of any location burning due to a wildfire based on historical ignition patterns. Using this data, fire occurrence was mapped for Clear Creek County and is shown in Figure 4-55 below. As shown below, large portions of the County are within areas rated 4 or 5 on the fire occurrence class scale, including the Town of Georgetown, City of Idaho Springs, and the majority of the route of Interstate 70 through the County. Based on this data the central and eastern portions of the County have the highest probability of future occurrence.

Figure 4-55: Clear Creek County Wildfire Occurrence



4.13.6 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 Clear Creek 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 is expected to increase due to a lengthening fire season and drier conditions. According to the Intergovernmental Panel on Climate Change's 2019 Special Report on Climate Change and Land:

> 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 Clear Creek 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. This project trend is apparent with the historic 2020 fire season, during which the state saw 3 separate fires become the largest in state history. The report's findings are consistent with previous studies on the relationship between climate change and fire risk. Colorado landscapes, including those that characterize Clear Creek County, are expected to become hotter and drier as the planet warms, which in turn is expected to increase regional wildfire risk.

4.13.7 Vulnerability

Wildfire has the potential to cause widespread damage and loss of life in Clear Creek County. The significance of this hazard and the availability of digital hazard data in GIS enables a more detailed vulnerability assessment than many hazards. Structures, aboveground infrastructure, critical facilities, and natural environments are all vulnerable to the wildfire hazard. The following sections summarize the results of GIS analysis of Clear Creek County with regards to the population, property, critical facilities and infrastructure, government services, economy, and historic, cultural, and natural resources within the county.

Population

Direct threat exists to residents exposed to wildfire risk by residing in the WUI areas. Population living in WUI areas was estimated using the structure count of buildings in the WUI area and applying the census value of 2.23 persons per household for Clear Creek County, 2.02 persons per household for Silver Plume,

2.07 persons per household for Idaho Springs, 1.92 persons per household for Georgetown, and 1.73 for Empire. These estimates are shown in Table 4-61.

Table 4-61: Population Within Wildfire Risk Areas

	Moderate Risk Population	High Risk Population	Extreme Risk Population
Georgetown	1,279	0	0
Idaho Springs	1,602	114	0
Silver Plume	291	0	0
Empire	0	0	0
Unincorporated	486	3,657	3,390
Total	**3,658**	**3,771**	**3,390**

Source: Clear Creek County Assessor, CO-WRAP, Wood GIS Analysis

Smoke and air pollution from wildfires can also be a severe health hazard, especially for sensitive populations, including children, the elderly, and those with respiratory and cardiovascular diseases. Smoke generated by wildfire consists of visible and invisible emissions that contain particulate matter (soot, tar, water vapor, and minerals), gases (carbon monoxide, carbon dioxide, nitrogen oxides), and toxics (formaldehyde, benzene). Emissions from wildfires depend on the type of fuel, the moisture content of the fuel, the efficiency (or temperature) of combustion, and the weather. Public health impacts associated with wildfire include difficulty in breathing, odor, and reduction in visibility.

Wildfire may also threaten the health and safety of those fighting the fires. First responders are exposed to the dangers from the initial incident and after-effects from smoke inhalation and heat stroke.

Property

Property damage from wildfires can be severe and can significantly alter entire communities. Loss estimations for the wildfire hazard were modeled by intersecting the CO-WRAP wildfire risk data with 2020 county tax assessor data for improved parcels and associated address points. Table 4-62 through Table 4-64 summarizes the estimated exposed value of improvements in each wildfire risk category. Wildfires typically result in total building loss, including contents. Contents values were estimated as a percentage of building value based on their property type, using FEMA/HAZUS estimated content replacement values. This includes 100% of the structure value for commercial and exempt structures, 50% for residential structures and 100% for vacant improved land. Improved and contents values were summed to obtain a total exposure value. In all, a total of 4,912 parcels and 5,633 buildings are in areas exposed to moderate to extreme risk wildfire, with a total value of over $1.2 billion. The greatest exposure is in the unincorporated parts of the County.

Table 4-62: Exposure and Value of Structures in Moderate Wildfire Risk Areas

Jurisdiction	Property Type	Improved Parcels	Building Count	Improved Value	Content Value	Total Value
Georgetown	Commercial	29	34	$1,216,510	$1,216,510	$2,433,020
	Exempt	20	25	$1,333,850	$1,333,850	$2,667,700
	Residential	601	666	$35,097,450	$17,548,725	$52,646,175
	Improved Vacant Land	17	17	$585,650	$585,650	$1,171,300
	Total	**667**	**742**	**$38,233,460**	**$20,684,735**	**$58,918,195**

Jurisdiction	Property Type	Improved Parcels	Building Count	Improved Value	Content Value	Total Value
Idaho Springs	Commercial	72	95	$4,293,800	$4,293,800	$8,587,600
	Exempt	46	49	$2,423,040	$2,423,040	$4,846,080
	Industrial	1	1	$7,040	$10,560	$17,600
	Mining	1	1	$30	$30	$60
	Residential	650	774	$19,528,470	$9,764,235	$29,292,705
	Improved Vacant Land	13	15	$561,470	$561,470	$1,122,940
	Total	**783**	**935**	**$26,813,850**	**$17,053,135**	**$43,866,985**
Silver Plume	Commercial	6	8	$248,910	$248,910	$497,820
	Exempt	17	18	$760,960	$760,960	$1,521,920
	Residential	130	144	$5,180,290	$2,590,145	$7,770,435
	Improved Vacant Land	8	9	$158,550	$158,550	$317,100
	Total	**161**	**179**	**$6,348,710**	**$3,758,565**	**$10,107,275**
Unincorporated	Commercial	2	3	$101,520	$101,520	$203,040
	Exempt	9	33	$1,261,630	$1,261,630	$2,523,260
	Mining	3	31	$330,433,820	$330,433,820	$660,867,640
	Residential	177	218	$6,368,390	$3,184,195	$9,552,585
	Improved Vacant Land	5	6	$72,140	$72,140	$144,280
	Total	**196**	**291**	**$338,237,500**	**$335,053,305**	**$673,290,805**
	Grand Total	**1,807**	**2,147**	**$409,633,520**	**$376,549,740**	**$786,183,260**

Source: Clear Creek County Assessor, CO-WRAP, Wood GIS Analysis

Table 4-63: Exposure and Value of Structures in High Wildfire Risk Areas

Jurisdiction	Property Type	Improved Parcels	Building Count	Improved Value	Content Value	Total Value
Idaho Springs	Commercial	1	1	$91,350	$91,350	$182,700
	Exempt	5	5	$321,530	$321,530	$643,060
	Residential	46	55	$1,259,740	$629,870	$1,889,610
	Improved Vacant Land	3	3	$47,320	$47,320	$94,640
	Total	**55**	**64**	**$1,719,940**	**$1,090,070**	**$2,810,010**
Unincorporated	Agriculture	4	5	$1,120	$1,120	$2,240
	Commercial	1	1	$160,790	$160,790	$321,580
	Exempt	28	32	$15,244,200	$15,244,200	$30,488,400
	Mining	29	35	$4,640	$4,640	$9,280
	Residential	1,409	1,640	$154,444,890	$77,222,445	$231,667,335
	Improved Vacant Land	46	52	$1,532,120	$1,532,120	$3,064,240
	Total	**1,517**	**1,765**	**$171,387,760**	**$94,165,315**	**$265,553,075**

Jurisdiction	Property Type	Improved Parcels	Building Count	Improved Value	Content Value	Total Value
	Grand Total	**1,572**	**1,829**	**$173,107,700**	**$95,255,385**	**$268,363,085**

Source: Clear Creek County Assessor, CO-WRAP, Wood GIS Analysis

Table 4-64: Exposure and Value of Structures in Extreme Wildfire Risk Areas

Jurisdiction	Property Type	Improved Parcels	Building Count	Improved Value	Content Value	Total Value
Unincorporated	Agriculture	1	2	$1,270	$1,270	$2,540
	Commercial	7	14	$1,047,110	$1,047,110	$2,094,220
	Exempt	22	25	$4,468,570	$4,468,570	$8,937,140
	Mining	33	35	$14,170	$14,170	$28,340
	Residential	1,410	1,520	$62,334,690	$31,167,345	$93,502,035
	Improved Vacant Land	60	61	$2,266,070	$2,266,070	$4,532,140
	Total	**1,533**	**1,657**	**$70,131,880**	**$38,964,535**	**$109,096,415**

Source: Clear Creek County Assessor, CO-WRAP, Wood GIS Analysis

Critical Facilities and Infrastructure

Critical facilities of wood frame construction are especially vulnerable during wildfire events. Most roads and railroads would be without damage except in the worst scenarios. Power lines are the most at risk from wildfire because most poles are made of wood and susceptible to burning. Fires can create conditions that block or prevent access and can isolate residents and emergency service providers. Wildfire typically does not have a major direct impact on bridges, but it can create conditions in which bridges are obstructed. Many bridges in areas of high to moderate fire risk are important because they provide the only ingress and egress to large areas and in some cases to isolated neighborhoods.

In the event of wildfire, there would likely be little damage to the majority of infrastructure. Most roads and railroads would be without damage except in the worst scenarios. Power lines are the most at risk to wildfire because most power poles are made of wood and susceptible to burning. In the event of a wildfire, pipelines could provide a source of fuel and lead to a catastrophic explosion.

Table 4-65 identifies critical facilities exposed to the moderate wildfire risk and Table 4-66 identifies those exposed to high wildfire risk in the county. A total of 20 critical facilities have been identified as located in areas exposed to wildfire risk; 2 of these are within high risk areas, including a fire station. Seventeen of the total facilities are in the unincorporated areas of the County.

Table 4-65: Critical Facilities at Moderate Wildfire Risk by Jurisdiction

Jurisdiction	FEMA Lifeline	Facility Type	Count
Idaho Springs	Hazardous Material	Hazardous Waste Facility	1
		Hazmat	2
		Total	**3**
Unincorporated	Communications	Communications	5
	Hazardous Material	Tier II	1
		Emergency Air Transportation	5
	Safety and Security	Fire Station	2

Jurisdiction	FEMA Lifeline	Facility Type	Count
	Transportation	Bridge	1
		Government Building	1
		Total	**15**
Grand Total			**18**

Source: CO-WRAP, HIFLD, Wood GIS Analysis

Table 4-66: Critical Facilities at High Wildfire Risk by Jurisdiction

Jurisdiction	FEMA Lifeline	Facility Type	Count
Unincorporated	Safety and Security	Fire Station	1
	Transportation	Bridge	1
		Total	**2**

Source: CO-WRAP, HIFLD, Wood GIS Analysis

Government Services

Large fires can affect the availability of resources over an extended period of time, which could impact the ability to provide a rapid response and recovery. Power interruption may occur if facilities are damage in a wildfire or are not adequately equipped with backup generation.

Economy

Tourism is an important component of Clear Creek County's economy. Wildland fires can have a direct impact on the County's scenery and environmental health, adversely affecting the presence of tourism activities and the ability of the County's residents to earn a living from the related industries. Clear Creek County's scenic beauty and cultural resources are a main draw for tourism, so the County can suffer economic losses from tourists not coming to the area due to wildfires. Fire suppression may also require increased cost to local and state government for water acquisition and delivery, especially during periods of drought when water resources are scarce. Fires can cause direct economic losses in the reduction of harvestable timber.

Historic, Cultural, and Natural Resources

Fire is a natural and critical ecosystem process in most terrestrial ecosystems, dictating in part the types, structure, and spatial extent of native vegetation. However, wildfires can cause severe environmental impacts:

- **Damaged Fisheries**—Critical fisheries can suffer from increased water temperatures, sedimentation, and changes in water quality.
- **Soil Erosion**—The protective covering provided by foliage and dead organic matter is removed, leaving the soil fully exposed to wind and water erosion. Accelerated soil erosion occurs, causing landslides and threatening aquatic habitats.
- **Spread of Invasive Plant Species**—Non-native woody plant species frequently invade burned areas. When weeds become established, they can dominate the plant cover over broad landscapes, and become difficult and costly to control.
- **Disease and Insect Infestations**—Unless diseased or insect-infested trees are swiftly removed, infestations and disease can spread to healthy forests and private lands. Timely active management actions are needed to remove diseased or infested trees.
- **Destroyed Endangered Species Habitat**—Catastrophic fires can have devastating consequences for endangered species.

- **Soil Sterilization**—Topsoil exposed to extreme heat can become water repellant, and soil nutrients may be lost. It can take decades or even centuries for ecosystems to recover from a fire. Some fires burn so hot that they can sterilize the soil.

Many ecosystems are adapted to historical patterns of fire occurrence. These patterns, called "fire regimes," include temporal attributes (e.g., frequency and seasonality), spatial attributes (e.g., size and spatial complexity), and magnitude attributes (e.g., intensity and severity), each of which have ranges of natural variability. Ecosystem stability is threatened when any of the attributes for a given fire regime diverge from its range of natural variability.

4.13.8 Development Trends

The continued migration of inhabitants to more remote areas of the county increases the probability of human-caused ignitions from vehicles, grills, campfires, and electrical devices. Population growth within the Evergreen Fire Protection District, which is partially located within Clear Creek County and makes up some of the highest WUI risk areas in the county, could drive increased exposure to wildfires. The expansion of the WUI can be managed with strong land use and building codes.

4.13.9 Risk Summary

- Overall significance of the hazard is considered high for all jurisdictions.
- A total of 4,160 parcels and 4,706 buildings are located in areas exposed to wildfire risk, with a total value of approximately $1.27 billion. The greatest exposure is located in the unincorporated parts of the County.
- Wildfires within Clear Creek County and in adjacent counties can deter tourism and affect the local economy and air quality.
- Public education and outreach to people living in or near the fire hazard zones should include information about and assistance with mitigation activities such as defensible space, and advance identification of evacuation routes and safe zones.
- Both the natural and human-caused conditions that contribute to the wildland fire hazard are tending to exacerbate through time.
- Wildfires could cause a range of secondary hazards, such as contamination of reservoirs, destabilized slopes and landslides, increased erosion, and flooding.
- Revisions to the Colorado Revised Statutes exempted properties divided into parcels of 35 acres or more from the statutory definition of a subdivision restricting the county's ability to enforce county regulations and mitigation.

4.14 Winter Storm

WINTER STORM HAZARD RANKING	
Clear Creek County	High
City of Idaho Springs	High
Town of Empire	High
Town of Georgetown	High
Town of Silver Plume	High
Clear Creek Fire Authority	High

DEFINITIONS

Freezing Rain—The result of rain occurring when the temperature is below the freezing point. The rain freezes on impact, resulting in a layer of glaze ice up to an inch thick. In a severe ice storm, an evergreen tree 60 feet high and 30 feet wide can be burdened with up to 6 tons of ice, creating a threat to power and telephone lines and transportation routes.

Severe Local Storm—Small-scale atmospheric systems, including tornadoes, thunderstorms, windstorms, ice storms, and snowstorms. These storms may cause a great deal of destruction and even death, but their impact is generally confined to a small area. Typical impacts are on transportation infrastructure and utilities.

Winter Storm—A storm having significant snowfall, ice, or freezing rain; the quantity of precipitation varies by elevation.

4.14.1 Description

Winter storms can include heavy snow, ice, and blizzard conditions. 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 damage can be 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 in injuries and deaths.

Winter storms in Clear Creek County, including strong winds and blizzard conditions, can result in property damage, localized power and phone outages and closures of streets, highways, schools, businesses, and non-essential government operations. People can also become isolated from essential services in their homes and vehicles. A winter storm can escalate, creating life-threatening situations when emergency response is limited by severe winter conditions. Other issues associated with severe winter weather include hypothermia and the threat of physical overexertion that may lead to heart attacks or strokes. Snow removal costs can also impact budgets significantly. Heavy snowfall during winter can also lead to flooding or landslides during the spring if the area snowpack melts too quickly.

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.

The Southwest Climate and Environmental Information Collaborative (SCENIC) reports data summaries from a station in the Town of Georgetown. Table 4-67 contains temperature summaries related to extreme cold for the station.

Table 4-67: Temperature Data from Georgetown (1990-2020)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Temperature (degrees Fahrenheit)												
Average Maximum Temperature	37	39	45	50	60	72	78	75	69	5	45	37
Average Minimum Temperature	16	15	21	25	34	42	48	46	39	30	22	15
Average Temperature	26	27	33	38	47	57	63	61	54	43	33	26
Extreme Temperatures (degrees Fahrenheit)												
Extreme Low Temperature	-17 1/12/97	-15 2/19/04	-13 3/16/15	-8 4/12/97	7 5/2/13	27 6/8/07	34 7/2/97	29 8/28/04	17 9/22/95	-4 10/30/19	-16 11/13/14	-16 12/6/13
Average Number of Days												
Minimum Temperature below 32 degrees Fahrenheit	30.5	29	29.6	26.1	12.7	1.1	0.0	0.2	5.0	19.1	28.2	30.6
Minimum Temperature below 0 degrees Fahrenheit	2.1	2	0.6	0.1	0.0	0.0	0.0	0.0	0.0	0.2	0.6	1.7
Snowfall												
Average Total Snowfall (in.)	12.5	18.9	18.4	20.9	6.5	0.2	0.0	0.0	1.5	7.5	11.1	14.3
Extreme Snowfall (in.)/year	45.7 1996	34.8 2020	83.9 2003	45.8 1997	25 1995	3.1 1998	0.0	0.0	12.4 1996	35.2 2006	25.2 1996	35.9 2006

Source: SCENIC

Clear Creek County receives varying amounts of snow throughout the area. Winter weather affects the entire County, but primarily in the high mountainous areas in the western portion of the county. Snow typically remains on the ground throughout winter but is more likely to melt in valley areas and in jurisdictions where snow plowing is frequent. The county receives approximately 93 inches of snow per year. March and April are on average the snowiest months in the county.

4.14.2 Past Events

A total of 467 winter weather events occurred in Clear Creek County between 1996 and 2020. The event types include a combination of blizzards, heavy snow, winter weather, and winter storms. Locations for the records are limited to one of four National Climate Data Center's-defined zones:

- Jefferson and W Douglas Counties above 6,000 feet/Gilpin/Clear Creek/NE Park Counties below 9,000 feet,

- South and Southeast Grand/W Central and SW Boulder/Gilpin/Clear Creek/Summit/ N and W Park Counties above 9,000 feet,
- Southern Front Range Foothills/Clear Creek Basin, and
- Summit County/Mosquito Range/Indian Peaks.

Table 4-68 shows the distribution of weather events throughout the county. Only one of the winter weather events resulted in property damage in the National Centers for Environmental Information database; additional details are below.

- March 17, 2003 – FEMA-EM-3185. A very moist, intense and slow-moving Pacific storm system made its way across the four corners area and into southeastern Colorado from March 17 to the 19, allowing for a deep easterly upslope flow to form along the Front Range. The storm dumped heavy wet snow that caused roofs of homes and businesses to collapse as well as downed trees, branches, and power lines. Up to 135,000 people lost power at some point during the storms and it took several days, in some areas, to restore power. The areas hardest hit by heavy snow were the northern mountains east of the Continental Divide, the Front Range Foothills and Palmer Divide, where snowfall totals ranged from 3 feet to over 7 feet. The storm totals included 70 inches at Georgetown and 66 inches at Idaho Springs. FEMA obligated over $6.1 million public assistance funds to help with emergency snow removal with this event.

The following events were noted by the HMPC:

- **January 4, 2017** - Heavy snow and high winds causing low visibility and difficulty keeping roads plowed/Countywide/ Loveland and Berthoud passes closed for high avalanche potential/ intermittent road closure to clear motor vehicle accidents.
- **May 18, 2017** – Heavy spring snowstorm impacted the entire county. Multiple motor vehicle accidents on I-70 and county roads/ power outages. Communications down in dispatch/power outages throughout the county. Large tree limbs falling and potentially blocking roads. Clear Creek County Offices and RE School District closed. Concern for at risk populations during power outages/communications/ public safety from multiple motor vehicle accidents due to overnight freezing on highways.
- **April 10, 2019** - Whiteout conditions/high winds/increased avalanche danger. Countywide event, intermittent road closures (I-70 and county roads), Clear Creek County Sheriff's Office early closure, Clear Creek County School
- **March 13, 2019** - Heavy wet snowstorm /high winds causing whiteout conditions/ increased potential for unplanned avalanche potentially trapping persons in vehicles/intermittent road closers to clear motor vehicle accidents. Countywide/along I-70 corridor. Clear Creek County Offices and School District RE1 closed

Table 4-68: Clear Creek County Winter Weather Events (1996-2020)

Location	Event Type	Number of Events
Jefferson and W Douglas Counties above 6,000 feet/Gilpin/Clear Creek/NE Park Counties below 9,000 feet	Heavy Snow	39
	Winter Storm	64
	Winter Weather	46

Location	Event Type	Number of Events
South and Southeast Grand/W Central and SW Boulder/Gilpin/Clear Creek/Summit/ N and W Park Counties above 9,000 feet	Heavy Snow	44
	Winter Storm	91
	Blizzard	1
	Winter Weather	90
Southern Front Range Foothills/Clear Creek Basin	Blizzard	1
	Heavy Snow	35
	Winter Storm	11
Summit County/Mosquito Range/Indian Peaks	Heavy Snow	23
	Blizzard	3
	Winter Storm	19

Source: National Centers for Environmental Information

4.14.3 Location

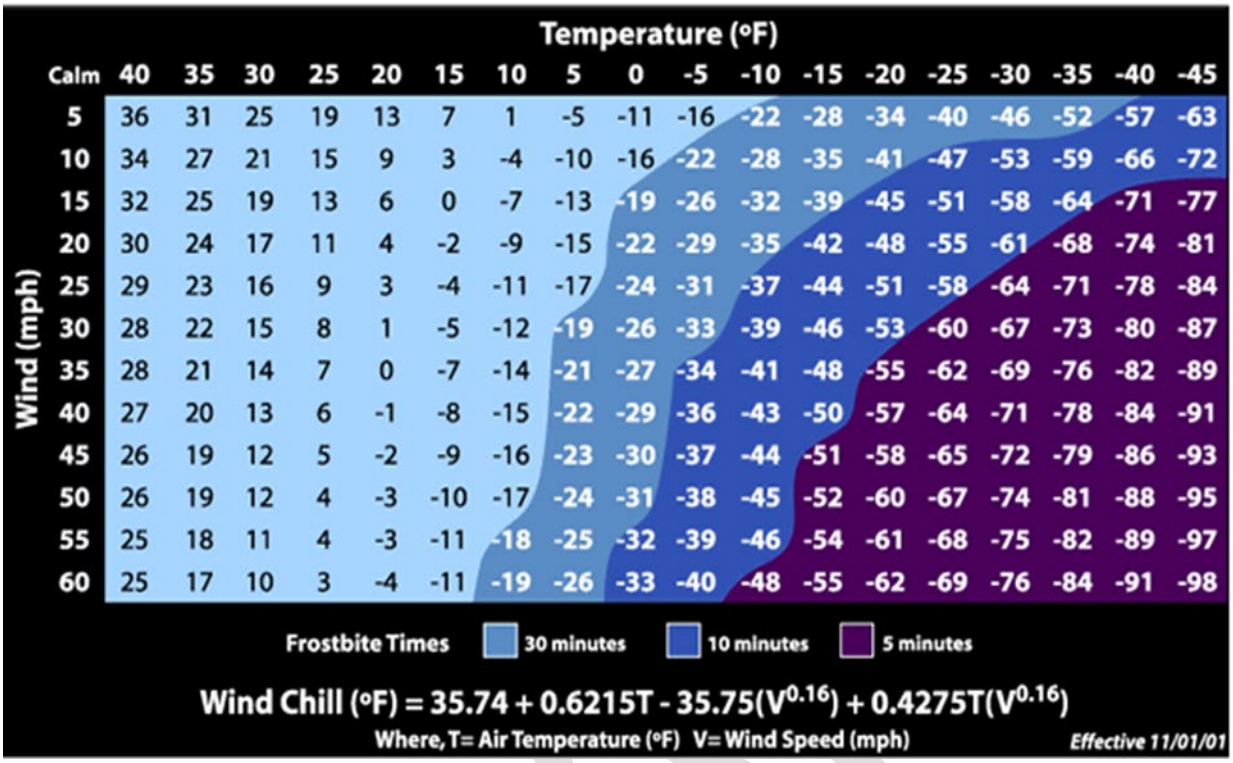
The entire county is susceptible to severe winter storms; although severe winter weather is primarily found in the higher elevations of the county and in the high mountainous areas of the Front Range Mountains in the north and western portions of the county. Interstate 70 runs east/west across the county and could have hazardous conditions to motorists if blizzard or severe winter weather conditions occur, which is frequent in winter. Interstate 70 runs through Idaho Springs, Georgetown, and Silver Plume. It also is a major access road to Empire. If there are winter issues on Interstate 70, it can cause a major disruption in the flow of goods and services in and out of the county and state.

4.14.4 Magnitude and Severity

The magnitude and severity of severe winter weather is considered severe in Clear Creek County, with an average loss expectancy of $41,667 per event for all 372 events that have occurred in Clear Creek County between 1996 and 2015. Therefore, the annualized loss for winter weather is $815,790. It is important to note that there has only been one reported winter storm event that has resulted in damages, so the annualized loss is based only on one loss event. However, Clear Creek County is a major transport center for Interstate 70 commuters. Interstate 70 through Clear Creek sees daily commuters from Denver, ski traffic in the winter, and is a major east/west route across the U.S. Winter storm events are considered a severe threat to the county because of possible disruption along the Interstate 70 corridor.

In 2001, the NWS implemented an updated wind chill temperature index (Figure 4-56). This index describes the relative discomfort or 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 4-56: National Weather Service Wind Chill Chart



Source: National Weather Service, www.nws.noaa.gov/om/windchill/index.shtml

A wind chill watch is issued by the NWS when wind chill warning criteria are possible in the next 12 to 36 hours. A wind chill warning is issued for wind chills of at least -25°F on the plains and -35°F in the mountains and foothills.

4.14.5 Probability of Future Occurrences

The annual rate of occurrence for the county is 20 events per year. Severe winter storms happen nearly every year in Clear Creek County and are thus considered highly likely, with nearly 100% chance of occurrence in any given year. Severe winter weather occurs most frequently in January and February, though early and late season (March and April) can have significant snow.

4.14.6 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, as well as impacts on the ski industry.

The effects of climate change in Colorado have already been observed. The following climate change observations are noted in the 2018 Colorado State Hazard Mitigation Plan:

- Snowpack, as measured by April 1, 2018 snow-water equivalent (SWE), has been mainly below average since 2000 in all of Colorado's river basins, but long-term (30-year, 50-year) declining trends have been detected.

- The timing of snowmelt and peak runoff has shifted earlier in the spring by 1 to 4 weeks across the state's river basins over the past 30 years, due to the combination of lower SWE since 2000, the warning trend in spring temperatures, and enhanced solar absorption from dust-on-snow.

4.14.7 Vulnerability

People

Vulnerable populations 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. Isolation of these populations is a significant concern. These populations face isolation and exposure during severe winter weather events and could suffer more secondary effects of the hazard. Commuters who are caught in storms may be particularly vulnerable. Stranded commuters may be vulnerable to carbon monoxide poisoning or hypothermia. Additionally, individuals engaged in outdoor recreation during a severe winter event may be difficult to locate and rescue.

Property

All property is vulnerable during severe winter weather events, but properties in poor condition or in particularly vulnerable locations may risk the most damage. Those that are located under or near overhead lines or near large trees may be vulnerable to falling ice or may be damaged in the event of a collapse.

Based on the 476 total winter weather events that have occurred in the county between 1996 and 2020, only one of the reported events resulted in property damage. The winter storm event occurred on March 17, 2003 and resulted in $15,500,000 worth of damages.

Critical Facilities and Infrastructure

Incapacity and loss of roads are the primary transportation failures resulting from severe winter weather, mostly associated with secondary hazards. Snowstorms can significantly impact the transportation system and the availability of public safety services. Of particular concern are roads providing access to isolated areas and to the elderly. Prolonged obstruction of major routes can disrupt the shipment of goods and other commerce. Large, prolonged storms can have negative economic impacts for an entire region.

Severe windstorms, downed trees, and ice can create serious impacts on power and above-ground communication lines. Freezing of power and communication lines can cause them to break, disrupting electricity and communication. Loss of electricity and phone connection would leave certain populations isolated because residents would be unable to call for assistance.

Economy

Roads may become impassable due to ice or snow. Ice accumulation on roadways can create dangerous driving conditions. There are limited county roads that are available to move people and supplies throughout the region. Many of the small side roads are narrow and curved. Interstate 70 is a major east/east highway that transports goods throughout Colorado and the rest of the country.

Historic, Cultural and Natural Resources

The environment is highly exposed to severe weather events. Natural habitats such as streams and trees risk major damage and destruction. Flooding events caused by snowmelt can produce river channel migration or damage riparian habitat.

4.14.8 Development Trends

All future development will be affected by severe storms. The vulnerability of community assets to severe winter storms is increasing through time as more people enter the planning area. The ability to withstand impacts lies in sound land use practices and consistent enforcement of codes and regulations for new construction. The planning partners have adopted the International Building Code. This code is equipped to deal with the impacts of severe weather events. Land use policies identified in general plans within the planning area also address many of the secondary impacts (flood and landslide) of the severe weather hazard. With these tools, the planning partnership is well equipped to deal with future growth and the associated impacts of severe weather.

Additionally, growth outside Clear Creek County has led and will likely continue to lead to increased traffic in and through the County by skiers and other winter recreationists.

4.14.9 Risk Summary

- The overall significance of extreme heat is low; the overall significance of drought is High.
- There is high vulnerability to severe winter weather along I-70.
- Increased population exposed to hazards and emergencies during high tourist seasons.
- Severe winter weather can isolate residents and travelers by closing roads into and out of the County.
- The County has experienced 476 severe winter weather events in the past 24 years.
- Most winter storms have not resulted in reported damages, but those that do can be significant. Average annualized losses from winter storms in the County are $620,000.
- Climate change projections show decreased levels of snowpack, resulting in impacts to the local economy and lifestyle.
- Related Hazards: Avalanche, windstorm, hazardous material incidents

5 Mitigation Strategy

DMA 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 shall include: *(i) A description of mitigation goals to reduce or avoid long-term vulnerabilities to the identified hazards.* *(ii) 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.* *(iii) 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 describes the mitigation strategy process and mitigation action plan for the Clear Creek County HMP. It explains how the County and participating jurisdictions 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 HMP 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 original goals and objectives from the 2016 Plan were reviewed and reaffirmed. The HMPC thought the goals and objectives are still valid and were kept as originally written. The mitigation actions from 2016 Plan were reviewed and assessed for progress and evaluated for their inclusion in this plan update.

Section 5.1 below establishes the goals and objectives of this plan; Section 5.2 describes the progress participating jurisdictions have made since the 2016 Plan; Section 5.3 outlines the process by which new mitigation actions were identified and prioritized; and Section 5.4 lists the updated mitigation action plan.

5.1 Goals and Objectives

Up to this point in the planning process, the HMPC has organized resources, assessed natural hazards and risks, and documented mitigation capabilities. The resulting goals, objectives, and mitigation actions were developed based on this profile. The HMPC developed the new 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. The goals for this plan were developed by the HMPC based on the plan's risk assessment. This analysis of the risk assessment identified areas where improvements could be made and provided the framework for the HMPC to formulate planning goals and objectives and the mitigation strategy for Clear Creek County.

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.
- 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.

Based upon the risk assessment review and goal setting process, the HMPC re-assessed the goals and objectives from the 2016 Plan. The HMPC determined they were still largely valid, although a number of changes in wording or organization were made. The following are the results of the final goal and objectives for the 2021 Plan.

- Goal 1: Increase awareness of natural hazards and how to mitigate against them.
  - Objective 1.1: Provide public outreach on the hazards identified in this plan and how to mitigate against them.
  - Objective 1.2: Promote specific actions homeowners and business owners can take to reduce impact of a natural hazard.
- Goal 2: Reduce impact of natural hazards on people, property, and the environment.
  - Objective 2.1: Develop projects focused on preventing loss of life and injuries from natural hazards.
  - Objective 2.2: Protect critical infrastructure and assets to minimize loss of critical services.
  - Objective 2.3: Minimize revenue losses in the community from natural hazard impacts.
  - Objective 2.3: Protect natural resources by adopting and implementing sustainable flood-management policies, debris management programs, snow removal, tree trimming and replacement, wildfire risk reduction, or energy conservation programs.
  - Objective 2.4: Identify possible construction, renovation, retrofitting or refurbishment to protect vulnerable structures and cultural resources from the effects of natural hazards.
- Goal 3: Stimulate coordinated efforts among partners to mitigate against natural hazard impacts.
  - Objective 3.1: Integrate hazard mitigation activities into preparedness, response and recovery activities.
  - Objective 3.2: Maintain regular, coordinated efforts to implement mitigation actions.
  - Objective 3.2: Establish a regular mechanism to monitor mitigation projects.

5.2 Progress on Previous Mitigation Actions

A review of 2016 mitigation actions progress reports indicates that Clear Creek County and the participating jurisdictions have been successful in implementing actions identified in the 2016 HMP Mitigation Strategy, thus, working diligently towards meeting the 2016 plan goals. Table 5-1 indicates the details for each 2016 mitigation action items that have been completed.

The 2016 mitigation strategy contained 54 separate mitigation actions. As of September 2021, 5 of these actions have been completed. An additional 5 actions were deleted as no longer relevant. The remaining 44 actions are continuing into 2021: 12 are currently in process, 10 are ongoing on an annual basis, and 13 have not yet been started due to a variety of reasons such as changes in priorities or lack of funding. Many

of the ongoing actions include actions that are implemented on a regular or annual basis that contribute to the goals of this plan that will continue to be needed into the future. The following table lists the 2016 actions completed and deleted.

Table 5-1: Completed and Deleted Actions

ID	Corresponding Hazard(s)	Mitigation Action	Action Status Notes
CCC – 7	Flooding	Floodplain Mapping. Create/Update/Enhance floodplain mapping/GIS database.	**Completed.**
CCC-10	Geologic Hazards	Mapping of Geological Hazard Areas. Create a Geological Hazard mapping/GIS database by coordinating with USGS, CGS and CDOT to further study and map vulnerable geologic hazard areas.	**Completed.**
Idaho Springs -2	Erosion and Deposition, Expansive Soils, Flood, Landslide, Mud/Debris Flow, Rockfall, Subsidence	Soda Creek Flood Mitigation. Coordinate with Clear Creek County regarding flood mitigation measures and improvements to portions of Soda Creek Road in the City of Idaho Springs and in Clear Creek County; retain a consultant to perform engineering and design of stormwater, water, sewer, and road improvements.	**Completed.** Reconstructed Soda Creek Road from Miner Street south to the City limits including new water, sewer and gas mains and a new stormwater management system. Clear Creek County was contacted, but chose not to participate in these improvements to Soda Creek Road beyond the City limits.
Idaho Springs -3	Avalanche, Dam/Levee Failure, Drought, Earthquake, Erosion and Deposition, Expansive Soils, Extreme Heat, Flood, Hail, Landslide, Mud/Debris Flow, Rockfall, Lightning, Wind, Space Weather, Subsidence, Tornado, Wildfire, Winter Storm	Update Building Codes. Update to the 2015 IBC and IRC. This will be coordinated with Clear Creek County and the other municipalities to try to get all updated at the same time.	**Completed.** Adopted the 2018 edition of the International Codes.
Empire – 2	Avalanche, Dam Failure,	Publicize Communications Center. Empire will turn the local fire house into	**Deleted.**

ID	Corresponding Hazard(s)	Mitigation Action	Action Status Notes
	Earthquake, Flood, Landslide, Severe Wind, Subsidence, Tornado, Wildfire, Winter Storm	the local communications center to coordinate with red cross for emergency services.	The local fire house in Empire is under the direction of CCFA, not the Town of Empire.
Empire – 5	Subsidence	Identify and map old mining areas. Identify and map old mining operations or geologically unstable terrain so that development can be prevented or eliminated.	**Deleted.** All old mining sites within the town limits have already been identified and signs posted, so this item is no longer relevant. The Town will continue to list identifying old mining sites in any educational materials we distribute to residents.
Empire – 6	Subsidence	Secure known mining areas and post proper signage. Once old mines are located, secure the site and educate the public with signage of the hazard.	**Deleted.** All old mining sites within the town limits have already been identified and signs posted, so this item is no longer relevant. The Town will continue to list identifying old mining sites in any educational materials we distribute to residents.
Empire – 7	Severe Wind, Tornado	Public Education - Tornado safe room. Encouraging homeowners to locate a safe room either within their home or nearby will significantly reduce the risk of personal injury and/or death.	**Deleted.** It is not practical to suggest creating tornado safe rooms, and tornados are not a significant threat in this area, so this item is no longer relevant. The Town will continue to encourage people to find the safest place in their home in the event of a tornado or severe wind in any educational materials we distribute to residents.
Empire – 9	Severe Wind, Tornado	Adopt construction standards for strong wind ratings. Work with the planning department to adopt construction design standards to meet the standards for strong wind ratings.	**Deleted.** Construction standards and inspections in Empire are carried out by Clear Creek County Building Department, not the Town of Empire.
Georgetown - 3	Flood, Winter Storm, Wind	Adopt newer IBC. Town of Georgetown plans to update the International Building Code (IBC) and International Residential Code (IRC) regulations to	**Completed.** On 2015 IBC codes at this time.

ID	Corresponding Hazard(s)	Mitigation Action	Action Status Notes
		address severe wind, winter storm, and flood. It currently uses the 2003 IBC.	

5.2.1 Continued Compliance with the National Flood Insurance Program

The NFIP makes federally backed flood insurance available to homeowners, renters, and business owners in participating communities. For most participating communities, FEMA has prepared a detailed Flood Insurance Study (FIS). The study presents water surface elevations for floods of various magnitudes, including the 1% annual chance flood (or 100-year flood) and the 0.2% annual chance flood (or 500-year flood). Base flood elevations (BFE) and the boundaries of the 100- and 500-year floodplains are shown on Flood Insurance Rate Maps (FIRM), which are the principal tool for identifying the extent and location of the riverine flood hazard. FIRMs are the most detailed and consistent data source available, and for many communities they represent the minimum area of oversight under their floodplain management program.

Participants in the NFIP must, at a minimum, regulate development in floodplain areas in accordance with NFIP criteria. Before issuing a permit to build in a floodplain, participating jurisdictions must ensure that three criteria are met:

- New buildings and those undergoing substantial improvements must, at a minimum, be elevated to protect against damage by the 100-year flood.
- New floodplain development must not aggravate existing flood problems or increase damage to other properties.
- New floodplain development must exercise a reasonable and prudent effort to reduce its adverse impacts on threatened salmonid species.

Clear Creek County, City of Idaho Springs, and the Towns of Georgetown, and Silver Plume participate in the NFIP program. Structures permitted or built in the County before 1980 when the county joined the NFIP (1978 for Idaho Springs, 1979 for Silver Plume and 1989 for Georgetown) are called “pre-FIRM” structures, and structures built afterwards are called “post-FIRM.” Post-FIRM structures built in compliance with the floodplain regulations are mitigated to withstand floods up through the 100-year event. The insurance rate is different for the two types of structures, as pre-FIRM are at higher risk of flooding. The effective date for the current countywide FIRM is December 20, 2019. The county and participating communities are currently in good standing with the provisions of the NFIP. Compliance is monitored by FEMA regional staff. Maintaining compliance with the NFIP is an important component of flood mitigation and risk reduction.

Given the flood hazard and risk in the planning area and recognizing the importance of the NFIP in mitigating flood losses, an emphasis is placed on continued compliance with the NFIP by Clear Creek County and all NFIP participating jurisdictions including Idaho Springs, Georgetown and Silver Plume. 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.

5.3 Identification and Analysis of Mitigation Actions

In order to identify and select mitigation measures to support the mitigation goals, each hazard identified in Chapter 4: Risk Assessment was evaluated. The HMPC analyzed a comprehensive set of viable mitigation alternatives for both new and existing buildings and infrastructure that would support identified goals and

objectives. Each HMPC member was provided with the following list of categories of mitigation measures, which originate from the NFIP CRS:

- **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.

The HMPC members were also provided with several lists of alternative multi-hazard mitigation actions for each of the above categories via email and at the mitigation strategy meeting. Another reference handout document titled “Mitigation Ideas” developed by FEMA was distributed to the HMPC via an online link. This reference provides four categories of mitigation actions that were discussed at the HMPC meeting in addition to the NFIP/CRS categories. These include:

- Plans and Regulations
- Structure and Infrastructure Projects
- Education and Awareness
- Natural systems protection

Other alternatives discussed in the meeting include the four ‘A’s’ of mitigation:

- **Alter** the physical nature of the hazard. wildfire defensible space and fuels treatments, snow fences etc.
- **Avert** the hazard away from people, buildings, and infrastructure: engineered solutions, drainage, and channel improvements, floodproofing, fuel breaks
- **Adapt** to the hazard: land use planning, building codes and design standards, warning systems etc.
- **Avoid** the hazard: natural systems protection, open space, acquisition, or relocation of properties out of hazardous areas

To facilitate the brainstorming process, the HMPC referred to a matrix of typical mitigation alternatives organized by CRS category for the hazards identified in the plan, in addition to a handout that explains the categories and provided examples. These materials are included in Appendix F. HMPC members were encouraged to develop mitigation alternatives that would protect future, as well as existing, development from hazards per the DMA 2000 regulations. A facilitated discussion then took place to examine the existing actions in the 2016 plan and analyze the other possible mitigation alternatives. With an understanding of the alternatives, a brainstorming session was conducted to generate a list of preferred mitigation actions. The result was new and updated project ideas with the intent of meeting the identified goals and mitigating identified hazards.

5.3.1 Prioritization Process

Once the mitigation actions were identified, the HMPC was provided with several decision-making tools, including FEMA's recommended prioritization criteria STAPLEE, sustainable disaster recovery criteria, and others, to assist in deciding why one recommended action might be more important, more effective, or more likely to be implemented than another. STAPLEE stands for the following:

- **S**ocial: Does the measure treat people fairly?
- **T**echnical: Will it work? (Does it solve the problem? Is it feasible?)
- **A**dministrative: Is there capacity to implement and manage the project?
- **P**olitical: Who are the stakeholders? Did they get to participate? Is there public support? Is political leadership willing to support the project?
- **L**egal: Does your organization have the authority to implement? Is it legal? Are there liability implications?
- **E**conomic: 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?
- **E**nvironmental: 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 STAPLEE). Other criteria used to recommend what actions might be more important, more effective, or more likely to be implemented than another included:

- Does action protect lives?
- Does action address hazards or areas with the highest risk?
- Does action protect critical facilities, infrastructure, or community assets?
- Does action meet multiple objectives (Multiple Objective Management)?

At the mitigation strategy meeting, the HMPC reviewed and discussed the STAPLEE considerations to determine which of the identified actions were most likely to be implemented and effective. Prioritization of previous mitigation actions identified in the 2016 HMP that are continuing in the updated plan were revisited during a HMPC meeting. New actions identified in 2021 also were prioritized based on discussions and review with the STAPLEE considerations in mind.

5.4 Mitigation Action Plan

This section outlines the development of the 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
Clear Creek County	18	2	0	16	4	20
Idaho Springs	9	2	0	7	1	8
Empire	11	0	5	6	18	24
Georgetown	8	1	0	7	1	8
Silver Plume	8	0	0	8	1	9
Clear Creek Fire Authority	NA	NA	NA	NA	4	4
Total	54	5	5	44	29	73

The results of the project identification and prioritization exercise for each participating jurisdiction are summarized in Table 5-3 through Table 5-8. These projects detail specific actions for reducing future hazard-related losses within Clear Creek County. The projects are organized by jurisdictions and include notes about the department and partners necessary to implement the project, estimated cost, potential funding sources, timeline, which goal(s) that the projects support, and their relative level of priority high, medium, and low. The tables also provides status/implementation notes that describe progress made on the actions so far, using the following categories, and, where applicable, notes if there were changes in the priority level from the previous plan:

- Not Started – Work has not begun
- In Progress – Work has begun but not completed
- Annual Implementation – Ongoing with no specific end date
- Completed – The action has been finished
- Deleted – The action is no longer relevant due to changing priorities, lack of funds, etc.

The parameters for the timeline are as follows:

- Short-Term – To be completed in 1 to 5 years
- Long-Term – To be completed in greater than 5 years
- Ongoing – Currently being funded and implemented under existing programs

Many of these mitigation actions are intended to reduce impacts to existing development. Those that protect future development from hazards, as required per the DMA 2000 regulations, are indicated by an asterisk '*' in the action identification number. 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, Shelter
- HAZ: Hazardous Waste
- H&M: Health & Medical
- S&S: Safety & Security
- TRN: Transportation

Table 5-3: 2021 Clear Creek County Mitigation Action Plan

ID	Title and Description	Hazards Mitigated	Goals & Lifelines	Lead Agency & Partners	Cost Estimate & Potential Funding	Priority	Timeline	Status & Implementation Notes
Clear Creek County Mitigation Actions								
1	**Wildfire Risk Reduction Public Education Program.** Conduct a public education program to encourage property owners to manage fuel loads on their own properties and use landscaping materials for existing and older homes built prior to current fire mitigation ordinance.	Wildfire	Goals 1,2; FWS, S&S	Emergency Management	< $10,000 General Budget, FEMA HMA Grants, State Wildfire Risk Reduction Grants, Ready-Set-Go and Firewise Communities Programs	High	Short Term	Not Started. CCFA does provide this information as various public events, but it is not a coordinated program. Need to identify grant to hire individual to manage wildfire mitigation program and update of Community Wildfire Protection Plans (CWPPs), to be done jointly with CCFA.
2	**Wildfire Fuels Reduction.** Identify and prioritize areas with heavy fuel loads along County road rights-of-way throughout the County; Implement fuels reduction wildfire mitigation projects following assessments.	Wildfire	Goals 2; S&S, TRN	Public Works	$10,000 - $100,000 General Budget, FEMA HMA Grants, State Wildfire Risk Reduction Grants	High	Short Term	Annual Implementation.
3	**Wildfire Fuel's Reduction – Defensible Space.** Work with private landowners to educate and find funding/grants to accomplish defensive space wildfire mitigation.	Wildfire	Goals 1,2; S&S	Emergency Management	< $10,000 General Budget, FEMA HMA Grants, State Wildfire Risk	High	Short Term	Annual Implementation. OEM manages $50K county grant for WF mitigation on personal property, via homeowner associations. Many ask for more, or

ID	Title and Description	Hazards Mitigated	Goals & Lifelines	Lead Agency & Partners	Cost Estimate & Potential Funding	Priority	Timeline	Status & Implementation Notes
Clear Creek County Mitigation Actions								
					Reduction Grants, USDA, and CSFS			something that pays for entire project versus 50%.
4	**Improve Access / Egress for Evacuation.** Work with public and private landowners and developers to find funding/grants to create/identify safe secondary means of access/egress. There are communities within Clear Creek County that have limited access/egress with only "one way in – one way out".	Avalanche, Flood, Landslide, Mud/Debris Flow, Rockfall, Tornado, Wildfire, Winter Storm	Goals 2; S&S, TRN	Emergency Management	>$100,000 General Budget	High	Long Term	In Progress. Have worked with Denver Water and private landowners to improve access to and improvement on egress roads to high priority areas.
5*	**Identification of Flood Mitigation Projects in High Flood Risk Areas.** Work with Mile High Flood District, Flood Plain Manager and Public Works Department to identify potential projects within the high-risk flood prone areas. Projects may include channel stabilization, increasing drainage or absorption capacities with detention and retention basins, relief drains, spillways, drain widening/dredging or rerouting, logjam and debris removal, extra culverts, bridge modification, dike setbacks, flood	Flood	Goals 2,3	County Manager	$10,000 - $100,000 General Budget, FEMA HMA Grants	Medium	Short Term	In progress.

ID	Title and Description	Hazards Mitigated	Goals & Lifelines	Lead Agency & Partners	Cost Estimate & Potential Funding	Priority	Timeline	Status & Implementation Notes
Clear Creek County Mitigation Actions								
	gates and pumps, or channel redirection.							
6*	**NFIP Floodplain and Stormwater Management Practices.** Continue to participate, implement and improve upon the NFIP Floodplain and Stormwater Management Practices.	Flood, Landslide, Mud/Debris Flow, Rockfall, Subsidence	Goals 1,2; S&S	Community Development	< $10,000 General County Budget	High	Long Term	In progress.
7	**Development of a Debris Management Plan.** Develop a Debris Management Plan that addresses all aspects of debris management by utilizing the knowledge, skills, and abilities of a consulting firm.	Avalanche, Dam/Levee Failure, Earthquake, Erosion and Deposition, Expansive Soils, Flood, Hail, Landslide, Mud/Debris Flow, Rockfall, Lightning, Wind, Space Weather, Subsidence, Tornado, Wildfire, Winter Storm	Goals 2,3; S&S	Emergency Management	$10,000 - $100,000 General Budget	Low	Short Term	Not Started.
8	**Slope Stabilization Projects.** Identify slope stabilization projects, and funding for implementation of project(s) to protect homes, buildings, businesses and infrastructure.	Erosion and Deposition, Expansive Soils, Landslide, Mud/Debris Flow, Rockfall, Subsidence	Goals 2; S&S	Community Development	>$100,000 FEMA HMA Grants, CDOT	Medium	Long Term	Annual Implementation with limited budget.

ID	Title and Description	Hazards Mitigated	Goals & Lifelines	Lead Agency & Partners	Cost Estimate & Potential Funding	Priority	Timeline	Status & Implementation Notes
Clear Creek County Mitigation Actions								
9*	**Integration of HMP Components into Master Plans.** Coordination between the County's HMP consultant and the county's Master Plan consultant team to ensure that hazard mitigation topics are included in the scope for the public outreach process and plan development for all relevant plan elements.	Avalanche, Dam/Levee Failure, Drought, Earthquake, Erosion and Deposition, Expansive Soils, Extreme Heat, Flood, Hail, Landslide, Mud/Debris Flow, Rockfall, Lightning, Wind, Space Weather, Subsidence, Tornado, Wildfire, Winter Storm	Goals 1,2,3	Community Development	< $10,000 General Budget	High	Short Term	In progress.
10	**Identifying Functional and Access Needs Population.** Identify specific functional and access needs populations that may be exceptionally vulnerable in winter storm, severe wind, or wildfire events that cause long-term power outages.	Wind, Wildfire, Winter Storm	Goals 1,2; S&S	County Department of Health and Human Services	< $10,000 General Budget	High	Short Term	In progress.
11	**Public Education to Mitigate Hazards.** Develop an emergency preparedness campaign that includes handouts, brochures, Emergency Preparedness Guide, community meetings, social media,	Avalanche, Dam/Levee Failure, Drought, Earthquake, Erosion and Deposition, Expansive Soils,	Goals 1; S&S	Emergency Management	< $10,000 General Budget, FEMA, State, and local Partners	High	Long Term	Not started. Is a high priority, but limited OEM staff capacity, no county graphics support, no county communications lead, and EOP & HMP updates in

ID	Title and Description	Hazards Mitigated	Goals & Lifelines	Lead Agency & Partners	Cost Estimate & Potential Funding	Priority	Timeline	Status & Implementation Notes
Clear Creek County Mitigation Actions								
	newspapers, radio, etc. to disseminate information to the public, businesses, and tourist regarding best practices on being personally prepared during disasters.	Extreme Heat, Flood, Hail, Landslide, Mud/Debris Flow, Rockfall, Lightning, Wind, Space Weather, Subsidence, Tornado, Wildfire, Winter Storm						2021 have delayed implementation.
12	**Development of Memorandums of Understanding and Intergovernmental Agreements.** Develop and execute Memorandum of Understandings (MOUs) with applicable partners for obtaining needed resources in an event that exceeds local capabilities and resources during and after an incident, event, emergency and/or disaster.	Avalanche, Dam/Levee Failure, Drought, Earthquake, Erosion and Deposition, Expansive Soils, Extreme Heat, Flood, Hail, Landslide, Mud/Debris Flow, Rockfall, Lightning, Wind, Space Weather, Subsidence, Tornado, Wildfire, Winter Storm	Goals 2,3; S&S	Emergency Management	< $10,000 General Budget	Medium	Long Term	In progress. OEM is currently developing MOU with Gilpin for animal and human sheltering.
13	**Portable Back-up Generator for Critical Infrastructure.** Purchase of a portable back-up large capacity generator and installation of quick connects at key facilities.	Avalanche, Dam/Levee Failure, Earthquake, Flood, Hail, Landslide, Mud/Debris Flow,	Goals 2; S&S, ENG, COM	Public Works	$10,000 - $100,000 General Budget	High	Long Term	In progress. OEM is planning to purchase a portable generator in June 2021 through a state Access and

ID	Title and Description	Hazards Mitigated	Goals & Lifelines	Lead Agency & Partners	Cost Estimate & Potential Funding	Priority	Timeline	Status & Implementation Notes
Clear Creek County Mitigation Actions								
		Rockfall, Lightning, Wind, Tornado, Wildfire, Winter Storm						Functional Needs (AFN) grant.
14*	**Identify Mitigation Projects for Critical Facilities in Floodways and Floodplains.** Projects may include relocation, elevation, floodproofing, channel stabilization, increasing drainage or absorption capacities with detention and retention basins, relief drains, spillways, drain widening/dredging or rerouting, logjam and debris removal, extra culverts, bridge modification, dike setbacks, flood gates and pumps, or channel redirection.	Flood	Goals 2; S&S	County Commissioners, County Manager, County Public Works	$10,000 - $100,000 County General Fund, HMA Grants	High	Short Term	In progress. Watersheds are working on several project but don't know specifics as to coordination with County.
15	**Expand storage capacity at Upper Beaver Brook Reservoir.** Current water storage capabilities of the District limit its ability to supply water throughout a long term drought.	Dam/Levee Failure	Goals 2; S&S	Lookout Mountain Water District	>$100,000 CWCB	High	Short Term	In progress.
16	**Repair Lower Beaver Brook Dam.** Following the flooding of 2013, the Colorado State Engineer determined that upgrades to the	Dam/Levee Failure	Goals 2; S&S	Lookout Mountain Water District	>$100,001 CWCB	High	Long Term	In progress.

ID	Title and Description	Hazards Mitigated	Goals & Lifelines	Lead Agency & Partners	Cost Estimate & Potential Funding	Priority	Timeline	Status & Implementation Notes
Clear Creek County Mitigation Actions								
	Lower Beaver Brook dam would be necessary.							
17	**Witter Gulch/Floyd Hill Defensible Space.** This project will develop defensible space for homes in the Witter Gulch and Floyd Hill areas if awarded. Some of the issues will be admin work/time for EFR and coordinating homeowners. The benefits will be 40 more homes with defensible space.	Wildfire	Goals 2,3; S&S	Evergreen Fire Rescue, CSFS, DFPC, DMP, USFS, Clear Creek County OEM	$100,000 - $1,000,000; FEMA HMA Grants	High	Short Term	New in 2021.
18	**Purchase Large Capacity Stationary Generator.** At present there is no power backup at the County Public Works facilities to supply fuel to responder vehicles (Sheriff's Deputies, Municipalities LE, Ambulance, Fire, County vehicles, etc.). There is also no other private or public fuel stations identified within the county that has backup power to provide fuel during countywide power outage. This can potentially lead to disruption of emergency services throughout the county. A large capacity stationary generator, fueled by diesel, would provide days of support to be able	Flood, Tornado, Wildfire, Winter Storm	Goals 2,3; S&S, H&M, ENG, TRN,	Emergency Management, Public Works	$10,000 - $1,000,000 FEMA HMA Grants	High	Short Term	New in 2021.

ID	Title and Description	Hazards Mitigated	Goals & Lifelines	Lead Agency & Partners	Cost Estimate & Potential Funding	Priority	Timeline	Status & Implementation Notes
Clear Creek County Mitigation Actions								
	to provide fuel to all emergency services.							
19	**Countywide Alert & Notification (Siren System).** A number of years ago the was a countywide siren alert system. Due to age and disrepair this system is no longer functional. At present Clear Creek County now relies on a phone system to provide alerts and notifications to residents and subscribers to the system. Being a mountainous and some areas being remote not all alerts & notification will reach the entire population of the county and the persons recreating throughout the county. Being a mountainous area sirens sound carries well to alert both residents and recreation individuals to oncoming dangers, be it wildland fire, flooding, landslides and debris flow.	Avalanche, Flood, Landslides, Debris Flow, Rockfalls, Tornado, Wildfire	Goals 1,2,3; S&S, H&M, COM, HAZ	Emergency Management, Sheriff's Office, CC Fire Authority, USFS	$10,000 - $1,000,000 State Grants	High	Short Term	New in 2021.
20	**Mass Care Sheltering-Purchase Large Capacity Stationary Generator.** None of the identified facilities within Clear Creek County have backup power generators. Often times, particularly during	Flood, Tornado, Wildfire, Winter Storm	Goals 2; S&S, FWS, H&M	Emergency Management County School District RE-1	$10,000 - $100,000 State Grants,	High	Short Term	New in 2021.

ID	Title and Description	Hazards Mitigated	Goals & Lifelines	Lead Agency & Partners	Cost Estimate & Potential Funding	Priority	Timeline	Status & Implementation Notes
Clear Creek County Mitigation Actions								
	winter storms and on occasion during wildland fires, power can be lost. With a potential capacity of 500 persons needing to be temporarily housed in our congregate sheltering facility, to include sheltering for person the AFN community reliant on power equipment for health reasons, backup power is a crucial necessity.							

Table 5-4: 2021 City of Idaho Springs Mitigation Action Plan

ID	Title and Description	Hazards Mitigated	Goals & Lifelines	Lead Agency & Partners	Cost Estimate & Potential Funding	Priority	Timeline	Status & Implementation Notes
City of Idaho Springs Mitigation Actions								
1	**Maintaining Secondary Water Supply.** Maintaining the Idaho Springs Reservoir Dam by getting the dam inspected on a yearly basis and making any repairs as needed. Then exercising the Dam Emergency Action Plan (EAP). The City has a lot of future growth potential and it is important to maintain the secondary water supply.	Dam/Levee Failure, Flood, Subsidence, Wildfire	Goals 2; FWS	Water/ Wastewater	$10,000 to $100,000 CRWA, CDPHE, DOLA, FEMA	High	Ongoing	Annual Implementation. Source Water Protection Plan completed. Reservoir dam is inspected annually.
2	**Assess Surge Protectors on City Critical Facilities.** The City will assess what critical facilities need surge protectors from lightning strikes and then purchase the necessary protectors and install.	Lightning, Space Weather	Goals 2; ENG	Public Works	< $10,000 General funds	High	Short Term	Not Started. Need to contact an electrical contractor for an assessment.
3	**Assess Sheltering Capabilities.** The City will coordinate with the county and American Red Cross to assess public shelter capabilities in the city and create MOUs on shelter operations. Then the city will educate residents and visitors about available shelters.	Wildfire, Winter Storm	Goals 1,2,3; S&S, FWS	City Administrator	< $10,000 General funds	High	Short Term	In Progress. Need to coordinate with Clear Creek County OEM.
4	**Natural Hazard Education.** The City will educate homeowners concerning how to mitigate hazard damages to their homes, such as	Avalanche, Dam/Levee Failure, Drought, Earthquake, Erosion and	Goals 1,2; S&S	City Administrator	< $10,000 General funds	High	Ongoing	Not Started. Need to coordinate with Clear Creek County OEM.

ID	Title and Description	Hazards Mitigated	Goals & Lifelines	Lead Agency & Partners	Cost Estimate & Potential Funding	Priority	Timeline	Status & Implementation Notes
City of Idaho Springs Mitigation Actions								
	surge protector on electronics, carbon monoxide detectors, proper roofs for high wind and snow load, etc. The City will post information on the City website and use the quarterly newsletters.	Deposition, Expansive Soils, Extreme Heat, Flood, Hail, Landslide, Mud/Debris Flow, Rockfall, Lightning, Wind, Space Weather, Subsidence, Tornado, Wildfire, Winter Storm						
5	**Create MOUs for Equipment Assistance.** The City will update/create MOUs with neighboring jurisdictions in the event of needing equipment to assist with a hazard response.	Avalanche, Dam/Levee Failure, Drought, Earthquake, Erosion and Deposition, Expansive Soils, Extreme Heat, Flood, Hail, Landslide, Mud/Debris Flow, Rockfall, Lightning, Wind, Space Weather, Subsidence, Tornado, Wildfire, Winter Storm	Goals 2,3; S&S	City Administrator, Public Works	< $10,000 General funds	High	Long Term	Not Started. Need to coordinate with Clear Creek County and nearby municipalities.
6	**Community Wildfire Protection Implementation Plan – Route 103 Corridor.** Work with officials and neighborhoods to facilitate creation	Severe Wind, Wildfire	Goals 2; S&S, TRN	Police	$10,000 to $100,000 CDHSEM,	High	Ongoing	Not Started. Need to coordinate with Clear Creek County OEM, Clear Creek Fire Authority,

ID	Title and Description	Hazards Mitigated	Goals & Lifelines	Lead Agency & Partners	Cost Estimate & Potential Funding	Priority	Timeline	Status & Implementation Notes
City of Idaho Springs Mitigation Actions								
	of defensible space; perform roadside mitigation/hazard tree removal and create fuel breaks south of I-70, along the Route 103 corridor.				CDFPC, CSFS, FEMA			and Arapahoe National Forest. Most of the State Highway 103 corridor area south of I-70 is outside City limits.
7	**Community Wildfire Protection Implementation Plan – Virginia Canyon.** Work with officials and neighborhoods to facilitate creation of defensible space; perform roadside mitigation/hazard tree removal and create fuel breaks north of I-70, in Virginia Canyon.	Severe Wind, Wildfire	Goals 2; S&S, TRN	Police	$10,000 to $100,000 CDHSEM, CDFPC, CSFS, FEMA	High	Ongoing	Not Started. Need to coordinate with Clear Creek County OEM & Clear Cree Fire Authority. Much of the Virginia Canyon Road corridor area to the north is outside City limits.
8	**Wildland Fire Mitigation – Soda Creek Road.** Conduct wildland fire mitigation measures in the wildland urban interface along the Soda Creek Road corridor south of Interstate 70, located ½ mile east of the State Highway 103 corridor. Of particular interest is the southern boundary of the City that is dense forest adjacent to the Arapahoe National Forest and is in the source water protection area for the City. Power transmission lines also cross the vicinity. This was the location of a wildfire several years ago near a residential neighborhood and	Wildfire	Goals 2,3; S&S, FWS, TRN, ENG	City Administration, Clear Creek Fire Authority, U.S. Forest Service	$10,000 - $100,000 State Grants	High	Short Term	New in 2021. Most of the Soda Creek Road corridor area is outside City limits.

ID	Title and Description	Hazards Mitigated	Goals & Lifelines	Lead Agency & Partners	Cost Estimate & Potential Funding	Priority	Timeline	Status & Implementation Notes
City of Idaho Springs Mitigation Actions								
	required the use of an aerial retardant to extinguish the fire.							

Table 5-5: 2021 Town of Empire Mitigation Action Plan

ID	Title and Description	Hazards Mitigated	Goals & Lifelines	Lead Agency & Partners	Cost Estimate & Potential Funding	Priority	Timeline	Status & Implementation Notes
Town of Empire Mitigation Actions								
1	**Publicize Town Hall as Emergency Shelter.** Educate residents and inform stranded motorists that shelter can be provided at Empire Town Hall. The Town Newsletter and website will inform the residents of Empire in the disaster of an avalanche, winter storm or other natural hazard in which their home is compromised, and notices at Town Hall and Visitors Center will inform tourists stranded because of highway closures, that there will be emergency shelter at Town Hall.	Avalanche, Dam Failure, Earthquake, Flood, Landslide, Severe Wind, Subsidence, Tornado, Wildfire, Winter Storm	Goals 1,2; S&S, FWS	Town Clerk	< $10,000 Town funds, ARC	Medium	Short Term	Annual Implementation.
2	**Water conservation techniques.** Educate residents on water saving techniques in Town monthly newsletter as well as in Board Meetings on measures, including but not limited to, water efficient appliances; low-flow water saving showerheads and toilets; adjusting sprinklers to water lawn only; xeriscaping and the use of recycled water where feasible.	Drought	Goals 1,2; FWS	Town Clerk	< $10,000 General funds	Medium	Short Term	Annual Implementation.
3	**Ordinance on water usage during drought and fire emergencies.** The Town of Empire will write and	Drought, Wildfire	Goals 1,2; FWS	Mayor's Office	< $10,000 General funds	High	Long Term	Not Started.

ID	Title and Description	Hazards Mitigated	Goals & Lifelines	Lead Agency & Partners	Cost Estimate & Potential Funding	Priority	Timeline	Status & Implementation Notes
Town of Empire Mitigation Actions								
	adopt an Ordinance mandating residence to control and prioritize their water use particularly during drought conditions and firefighting operations.							
4	**Reduce flammable vegetation and clearance of trees.** Encourage homeowners to reduce flammable vegetation on their property, keep tree limbs trimmed, dead tree removal, and debris cleared from around home to minimize high wind and wildfire damages.	Severe Wind, Wildfire	Goals 1,2; S&S	Town Clerk	< $10,000 General funds, state and federal grants	High	Long Term	Annual Implementation.
5	**Community Awareness of Hazards.** Educate homeowners on safety techniques to mitigate homes from all hazards. Distribute educational materials to residents.	Avalanche, Dam Failure, Drought, Earthquake, Erosion, Expansive Soils, Extreme Heat, Flood, Hail, Landslide, Lightning, Severe Wind, Space Weather, Subsidence, Tornado, Wildfire, Winter Storm	Goals 1,2; S&S	Town Clerk	< $10,000 General funds	Medium	Long Term	Annual Implementation.
6	**Acquire town volunteers to assist the functional and access needs residents during extreme winter storms or evacuation for any other hazard.** The Town will create	Dam Failure, Earthquake, Extreme Heat, Flood, Landslide, Wildfire, Winter Storm	Goals 1,2; S&S	Mayor's Office	< $10,000 General funds	Medium	Long Term	In Progress.

ID	Title and Description	Hazards Mitigated	Goals & Lifelines	Lead Agency & Partners	Cost Estimate & Potential Funding	Priority	Timeline	Status & Implementation Notes
Town of Empire Mitigation Actions								
	an Emergency Committee and supply those volunteers with a list of specific duties and expectations to assist the functional & access needs residents during evacuation for any hazard.							
7	**Ordinance on Authority to implement a Town Fire Ban based on recommendations from Clear Creek County.** The Town of Empire will write and adopt an Ordinance giving the Emergency Manager the authority to implement a Town Fire Ban based on recommendations from Clear Creek County.	Wildfire	Goals 1,2,3; S&S	Mayor's Office	< $10,000 General funds	High	Short Term	New in 2021.
8	**Integrate Hazard Mitigation Plans and updates into the Empire Emergency Operations Plan.** Integrate Hazard Mitigation Plans and updates, and expand the scope of Empire's Emergency Operations Plan to include information for all possible hazard responses and update all emergency operations.	Avalanche, Dam Failure, Drought, Earthquake, Erosion, Expansive Soils, Extreme Heat, Flood, Hail, Landslide, Lightning, Severe Wind, Space Weather, Subsidence, Tornado, Wildfire, Winter Storm	Goals 2,3; S&S	Town Clerk	< $10,000 General funds	Medium	Short Term	New in 2021.

ID	Title and Description	Hazards Mitigated	Goals & Lifelines	Lead Agency & Partners	Cost Estimate & Potential Funding	Priority	Timeline	Status & Implementation Notes
Town of Empire Mitigation Actions								
9	**Integrate Hazard Mitigation Plans and updates into the Town of Empire Comprehensive Master Plan.** Integrate Hazard Mitigation Plans and updates into the Town of Empire Comprehensive Master Plan to encourage more frequent use and further education and evaluation of all hazards.	Avalanche, Dam Failure, Drought, Earthquake, Erosion, Expansive Soils, Extreme Heat, Flood, Hail, Landslide, Lightning, Severe Wind, Space Weather, Subsidence, Tornado, Wildfire, Winter Storm	Goals 1,2,3; S&S	Town Clerk	< $10,000 General funds	Medium	Short Term	New in 2021.
10	**Provide one or more "Fire Danger" dial signs within the Town to inform residents and visitors.** Purchase signs and determine locations, possibly near the Visitor Center and at each park, for "Fire Danger" sign.	Wildfire	Goals 1,2; S&S	Police/ Emergency Services	< $10,000 General funds	Medium	Short Term	New in 2021.
11	**Assess street signs for appropriate visibility and accurate communication for emergency services to locate reported incidents that lead to hazard conditions.** Identify inadequate signage and replace or add signs for proper visibility and communication for emergency services.	Avalanche, Dam Failure, Drought, Earthquake, Erosion, Expansive Soils, Extreme Heat, Flood, Hail, Landslide, Lightning, Severe Wind, Space Weather, Subsidence,	Goals 1,2; S&S	Police/ Emergency Services	< $10,000 General funds, State & Federal Grants, FEMA, CDOT	High	Short Term	New in 2021.

ID	Title and Description	Hazards Mitigated	Goals & Lifelines	Lead Agency & Partners	Cost Estimate & Potential Funding	Priority	Timeline	Status & Implementation Notes
Town of Empire Mitigation Actions								
		Tornado, Wildfire, Winter Storm						
12	**Require house numbers on all locations within the Town limits to easily identify critical facilities and proper locations for emergency services.** Purchase and provide standard house number signs for all locations within the Town limits and require them to be posted at the driveway.	Avalanche, Dam Failure, Drought, Earthquake, Erosion, Expansive Soils, Extreme Heat, Flood, Hail, Landslide, Lightning, Severe Wind, Space Weather, Subsidence, Tornado, Wildfire, Winter Storm	Goals 2,3; S&S, TRN	Police/ Emergency Services	< $10,000 General funds, State & Federal Grants, FEMA,	High	Short Term	New in 2021.
13	**Participate in the national Wildland Fire Decision Support System (WFDSS) as part of our Source Water Protection Program.** Colorado Rural Water Association (CRWA) will help evaluate critical water infrastructure to share with federal fire managers and response teams.	Wildfire	Goals 1,2,3; S&S	Water Department	< $10,000 General funds, CRWA	High	Short Term	New in 2021.
14	**Drill a new well to protect the Town's ability to provide drinking water during a hazard that threatens Madd Creek.** The Town's only water supply is surface water from Madd Creek, which is vulnerable to hazards including but	Avalanche, Dam Failure, Drought, Earthquake, Extreme Heat, Flood, Hail, Landslide, Severe Wind, Tornado,	Goals 2; FWS, S&S	Water Department	>$1M; General Funds, State & Federal Grants. FEMA, CDPHE,	High	Short Term	New in 2021.

ID	Title and Description	Hazards Mitigated	Goals & Lifelines	Lead Agency & Partners	Cost Estimate & Potential Funding	Priority	Timeline	Status & Implementation Notes
Town of Empire Mitigation Actions								
	not limited to wildfire, landslide (both rock and mud), downed trees, avalanche further up the mountain from the Town's water processing facilities, and depletion during drought and extreme heat from evaporation that could all negatively impact our water source.	Wildfire, Winter Storm			CWRPDA, ARPA			
15	**Evaluate the need for larger or additional raw water holding tanks and treated water storage tanks, for additional resources for firefighting.** Consult with professionals to identify the necessary capacity and locations of possible additional tanks.	Drought, Wildfire	Goals 2,3; FWS, S&S	Water Department	$10K-$100K; General Funds, State & Federal Grants. FEMA, CDPHE, CWRPDA	High	Long Term	New in 2021.
16	**Assess defensible space around critical Town facilities to mitigate wildfire hazard and reduce fuel.** Consult with professionals to identify defensible space, remove excess fuel by trimming trees and vegetation, and disposing of fuel by chipping.	Severe Wind, Tornado, Wildfire, Winter Storm	Goals 2,3; S&S	Public Works	$10K-$100K; General Funds, State & Federal Grants. FEMA, USFS	High	Long Term	New in 2021.
17	**Assess defensible spaces along Hwy 40 as an evacuation route to mitigate wildfire hazard and reduce fuel.** Consult with professionals to identify defensible space, remove excess fuel by	Severe Wind, Tornado, Wildfire, Winter Storm	Goals 2,3; S&S	Public Works	$10K-$100K; General Funds, State & Federal Grants, FEMA, USFS	High	Long Term	New in 2021.

ID	Title and Description	Hazards Mitigated	Goals & Lifelines	Lead Agency & Partners	Cost Estimate & Potential Funding	Priority	Timeline	Status & Implementation Notes
Town of Empire Mitigation Actions								
	trimming trees and vegetation, and disposing of fuel by chipping.							
18	**Assess defensible space along Town roads and Town ROW as evacuation routes for locals to mitigate wildfire hazard and reduce fuel.** Consult with professionals to identify defensible space, remove excess fuel by trimming trees and vegetation, and disposing of fuel by chipping.	Severe Wind, Tornado, Wildfire, Winter Storm	Goals 2,3; S&S	Public Works	$10K-$100K; General Funds, State & Federal Grants, FEMA, USFS	High	Long Term	New in 2021.
19	**Assess main Town road conditions as emergency access to critical Town facilities and evacuation routes to mitigate all hazards.** Identify and implement capital road improvements necessary to upgrade roads for emergency access.	Avalanche, Dam Failure, Earthquake, Extreme Heat, Flood, Landslide, Wildfire, Winter Storm	Goals 2; S&S, TRN	Public Works	$10K-$100K; General Funds, State & Federal Grants, FEMA, CDOT	High	Long Term	New in 2021.
20	**Evaluate Stormwater Management; drainage, flooding, and erosion issues on Town roads during storms.** Consult with professionals to identify areas for improvements for drainage, culverts, and cisterns to prevent persistent flooding and erosion for houses on our sloped town roads. Professionals must consult with CDOT for drainage issues	Dam Failure, Erosion, Flood, Hail, Landslide, Winter Storm	Goals 2,3; TRN	Public Works	$10K-$100K; General Funds, State & Federal Grants, FEMA, CDOT	High	Long Term	New in 2021.

ID	Title and Description	Hazards Mitigated	Goals & Lifelines	Lead Agency & Partners	Cost Estimate & Potential Funding	Priority	Timeline	Status & Implementation Notes
Town of Empire Mitigation Actions								
	stemming from Highway 40 which cuts through the middle of Town.							
21	**Evaluate all four bridges in the Town of Empire to mitigate any vulnerabilities to hazards and preserve emergency escape routes for all residents.** Consult with professionals to evaluate the integrity of all four bridges in the Town of Empire.	Flood, Landslide, Wildfire	Goals 2,3; TRN	Public Works	$10K-$100K; General Funds, State & Federal Grants, FEMA	Low	Long Term	New in 2021.
22	**Install backup power for critical facilities.** Install permanent generators in all critical facilities: Town Hall/Police Station, Wastewater Treatment Plant (WWTP), Ultraviolet (UV) Plant, Chlorination Plant, Well Pump Station, Maintenance Garage.	Avalanche, Dam Failure, Earthquake, Flood, Landslide, Lightning, Severe Wind, Tornado, Wildfire, Winter Storm	Goals 2; S&S	Public Works	$10K-$100K; General Funds, State & Federal Grants, FEMA	Medium	Long Term	New in 2021.
23	**Install Surge Protectors on Town Critical Facilities.** The town will assess what critical facilities need surge protectors from lightning strikes and then purchase the necessary protectors and install.	Lightning, Winter Storm	Goals 2; S&S	Public Works	< $10K; General Funds	Low	Long Term	New in 2021.
24	**Evaluate utilities in the Town limits for defensible spaces and secure installation.** Consult the utility companies to ensure defensible spaces surrounding utilities. Trim trees close to power	Avalanche, Dam Failure, Earthquake, Hail, Landslide, Lightning, Severe Wind, Tornado,	Goals 2,3; FWS, S&S	Public Works	$100K-$1M General Funds, State & Federal Grants,	Low	Long Term	New in 2021.

ID	Title and Description	Hazards Mitigated	Goals & Lifelines	Lead Agency & Partners	Cost Estimate & Potential Funding	Priority	Timeline	Status & Implementation Notes
Town of Empire Mitigation Actions								
	lines to mitigate for fire hazard, and ensure proper installation to mitigate severe storms and high wind events, including the possibility of undergrounding power lines.	Wildfire, Winter Storm			FEMA, XCEL, Xfinity			

Table 5-6: 2021 Town of Georgetown Mitigation Action Plan

ID	Title and Description	Hazards Mitigated	Goals & Lifelines	Lead Agency & Partners	Cost Estimate & Potential Funding	Priority	Timeline	Status & Implementation Notes
Town of Georgetown Mitigation Actions								
1	**Vegetation Thinning Program.** Implement vegetation thinning program in and around the Town of Georgetown to create both defensible space and reduce the overall potential impacts of wildfire to residents, the National Historic Landmark District, and the Town.	Wildfire	Goals 2; S&S	Town Administrator	>$100,000 EIAF – DOLA, State and federal grants, local match	High	Short Term	Annual implementation. Ongoing - but no specifics completed in last couple years except on local roads (Argentine St.).
2*	**NFIP Floodplain Practices.** Continue to participate, implement and improve upon the NFIP floodplain practices. This regulates development on South Clear Cleek and Clear Creek within the Town.	Dam/Levee Failure, Flood	Goals 2; S&S	Town Administrator	< $10,000 Town funds, CWCB	High	Long Term	Annual implementation.
3	**Water Conservation Measures.** Coordinate with water department to continually identify and promote water conservation measures, including but not limited to, water efficient appliances, xeriscaping, the use of recycled water where feasible and install water meters.	Drought	Goals 2; FWS	Town Administrator	< $10,000 State and federal grants, local funds	High	Long Term	Annual implementation. Resolution passed that implements water restrictions when water use call is issued on Georgetown's water rights.
4	**Replace Floodwall along Clear Creek and South Clear Creek.** Town of Georgetown has updated flood ordinance and needs funding to replace the flood prone, landslide, mud/debris flow, rockslide floodwall protection along Clear	Erosion and Deposition, Flood, Landslide, Mud/Debris Flow, Rockfall, Subsidence	Goals 2, S&S	Town Administrator	>$100,000 EIAF – DOLA, State and federal grants, local match	Medium	Short Term	Not Started.

ID	Title and Description	Hazards Mitigated	Goals & Lifelines	Lead Agency & Partners	Cost Estimate & Potential Funding	Priority	Timeline	Status & Implementation Notes
Town of Georgetown Mitigation Actions								
	Creek and South Clear Creek through the historic area.							
5	**Public Education and Outreach.** Promote public education of all hazards and how to mitigate damage to homes.	Dam/Levee Failure, Earthquake, Erosion and Deposition, Expansive Soils, Extreme Heat, Flood, Hail, Landslide, Mud/Debris Flow, Rockfall, Lightning, Wind, Space Weather, Subsidence, Wildfire, Winter Storm	Goals 1,2, S&S	Town Administrator	< $10,000 State and federal grants	High	Short Term	Not Started.
6	**Identify slope stabilization projects.** Georgetown is vulnerable unstable slopes including damage to private property, historic buildings and infrastructure, bridges and road closures, service disruption and fatalities.	Erosion and Deposition, Expansive Soils, Landslide, Mud/Debris Flow, Rockfall, Subsidence	Goals 2; TRN	Town Administrator	$10,000 to $100,000 FEMA HMA grants	Medium	Long Term	Not Started. Has come up in recent discussion during a subdivision approval process.
7	**Organizing outreach to functional and access needs population.** Organize outreach to functional and access needs populations that may be exceptionally vulnerable in winter storm, severe wind, or wildfire events that cause long-term power outages. Maintain public information and awareness programs for the	Wind, Wildfire, Winter Storm	Goals 1,2; S&S	Town Administrator	< $10,000 Town funds	Medium	Short Term	Not Started.

ID	Title and Description	Hazards Mitigated	Goals & Lifelines	Lead Agency & Partners	Cost Estimate & Potential Funding	Priority	Timeline	Status & Implementation Notes
Town of Georgetown Mitigation Actions								
	functional and access needs population and create policies and procedures to ensure that needs are met during long-term power outages.							
8	**Community Wildfire Protection Implementation Plan - Recommended Treatment Priority Number 1.** Work with officials and residents to facilitate creation of Defensible Space: Rural and Urban Properties Creation or personal defensible space is critical to area protection. The Town recommends collaboration with Clear Creek Fire Authority, the Colorado State Forest Service Golden District and Clear Creek offices to use neighborhood/community events to educate residents and promote their efforts to create defensible space on residential lands within the plan area.	Wildfire	Goals 1,2; S&S	Town Administrator, CC Fire Authority	Unknown; DOLA grant, local match	High	Medium Term	New in 2021

Table 5-7: 2021 Town of Silver Plume Mitigation Action Plan

ID	Title and Description	Hazards Mitigated	Goals & Lifelines	Lead Agency & Partners	Cost Estimate & Potential Funding	Priority	Timeline	Status & Implementation Notes
Town of Silver Plume Mitigation Actions								
1*	**Identify and train new floodplain administrator in order to maintain NFIP status and proactively address floodplain issues within the Town.** The Town Board will work to fill the recently vacated Floodplain Administrator Position in the near future. Once the position is filled, they will schedule a meeting with State and/or FEMA NFIP staff to ensure they understand the responsibilities of managing the NFIP and/or obtain training on floodplain management.	Dam/Levee Failure, Flood, Landslide, Mud/Debris Flow, Rockfall	Goals 1,2,3; S&S	Town Board	$10,000 to $100,000 General Fund, state and federal grants	Medium	Short Term	TBD
2*	**Continue to participate in NFIP.** Continue to participate, implement and improve upon the NFIP floodplain practices.	Flood	Goals 2; S&S	Town Board	< $10,000 General Fund, CWCB	High	Long Term	TBD
3	**Community Outreach and Education for Winter Storms.** Community Outreach and Education to work with residents and business owners on proactive mitigation measures to reduce the impacts of winter storms on the community.	Severe Wind	Goals 1,2; S&S	Town Board	< $10,000 General Fund	Medium	Ongoing	TBD
4	**Improve Access / Egress for Evacuation.** Work with homeowners to improve access/	Avalanche, Flood, Landslide, Mud/Debris Flow,	Goals 2; S&S, TRN	Planning/Zoning	< $10,000 General Fund	Medium	Short Term	TBD

ID	Title and Description	Hazards Mitigated	Goals & Lifelines	Lead Agency & Partners	Cost Estimate & Potential Funding	Priority	Timeline	Status & Implementation Notes
Town of Silver Plume Mitigation Actions								
	egress for evacuations and preventative forest maintenance.	Rockfall, Wildfire, Winter Storm						
5	**Community Outreach for Severe Wind Events.** Encourage homeowners and business owners to implement mitigation measures to reduce the impacts of fallen and blowing debris on homes and businesses during high wind events.	Severe Wind	Goals 1,2; S&S	Town Board	< $10,000 General Fund and homeowners	Medium	Ongoing	TBD
6	**Wildfire Fuels Reduction.** Encourage work parties to reduce fuel loads on homeowner property and the impact of wildfires and high wind damage.	Severe Wind, Wildfire	Goals 2; S&S	Town Board	< $10,000 General Fund and grants	High	Short Term	TBD
7	**Water Restriction Ordinance.** Drought events can potentially effect or reduce the availability of water for residents and businesses in the community.	Drought	Goals 1,2; FWS	Town Board	< $10,000 General Fund	Low	Short Term	TBD
8	**Water Saving Techniques.** Encourage residents to take water-saving measures, including but not limited to, water efficient appliances, adjusting sprinklers to water lawn and not the sidewalk, xeriscaping, checking for leaks in plumping.	Drought	Goals 1,2; FWS	Town Board	< $10,000 State and federal grants, local funds	Medium	Long Term	TBD
9	**Drainage/storm water mitigation.** Mitigate problem areas in the Town with regard to heavy rains, snow melt, runoff of water through town	Erosion & Deposition, Flood, Landslides, Debris Flows, Rockfalls,	Goals 2; S&S, FWS COM, TRN	Public Works Dept., CDPHE	$100,000 - $1,000,000	Medium	Short Term	New in 2021. In design phase; construction is expected to start in Spring 2022.

ID	Title and Description	Hazards Mitigated	Goals & Lifelines	Lead Agency & Partners	Cost Estimate & Potential Funding	Priority	Timeline	Status & Implementation Notes
Town of Silver Plume Mitigation Actions								
	streets. Focus area will include on Main Street, Silver, Willis & Jefferson Streets to Clear Creek	Winter Storm, Subsidence						

Table 5-8: 2021 Clear Creek Fire Authority Mitigation Action Plan

ID	Title and Description	Hazards Mitigated	Goals & Lifelines	Lead Agency & Partners	Cost Estimate & Potential Funding	Priority	Timeline	Status & Implementation Notes
Clear Creek Fire Authority								
1	**Wildfire Mitigation Project Area FM43 Saddle Back.** Floyd Hill CWPP Clear Creek North Area. Project Size: 16 Acres. 1.Reduce ground fuels in the project area to limit fire spread. 2. Establish a fire break on the west side of the project area. 3. Thin existing stand to allow 10 15 foot between crowns starting on the east edge of the area. 4. Thin under the power lines and install fuel breaks.	Wildfire	Goals 2; FWS	Clear Creek Fire Authority, Clear Creek Watershed & Forest Health Partnership	$27,400; Colorado State Forest Service Forest FRWRM Grant	High	Short Term	New in 2021.
2	**Wildfire Mitigation Project Area FM1 Georgetown.** Georgetown Reservoir/ Silver Creek Area. Project Size: 45 Acres. 1. Thin Trees within 200 Feet of the Reservoir. 2. Remove ground fuels and thin trees within 30 feet of the Silver Creek Trails. 3. Identify fuel break sites and begin the approval process for their installation with the town of Georgetown.	Wildfire	Goals 2; FWS	Clear Creek Fire Authority, Clear Creek Watershed & Forest Health Partnership	$99,000; Colorado State Forest Service Forest FRWRM Grant	High	Short Term	New in 2021.
3	**Wildfire Mitigation Idaho Springs Reservoir Project.** Project Size: 13 Acres.	Wildfire	Goals 2; FWS	Clear Creek Fire Authority, Clear Creek Watershed	$33,600; Colorado State Forest	High	Short Term	New in 2021.

ID	Title and Description	Hazards Mitigated	Goals & Lifelines	Lead Agency & Partners	Cost Estimate & Potential Funding	Priority	Timeline	Status & Implementation Notes
	1. Thin Trees within 200 Feet of the Reservoir. 2. Improve access by thinning 50 feet on each side of the access road.			& Forest Health Partnership	Service Forest FRWRM Grant			
4	**Capacity Building Grant Project.** Purchase additional equipment to help implement the above projects and other mitigation activities, to include a mower, a chipper, and ATV, and a 14' Trailer.	Wildfire	Goals 2; FWS	Clear Creek Fire Authority, Clear Creek Watershed & Forest Health Partnership	$40,000; Colorado State Forest Service Forest FRWRM Grant	High	Short Term	New in 2021.

6 Plan Implementation and Maintenance

DMA Requirement §201.6(c)(4)(ii):
[The plan shall include] a plan maintenance process that includes: *(i) A section describing the method and schedule of monitoring, evaluating, and updating the mitigation plan within a five-year cycle.* *(ii) A process by which local governments incorporate the requirements of the mitigation plan into other planning process by which local governments incorporate the requirements of the mitigation plan into other planning mechanisms such as comprehensive or capital improvement plans, when appropriate.* *(iii) Discussion on how the community will continue public participation in the plan maintenance process.*

6.1 Plan Adoption & Implementation

The purpose of formally adopting this Plan is to secure buy-in from Clear Creek County and the participating jurisdictions, raise awareness of the plan, and formalize the plan's implementation. The adoption of this plan completes Planning Step 9 of the 10-step planning process: Adopt the Plan. The governing board for each participating jurisdiction has adopted this local HMP by passing a resolution. A copy of the generic resolution and the executed copies are included in Appendix E: Plan Adoptions and Approval.

Once adopted, the plan faces the truest test of its worth: implementation. While this plan contains many worthwhile projects, the 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) and through constant, pervasive, and energetic efforts to network and highlight the multi-objective, win-win benefits of each project to the Clear Creek 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 Implementation and Maintenance of the 2016 Plan

The maintenance and evaluation process described in the 2016 HMP was not followed due to conflicting priorities and events. However, the templates for annual status meetings/mitigation action status created in 2016 were useful during the 2021 Plan Update in gaining information on the status of actions.

6.1.2 Role of the Hazard Mitigation Committee in Implementation and Maintenance

With adoption of this plan, Clear Creek County, the City of Idaho Springs, Towns of Georgetown, Silver Plume, and Empire, along with Clear Creek Fire Authority, will be tasked with plan implementation and maintenance. The participating jurisdictions, led by the Clear Creek County Emergency Manager, agree to:

- Act as a forum for hazard mitigation issues;
- Disseminate hazard mitigation ideas and activities to all participants;
- Pursue the implementation of high-priority, low/no-cost recommended actions;
- Keep the concept of mitigation in the forefront of community decision making by identifying plan recommendations when other community goals, plans, and activities overlap, influence, or directly affect increased community vulnerability to disasters;
- Maintain a monitoring of multi-objective cost-share opportunities to help the community implement the plan's recommended actions for which no current funding exists;
- Monitor and assist in implementation and update of this plan;
- Report on plan progress and recommended changes to the Board of County Commissioners, municipal councils, and other partners; and
- Inform and solicit input from the public.

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 jurisdictions' websites and in the local newspaper.

6.2 Plan Maintenance/Monitoring Strategy

The Clear Creek County HMP is a living document that may be adjusted or updated as conditions change, actions progress, or new information becomes available. This section describes the method and schedule the participating jurisdictions will follow for monitoring, evaluating, and updating the Plan over the next five years. All participating jurisdictions will follow the process and schedule described below.

6.2.1 Monitoring

Monitoring refers to tracking the implementation of the plan over time. Clear Creek County OEM will be responsible for reaching out to lead and supporting agencies identified in the Mitigation Actions table for status on those mitigation actions. OEM will also coordinate with Planning Team members at least annually to identify and track any significant changes in their agencies' mitigation efforts.

Clear Creek County OEM will use the following process to track progress, note changes in vulnerabilities, and consider changes in priorities as a result of project implementation:

- A representative from the responsible entity identified in each mitigation action will be responsible for tracking and reporting to the HMPC when project status changes. The representative will provide input on whether the project as implemented meets the defined goals and objectives and is likely to be successful in reducing vulnerabilities.
- If the project does not meet identified goals and objectives, the HMPC may select alternative projects for implementation.

- Projects that were not ranked high priority but were identified as potential mitigation strategies will be reviewed periodically to determine feasibility of future implementation.
- New mitigation projects identified will require an individual assigned to be responsible for defining the project scope, implementing the project, monitoring success of the project.
- Mitigation activities not identified as actions in this plan will also be tracked to ensure a comprehensive hazard mitigation program, and to assist with future updates.

As part of this coordination, OEM and the HMPC will also monitor repetitive losses; evaluate changes in hazards, vulnerabilities, or the distribution of risk across the county; and seek to identify new and ongoing mitigation opportunities.

6.2.2 Evaluation

Evaluating refers to assessing the effectiveness of the plan at achieving its stated purpose and goals. Evaluation of progress can be achieved by monitoring changes in vulnerabilities identified in the plan, such as:

- Decreased vulnerability because of implementing recommended actions,
- Increased vulnerability because of failed or ineffective mitigation actions, and/or
- Increased vulnerability because of new development (and/or annexation).

The HMPC will meet annually to evaluate the implementation of the plan and consider any changes in priorities that may be warranted. The annual evaluation will not only include an investigation of whether mitigation actions were completed, but also an assessment of how effective those actions were in mitigating losses. A review of the qualitative and quantitative benefits (or avoided losses) of mitigation activities will support this assessment. Results of the evaluation will then be compared to the goals established in the plan and decisions will be made regarding whether actions should be discontinued or modified in any way in light of new developments in the community. Progress will be documented by the HMPC for use in the next plan update. Finally, the Planning team will monitor and incorporate elements of this Plan into other planning mechanisms, as detailed in Section 6.3.

Clear Creek County OEM will coordinate with all participating jurisdictions to facilitate an effective maintenance and implementation process. Completed projects will be evaluated to determine how they have reduced vulnerability. 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.

Annual Progress Report

The minimum task of each planning partner will be the evaluation of the progress of its individual action plan during a 12-month performance period. Completion of the annual progress report is the responsibility of each planning partner, not solely the responsibility of Clear Creek County OEM. The HMPC will review the annual progress reports in an effort to identify issues needing to be addressed by future plan updates. This review will include the following:

- Summary of any hazard events that occurred during the performance period and the impact these events had on the planning area
- Review of mitigation success stories
- Review of continuing public involvement
- Brief discussion about why targeted strategies were not completed

- Re-evaluation of the action plan to evaluate whether the timeline for identified projects needs to be amended (such as changing a long-term project to a short-term one because of new funding)
- Recommendations for new projects
- Changes in or potential for new funding options (grant opportunities)
- Impact of any other planning programs or initiatives that involve hazard mitigation

The planning team has created a template to guide the planning partners in preparing a progress report (see Appendix G). The plan maintenance committee (HMPC) will provide feedback to the planning team on items included in the template. The planning team will then prepare a formal annual report on the progress of the plan. This report should be used as follows:

- Posted on the Clear Creek County OEM website page dedicated to the hazard mitigation plan
- Provided to the local media through a press release
- Presented to planning partner governing bodies to inform them of the progress of initiatives implemented during the reporting period

6.2.3 Updates

The Clear Creek County HMP will be reviewed and revised at least once every five years in accordance with the DMA 2000 requirements and latest FEMA and DHSEM hazard mitigation planning guidance. Updates to this plan will consider:

- Has the nature or magnitude of hazards affecting the county and jurisdictions changed?
- Are there new hazards that have the potential to impact the county and jurisdictions?
- Have growth and development changed the county's and jurisdictions' vulnerabilities?
- Do the identified goals and actions still address current and expected conditions?
- Have mitigation actions been implemented or completed?
- Has the implementation of identified mitigation actions resulted in expected outcomes?
- Are current resources adequate to implement the plan?
- Should additional local resources be committed to address identified hazards?

The HMPC members and those entities identified in Appendix C, will be reconvened for this process by Clear Creek County Emergency Management. The updated plan will document success stories where mitigation efforts have proven effective, as well as areas where mitigation actions were not effective, and will include re-adoption by all participating entities following DHSEM/FEMA approval.

Any interested party wishing for an update of this Plan sooner than the regular 5-year update will submit such a request to Clear Creek County OEM for consideration. OEM will evaluate all such requests and bring them to the full HMPC for consideration.

6.3 Continuing Public Involvement

The public will continue to be apprised of the plan's progress through the Clear Creek County OEM's website and by providing copies of annual progress reports to the media. The Clear Creek County OEM will maintain the HMP website. This site will not only house the final plan, but it will also become the one-stop shop for information regarding the plan, the partnership and plan implementation. Upon initiation of future update processes, a new public involvement strategy will be initiated based on guidance and input from the HMPC. This strategy will be based on the needs and capabilities of the planning partnership at the time of the update. At a minimum, this strategy will include the use of local media outlets within the planning area.

The update process provides an opportunity to publicize success stories from the Plan implementation and seek additional public comment. When the HMPC 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.

6.4 Incorporation into Other Planning Mechanisms

The information on hazards, risk, vulnerability, and mitigation contained in this plan is based on the best science and technology available at the time this plan was prepared. The comprehensive plans, zoning and subdivision regulations, and ordinances of Clear Creek County and the partner cities/towns are considered to be integral parts of this Plan. The county and partner municipalities, through adoption of comprehensive plans and zoning ordinances, have planned for the impact of natural hazards. The plan development process provided the county and the cities/towns with the opportunity to review and expand on policies contained within these planning mechanisms. The planning partners used their comprehensive plans and the hazard mitigation plan as complementary documents that work together to achieve the goal of reducing risk exposure to the citizens of the planning area. An update to a comprehensive plan may trigger an update to the HMP.

All municipal planning partners are committed to creating a linkage between the hazard mitigation plan and their individual comprehensive plans. Other planning processes and programs to be coordinated with the recommendations of the HMP include the following:

- Municipal codes
- Community design guidelines
- Water-efficient landscape design guidelines
- Stormwater management programs
- Water system vulnerability assessments
- Community wildfire protection plans

6.4.1 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 Clear Creek County Community Master Plan was last updated in 2017, and included hazards information from the County's previous HMP, which is cited as a supporting document and considered part of the planning process for the Community Master Plan. Hazard Mitigation and the establishment of goals addressing community mitigation and resilience to natural hazards are integrated into the Community Master Plan.

Mitigation action #9 (Table 5-3) call for integrating the 2020 HMP into the next comprehensive plan update.

6.4.2 Threat and Hazard Identification and Risk Assessment (THIRA)

Clear Creek 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 (Chapter 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.

6.4.3 Response Plans

The Clear Creek County Emergency Operations Plan (EOP) is currently under revision. While the EOP is an all hazards document, it also contains hazard-specific information and concerns. Hazard information from this HMP update should be incorporated into the next EOP update. At a minimum, all high significance hazards identified in this Plan should be addressed in future EOP updates.

Several other operational or functional response plans are also influenced by information contained in the HMP. These plans include but are not limited to:

- **Damage Assessment Plan**: A review of the vulnerability and estimated losses detailed in the hazard profiles can help identify what areas to initially prioritize following a hazard event. Similarly, a review of Section 4.2 Asset Summary can help identify what critical facilities need to be assessed following a hazard event.
- **Evacuation & Sheltering Plan**: A review of the vulnerability and estimated losses detailed in the hazard profiles can help identify what areas are more likely to need evacuation in different hazard scenarios. The Community Profile in Chapter 2 can help identify not only how many people would potentially be impacted by disasters, but how many are likely to need assistance with transportation, special medical or sheltering needs, etc. This review can also help evaluate the impacts of multiple or cascading hazards, so that evacuees are not relocated into an area that puts them at risk from other hazards.

6.4.4 Recovery Plan

Clear Creek County has a Disaster Recovery Plan from 2018. The County (OEM) will revise the plan using the 2-year state Recovery Roadmap process. The risk and vulnerability data in the HMP will 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 Public Assistance (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."

6.4.5 Continuity of Operations Plan (COOP)

All departments and agencies of Clear Creek 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 Chapter 4 should be prioritized for COOP planning.

6.4.6 Training and Exercise Plan

Training on hazard mitigation principles and procedures should be included in the county's training and exercise planning. Any training and exercise needs identified in the Capabilities Assessment (Chapter 2) and Mitigation Strategy (Chapter 5) should also be included in the county's training and exercise planning.

6.4.7 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.

6.4.8 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.

6.4.9 Capital Improvements Plan

High-cost mitigation actions listed in Chapter 5 or identified in the future may be added to the Capital Improvements Plan (CIP) 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 CIP, given that most mitigation grants require significant local matching funds.

6.4.10 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.

Appendix A: Approval and Adoption

Appendix B: Hazard Mitigation Planning Committee

Appendix C: Planning Process Documentation

Appendix D: Public Survey Results

Appendix E: References

Appendix F: Definitions and Acronyms