EXECUTIVE SUMMARY

Plan Overview

Each year in the United States, disasters take the lives of hundreds of people and injure thousands more. Nationwide, taxpayers pay billions of dollars annually to help communities, organizations, businesses, and individuals recover from disasters. These monies only partially reflect the true cost of disasters, as additional expenses to insurance companies and nongovernmental organizations are not reimbursed by tax dollars. Many disasters are predictable, and much of the damage caused by these events can be alleviated or even eliminated.

Jefferson County's Multi-Hazard Mitigation Plan is an effort to reduce the impacts of natural hazards on citizens and property in Jefferson County by outlining actions that will mitigate the hazards' effects and break the cycle of repetitive disaster losses. 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." 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. The Jefferson County Multi-Hazard Mitigation Plan documents Jefferson County's hazard mitigation planning process, identifies relevant hazards and risks, and outlines the strategy the County and participating jurisdictions will use to decrease hazard vulnerability and increase resiliency and sustainability.

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

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1 INTRODUCTION

1.1 Purpose

Jefferson County, including the participating jurisdictions of the cities of Arvada, Edgewater, Golden, Lakewood and Wheat Ridge; the towns of Lakeside, Morrison and Mountain View; the fire districts of Evergreen, Indian Hills, and North Fork; Lookout Mountain Water District, and Pleasant View Metropolitan District, have prepared this local hazard mitigation to better protect the people and property of the County from the effects of hazard events. This plan demonstrates the community's commitment to reducing risks from hazards and serves as a tool to help decision makers direct mitigation activities and resources. This plan was also developed to position Jefferson County and its participating jurisdictions for the eligibility of certain federal disaster assistance, specifically, the Federal Emergency Management Agency's (FEMA) Hazard Mitigation Assistance grant programs (HMA), which include Hazard Mitigation Grant Program (HMGP), Pre-Disaster Mitigation (PDM), Flood Mitigation Assistance (FMA), Repetitive Flood Claims (RFC), and Severe Repetitive Loss (SRL) as well as earning credits for the National Flood Insurance Program's Community Rating System, and State Hazard Mitigation Program (SHMP) funding.

1.2 Background and Scope

Each year in the United States, disasters take the lives of hundreds of people and injure thousands more. Nationwide, taxpayers pay billions of dollars annually to help communities, organizations, businesses, and individuals recover from disasters. Additional expenses to insurance companies and nongovernmental organizations are not reimbursed by tax dollars, making the costs of disasters several times higher than calculated amounts. 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 $4 in avoided future losses in addition to saving lives and preventing injuries.[1]

This plan documents Jefferson County's hazard mitigation planning process, identifies relevant hazards and risks, and identifies the strategy the County and participating jurisdictions will use to decrease vulnerability and increase resiliency and sustainability.

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

Jefferson County, including the participating jurisdictions noted previously, had the choice to continue to be a participant in the 2010 update of the Denver Regional Council of Governments (DRCOG) Natural Hazard Mitigation Plan or develop a separate more detailed Jefferson County specific multi-jurisdictional mitigation plan. The County and three participating jurisdictions chose to separate out from the DRCOG Region plan in order to develop a more specific risk assessment, goals, objectives, and action items. In addition to the four jurisdictions that participated in the DRCOG plan, ten additional jurisdictions were included in the planning process in 2009. Thus the development of this plan was approached as a "new plan" rather than an update of the Jefferson County specific information in the 2003 DRCOG plan. See Section 3.1 for details on participating jurisdictions.

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

[1] National Institute of Building Science Multi-Hazard Mitigation Council 2005

1.3 Plan Organization

The Jefferson County Multi-Hazard Mitigation Plan is organized in alignment with the DMA planning requirements and the FEMA plan review crosswalk, as follows:

- Chapter 2: Community Profile
- Chapter 3: Planning Process
- Chapter 4: Risk Assessment
- Chapter 5: Mitigation Strategy
- Chapter 6: Plan Adoption
- Chapter 7: Plan Implementation and Maintenance
- Annexes
- Appendices

Jurisdictional Annexes

Each jurisdiction participating in this plan developed its own annex, which provides a more detailed assessment of the jurisdiction's unique risks as well as their mitigation strategy to reduce long-term losses. Each jurisdictional annex contains the following:

- Community profile summarizing geography and climate, history, economy, and population
- Hazard information on location, previous occurrences, probability of future occurrences, and magnitude/severity for geographically specific hazards
- Hazard map(s) at an appropriate scale for the jurisdiction, if available
- Number and value of buildings, critical facilities, and other community assets located in hazard areas, if available
- Vulnerability information in terms of future growth and development in hazard areas
- A capability assessment describing existing regulatory, administrative, technical, and fiscal resources and tools as well as outreach efforts and partnerships and past mitigation projects
- Mitigation actions specific to the jurisdiction

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2 COMMUNITY PROFILE

Section 2 provides a brief overview of the geography of Jefferson County. Additional geographic profiles of the municipalities are provided in the community specific annexes.

2.1 Geography and Climate

Situated in the north-central part of Colorado, west of the City of Denver, Jefferson County is split between foothills on the west and plains on the east.[2] In addition, the county may be divided into north and south characterizations. The majority of the population is located in the northern portion of the county, while the southern portion is dominated by Pike National Forest. The county is 773 square miles in size, and 655 square miles are unincorporated areas.[3] The ecologies located in the county include prairies, forests, and tundra environments. This area includes a significant interfacing between development and forest areas, which increases the wildfire risks in those regions. The land is divided approximately 70% mountains and 30% plains, with about 23% of the land use devoted to national forest land.[4] In addition to three national parks, Jefferson County is also home to two state parks. Golden Canyon State Park and Chatfield State Recreation area offer a variety of activities, trails, boating, and other events. Chatfield State Recreation is also home to the Denver Botanic Gardens at Chatfield. [5]

Jefferson County is marked by some distinctive geologic features. The hogback formations, which are rock formations that rise sharply just at the base of the foothills and provide a steep valley between the formation and the formal foothill regions, are unique in appearance and easily identified by travelers. One of the most notable elements of the hogback is the Dinosaur Ridge foundation, where fossils and dinosaur tracks are easily accessible.[6] Other notable geologic features include Green Mountain, North and South Table Mountains and Red Rocks Amphitheater and Park.[7] Several large reservoirs are located in the County as well, including, Arvada, Chatfield, Bear Creek, Ralston; as well as Marston, Bow Mar, Sloan, and Standley Lake. The site of the former Rocky Flats facility is also located in the county.

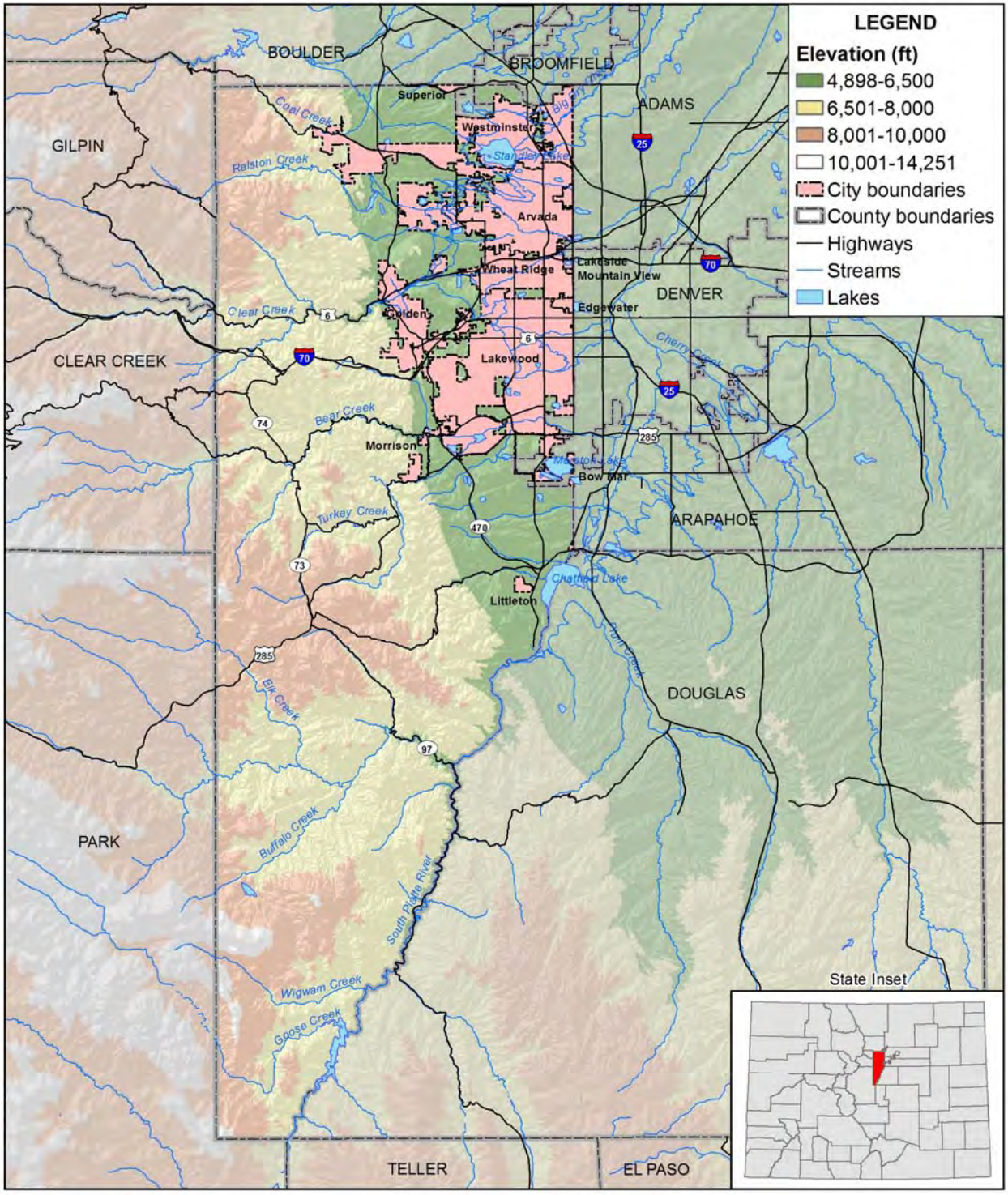
Jefferson County's climate is fairly temperate but demonstrates four distinct seasons. The average temperature in July (the hottest month) is 74°F and in January (the coldest month) is 30°F. The county averages 15.4 inches of precipitation and 60.3 inches of snow.[8] There are

[2] 2008 State Hazard Mitigation Plan, County Descriptions (Section 3) page 40.
[3] http://www.co.jefferson.co.us/jeffco/planning_uploads/demographics/at_a_glance.pdf
[4] http://www.co.jefferson.co.us/aboutjeffco.htm
[5] http://www.botanicgardens.org/content/our-gardens-chatfield-location
[6] http://parks.state.co.us/NaturalResources/CNAP/NaturalAreasInfo/AlphabeticalListing/DakotaHogback.htm
[7] http://www.cliffshade.com/colorado/dakota_hogback/
[8] http://www.co.jefferson.co.us/aboutjeffco.htm

periods of extreme temperature variations, but they are generally accompanied by other climactic considerations such as drought or winter storms.

A base map of Jefferson County is illustrated in Figure 2.1. A closer picture of the planning area is also presented in Figure 2.2.

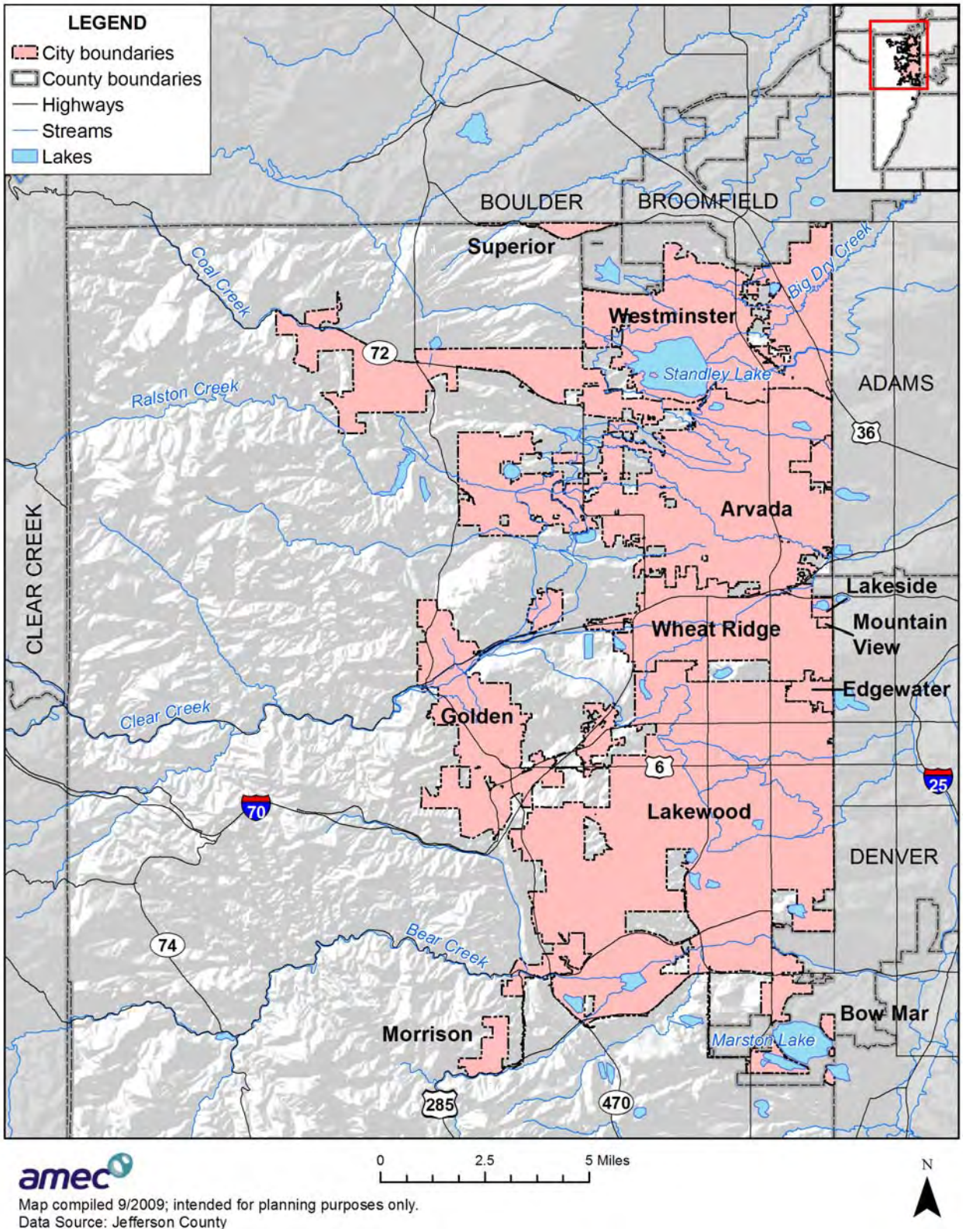
Figure 2.1 Jefferson County Base Map



amec

Map compiled 10/2009; intended for planning purposes only.
Data Source: Jefferson County

Figure 2.2 Jefferson County Base Map (North Section)



amec

Map compiled 9/2009; intended for planning purposes only.
Data Source: Jefferson County

2.2 Population

Jefferson County has grown an estimated 3 percent since the 2000 U.S. Census. The estimated 2008 County population was 543,053. The majority of the population resides in the unincorporated areas of the county and the cities of Lakewood, Arvada and Golden. Population estimates for the year 2008 for each of the incorporated municipalities and overall unincorporated Jefferson County are provided in Table 2.1.

Table 2.1 Jefferson County Population

Jurisdiction	2000 Population	2008 Population Estimate	Estimated Percent Change (%) 2000-2007
Arvada (part)	99,306	104,818	5.6%
Bow Mar (part)	240	235	-0.3%
Edgewater	5,445	5,273	-3.3%
Golden	17,159	17,804	3.8%
Lakeside	20	20	0.0%
Lakewood	144,126	144,382	0.0%
Littleton (part)	109	1,556	1327%
Morrison	430	420	-2.3%
Mountain View	569	532	-7.0%
Westminster (part)	43,521	46,382	6.5%
Wheat Ridge	32,913	31,650	-4.0%
Unincorporated Area	181,666	189,981	4.6%
Total County	**527,056**	**543,053**	**3.0%**

Source: Colorado Department of Local Affairs, www.dola.colorado.gov/

Select Census 2000 and American Community Survey 2006-2008 demographic and social characteristics for Jefferson County are shown in Table 2.2. Characteristics for Jefferson County are for the entire County.

Table 2.2 Jefferson County Demographic and Social Characteristics

Characteristic	Jefferson County	Arvada	Bow Mar*	Edgewater*	Golden*	Lakeside*	Littleton	Lakewood	Morrison*	Mountain View*	Westminster	Wheat Ridge
Gender/Age												
Male (%)	49.9	47.9	49.8	50.0	54.6	70.0	54.2	50.0	39.3	49.2	50.3	48.6
Female (%)	50.1	52.1	50.2	50.0	45.4	30.0	45.8	50.0	60.7	50.8	49.7	51.4
Under 5 Years (%)	5.8	6.2	6.5	8.3	5.7	5.0	4.9	5.7	1.6	6.0	7.2	5.5

Characteristic	Jefferson County	Arvada	Bow Mar*	Edgewater*	Golden*	Lakeside*	Littleton	Lakewood	Morrison*	Mountain View*	Westminster	Wheat Ridge
65 Years and Over (%)	11.1	12.1	16.8	10.0	8.0	20.0	16.5	13.7	43.7	14.1	12.6	19.2
Demographics												
Speak language other than English at home (%)	11.1	9.3	5.9	22.9	10.5	12.5	12.2	15.1	3.1	14.3	15.3	-
Reporting some disability above age 5 (%)*	11.7	13.3	11.0	23.4	12.4	0	15.3	13.4	11.2	21.7	13.9	18.7
Average Household Size	2.42	2.5	2.87	2.34	2.31	2.22	2.30	2.24	2.18	2.09	2.61	2.06
High School Graduate or Higher (%)	92.3	92.0	98.5	79.3	92.4	100	92.5	89.0	79.3	78.4	90.5	86.3

Source: U.S. Census Bureau 2006-2008 3 Year Estimates, www.census.gov/, * indicates 2000 Census data.

2.3 History

Jefferson County has a history rich in people, events and progress. Taking the name of the third U.S. president Thomas Jefferson, the county was formally organized in 1861 by the Colorado Territorial Legislature. The need for an organized local government began in the late 1850s when droves of gold-seeking settlers came west. In 1858, when gold was discovered in the Rocky Mountains, there were fewer than 200 settlers in the area. An influx of nearly 35,000 people arrived two years later, lured by the glitter of gold. The first provisional governor of Jefferson Territory was Robert W. Steele, who lived at Mount Vernon. County offices were located in Loveland Hall until 1877 when the first Jefferson County Courthouse was built. Commissioners in 1862 were paid $3 per day for their meetings plus mileage to the meeting hall. The City of Golden served as the capital for the Colorado Territory from 1862 to 1867.[9]

The county tax was 6 mills and the school tax was 2.5 mills in 1862. County taxes for that year amounted to $1,594.61. By comparison, in 1996 Jefferson County's mill levy was 25.584 and property taxes alone exceeded $96,000,000. In the early years, farmers and ranchers thrived by supplying food and supplies to the mining towns scattered throughout the mountains. Mining occurred along the Hogback in Idledale, on Lookout Mountain, and in Genesee.[10]

Contemporary elements within the County include a variety of industries. Some of these are aerospace engineering from companies such as Lockheed Martin, environmental engineering from Ball Corp., the Coors brewery, the Colorado School of Mines, local grocery chains such as King Soopers, and numerous private, locally owned, or large corporate businesses. Many of these, such as the School of Mines and Coors Brewery, were established in the late 1800s and are nearly as old as the territory itself. Dinosaur Ridge, where fossils were first discovered in 1877,

[9] Jefferson County Archives and Records Website. http://www.co.jefferson.co.us/archives/archives_T77_R66.htm
[10] Jefferson County website. http://www.co.jefferson.co.us/archives/archives_T77_R8.htm

remains a prominent and archaeologically significant resource. Mount Olivet Cemetery, which opened in 1892 and was called "The New City of the Dead" remains one of the largest cemeteries in Colorado and is still active.

2.4 Economy

According to the Jefferson Economic Council, the top employers in the county are the Jefferson County R-1 School District, Denver Federal Center, Lockheed Martin, Exempla-Lutheran Medical Center, Coors Brewing Company, Gambro Companies, King Soopers, CoorsTek, Ball Corporation, Safeway Stores, Inc., and the National Renewable Energy Laboratory (NREL), each of which employ more than 1,000 people.[11] Select economic characteristics for Jefferson County from the 2005-2007 American Community Estimates or 2000 Census and the Bureau of Labor Statistics (2009) are shown in Table 2.3. In some cases, unemployment statistics are not available for incorporated areas within the county. Characteristics for Jefferson County are for the entire County.

Table 2.3 Jefferson County Economic Characteristics

Characteristic	Jefferson County	Arvada	Bow Mar*	Edgewater*	Golden*	Lakeside*	Lakewood	Morrison*	Mountain View*	Wheat Ridge
Families below Poverty Level (%)	5.4	7.4	2.4	8.1	3.5	66.7	8.5	4.9	12.2	9.2
Individuals below Poverty Level (%)	7.7	5.5	3.4	10.2	11.3	44.4	11.1	5.5	13.0	10.2
Median Home Value ($)	261,100	241,100	527,600	132,700	198,300	0	239,800	277,900	125,000	229,800
Median Household Income ($)	65,909	66,103	112,300	35,023	49,115	34,375	52,512	53,438	41,364	55,165
Per Capita Income ($)	34,850	31,588	53,558	19,166	25,257	16,339	29,772	24,347	21,425	27,268
Population in Labor Force (%)	71.7	71.7	57.2	70.7	70.2	62.5	68.6	47.2	75.5	65.5
Unemployment Rate (%)	6.9	8.1	n/a	n/a	n/a	n/a	7.5	n/a	n/a	8.3

Source: U.S. Census Bureau (2006-2008 and 2000), www.census.gov/; Bureau of Labor Statistics, www.bls.gov/
*2000 Census Data
**August 2009

[11] http://www.jeffco.org/sitesel-employersindustries.htm

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3 PLANNING PROCESS

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:

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

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

The planning process and development of this plan was initiated in March of 2009 under the coordination of the Jefferson County Office of Emergency Management. Funding was secured through the Pre-Disaster Mitigation Grant Program administered by FEMA to enable a consultant to be hired to facilitate the process and develop the plan. AMEC Earth and Environmental (AMEC) of Lakewood, Colorado, contracted with the County to provide professional planning services.

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

3.1 Local Government Participation

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

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

For the Jefferson County Multi-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 bodies.

Jefferson County and the cities of Arvada, Lakewood, and Wheat Ridge previously participated in a regional hazard mitigation planning process with DRCOG ending in 2003. The Denver Regional Council of Governments was one of the first governmental entities in FEMA Region VIII to pursue a regional Mitigation Plan. As Jefferson County and its communities faced a series of natural hazard events, a consensus amongst the jurisdictions to create their own, more detailed mitigation plan, fueled the effort to apply for a Pre-Disaster Mitigation Program Grant. Their successful application secured funding and the planning process began in March 2009. This is a multi-jurisdictional plan that is geographically limited to within the jurisdictional boundaries of Jefferson County, Colorado, which includes unincorporated Jefferson County; the cities of Arvada, Edgewater, Golden, Lakewood and Wheat Ridge; the towns of Lakeside, Morrison and Mountain View; the fire districts of Evergreen, Indian Hills, and North Fork; Lookout Mountain Water District and Pleasant View Metropolitan District. The Town of Bow Mar elected not to participate in the Jefferson County multi-jurisdictional planning process. The City of Westminster elected not to participate in the Jefferson County multi-jurisdictional planning process, but to develop a multi-hazard mitigation plan in-house specific to the City of Westminster since the City lies within both Jefferson and Adams County. The Town of Superior has a portion of their Town in Jefferson County but opted to participate in the Boulder County Hazard Mitigation Plan. The City of Littleton also has a small area in Jefferson County but is participating in the DRCOG plan.

3.2 The 10-Step Planning Process

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

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

Into this four-phase process, AMEC integrated a more detailed 10-step planning process used for FEMA's Community Rating System (CRS) and Flood Mitigation Assistance programs. Thus, the modified 10-step process used for this plan meets the requirements of six major programs: FEMA's Hazard Mitigation Grant Program, Pre-Disaster Mitigation program, CRS, Flood

Mitigation Assistance Program, Severe Repetitive Loss program, and new flood control projects authorized by the U.S. Army Corps of Engineers. Jefferson County, the City of Arvada, Golden, Lakewood, Wheat Ridge, and the town of Morrison participate in the CRS, and thus could potentially earn planning credits from the development of this plan.

Table 3.1 shows how the modified 10-step process fits into FEMA's four-phase process. FEMA's 4-Phase Process and the 10-Step CRS Process Used to Develop Jefferson County's Local Hazard Mitigation Plan

Table 3.1 Jefferson County Hazard Mitigation Planning Process

FEMA's 4-Phase DMA Process	Modified 10-Step CRS Process
1) Organize Resources	
201.6(c)(1)	1) Organize the Planning Effort
201.6(b)(1)	2) Involve the Public
201.6(b)(2) and (3)	3) Coordinate with Other Departments and Agencies
2) Assess Risks	
201.6(c)(2)(i)	4) Identify the Hazards
201.6(c)(2)(ii)	5) Assess the Risks
3) Develop the Mitigation Plan	
201.6(c)(3)(i)	6) Set Goals
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
201.6(c)(4)	10) Implement, Evaluate, and Revise the Plan

3.2.1 Phase 1: Organize Resources

Planning Step 1: Organize the Planning Effort

AMEC worked with Jefferson County Sheriff's Emergency Management team to establish the framework and organization for the development of this Plan. Key stakeholders were identified including representatives from the various county departments, each municipal jurisdiction, and other state and local government agencies. Letters and emails were sent to describe the upcoming mitigation planning efforts and invite potential members to participate in a kickoff meeting where an HMPC would be organized. Suggested representation from each municipality included City/Town Manager, Emergency Manager, Floodplain Manager, Public Works/Engineering, Building Department and Fire Department/District. Table 3.2 lists the HMPC participants and their respective jurisdiction in the development of the plan. Other

stakeholders that participated in the planning process are discussed under Planning Step 3: Coordinate with Other Departments and Agencies.

Table 3.2 Jefferson County Hazard Mitigation Planning Committee Framework

Jefferson County	Municipalities	Districts
Emergency Management	Arvada	West Metro FD
Planning and Zoning	Golden	Golden Fire Department
Jefferson Co Open Space	Lakeside	Fairmount FD
Assessors	Lakewood	Genesee FD
Building Department	Morrison	Evergreen FD
Information Technology	Mountain View	Indian Hills FPD
Fairgrounds	Wheat Ridge	North Fork FPD
Road and Bridge		Pleasant View Metro Dist
Parks and Recreation		Lookout Mountain Water Dist
Administrative Services		
Board of Co. Commissioners		

A comprehensive list of HMPC representatives and alternates is included in Appendix B along with a full list of invited representatives, who declined to participate.

The participation of the HMPC is documented by their attendance in the planning meetings held, in minutes and summaries recorded, by participation in conference calls, by email and phone conversation notes, tracking of time for in-kind grant match purposes, and by communication through an ftp (file transfer protocol) site and project website. Four specific planning meetings were held during the plan development phase between April and October 2009. The meeting schedule and topics are listed in Table 3.3. The Kickoff Meeting was held at Jefferson County District Attorney's Office training room. The Risk Assessment meeting was held in the training room at the Jefferson County Sheriff's Emergency Management Office. The Goals and Objectives and the Mitigation Actions meetings were held in a large training facility located adjacent to the Jefferson County Detention Center. Sign-in sheets and agendas for each of the meetings can be viewed in Appendix F.

Table 3.3 Schedule of HMPC Meetings

HMPC Meeting	Meeting Topic	Meeting Date
1	Introduction to DMA Planning/Kickoff Meeting	April 23, 2009
2	Risk Assessment Review	September 24, 2009
3	Goals Development	October 15, 2009
4	Mitigation Strategy Development	October 22, 2009

The kickoff meeting was designed to bring stakeholders together with the intent of developing a Hazard Mitigation Planning Committee who will take responsibility for developing a mitigation plan specific to their jurisdictions, to present information on the scope and purpose of a mitigation plan, what the participation requirements of the HMPC members are, and the proposed project work plan and schedule. A plan for public involvement (Step 2) and coordination with other agencies and departments (Step 3) were discussed. A preliminary introduction to hazard identification for the county and its municipalities was given where attendees could comment and refine the focus. An AMEC data collection tool was presented and distributed as a guide for the collection of pertinent initial information needed to support the first phases of plan development. Each represented jurisdiction was responsible for returning data on historic hazard events, at risk locations, vulnerabilities, and existing planning mechanisms that could strengthen mitigation capabilities.

Planning Step 2: Involve the Public

Involving the public assures support from the community at large and is a part of the planning process. A Public Participation Plan (PPP) was developed early in the planning process and is attached as Appendix E. The PPP captures ideas for ways the public could be involved in the process, as suggested by HMPC members at the kick off meeting, and outlines the public participation strategy. The public participation strategy relies upon several input tools for different circumstances to gather public input. Individual surveys, personal discussions, regional town hall meetings, local public television newscasts, and public meetings were used, each with a purpose, be it to gather data, hear opinions, help determine recommendations, or guide the plan process. A mitigation planning backgrounder geared towards the public was created during the planning process. This was used as a handout a public meetings, and was also posted on the project website.

A public town hall meeting was conducted in the unincorporated Jefferson County area of Conifer on November 18, 2009, at which approximately 50 citizens attended. Announcements of the town hall meeting had been distributed well in advance through the local newspaper and over email to residents and businesses. The purpose of the meeting was to introduce the community to the mitigation planning process the county and its municipalities were undertaking and the progress to date with a review of the risk assessment findings. State Senator Kopp representing the 22nd Senatorial District of Colorado and State House Representative Gerou representing the 25th House District of Colorado were in attendance as well as CDOT and other Jefferson County representatives. Attendance was taken and the meeting was filmed for presentation on the local cable channel so that others not in attendance could view.

Since Jefferson County covers a large area both rural and urban, it was decided that a broader public participation effort was in order. The City of Lakewood has its own news studio, equipped with everything necessary for a newscast. Lakewood facilitated a meeting between AMEC and the producer, who together developed a public announcement newscast describing the ongoing mitigation planning efforts. The newscast displayed the project website URL and

AMEC contact information for the public response and comment. Then the newscast was recorded on a DVD and shared with other municipalities to broadcast on their local cable channel. It was broadcast on KLTV Lakewood Channel 8 from September to November 2009. This style of public engagement allowed for a broader dissemination of information raising the level of awareness about mitigation to neighboring communities, businesses, non-profits and academia, as well as to the typical viewer. A final public meeting occurred during the draft review stage. This meeting was held January 14, 2010 at the Jefferson County Administration Building, Room 1554, following an announcement of the availability of the public review draft. The meeting introduced the draft plan to the public, announced the public comment period, and how to provide feedback. Unfortunately there were no public attendees, but seven (7) HMPC members were present and provided additional comments on the draft. The draft plan was advertised through the Jefferson County public information channels, which included an electronic copy at each of the Jefferson County Library branches, posted on the project website for a two and a half week review period in late January, and directly hyperlinked from the Jefferson County Website. No comments were received from the public review period. However extensive comments were received from certain HMPC members, particularly Robert D. Jarrett, Ph.D. National Research Program Paleohydrology and Climate Change of the United States Geological Survey, who thoroughly reviewed the document and commented from the perspective of both a stakeholder/scientist and that of a Jefferson County resident; and Kevin G. Stewart, P.E., Manager of the Information Services and Flood Warning Program for the Urban Drainage Flood Control District. Many of these comments were related to technical accuracies on the flood hazard profile. Most comments were integrated to improve the technical accuracy of the plan or add supplemental information. In addition Jefferson County staff provided significant review and revision comments that were incorporated to improve technical accuracy or clarify elements of the plan.

The public meetings schedule is recounted in Table 3.4.

Table 3.4 Schedule of Public Meetings

Public Meeting	Meeting Topic	Meeting Date
1	Conifer Town Hall meeting	Nov. 18, 2009
2	Public news broadcast	Nov 2009 through Jan 2010
3	Presentation of draft plan	January 14, 2010

Planning Step 3: Coordinate with Other Departments and Agencies

Early in the planning process, state, federal, and local agencies and organizations were invited to participate as stakeholders in the process. Stakeholders could participate in various ways, either by contributing input at HMPC meetings, being aware of planning activities through an email

group, providing information to support the effort, or reviewing and commenting on the draft plan. Based on their involvement in other hazard mitigation planning efforts, status in the County, and interest as a neighboring jurisdiction, representatives from the following agencies were invited to participate as stakeholders in the process:

- Colorado Geological Survey*
- Colorado State Forest Service
- Colorado Water Conservation Board
- Colorado Department of Transportation*
- Colorado Division of Emergency Management*+
- Colorado State Parks
- Denver Water
- Denver Regional Council of Governments (DRCOG)
- Jefferson County Airport
- Jefferson County Fire Chiefs' Association
- Xcel Energy
- Qwest
- Lockheed Martin
- National Weather Service
- FEMA Region VIII*
- Regional Transportation District
- United States Geological Survey*+
- United States Forest Service
- Urban Drainage and Flood Control District*+

* Participated at HMPC meetings
+Provided comment on the draft plan

Other Community Planning Efforts and Hazard Mitigation Activities

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

- Jefferson County Master Plan
- Jefferson County Comprehensive Land Use Plan

- Jefferson County Open Space Master Plan
- Individual Community's Land Use Plans
    - Conifer/285 Corridor Area Community Plan
    - Central Plains Community Plan
    - Central Mountains Community Plan
    - Clear Creek/I-76 Plans Evergreen Area Community Plan
    - Indian hills community plan
    - South Jefferson County Community Plan
    - North Mountains Community plan
    - The North Plains Community Plan
    - Jefferson County Telecommunications Land use Plan
    - Mineral Extraction Policy plan
    - Sanitary Landfill Plan Policy Summary
- Individual Community Wildfire Protection Plans
- Jefferson County Land Development Regulation
- Jefferson County Zoning Resolution
- Jefferson County Floodplain Regulations
- Small Site Erosion Control Manual
- Construction/Land Disturbance Activities
- Jefferson County Roadway Design and Construction Manual
- Denver Regional Council of Governments Hazard Mitigation Plan
- The State of Colorado Natural Hazards Mitigation Plan 2008
- Colorado Drought Mitigation & Response Plan 2007
- City of Arvada Comprehensive Plan
- City of Arvada Sustainable Action Plan (ASAP)
- City of Arvada Land Development Code
- City of Arvada Parks and Open Space Master Plan
- City of Lakewood Community Resources Master Plan
- City of Lakewood Comprehensive Plan
- City of Lakewood Zoning Ordinance/Floodplain Management
- City of Wheat Ridge Strategic Plan
- City of Wheat Ridge Comprehensive Plan
- City of Wheat Ridge Parks and Recreation Master Plan
- City of Wheat Ridge Zoning and Development Code
- City of Golden Comprehensive Plan
- City of Golden Land Use Plan
- City of Edgewater Master Plan
- Town of Morrison Ordinances
- Town of Mountain View Master Plan

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

3.2.2 Phase 2: Assess Risks

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

AMEC led the HMPC in an exhaustive research effort to identify and document all the hazards that have, or could, impact the planning area. Data collection worksheets were used in this effort to aid in determining hazards and vulnerabilities and where risk varies across the planning area. Geographic information systems (GIS) were used to display, analyze, and quantify hazards and vulnerabilities. The HMPC also conducted a capability assessment 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 and capability assessment process and the results are included in Chapter 4 Risk Assessment.

3.2.3 Phase 3: Develop the Mitigation Plan

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

AMEC facilitated discussion sessions using brainstorming techniques with the HMPC that described the purpose and the process of developing planning goals and objectives, a comprehensive range of mitigation alternatives, and a method of selecting and defending recommended mitigation actions using a series of selection criteria. The results of this collaborative process are captured in Chapter 5 Mitigation Strategy.

Planning Step 8: Draft an Action Plan

Based on input from the HMPC regarding the draft risk assessment and the goals and activities identified in Planning Steps 6 and 7, AMEC produced a complete first draft of the plan. This complete draft was posted for HMPC review and comment on the project website. 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. AMEC 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 Emergency Management and FEMA Region VIII to review and approve, contingent upon final adoption by the governing boards of each participating jurisdiction.

3.2.4 Phase 4: Implement the Plan and Monitor Progress

Planning Step 9: Adopt the Plan

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

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

The true worth of any mitigation plan is in the effectiveness of its implementation. Up to this point in the planning process, all of the HMPC's efforts have been directed at researching data, coordinating input from participating entities, and developing appropriate mitigation actions. Each recommended action includes key descriptors, such as a lead manager and possible funding sources, to help initiate implementation. An overall implementation strategy is described in Chapter 7 Plan Implementation and Maintenance.

Finally, there are numerous organizations within the Jefferson County planning area whose goals and interests interface with hazard mitigation. Coordination with these other planning efforts, as addressed in Planning Step 3, is vital to the ongoing success of this plan and mitigation in Jefferson County and is addressed further in Chapter 7. A plan update and maintenance schedule and a strategy for continued public involvement are also included in Chapter 7.

4. RISK ASSESSMENT

44 C.F.R. 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 the 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.

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

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

This risk assessment followed the methodology described in the FEMA publication Understanding Your Risks—Identifying Hazards and Estimating Losses (2002), which breaks the assessment down to a four-step process:

1. Identify Hazards
2. Profile Hazard Events
3. Inventory Assets
4. Estimate Losses

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

- **Section 4.1 Hazard Identification** identifies the hazards that threaten the planning area and describes why some hazards have been omitted from further consideration.
- **Section 4.2 Hazard Profiles** discusses the threat to the planning area and describes previous occurrences of hazard events and the likelihood of future occurrences.
- **Section 4.3 Vulnerability Assessment** assesses the County's total exposure to natural hazards, considering assets at risk, critical facilities, evaluates where risks vary by jurisdiction within the planning area and future development trends.
- **Section 4.4 Capabilities Assessment** inventories existing mitigation activities and policies, regulations, and plans that pertain to mitigation and can affect net vulnerability.
- **Jurisdictional Annexes** discusses each participating jurisdiction's individual exposure to natural hazards, including an asset inventory. While not required by FEMA, the Hazard Mitigation Planning Committee (HMPC) also conducted a mitigation capability assessment, which inventoried existing mitigation activities and existing policies, regulations, and plans that pertain to mitigation and can affect net vulnerability. The findings from this undertaking are in the respective jurisdictional annexes.

4.1 Hazard Identification

Requirement §201.6(c)(2)(i): [The risk assessment shall include a] description of the type…of all natural hazards that can affect the jurisdiction.

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

4.1.1 Results and Methodology

Using existing hazards data, plans from participating jurisdictions, and input gained through planning and public meetings, the HMPC agreed upon a list of hazards that could affect Jefferson County. Hazards data from FEMA, the Colorado Division of Emergency Management (including the State of Colorado Natural Hazards Mitigation Plan), the National Oceanic and Atmospheric Administration, the Spatial Hazard Events and Losses Database for the United States (SHELDUS), and many other sources were examined to assess the significance of these hazards to the planning area. The hazards evaluated in this plan include those that have occurred historically or have the potential to cause significant human and/or monetary losses in the future.

The following hazards, listed alphabetically, were identified and investigated for the Jefferson County Multi-Hazard Mitigation Plan:

- Avalanche
- Dam Failure
- Drought
- Earthquake
- Erosion and Deposition
- Expansive Soils
- Extreme Temperatures
- Flood
- Hailstorm
- Landslides/Debris Flows/Rockfalls
- Lightning
- Severe Winter Storms
- Subsidence
- Tornado
- Wildfire
- Windstorm

Each of the hazards was identified based on geographic extent, previous occurrences, potential for future occurrence, and a discussion on the potential severity and magnitude of the event. Once these elements were examined, each hazard was assigned an overall rating for the County. The more significant hazards (high or medium overall ratings) have a more detailed hazard

profile in this section and are analyzed further in **Section 4.3 Vulnerability Assessment** to the extent possible. Low hazards are profiled in a little less detail in this section, with an explanation of potential impact and vulnerability. In some cases, the overall significance of the hazard may vary between jurisdictions. The jurisdictional annexes provide more explicit detail to explain the variance levels.

As part of the initial hazard identification process, members of the HMPC used a hazards worksheet to identify and rate the significance of a variety of possible hazards. Significance was measured in general terms, focusing on key criteria such as the geographic extent of the hazard, the probability of an event occurring, and the likely magnitude and severity levels. **Table F.1** in Appendix F shows the results of the preliminary hazard identification worksheet.

4.1.2 Hazard Identification Summary

Table 4.1 reflects the hazard identification summaries discussed in detail in the rest of this section. The table is based on the Jefferson County Hazards Identification Worksheet but also reflects the input from the HMPC to address magnitude and severity, which in some cases altered the overall rating of the hazard compared to the other hazards profiled. It is particularly important to remember, when viewing these ratings, that the hazards are all possible in the planning area, and therefore are potentially dangerous. The overall rating, then, is not a reflection of significance but a method of prioritizing hazards relative to one another for the development of mitigation actions and goals.

Other differences between the tables include the final assessment of hazards to include or the deletion of irrelevant profiles. For example, Table 4.2 only examines dam failures, as no levees were reported in Jefferson County. Extreme Heat has been changed to Extreme Temperatures, as the effects of severe cold were also profiled. Fog was removed after discussion with the HMPC, which determined that it is not a true disaster-level hazard for the planning area. The volcano hazard was also removed due to the extraordinary circumstances required for such a disaster event to severely impact the planning area.

Table 4.1 Hazards Identification Summary

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

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

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

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

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

4.1.3 Disaster Declaration History

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

The federal government may issue a disaster declaration through FEMA, the U.S. Department of Agriculture (USDA), and/or the Small Business Administration (SBA). FEMA also issues emergency declarations, which are more limited in scope and without the long-term federal recovery programs of major disaster declarations. The quantity and types of damage are the determining factors.

A USDA declaration will result in the implementation of the Emergency Loan Program through the Farm Services Agency. This program enables eligible farmers and ranchers in the affected county as well as contiguous counties to apply for low interest loans. A USDA declaration will automatically follow a major disaster declaration for counties designated major disaster areas and those that are contiguous to declared counties, including those that are across state lines. As part of an agreement with the USDA, the SBA offers low interest loans for eligible businesses that suffer economic losses in declared and contiguous counties that have been declared by the USDA. These loans are referred to as Economic Injury Disaster Loans.

Table 4.2 provides information on federal emergencies and disasters declared in Jefferson County between 1953 and December 2007. An asterisk (*) indicates that Jefferson County was included in the declaration but did not receive funding.

Table 4.2 Jefferson County Disaster and Emergency Declarations, 1953-2007

Year	Declaring Jurisdiction	Disaster Type
1969	Federal Disaster Declaration	Severe Storms and Flooding
1973	Federal Disaster Declaration	Heavy Rains, Snowmelt
2002	Fire Management Assistance Declaration	Schoonover Fire
2002	Fire Management Assistance Declaration	Black Mountain Fire
2002	Fire Management Assistance Declaration	Snaking Fire
2002	Fire Management Assistance Declaration	Hayman Fire
2003	Emergency Declaration	Snow
2005	Emergency Declaration	Hurricane Katrina Evacuation*
2007	Emergency Declaration	Snow

Source: State of Colorado Natural Hazard Mitigation Plan, 2004; Federal Emergency Management Agency, PERI Presidential Disaster Declaration Site. U.S. Department of Agriculture

4.1.4 Hazards Not Profiled

Other hazards were discussed by the HMPC but ultimately not included in this plan. Thunderstorm is not identified as an individual hazard, but is recognized for its role in the flood, lightning, and windstorm hazards, and addressed accordingly in those hazard profiles. Precipitation, while profiled in the State Hazard Mitigation Plan, is not included as a separate hazard in this document. Instead, the effects of extreme precipitation are profiled in flooding, expansive soils, erosion, landslides, and debris flow hazards. Fog was considered but removed from the list due to a lack of documentation and impact data. Volcanoes were also discussed but ultimately removed from the profile list due to a minor occurrence/impact ratio in the state. Discussions about the Wyoming Caldera were brief and it was determined during the Kickoff Meeting that the response to such a globally-catastrophic event exceeded the scope and scale of this plan. The natural hazards of coastal erosion, coastal storm, hurricane, and tsunami were excluded from this plan because they are not applicable in Jefferson County. After extensive discussion during the kickoff meeting, man-made and technological hazards were also excluded from the scope of this plan, as it focuses on natural hazards. The secondary impacts of natural hazards which may contribute to technological or man-driven hazards, such as a hazardous materials exposure, will be addressed in the applicable vulnerability assessments.

Pandemic flu and other disease events are also not profiled in this plan. While disease is, technically, a naturally occurring hazard, it is greatly impacted by technological and man-driven considerations. For example, the spread of pandemic diseases is, by definition, conducted through sustained peer-to-peer contact and heightened by modern transportation methods such as air travel. In Jefferson County, the concerns for mass care and mass casualty incidents caused by disease are addressed in public health planning efforts. These plans include efforts by the public health departments at a state, county, and local level. In addition to the specific pandemic event plans, they are often closely tied to portions of Emergency Operations Plans, Donations and Volunteer Management efforts, and Continuity of Operation (COOP) or Continuity of Government (COG) plans. Individuals interested in obtaining information on the preparation and prevention of, response to, and recovery from widespread-disease events should contact the Jefferson County Office of Emergency Management or the Jefferson County Department of Public Health for more information.

4.2 Hazard Profiles

Requirement §201.6(c)(2)(i): [The risk assessment shall include a] description of the…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.

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

4.2.1 Profile Methodology

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

Description

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

Geographic Extent

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

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

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

Previous Occurrences

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

Probability of Future Occurrences

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

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

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

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

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

Magnitude and Severity

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

- **Negligible:** Less than 10 percent of property is severely damaged, facilities and services are unavailable for less than 24 hours, injuries and illnesses are treatable with first aid or within the response capability of the jurisdiction.

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

The rating is calculated by evaluating the event of record against these criteria. Since most events incur different levels of severity for each element, the rating is assigned to the classification with the most documented occurrences. For example, assume an F3 tornado is the event of record. This event caused limited damage to services and facilities but strained the medical capacity of the jurisdiction, caused critical property damage, and killed one person. The event would be calculated as critical, even though elements also fell into both the limited and catastrophic categories. The purpose of a magnitude and severity rating is to establish the highest known potential threshold of an event to help guide the mitigation goals and actions development. If there are significant events with much lower magnitude and severity ratings than the event of record, this discrepancy will be noted.

Overall Hazard Significance

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

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

4.2.2 Avalanche

Description

Avalanche hazards occur predominantly in the mountainous regions of Colorado above 8,000 feet. The vast majority of avalanches occur during and shortly after winter storms. Avalanches occur when loading of new snow increases stress at a rate faster than strength develops, and the slope fails. Critical stresses develop more quickly on steeper slopes and where deposition of wind-transported snow is common.

The combination of steep slopes, abundant snow, weather, snowpack, and an impetus to cause movement create an avalanching episode. According to the Colorado Avalanche Information Center (CAIC), about 90 percent of all avalanches start on slopes of 30-45 degrees, and that increases to about 98 percent in the slope range of 25-50 degrees. Avalanches release most often on slopes above timberline that face away from prevailing winds (leeward slopes collect snow blowing from the windward sides of ridges). Avalanches can also run on small slopes well below timberline, such as gullies, road cuts, and small openings in the trees. Very dense trees can anchor the snow to steep slopes and prevent avalanches from starting; however, avalanches can release and travel through a moderately dense forest. An average-sized avalanche travels around 80 mph; the typical range of impact pressure from an avalanche is from 0.5 to 5.0 tons per square foot.

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

The 2008 State Hazard Mitigation Plan indicates that between the winter of 1950/1951 and 2005/2006, Colorado suffered the highest number of avalanche fatalities in the United States. This hazard generally affects climbers, backcountry skiers, snowmobilers, and skiers and snowboarders. A smaller number of motorists along highways are also at risk of injury and death due to avalanches, as are residents who live in avalanche-prone areas and other individuals working in those areas. Road and highway closures, damaged structures, and destruction of forests are also a direct result of avalanches. Some residents may live in areas prone to avalanches, and may be impacted directly if an avalanche occurs on their property, or indirectly if an avalanche limits or removes accessibility to the property, both for the resident(s) and for emergency response personnel. Recognizing areas prone to avalanches is critical in determining the nature and type of development allowed in a given area.

Geographic Extent

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

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

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

Previous Occurrences

The National Climactic Data Center does not track avalanche occurrences. The 2009 State Hazard Mitigation Plan indicates that over 100,000 avalanches occur yearly, but less than 10,000 are reported. The Colorado Avalanche Information Center (CAIC) database recorded 95 occurrences in the State between late 1996 and early 2009. However, the database only captures accidents with unusual circumstances, fatalities, and injuries, and therefore represents only a fraction of occurrences.

There are no known previous occurrences of avalanches in the planning area. However, there have been many occurrences in neighboring Clear Creek County, which have impacts on Jefferson County. Clear Creek County falls almost entirely in the Front Range forecast zone, with the western-most area falling into the Vail-Summit forecast zone. (These zones are explained in the ‘geographic extent’ section below.) Impacts from avalanches as far away as Summit County may also impact Jefferson County. Avalanches along the I-70 corridor and U.S. Highway 6 threaten transportation routes into Jefferson County from the Western Slope, and may threaten water supplies for downstream residents by jamming creeks, damaging dams, or

destroying infrastructure. Since there are no recorded avalanche events for the planning area, several previous occurrences which indirectly impacted the planning area are recounted below. These occurrences help establish the threat of secondary impacts of avalanches on Front Range counties.

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

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

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

In addition, the Denver Regional Council of Government (DRCOG) Natural Hazard Mitigation Plan from 2003, in which Jefferson County previously participated, noted that the CIAC recorded 16 avalanche events with 8 injuries and 10 deaths in the planning area.[1]

Probability of Future Occurrences

There have been no known incidents in Jefferson County, thus it is difficult to calculate a recurrence interval. The methodology for calculating the probability of future occurrences is described in Section 4.2.1. This formula evaluates that the probability of an avalanche occurring in any given year in Jefferson County is 0%. This corresponds to a probability of future occurrences rating of **unlikely**.

This methodology relies on previous occurrences over a significant period of record to make an estimate based on averages. Where no data is available, as is the case with avalanches in Jefferson County, there is a danger that the 0% probability rating may be incorrectly interpreted to reflect a non-occurrence potential in the region. In fact, this rating merely indicates that the

[1] The DRCOG Natural Hazard Mitigation Plan (2003) participants included the counties of Adams, Arapahoe, Boulder, Broomfield, Clear Creek, Denver, Douglas, Gilpin and Jefferson Counties. With the exception of Elbert County, this coincides with the North Central All-Hazards Region, which is one of nine emergency preparedness and response regions in the State of Colorado. The DRCOG plan is being updated during the same timeframe as the development of this planning document. (Summer/Fall 2009). The DRCOG plan is available online at http://www.dola.state.co.us/dem/mitigation/localpdm_plans.htm.

hazard is not *probable*. This plan operates on the assumption that all hazards profiled in this section, due to the topography and climatology of the planning area, are *possible*. When future events of avalanches in the planning area are recorded, this prediction model should be updated.

Magnitude and Severity

According to the Colorado Avalanche Information Center (CAIC), there have been no reported deaths in Jefferson County due to avalanches between 1950 and 2007.[2] This corresponds to the 0 known avalanche events in the planning area as well. In addition, indirect impacts of avalanches on the planning area, such as economic losses due to road closures, are a matter of speculation rather than quantifiable data. With no reported damage amounts and no impact to the operation and delivery of critical services and functions it is difficult to consider the hazard very severe.

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

Overall Hazard Significance

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

4.2.3 Dam Failure

Description

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

[2] http://avalanche.state.co.us/pub/accidents_stats.php

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

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

Dam failure occurs when the retention function of the dam is compromised, in part or in its entirety. Damage to a dam structure that may result in a failure may be caused by many sources. Possible damages include poor maintenance, age, animal incursion (particularly in earthen dams), erosion, and damages sustained as a result of seismological activity. A dam failure is not the only type of emergency associated with dams. Spillway discharges that are large enough to cause flooding in downstream areas or flooding upstream of dams due to backwater effects or high pool levels are both considered dam emergencies and may cause significant property damage and loss of life.[3]

Dam failures result in a unique source of flash flooding, when a large amount of previously detained water is suddenly released into a previously dry area due to a failure in some way of the dam. Dams are classified into four classes. The 2008 State Hazard Mitigation Plan defines Class I (High Hazard) dams as those rated based on an expected loss of human life, should the dam fail, and Class II (Significant Hazard) dams as those rated based on expected significant damage, but not loss of human life. Significant damage refers to structural damage where humans live, work, or recreate; or public or private facilities exclusive of unpaved roads and picnic areas. Damage refers to making the structures inhabitable or inoperable.[4]

Privately owned Class I and II dams are required by Colorado regulations to have Emergency Action Plans (EAPs) in place.[5] Class I dams are required to have inundation maps as well. Federally-owned Class I dams are also required to have EAPs by Federal Regulations.[6] According to the 2008 State Hazard Mitigation Plan, all high-hazard dams in Colorado have EAPs in place, which provide for the emergency response procedures in the event of a dam emergency event. According to the National Performance of Dams Program (NPDP) database,

[3] US Army Corps of Engineers *Flood Emergency Plans: Guidelines for Corps Dams*. Hydrologic Engineering Center, (June 1980) p 4.
[4] Colorado Office of Emergency Management, *2008 Colorado State Hazard Mitigation Plan*, p Hazards-54.
[5] Further information regarding the regulations governing dams in the State of Colorado can be found in the "Guide to Construction and Administration of Dams in Colorado", available online at http://water.state.co.us/damsafety/damguide.pdf.
[6] Dam Operations Management Policy, ER 1130-2-419.

housed in the Department of Civil and Environmental Engineering at Stanford University, there are 318 Class I dams in Colorado.[7]

Levees are defined by the Army Corps of Engineers as "earthen embankments whose primary purpose is to furnish flood protection from seasonal high water for a few days or weeks a year. Levees are broadly classified as either urban or agricultural because of different requirements from each."[8] Riverine levees are those built to protect from flooding of river ways, whereas coastal levees are those built to protect from coastal water flooding. Levee failures can occur when a flood occurs that exceeds the designed level of protection. In this case the levee may fail or be overtopped. Levees that are not maintained are at risk from failure due to erosion, rodent activity, or piping along roots from vegetation growing on the levee. According to the Colorado Levee Report dated February 2009 and the Jefferson County HMPC, there are no levees in the planning area.

Jefferson County contains 91 dams: 22 high hazard, 18 significant hazard and 52 low hazard dams.[9] In addition, there are communities inside Jefferson County that are at risk to dam failures outside of the County. A list of the high and significant hazard dams is located in Table 4.4.

Geographic Extent

According to information provided by the Jefferson County Office of Emergency Management, there are 22 high hazard dams and 18 significant hazard dams in Jefferson County. These dams are listed in Table 4.3 by hazard potential, and then alphabetically. Figure 4.1 shows where these dams are located within the County, with a more focused view presented in Figure 4.2.

Table 4.3 High and Significant Hazard Dams in Jefferson County[10]

Name	Dam ID	River/ Stream	Downstream City	Rating	Dam Owner
Bear Creek	090112	Bear Creek	Lakewood	I	U.S. Army Corps of Engineers
Bergen East	090104	Weaver Gulch	Lakewood	I	Bergen Ditch & Reservoir Company
Blunn (aka Arvada)	070302	Ralston Creek	Arvada	I	City Of Arvada
Chatfield	080324	South Platte River	Littleton	I	U.S. Army Corps Of Engineers
East	075309	Weir Gulch	Lakewood	I	Agricultural Ditch & Reservoir Company
Evergreen	090111	Bear Creek	Evergreen	I	Evergreen Metropolitan District

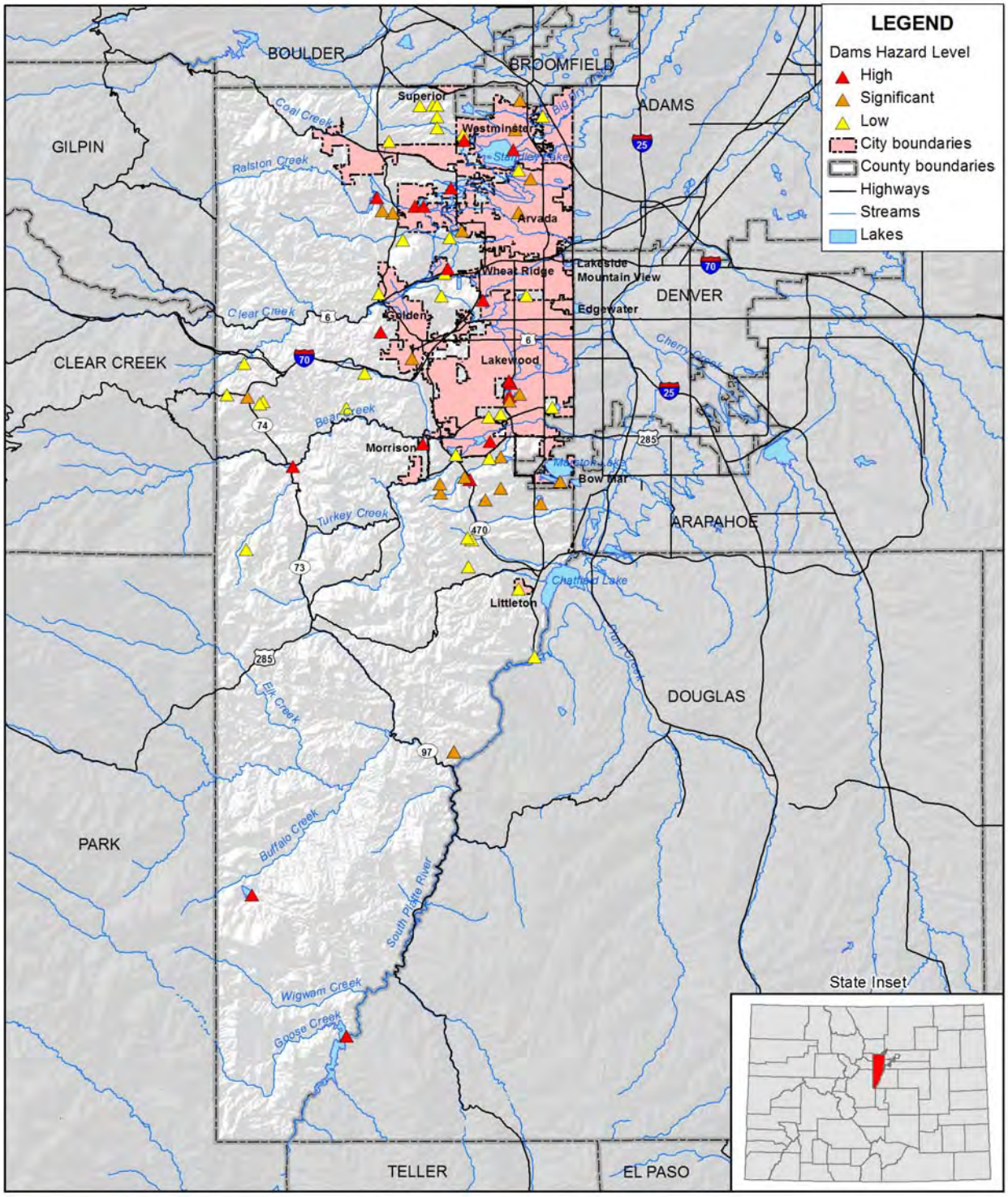
[7] National Performance of Dams Program, *DPDP Dams Directory*. Available online at http://npdp.stanford.edu/npdphome/damdir.htm last accessed July 13, 2009.
[8] U.S. Army Corps of Engineers, *Levees Website: Last Updated October 16, 2007*. Available online at http://www.mvm.usace.army.mil/floodcontrol/levees/levees.htm, last accessed July 13, 2009.
[9] This information is provided by the Jefferson County Office of Emergency Management.
[10] This information is provided from the Jefferson County Office of Emergency Management

Name	Dam ID	River/ Stream	Downstream City	Rating	Dam Owner
Fairmount Reservoir	070312	Clear Creek	Wheat Ridge	I	Consolidated Mutual Water Co.
Fortune	020635			I	Consolidated Mutual Water Co.
Great Western	020212	Walnut Creek	Westminster	I	City Of Broomfield
Leyden	070209	Leyden Creek	Arvada	I	City Of Arvada
Lookout Mountain	070104	Clear Creek	Golden	I	Lookout Mountain Water District
Main	075310	Weir Gulch	Lakewood	I	Agricultural Ditch & Reservoir Company
Maple Grove	070219	Lena Gulch	Lakewood	I	Consolidated Mutual Water Co.
Morrison Raw Water	090208	Bear Creek	Morrison	I	Town Of Morrison
Ralston	070224	Ralston Creek	Arvada	I	Denver Board Of Water Commissioners
Smith	075311	Bear Creek	Lakewood	I	Agricultural Ditch & Reservoir Company
Standley Lake	020326	Big Dry Creek	Westminster	I	Farmers Reservoir And Irrigation Company
Tucker Lake	070232	Ralston Creek	Arvada	I	Denver View Reservoir & Irrigation Co.
Wellington	800116	S. Fork Buffalo Creek	Buffalo Creek	I	Wellington Reservoir Co.
Willow Springs #1	090204	Turkey Creek	Lakewood	I	Red Rocks Country Club
Woman Creek	020633	Woman Creek	Westminster	I	Woman Creek Reservoir Authority
Welton Reservoir*	unknown		Arvada	I	
Beers Sisters Lake	090102	S. Platte River	Littleton	II	Foothills Recreation District
Bergen West	090105	Weaver Gulch	Lakewood	II	Bergen Ditch & Reservoir Company
Bowles #1	090109	South Platte River	Bowmar	II	Joseph Bowles Reservoir Co.
Carmody	090110	Sanderson Gulch	Lakewood	II	City Of Lakewood
Harriman	090115	Weaver Creek	Lakewood	II	Denver Board Of Water Commissioners
Harwood's Storage Reservoir	090117	Weaver Gulch	Lakewood	II	Red Rocks Country Club
Hyatt	070136	Van Bibber Creek	Arvada	II	Farmers Highline Canal & Reservoir Co.
Johnston	095220	Lilley Gulch	Littleton	II	Foothills Recreation District

Name	Dam ID	River/ Stream	Downstream City	Rating	Dam Owner
Kendrick	095223	Sanderson Gulch	Lakewood	II	City Of Lakewood
Ketner	020226	Walnut Creek	Westminster	II	City Of Westminster
Lockport	090217	Troublesome Creek	Kittredge	II	Evergreen Parks & Recreation District
Lower Long Lake	070115	Ralston Creek	Arvada	II	Denver Board Of Water Commissioners
Magic Mountain #1	070214	Apex Gulch	Pleasant view	II	Eagle Admixtures Ltd
Oberon Lake No. 1	070220	Ralston Creek	Arvada	II	Oberon Water Co.
Polly A. Deane	090131	Dutch Creek	Littleton	II	Bergen Ditch & Reservoir Company
Pomona No. 2 And No. 3	070223	Little Dry Creek	Arvada	II	City Of Arvada
Strontia Springs	02219	South Platte	Littleton	II	Denver Board of Water Commissioners
Upper Church Lake	060220	Big Dry Creek	Broomfield	II	Jefferson County Airport
Upper Long Lake	070114	Ralston Creek	Arvada	II	Denver Board Of Water Commissioners

* Reservoir was identified in planning process, but not in HAZUS database or on list from Jefferson County Emergency Management.

Figure 4.1. High and Significant Hazard Dams in Jefferson County



amec

0 5 10 Miles

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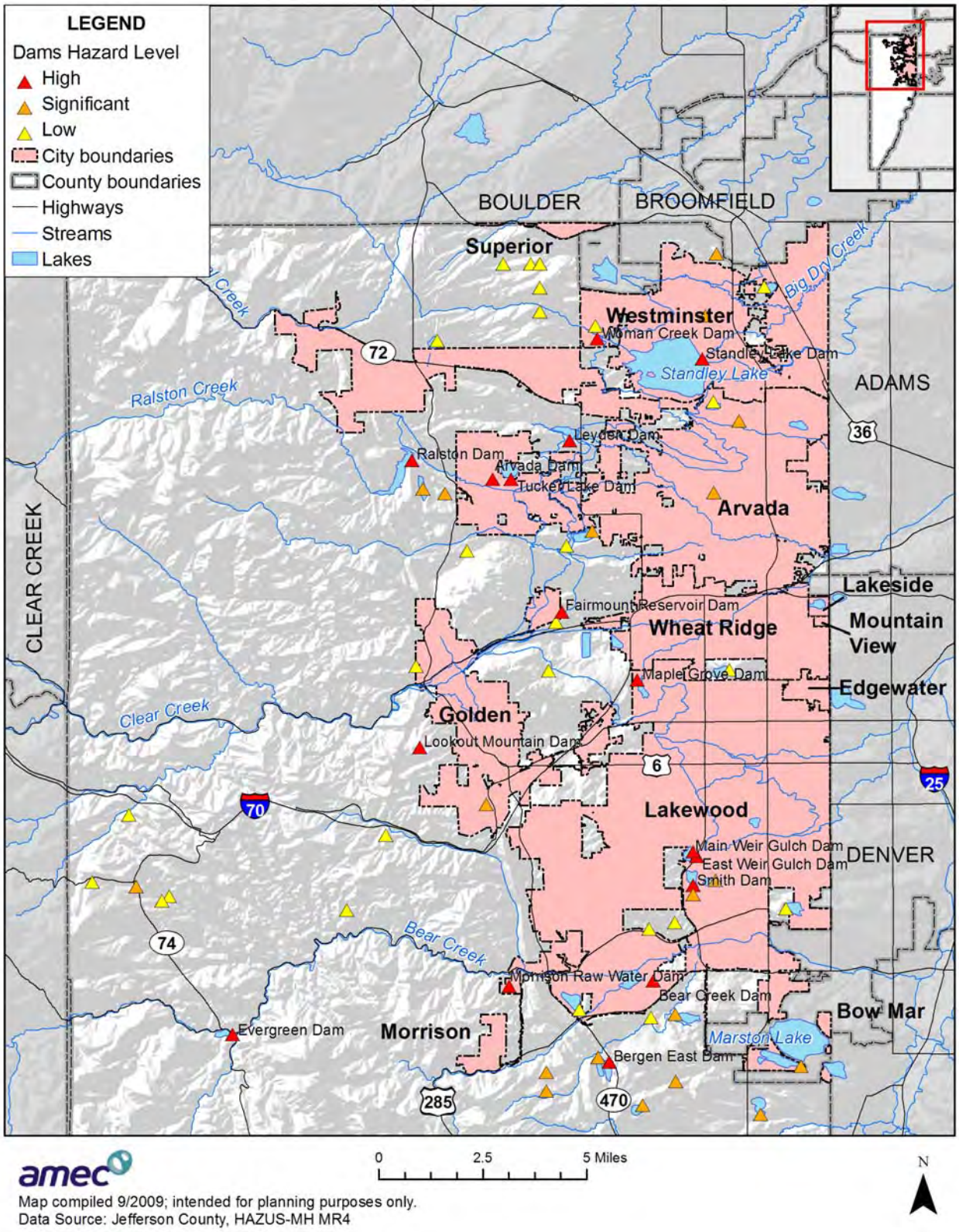
Map compiled 10/2009; intended for planning purposes only.
Data Source: Jefferson County, HAZUS-MH MR4

Figure 4.2. High and Significant Hazard Dams in Jefferson County (North Focus Map)



This record indicates that a large portion of the County and County population centers, certainly more than 25%, are exposed to potential dam failures. For example, in a failure of **Ralston Reservoir Dam** and **Blunn Dam** at Arvada Reservoir, almost 5% of the County would be impacted. Even if only 2% of the County were vulnerable to any given dam failure, this equates to an overall geographic extent of 42% for just high-hazard dams.

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

Previous Occurrences

While there are numerous dams in Jefferson County, there have only been four incidents reported to the National Performance of Dams database housed at Stanford University. Those incidents are recorded below. Specifics related to these dam failures are not available, but a brief profile of the anticipated impacts for dam failures for the high hazard dams, based on the contents of the dam emergency action plans (EAP) is discussed.

Table 4.4 Jefferson County Dam Failure Events

Date	Dam Name	Waterway	Nearest Town	Dam Class	Event	Failure?
1952	Clear Lake*	Clear Creek	Georgetown	Class II (significant)	Inflow flood-hydrologic event	Yes
1974	Oberon Lake No. 1	Ralston Creek	Arvada	Class II (significant)	Inflow flood-hydrologic event	Yes
February 1979	Maple Grove	Lena Gulch	Lakewood, Wheat Ridge	Class I (high)	Vandalism	Yes
January 1993	Standley Lake	Big Dry Creek	Westminster	Class I (high)	Reservoir-Wind Waves	No
April 1998	Fairmount	Clear Creek	Wheat Ridge	Class I (high)	Reservoir Incident	No

* This dam is located in Clear Creek County, but the dam failure affected the City of Golden in Jefferson County

Maple Grove: The dam, which reaches 41′ in height and covers a surface area of 50.27 acres, has a capacity of 1,103 acre feet. According to the dam's EAP, flooding from this dam is anticipated to reach the nearest home in less than three minutes, which indicates that warning time for evacuations from a failure is minimal. Two major hospitals are within five miles of the site, but no major critical infrastructure facilities are within the predicted floodplain of a dam failure. However, numerous private structures are expected to be damaged or destroyed by a failure of this dam. Other potentially impacted structures include the Wheat Ridge Recreation Center, numerous roadways, pedestrian bridges, and open park spaces. The dam is part of the Lena Gulch Flood Warning Plan.

Standley Lake: This earthen dam has a height of 123′ and an unspecified surface area and capacity. According to the dam's EAP, the areas directly impacted by a dam failure are Wadsworth Boulevard just south of 100 Ave., the Union Pacific Railroad tracks south of 100 Ave, housing developments in unincorporated Jefferson County south of 100 Ave. between Wadsworth By-Pass and Old Wadsworth Blvd, and the area just north and south of 100 Ave. in

Westminster. The Boulder Turnpike (Highway 36) north of 100 Ave. across Sheridan Blvd. in Adams County and down into Denver County would also be impacted. In addition, the dam is protected from contamination from the Rocky Flats facility by Woman Creek Dam. The date of this EAP is May 14, 2009.

Fairmount: This dam is 35′ high and covers a surface area of 38.7 acres. The capacity for the dam is 978.6 acre feet. According to the EAP, flooding from this dam is anticipated to reach the nearest homes in less than three minutes, indicating a minimal warning time. The EAP indicates there are no critical facilities in the floodplain for this dam. The inundation map indicates that Highway 58, railroad tracks, Arapahoe Park, significant portions of Mount Olivet Cemetery, and housing and commercial districts between approximately 48th Avenue and Highway 58 (north to south) and approximately Table Mountain Parkway to Tabor Road north of I-70 (west to east).

Probability of Future Occurrences

There have been 4 incidents in Jefferson County since 1890, or a span of 119 years. (2008-1890 = 119 years). The methodology for calculating the probability of future occurrences is described in Section 4.2.1.This formula evaluates that the probability of a dam failure occurring in any given year is 3.4%. This corresponds to a probability of future occurrences rating of **occasional**.

Magnitude and Severity

In order to calculate a magnitude and severity rating for comparison with other hazards, and to assist in assessing the overall impact of the hazard on the planning area, information from the event of record is used. In some cases, the event of record represents an anticipated worst-case scenario, and in others, it is a reflection of common occurrence. There is no event of record for Jefferson County with a sufficiently detailed profile that allows for a specific discussion on the severity and magnitude of such an event. However, the rating systems utilized in dam classification is a useful measurement for assessing the potential magnitude and severity of a dam failure. In addition, all high-hazard dams in Colorado are required to have Emergency Action Plans (EAPs) that include predicted inundation maps for dam failure scenarios. These tools allow planners to measure the estimated worst-case or event-of-record occurrences for a dam failure. The Jefferson County Office of Emergency Management indicated that the most hazardous dam within the planning area is Ralston Reservoir Dam, so this profile will serve as the hypothetical event of record for this profile. Since the information for the assessment is drawn from the dam's EAP, the results reflect the best estimate of potential affects, rather than those drawn from a known occurrence. As such, the magnitude and severity may vary from the predictions issued here. The intent is to portray the extreme worst case, with the hope that any actual failures in the County will incur lesser impacts.

Based on the inundation maps provided in the dam's EAP, a failure of Ralston Reservoir Dam is estimated to directly impact a 12-mile long path of damage (from the Reservoir to the County line) and an area up to three miles in width. This equates to only approximately 36 square miles, or 4.6% of the total area of the County. However, within that area, floodwaters are anticipated to

arrive within 80 minutes and reach the maximum flood depth in no more than 100 minutes. Maximum flood depths range from 20′ to 27′, indicating that many properties in the inundation areas will be destroyed or severely damaged. The damages inflicted on critical facilities and services (critical infrastructure) may result a loss or disruption of serves for several days and may extend into weeks or longer, depending on the nature of the dam failure. While the inundation maps reflect that the only critical infrastructure located in the inundation area are schools, this impacts the ability of the area to provide shelters and presents potential evacuation challenges if a failure occurred during a school day. The inundation area also includes numerous parks, golf courses, recreation centers, cemeteries, power lines, commercial centers, main roadways and highways, and rail lines.

While no fixed facility hazardous materials sites, police stations, fire stations, or health care facilities are located directly in the inundation area, they would be indirectly impacted by the event, which would not only overwhelm local emergency response capabilities (who would be entirely consumed in the evacuation process and require additional assistance from neighboring counties to assist in both the evacuation and routine calls), but hinder response activities through the direct impacts on roads, bridges and railways.

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

Overall Hazard Significance

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

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

4.2.4 Drought

Description

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

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

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

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

Drought impacts are wide-reaching and may be economic, environmental, and/or societal. The most significant impacts associated with drought in Colorado are those related to water intensive activities such as agriculture, wildfire protection, municipal usage, commerce, tourism, recreation, and wildlife preservation. A reduction of electric power generation and water quality deterioration are also potential problems. Drought conditions can also cause soil to compact and not absorb water well, potentially making an area more susceptible to flash flooding and erosion. A drought may also increase the speed at which dead and fallen trees dry out and become particularly dangerous as fuel sources in wildfires. Drought may also weaken trees in areas already affected by mountain pine beetle infestations, causing more extensive damage to trees

and increasing wildfire risks. An ongoing drought which severely inhibits natural plant growth cycles may increase the susceptibility of the area to wildfire for a period of time. Drought impacts increase with the length of a drought, as carry-over supplies in reservoirs are depleted and water levels in groundwater basins decline.

Geographic Extent

According to the 2008 State Hazard Mitigation Plan, Jefferson County is considered at high risk to drought events. Droughts are regional events on a national level, impacting multiple states simultaneously. Therefore, as the climate of the planning region is fairly continuous, it is reasonable to assume that a drought will impact the entire planning region simultaneously. Based on this information, the geographic extent rating for drought is **extensive**.

Previous Occurrences

The planning area has experienced 6 multi-year droughts since 1893, with the most pronounced being in the 1930s and 1950s. Table 4.5 is from the *Colorado Drought Mitigation & Response Plan (2002).*

Table 4.5 Historical Dry and Wet Periods in Colorado

Date	Dry	Wet	Duration (years)
1893-1905	X		12
1905-1931		X	26
1931-1941	X		10
1941-1951		X	10
1951-1957	X		6
1957-1959		X	2
1963-1965	X		2
1965-1975		X	10
1975-1978	X		3
1979-1996		X	17

Source: 2002 Colorado Drought Mitigation and Response Plan

The *Colorado Drought Mitigation and Response Plan* was last updated in 2007. The update provided the following additional information to the table above, drawn from the 2004 *Drought & Water Supply Assessment* (DWSA):

"The period 2000 through 2003 was a 'significant multi-year statewide drought, with many areas experiencing [the] most severe conditions in Colorado instrumented history.'"[11] The 2007

[11] Colorado Water Conservation Board, *Updated Information Provided in Support of the 2002 Colorado Drought Mitigation and Response Plan*, June 2007. Available online at http://cwcb.state.co.us/NR/rdonlyres/1F537E1C-A4FC-4B8D-A553-7C5D381BA250/0/FinalReportJune2007.pdf last accessed July 13, 2009.

DWSA Update notes that the "effects of Colorado's recent drought (1999-2003) still linger among municipal providers."

However, as of July 2009, the U.S. Seasonal Drought Outlook housed by the Climate Prediction Center indicated that only the southeastern-most portion of Colorado was in a drought cycle and the drought conditions were not anticipated to worsen for the duration of the season.

Jefferson County lies in the South Platte River Basin. Table 4.6, drawn from the 2007 *DWSA*, depicts the extent of drought recovery by water division from the 1999-2003 drought, as reported by municipal water providers for the South Platte River Division.

Table 4.6 River Division Drought Status, 2007

South Platte River Division	
Still in severe drought	4%
About halfway to recovery	18%
Fully recovered, reservoirs are full	67%
Don't know/refused	11%
Total	100%

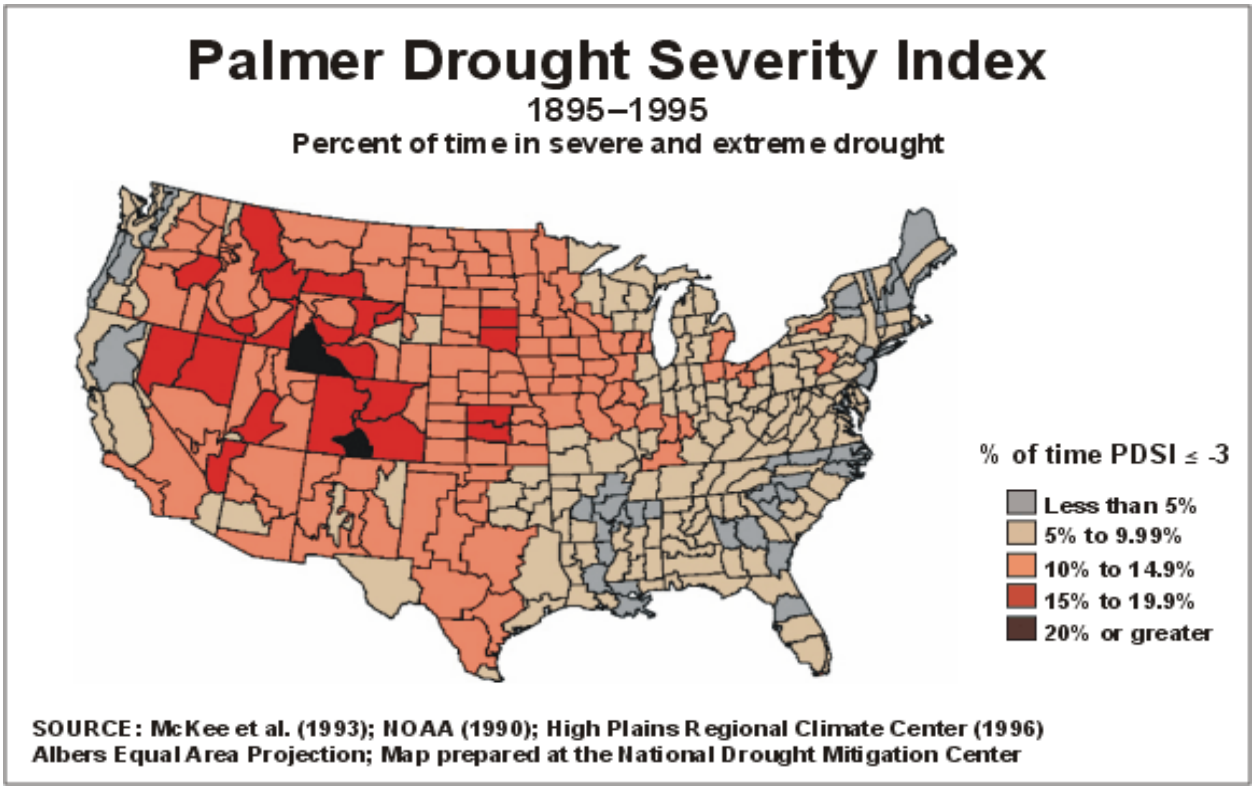
Source: 2007 Drought and Water Supply Assessment

This information indicates that recovery periods from droughts are lengthy, but vary greatly depending on the location of the water resource in question. For Jefferson County, more than half of the water providers in the South Platte River Division reported to be fully recovered at the five-year mark. If the average wet period following a drought is 11.8 years, this indicates that, on average, the counties in the planning area can expect to recover between droughts, but also emphasizes the need for drought mitigation planning.

Probability of Future Occurrences

Figure 4.3, sourced from the National Drought Mitigation Center, shows that Jefferson County and most of Colorado experienced severe or extreme drought 15-19.9 percent of the time over a 100 year period.

Figure 4.3. United States: Percent of Time in Drought, 1895–1995



According to the *2004 Drought Water Supply Assessment*, there have been 6 recorded drought incidents totaling 36 'dry' years which impacted Jefferson County since 1893, or a span of 115 years. (2008-1893 = 115 years). The methodology for calculating the probability of future occurrences is described in Section 4.2.1. This formula evaluates that the probability of a drought occurring in any given year is 31.3%. Both of these data sets correspond to a probability of future occurrences rating for drought of **likely**.

Magnitude and Severity

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

Urban settings house the consumers which must pay higher prices for produce and foodstuffs impacted by the drought conditions. Urban areas are also impacted by rising water costs, which may impact personal property and personal water usage bills. Recreational uses which are water-dependant may increase significantly in price or decrease in availability, particularly those

which are based in reservoirs or lakes, as the water levels may be too low to sustain safe recreation. Finally, the increased risk of wildfires impacts the planning region. While the hazard of fire itself is profiled separately, drought conditions increase the likelihood that wildfires will occur, either naturally or due to human causes.

In order to calculate a magnitude and severity rating for comparison with other hazards, and to assist in assessing the overall impact of the hazard on the planning area, information from the event of record is used. In some cases, the event of record represents an anticipated worst-case scenario, and in others, it is a reflection of common occurrence. The event of record for Jefferson County occurred between 1999 and 2003. The event impacted the entire planning area, although the exact percent of directly-impacted property in the County is not available. Any damages inflicted on critical facilities and services (critical infrastructure) resulted in no loss or disruption of services. There were no directly attributable documented illnesses or injuries and the medical response capability of the County was not impacted. However, the drought seriously impacted water supply levels and water quality, and several severe wildfires, augmented by drought conditions, occurred in the planning area during this time. The impact on the costs of water resulted in significantly higher water billing rates which have not rebounded as of 2009, and some jurisdictions implemented water regulation measures which also extended beyond the drought period.

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

Overall Hazard Significance

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

4.2.5 Earthquake

Description

An earthquake is caused by a sudden slip on a fault. Stresses in the earth's outer layer push the sides of the fault together. Stress builds up and the rocks slip suddenly, releasing energy in waves that travel through the earth's crust and cause the shaking that is felt during an earthquake. The amount of energy released during an earthquake is usually expressed as a Richter magnitude and is measured directly from the earthquake as recorded on seismographs. Another measure of

earthquake severity is intensity. Intensity is an expression of the amount of shaking at any given location on the ground surface as felt by humans or resulting damage to structures and defined in the Modified Mercalli scale (see Table 4.7). Seismic shaking is typically the greatest cause of losses to structures during earthquakes.

Table 4.7 Modified Mercalli Intensity (MMI) Scale

MMI	Felt Intensity
I	Not felt except by a very few people under special conditions. Detected mostly by instruments.
II	Felt by a few people, especially those on upper floors of buildings. Suspended objects may swing.
III	Felt noticeably indoors. Standing automobiles may rock slightly.
IV	Felt by many people indoors, by a few outdoors. At night, some people are awakened. Dishes, windows, and doors rattle.
V	Felt by nearly everyone. Many people are awakened. Some dishes and windows are broken. Unstable objects are overturned.
VI	Felt by everyone. Many people become frightened and run outdoors. Some heavy furniture is moved. Some plaster falls.
VII	Most people are alarmed and run outside. Damage is negligible in buildings of good construction, considerable in buildings of poor construction.
VIII	Damage is slight in specially designed structures, considerable in ordinary buildings, great in poorly built structures. Heavy furniture is overturned.
IX	Damage is considerable in specially designed buildings. Buildings shift from their foundations and partly collapse. Underground pipes are broken.
X	Some well-built wooden structures are destroyed. Most masonry structures are destroyed. The ground is badly cracked. Considerable landslides occur on steep slopes.
XI	Few, if any, masonry structures remain standing. Rails are bent. Broad fissures appear in the ground.
XII	Virtually total destruction. Waves are seen on the ground surface. Objects are thrown in the air.

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

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

Colorado's earthquake hazard is similar to other states in the intermountain west region. It is less than in states like California, Nevada, Washington, and Oregon, but greater than many states in the central and eastern United States. There are many unknowns about the earthquake hazard in Colorado, but the potential does exist for damaging earthquakes.

Geographic Extent

Geological research indicates there are about 100 potentially active faults in Colorado with documented movement within the last 2 million years (Quaternary). The map in Figure 4.8 indicates that potentially active faults exist in the vicinity of Jefferson County that are capable of producing damaging earthquakes. There could be other faults in the state that may have potential for producing future earthquakes that are not known to be hazardous or do not rupture the ground surface.

Previous Occurrences

According to the U.S. Geological Survey (USGS), eastern Colorado is nearly aseismic, with just a few epicenters in the Arkansas and Platte river valleys. Most shocks in the history of Colorado have been centered west of the Rocky Mountain Front Range. The first seismographs in Colorado of sufficient quality to monitor earthquake activity were installed in 1962. Newspaper accounts are the primary source of published data for earthquake events before that time. Figure 4.5 illustrates historic earthquakes and Quaternary faults in Colorado.

More than 400 earthquake tremors of magnitude 2.5 or higher have been recorded in Colorado since 1867. More earthquakes of magnitude 2.5 to 3 probably occurred during that time, but were not recorded because of the sparse distribution of population and limited instrumental coverage in much of the state. For comparison, more than 20,500 similar-sized events have been recorded in California during the same time period. The largest known earthquake in Colorado occurred on November 7, 1882 and had an estimated magnitude of 6.6. The location of this earthquake, which has been the subject of much debate and controversy over the years, is thought to have originated in the northern Front Range west of Fort Collins and north of Estes Park.

Although many of Colorado's earthquakes occurred in mountainous regions of the state, some have been located east of the mountains. The best known Colorado earthquakes were a series of events in the 1960s that were later shown to be triggered by the injection of liquid waste into a deep borehole at the Rocky Mountain Arsenal northeast of Denver. Twelve of the "Rocky Mountain Arsenal" earthquakes caused damage, including a magnitude 5.3 earthquake on August 9, 1967 that resulted in more than a million dollars in damage in Denver and the northern suburbs. This series of earthquakes continued for about ten years and was followed by about six years of inactivity that coincided with the cessation of fluid waste injections. Earthquake activity resumed in the northeast Denver area in 1978, including a magnitude 4.3 event on April 2, 1981.

These and other notable earthquakes affecting Jefferson County include:

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

September 29, 1965 – A magnitude 4.7 earthquake epicentered near Arvada shook the northern metro area and cracked plaster and windows.[12]

February 16, 1965 – A magnitude 4.6 located in northeastern Jefferson County – no further information.[13]

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

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

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

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

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

May 23, 1970 – A magnitude 4.1 earthquake struck northeastern Jefferson County on County line – no further information. [14]

[12] Colorado Geologic Survey (CGS) Colorado Late Cenozoic Fault, Fold and Earthquake database

[13] Ibid.

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

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

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

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

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

[14] CGS Colorado Late Cenozoic Fault, Fold and Earthquake database

Figure 4.4. Colorado Major Fault Map

Source: State of Colorado Natural Hazard Mitigation Plan, 2007

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

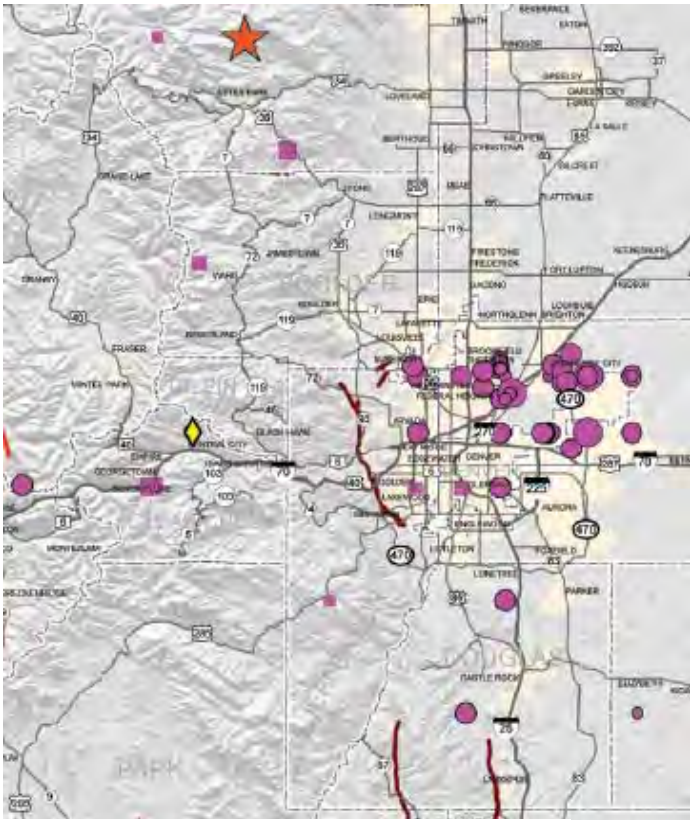
- H—Holocene (within past 15,000 years)
- LQ—Late Quaternary (15,000-130,000 years)
- MLQ—Middle to Late Quaternary (130,000 - 750,000 years)
- Q—Quaternary (approximately past 2 million years)

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 2 million years ago may be considered potentially active (Source: Colorado Earthquake Hazards 2008). The only known potentially active fault in Jefferson County is the Golden Fault, which is a Quaternary fault. This fault runs along the base of the foothills west of Golden roughly paralleling Highway 93 from Highway 72 to the north down to Highway 285 near Morrison, and is shown on the map in Figure 4.5, which is taken from a statewide map of Colorado earthquake hazards developed by the Colorado Geological Survey. The fault runs through sparsely developed sections of western Arvada, Golden, western Lakewood, and just east of Morrison. According to the Colorado Earthquake Evaluation Report associated with the Colorado Hazard Mitigation Plan the fault is thought to be

capable of producing a M6.5 earthquake. The Colorado Late Cenozoic Fault, Fold, and Earthquake Database considers this a "suspect feature" that has not shown evidence of movement in the past 500,000 years, and that definitive evidence of Quaternary movement is lacking.

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

Figure 4.5. Colorado Earthquake Fault Map- Jefferson County Excerpt



EARTHQUAKE EPICENTERS

Instrumentally located epicenters (~1962 to 2007)
Size of dot indicates magnitude.

- 5–5.5
- 4–4.9
- 3–3.9

Approximate location of pre-instrumental earthquake epicenters (~1867 to 1961). Square size indicates the maximum Modified Mercalli intensity for the earthquake (see back of map for intensity scale).

- VII
- VI
- V
- IV
- I-III

1882 Earthquake; magnitude estimated at 6.6 +/- 0.6 (Spence and others, 1996)

QUATERNARY FAULTS

Geologically young faults that displace sediments or rocks deposited during the Quaternary Period (approximately past 2 million years).

- Known or suspected fault with displacement of late Quaternary deposits (approximately past 130,000 years)
- Known or suspected fault with displacement of middle to early Quaternary deposits (approximately past 130,000 to 2 million years old)

Permanent Seismic Stations—
Includes four seismographs currently operated by the U.S. Geological Survey as part of the Advanced National Seismic System.

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

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

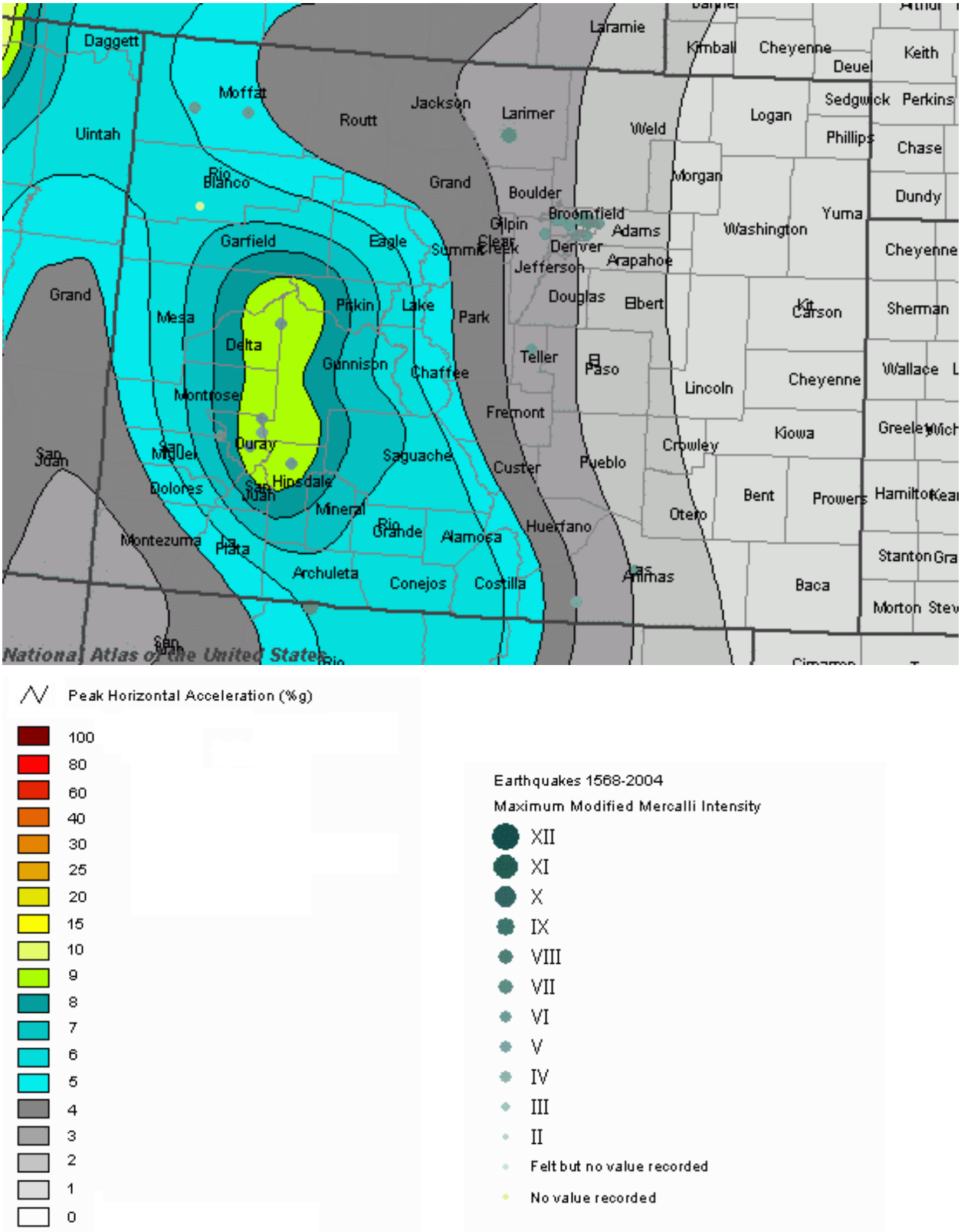
Probability of Future Occurrences

According to the Colorado Geological Survey it is not possible to accurately estimate the timing or location of future dangerous earthquakes in Colorado because the occurrence of earthquakes is relatively infrequent in Colorado and the historical earthquake record is relatively short (only about 140 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 4.6 and Figure 4.7 are probabilistic seismic hazard maps of Colorado from the USGS that depict 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 4.6 depicts the shaking level that has a 10 percent chance of being exceeded over a period of 50 years (as well as earthquakes in Colorado between 1568 and 2004). Jefferson County lies in the range of 3-4 percent peak acceleration. Figure 4.7, which is more of a worst-case scenario, depicts the shaking level that has a 2 percent chance of being exceeded over a period of 50 years. In this scenario, Jefferson County lies in the range of 10-12 percent peak acceleration. Typically, significant earthquake damage occurs when accelerations are greater than 30 percent of gravity.

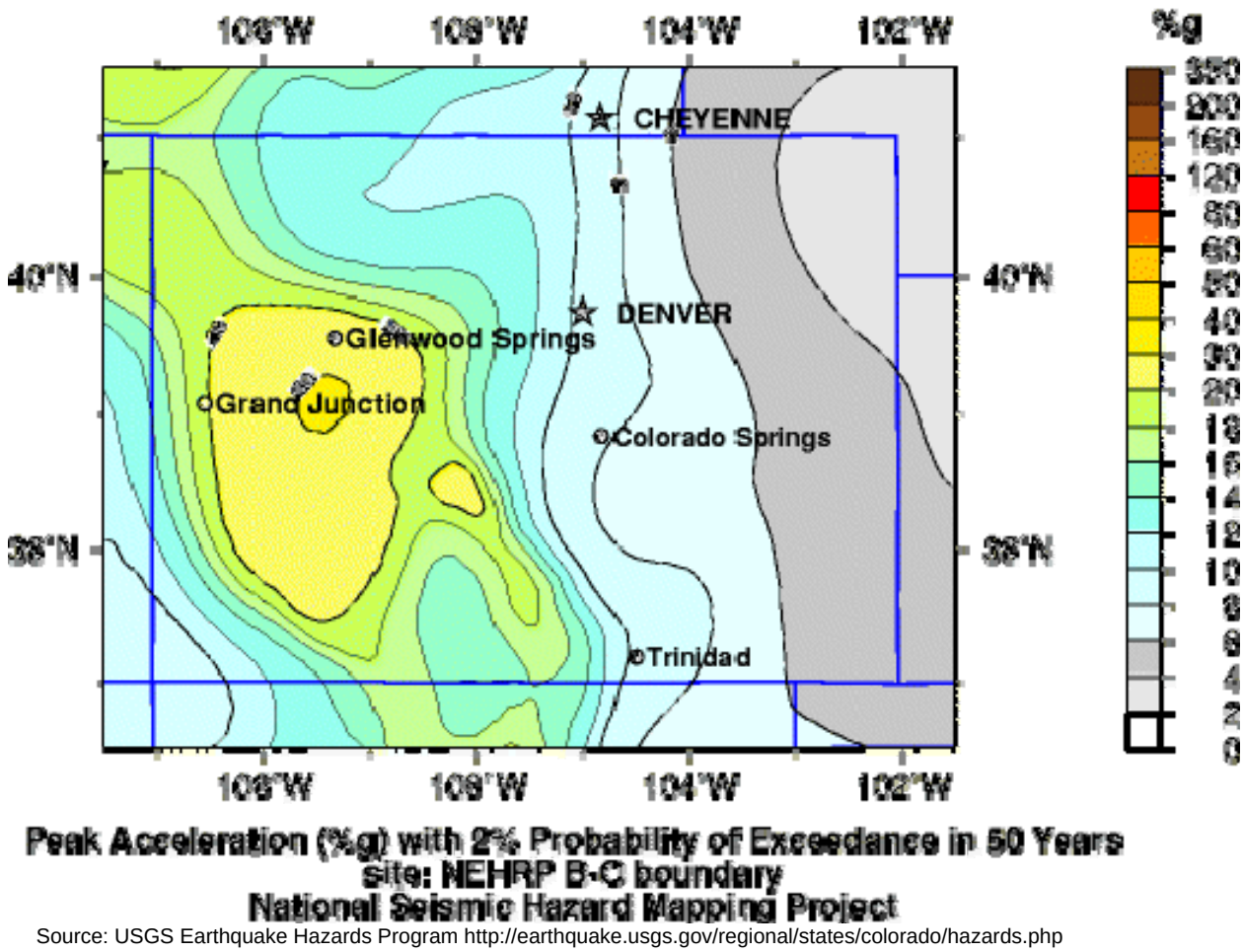
Thus, probability for an earthquake producing minor shaking is considered **occasional** and an earthquake causing significant damage is **unlikely**, with less than a 1 percent chance of occurrence over the next 100 year period.

Figure 4.6. Colorado Seismic Hazard Map—10% Probability of Exceedance in 50 Years



Source: USGS, www.nationalatlas.gov

Figure 4.7. Colorado Seismic Hazard Map—2% Probability of Exceedance in 50 Years



Source: USGS Earthquake Hazards Program http://earthquake.usgs.gov/regional/states/colorado/hazards.php

Magnitude and Severity

Earthquakes in or near Jefferson County are low probability but potentially high consequence events. The primary earthquake hazard in Jefferson County includes strong ground shaking, which could affect the entire County. While structural damage could result to buildings, damage to non-structural building elements and contents will account for the majority of damages. A 6.5 earthquake has the potential to cause multiple fatalities and injuries. The general perception is that earthquakes don't happen in Colorado, thus the populace is ill-prepared for what to do when one occurs. There is also potential for rupture of the ground surface, which could happen along a fault trace. Though a remote possibility, the potential for fault rupture would be most likely along the Golden Fault, in the vicinity of Golden along the base of the foothills. Fault rupture could impact homes and highways in west Golden. Secondary earthquake hazards that could occur in the western Jefferson County and near Golden include landslides and rockfall, which could potentially damage transportation infrastructure, property, and cause death or injury. There is also the potential for damaging large waves called seiches that can form in lakes during

earthquakes. This could impact reservoirs such as Chatfield, Strontia Springs, and Cheeseman, potentially causing damage to the marina and property at Chatfield.

During the development of this mitigation plan HAZUS-MH was used to model the consequences of a large earthquake in Jefferson County. The results of this analysis are presented in Section 4.3 Vulnerability Assessment. This analysis complements HAZUS-MH studies performed by the Colorado Geological Survey on various faults statewide. According to those studies Jefferson County ranks 2nd in the state, behind El Paso County, as having the highest earthquake risk while comparing potential for economic loss and casualties. Considering a worst case scenario, the potential magnitude/severity rating of earthquakes is **catastrophic,** with widespread property damage, shutdown of facilities for more than two weeks and/or multiple fatalities.

Overall Hazard Significance

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

4.2.6 Erosion and Deposition

Description

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

The rate of erosion depends on many factors. Climatic factors include the amount and intensity of precipitation, freeze-thaw cycles, seasonality, the wind speed, and storm frequency. The geologic factors include the sediment or rock type, its porosity and permeability, the slope of the land, and whether the rocks are tilted, faulted, folded, or weathered. The biological factors include ground cover from vegetation or lack thereof, the type of organisms inhabiting the area, and the land use. Areas with high-intensity precipitation, more frequent rainfall, more wind,

freeze-thaw cycles, or more storms are expected to have more erosion. Sediment with high sand or silt contents and areas with steep slopes erode more easily, as do areas with highly fractured or weathered rock. The porosity and permeability of the sediment or rock also affect how fast water can percolate into the ground. If the water moves underground, less runoff is generated, reducing the amount of surface erosion. Sediments containing more clay tend to erode less than those with sand or silt.

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

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

Poor land use practices can also lead to increased erosion. Some of those practices include deforestation, overgrazing, unmanaged construction activity and road-building. Land that is used for the production of agricultural crops generally experiences a significant greater rate of erosion than that of land under natural vegetation. In the case of construction or road building, when the litter layer is removed or compacted, the susceptibility of the soil to erosion is greatly increased and the process, without proper engineering, can significantly change drainage patterns. There has been a marked increase in recreational land use that has left erosive remnants. Large numbers of hikers use trails leaving furrowed foot traffic, or extensive use of off-road vehicles leave paths of beaten down vegetation and gouged terrain. There is a potential for the impacts of "beetle kill" to negatively affect soil stability and lead to erosion and watershed degradation as well. As discussed in Section 4.2.16 Wildfire, these predictions are difficult to quantify the impacts have not yet occurred, though the precedence is set. Future evaluation on the impacts of beetle kill on erosion may be merited in future planning efforts. While a certain amount of erosion is natural and, in fact, healthy for the ecosystem, wise land use practices are also necessary to keep it balanced.

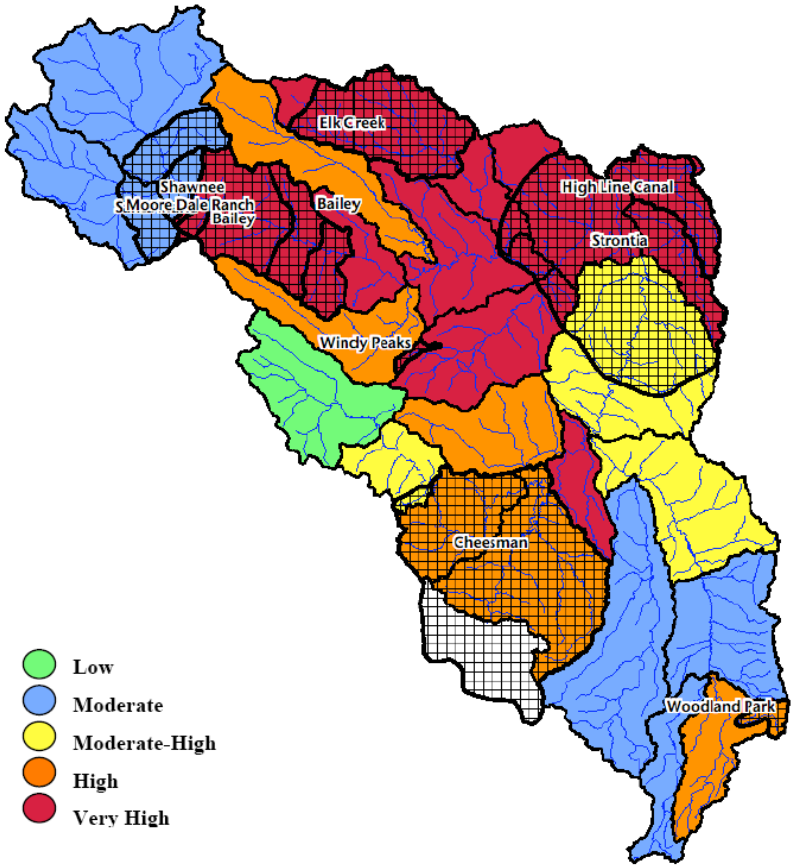
Geographic Extent

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

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

The Front Range Watershed Protection Data Refinement Work Group has developed a technical approach to protecting watersheds from post wildfire erosion. The purpose of this group is to identify and prioritize those watersheds that provided or convey water used by communities and municipalities. The data analysis is designed to identify and prioritize watersheds for hazard reduction treatments or other watershed protection measures. Through GIS analysis of soil erodibility, water uses, wildfire hazard, and flood or debris flow risk hazardous watersheds have been identified. Many of these are within Jefferson County are displayed on the following map. The source water area upstream from important surface water intakes, upstream diversion points, and classified drinking water supply reservoirs that have a higher potential for contributing significant sediment or debris is referred to as the Zone of Concern.[15]

Figure 4.8. Upper South Platte Zones of Concern and Watershed Prioritization Map



Source: Front Range Watershed Protection Data Refinement Workgroup Executive Summary

[15] Front Range Watershed Protection Data Refinement Workgroup Executive Summary, 2009. Available online at http://jw-associates.org/Projects/Front_Range/assets/FINAL_ExecutiveSummary_DataRefinementWorkGroup.pdf last accessed October 09, 2009

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

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

Previous Occurrences

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

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

The Buffalo Creek Fire in Jefferson County in May of 1996 was followed by substantial flooding and erosion two months later. The burned area is within the Pike National Forest, in the South Platte Watershed and foothills of Jefferson County. The flooding transported approximately 331,000 m^3 of coarse sediment into Strontia Springs Reservoir in three months after the fire. This reservoir supplies over 75% of the drinking water to the city of Denver. Studies indicate the sedimentation rate was nearly 30 times the annual rate of sediment input used in designing the reservoir. The reservoir also experienced a significant degradation in water quality as a result of the input of burned material and sediment. Denver Water, the agency responsible for distributing drinking water from the reservoir, estimates that it spent over $1 million in immediate clean-up efforts after the fire Denver Water is in the process of dredging excess sediment from the reservoir, at an estimated cost of $23 million.[16]

The 2002 wildfire season, detailed in the wildfire hazard profile, was unusually severe in terms of both the number and extent of wildfires the state experienced, and the severity of the lasting impacts of those fires. Unlike the 1996 Buffalo Creek post-fire recovery time, localized extreme flooding and substantial erosion and deposition that pose significant hazards to the public have continued to 2009 and will likely continue for several more years, particularly in and near the community of West Creek and on Six Mile Creek near Deckers. In 2009, seven years after the fire, Vail Resorts, the U.S. Forest Service, and the National Forest Foundation announced plans

[16] Studies of Post-Fire Erosion in the Colorado Front Range Benefit the Upper South Platte Watershed Protection and Restoration Project – Deborah Martin USGS 2000, http://watershed.org/news/win_00/5_postfire.htm).

to raise $4 million to undo damages caused by the Hayman fire, including watershed cleanup, restoration of burned lands, and rebuilding of recreational trails. Based on the lessons learned from the Buffalo Creek Fire, Denver Water installed sediment traps on Turkey Creek to protect Cheesman reservoir from siltation, at a cost of $2 million. These sediment traps require periodic mucking out, which costs about $350,000 each time, but should mitigate more expensive dredging operations at the reservoir in addition to water quality impacts.

Probability of Future Occurrences

Erosion occurs daily as a natural process in both developed and undeveloped lands, and such natural erosion is not considered a hazard. Hazardous incidents of erosion, such as those caused by construction, are difficult to document, as established in the previous section, and should theoretically have no future occurrence, as regulations and statues are in place to limit such events.

Future incidents of erosion associated with wildfires are more easily predicted, as one may assume that erosion will occur after a large burn, particularly in a mountainous area where the ground lends itself to sloping. As such, for this specific incident, the probability of future occurrence mimics that of the wildfire hazard.

As such, there have been 25 major wildfire incidents resulting in erosion in Jefferson County since 1978, or a span of 30 years. (2008-1978 = 30 years). The methodology for calculating the probability of future occurrences is described in Section 4.2.1. This formula evaluates that the probability of erosion occurring as a result of wildfire in any given year is 83.3%. This corresponds to a probability of future occurrences rating of **likely**.

Magnitude and Severity

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

Post-fire erosion in the foothills of Jefferson County has and will continue to cause watershed health problems. Erosion rates due to wildfires varies based on the terrain, slope, severity of the burn, subsequent rainfall until groundcover can be re-established, and the overall erodibility of the soil in question.[17] While a methodology is still under development, the impacts of erosion into watersheds is well documented. Erosion carries sediment, organic debris, and chemicals into the water supplies, which may damage aquatic habitats and impact the water quality utilized by

[17] Brian Drake, *Estimating Increased Erosion and Sediment Delivery Caused by Wildfires.* Student paper, published online at http://www.crwr.utexas.edu/gis/gishydro06/Introduction/TermProjects/FinalReport_Drake.htm last accessed October 1, 2009.

populations.[18] As water is a critical resource to Jefferson County's large population, the impacts may be widespread. Erosion, therefore, could pose significant indirect impacts on the planning area, even if it does not directly impact life quality and other critical services.

In order to calculate a magnitude and severity rating for comparison with other hazards, and to assist in assessing the overall impact of the hazard on the planning area, information from the event of record is used. In some cases, the event of record represents an anticipated worst-case scenario, and in others, it is a reflection of common occurrence. The event of record for this hazard is the resulting erosion caused by the Buffalo Creek Fire in 1996, but the impacts have been long-range and are continuing today. Response and recovery costs to address erosion problems have cost Denver Water alone over $24 million. Erosion may occur and damage the entire burn area, with damages inflicted on critical facilities from the loss or disruption of services, particularly if reservoirs, water treatment plants, roads, or communication lines are impacted or damaged. Erosion may cause illnesses to the watershed populations who are exposed to diminished water quality but the burden on the medical community is anticipated to be minimal. Knowledge of these impacts is well addressed in local planning and mitigation efforts, however, which decreases the likely occurrence of these impacts.

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

Overall Hazard Significance

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

4.2.7 Expansive Soils

Description

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

[18] Deborah A. Martin and Moody, John, "Hydrologic and Erosion Responses of Burned Watersheds." April 4, 2007, available online at http://wwwbrr.cr.usgs.gov/projects/Burned_Watersheds/ last accessed October 1, 2009.

clay, while swelling bedrock contains claystone.[19] In this profile, the term is used to refer to both materials, as they are both relevant to the planning area.

The clay materials in swelling soils are capable of absorbing large quantities of water and expanding 10 percent or more as the clay becomes wet. The force of expansion is capable of exerting pressures of 15,000 pounds per square foot or greater on foundations, slabs, and other confining structures.[20] The amount of swelling (or potential volume of expansion) is linked to five main factors: the type of mineral content, the concentration of swelling clay, the density of the materials, moisture changes in the environment, and the restraining pressure exerted by materials on top of the swelling soil. Each of these factors impact how much swelling a particular area will experience, but may be modified, for better or worse, by development actions in the area.

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

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

Swelling soils are one of the nation's most prevalent causes of damage to buildings. According to the 2008 State Hazard Mitigation Plan, annual losses nationwide are estimated in the range of $2 billion. In Colorado, the cost is estimated at $16 million annually. Potential damages include severe structural damage; cracked driveways, sidewalks, and basement floors; heaving of roads and highway structures; condemnation of buildings; and disruption of pipelines and other utilities. Destructive forces may be upward, horizontal, or both. Buildings designed with lightly loaded foundations and floor systems often incur the greatest damage and costly repairs from expansive soils. Building in and on swelling soils can be done successfully, although more

[19] Colorado Geological Survey Department of Natural Resources, *A Guide to Swelling Soils for Colorado Homebuyers and Homeowners*. (Denver, Colorado.) 1997. p 15-16.
[20] Ibid., p 17.

expensively, as long as appropriate construction design and mitigation measures are followed. In some cases avoidance may be the best mitigation policy.

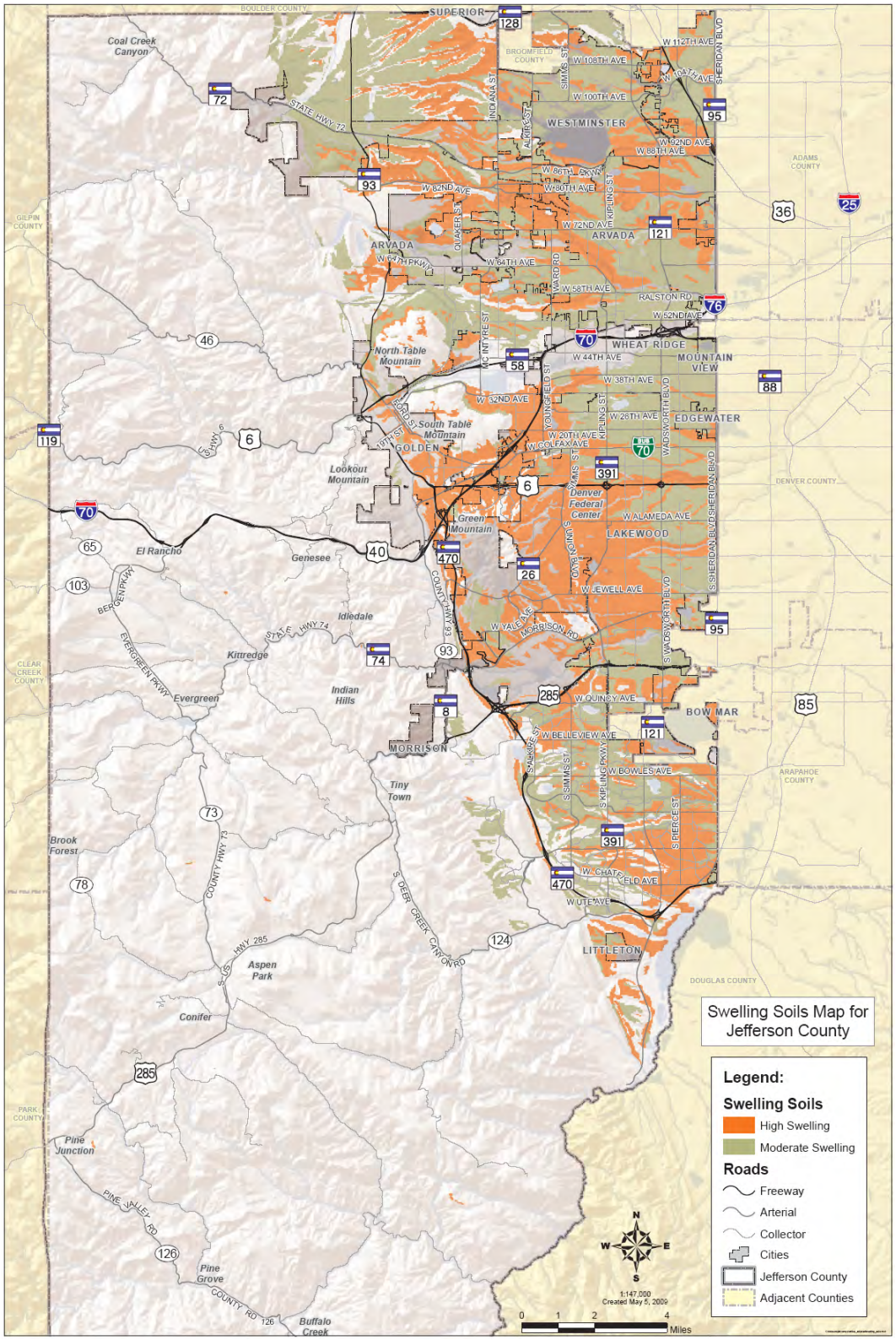
Geographic Extent

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

Previous Occurrences

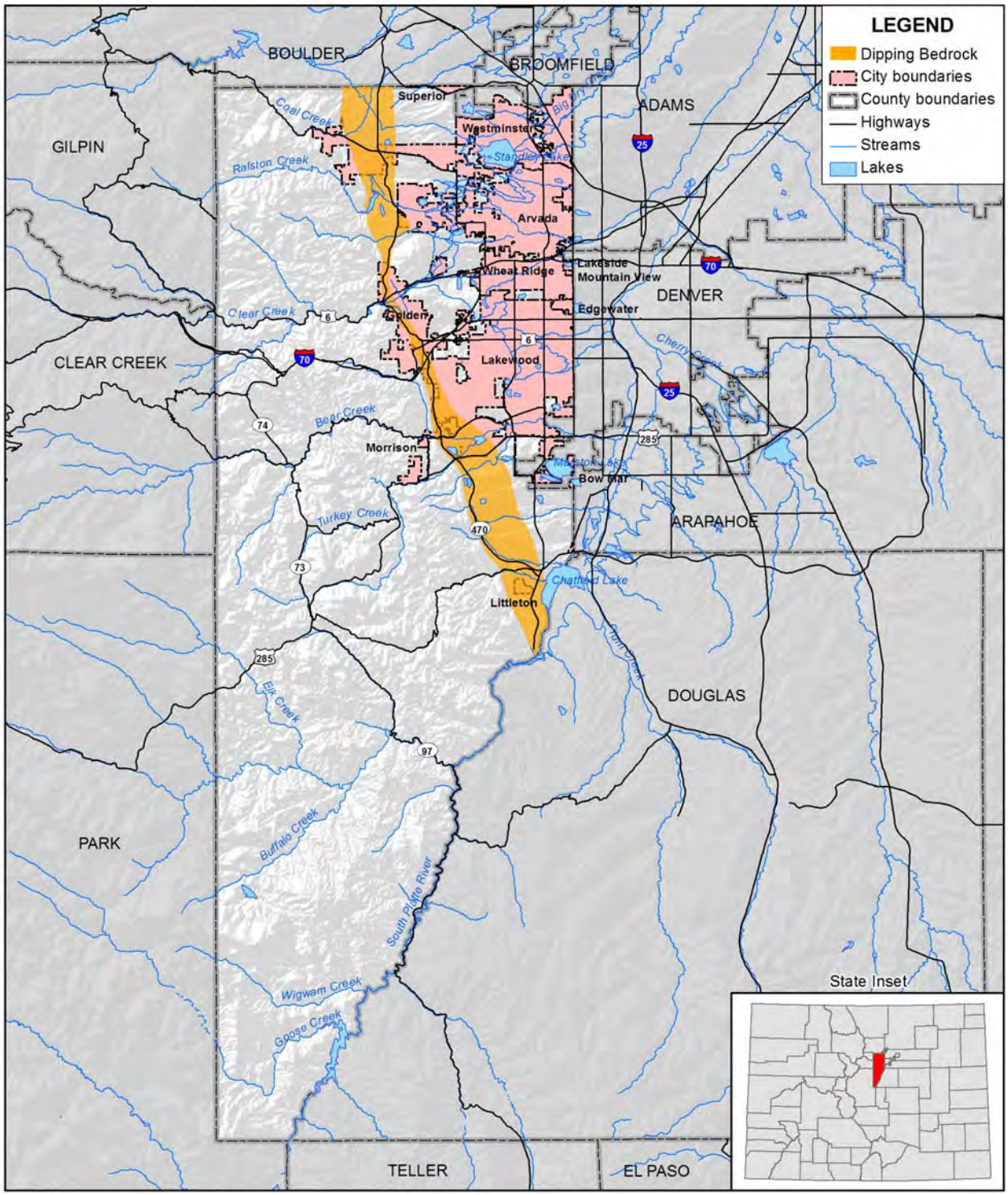
Damage of varying degrees of severity occurs on an ongoing and seasonal basis. The frequency of damage from expansive soils is associated with the cycles of drought and heavy rainfall and also reflects changes in moisture content based on typical seasonal patterns. Building codes and structure ages also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

Figure 4.9. Jefferson County Swelling Soils



Source: Jefferson County Land Use Plan

Figure 4.10. Jefferson County Dipping Bedrock



amec

Map compiled 11/2009; intended for planning purposes only.
Data Source: Jefferson County

The most significant areas that intersect Golden, Morrison, Lakewood and western Arvada are currently undeveloped. The mapped extent of the hazards clearly impacts approximately 50% of the planning area. However, when considering the geographic impact on the planning area, it is important to note that the entire southern portion of the County is occupied by Pike National Forest, and therefore has a minimal impact on this hazard mitigation plan as development in the area is highly regulated outside of County authority. Therefore, of the actively developed and monitored lands in the County, more than 75% is subject to swelling soils or dipping bedrock hazards.[21]

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

Probability of Future Occurrences

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

Since records of specific occurrences are not available to the planning process, it is difficult to estimate the probability of future occurrences using the mathematical equation expressed in other planning hazards. The hazards occur seasonally and annually, which should theoretically equate to a highly likely rating. However, the excellent mitigation efforts in place in the County since 1995 should prevent the extent of the hazard from increasing, so the occurrence rating may seem overly severe relative to actual incurred damages and reflect a more appropriate rating of negligible. Existing development in the expansive soils regions, however, will continue to be subjected to damages and in particular for those areas where appropriate mitigating construction techniques were not utilized.

As such, the hazard is rated as **occasional** to **limited**, pending further data analysis.

Magnitude and Severity

In order to calculate a magnitude and severity rating for comparison with other hazards, and to assist in assessing the overall impact of the hazard on the planning area, information from the event of record is used. In some cases, the event of record represents an anticipated worst-case scenario, and in others, it is a reflection of common occurrence. For this hazard, there is no specific event of record, and the extensive mitigation efforts taken since the initial identification of the hazard nearly thirty years ago have changed the magnitude and severity ratings. Therefore, this hazard will be evaluated for potential worst-case scenarios possible under current regulatory standards. Such an event could potentially damage entire neighborhoods, including

[21] This is not to imply that the Pike National Forest has a significant expansive soils hazard rating. Indeed, the area has a minimal overlapping of the hazard area (identified in the maps above) and the forested land. The point is to emphasize that the hazard impacts most of the planning area that is currently or may be developed, even if that rating does not correspond to the strictest definition of 'geographic extent'.

roads, sidewalks, properties, and utility pipes. Even minor damages on such a scale would quickly incur enormous costs. While critical infrastructure services are not directly vulnerable to the hazard, structures experience the same risks identified for private and commercial properties: if they are built on swelling soil without adequate or appropriate building mitigation, they are vulnerable to damage. In worst case scenarios, this could include loss of communication lines or severe damages to structures rendering them uninhabitable. If this occurred to a hospital or jail, for instance, it could have significant social repercussions, in addition to the incurred costs. Injuries, illnesses and deaths associated with the hazard would be unique and minimal, and probably incurred as secondary hazards resulting from damages to infrastructure. Overall, though the fiscal damage may be extensive, the overall severity and impacts of the hazard are readily mitigated, reducing the overall impacts.

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

Overall Hazard Significance

Swelling soil in Jefferson County has, historically, exerted significant impacts on the County, particularly during the large growth expansion experienced between 1970 and 1995. In response to the growing hazard, Jefferson County formed and convened an Expansive Soils Task Force in the spring of 1994, and implemented development regulations by 1995.[22] As a result, the impacts of the hazards in the planning area have been extensively mitigated, either by restricting where development is permitted or by heavily regulating the type of construction permitted in certain areas to adequately address the hazard. The geographic extent of the hazard is considered **extensive**. The probability of future occurrences is considered **occasional** to **limited** and the magnitude/severity for the event of record is **limited**. In addition, the HMPC considers the hazard to have a **low** overall impact on the jurisdiction. This equates to an overall impact rating of **medium**. In many ways, the swelling soils hazard is an excellent example for demonstrating the effectiveness of how mitigation efforts may reduce the vulnerabilities and risks of a previously high-concern hazard. Sound planning and engineering practices should keep the impact to future development low, however the potential for damages exist in older residential areas.

4.2.8 Extreme Temperatures

Description

Extreme Heat

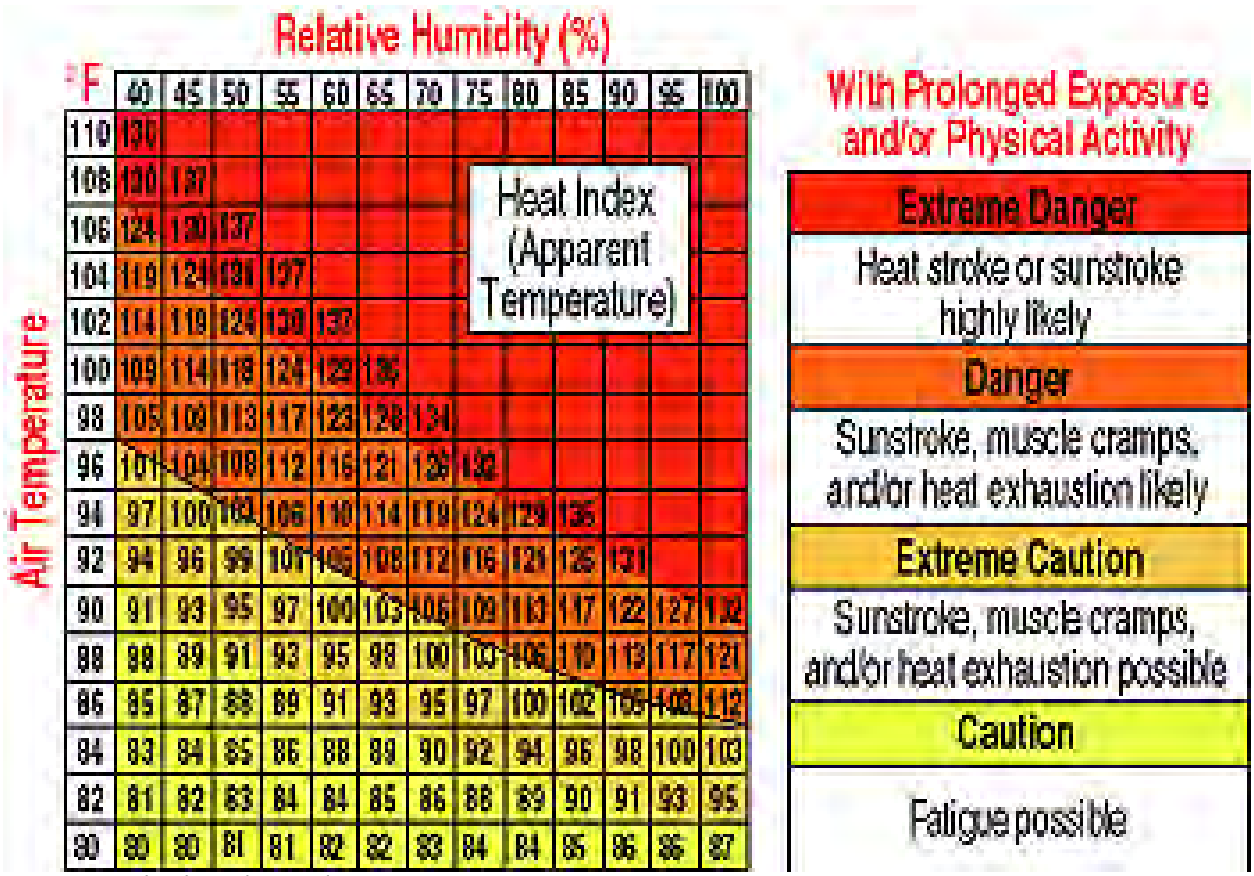
According to information provided by FEMA, extreme heat is defined as temperatures that hover 10 degrees or more above the average high temperature for the region and last for several weeks. Heat kills by taxing the human body beyond its abilities. In a normal year, about 175 Americans

[22] David C. Noe, *Heaving –Bedrock Hazards, Mitigation, and Land-Use Policy: Front Range Piedmont, Colorado*. Published 1997, available online at http://www.surevoid.com/surevoid_web/soils/pub45.html Last accessed September 30, 2009.

succumb to the demands of summer heat. According to the National Weather Service (NWS), among natural hazards, only the cold of winter—not lightning, hurricanes, tornadoes, floods, or earthquakes—takes a greater toll. In the 40-year period from 1936 through 1975, nearly 20,000 people were killed in the United States by the effects of heat and solar radiation. In the heat wave of 1980, more than 1,250 people died.

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

Figure 4.11. National Weather Service Heat Index



Source: National Weather Service

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

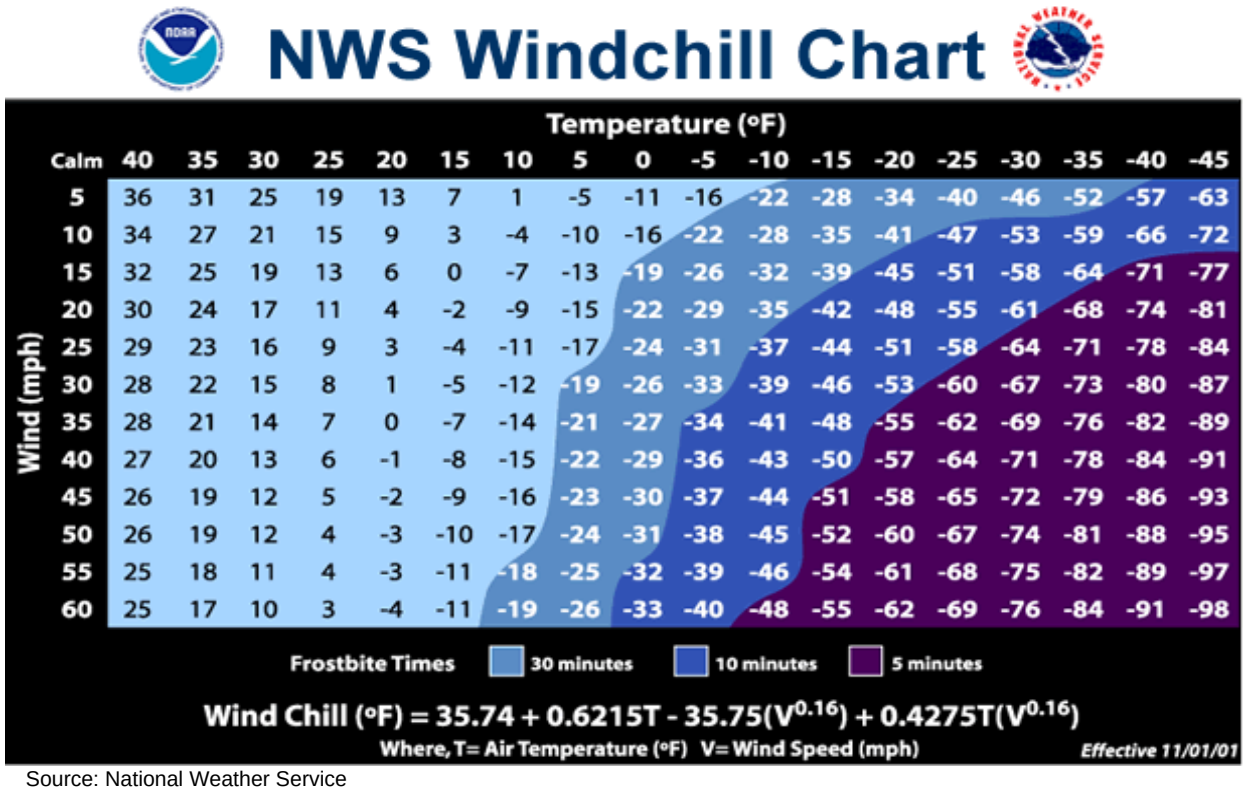
The NWS has in place a system to initiate alert procedures (advisories or warnings) when the Heat Index is expected to have a significant impact on public safety. The expected severity of the heat determines whether advisories or warnings are issued. A common guideline for the issuance of excessive heat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

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.

In 2001, the NWS implemented an updated Wind Chill Temperature index (see Figure 4.12). This index was developed to describe the relative discomfort/danger resulting from the combination of wind and temperature. Wind chill is based on the rate of heat loss from exposed skin caused by wind and cold. As the wind increases, it draws heat from the body, driving down skin temperature and eventually the internal body temperature.

Figure 4.12. National Weather Service Wind Chill Chart



NWS Windchill Chart

Wind (mph) \ Temperature (°F)	Calm	40	35	30	25	20	15	10	5	0	-5	-10	-15	-20	-25	-30	-35	-40	-45
5	36	31	25	19	13	7	1	-5	-11	-16	-22	-28	-34	-40	-46	-52	-57	-63
10	34	27	21	15	9	3	-4	-10	-16	-22	-28	-35	-41	-47	-53	-59	-66	-72
15	32	25	19	13	6	0	-7	-13	-19	-26	-32	-39	-45	-51	-58	-64	-71	-77
20	30	24	17	11	4	-2	-9	-15	-22	-29	-35	-42	-48	-55	-61	-68	-74	-81
25	29	23	16	9	3	-4	-11	-17	-24	-31	-37	-44	-51	-58	-64	-71	-78	-84
30	28	22	15	8	1	-5	-12	-19	-26	-33	-39	-46	-53	-60	-67	-73	-80	-87
35	28	21	14	7	0	-7	-14	-21	-27	-34	-41	-48	-55	-62	-69	-76	-82	-89
40	27	20	13	6	-1	-8	-15	-22	-29	-36	-43	-50	-57	-64	-71	-78	-84	-91
45	26	19	12	5	-2	-9	-16	-23	-30	-37	-44	-51	-58	-65	-72	-79	-86	-93
50	26	19	12	4	-3	-10	-17	-24	-31	-38	-45	-52	-60	-67	-74	-81	-88	-95
55	25	18	11	4	-3	-11	-18	-25	-32	-39	-46	-54	-61	-68	-75	-82	-89	-97
60	25	17	10	3	-4	-11	-19	-26	-33	-40	-48	-55	-62	-69	-76	-84	-91	-98

Frostbite Times: 30 minutes, 10 minutes, 5 minutes

$$\text{Wind Chill (°F)} = 35.74 + 0.6215T - 35.75(V^{0.16}) + 0.4275T(V^{0.16})$$

Where, T= Air Temperature (°F) V= Wind Speed (mph)

Effective 11/01/01

Source: National Weather Service

Jefferson County is located along the foothills of the Rocky Mountains and encompasses the West Denver Metro area municipalities of Arvada, Golden, Lakewood, Lakeside, Morrison, Mountain View, Westminster and Wheat Ridge. It experiences similar temperate climate to the remaining Denver Metropolitan Area, although areas of higher elevations like Kittridge, Evergreen, Idledale, and the unincorporated rural mountain areas are more susceptible to extreme variations, which can pose a danger to those citizens that may be more vulnerable and certainly so if those extremes temperatures are extended.

Geographic Extent

As discussed earlier, the inherent nature of temperature hazards makes them a regional threat, impacting most or all of the planning area simultaneously as well as extending the effects into the surrounding jurisdictions. This is reflected in the previous occurrence record, which consistently discusses the Denver Metro Area, rather than singling out particular counties or communities.

Based on this information, the geographic extent rating for extreme temperatures is **extensive**.

Previous Occurrences

According to the 2008 State Hazard Mitigation Plan, the Denver Metro Area averages 33 days a year with temperatures above 90°F. By contrast, the Denver Metro area averages 156 days a

year with a minimum temperature of 32°F or less. The highest recorded temperature for Jefferson County is 103°F and the lowest is -41°F.

Since temperature variations are a regional hazard, many of the previous occurrences are documented at a regional level as well. For example, the NCDC database reflects 0 incidents of extreme temperatures for Jefferson County, but documents 6 waves in neighboring Denver County. Therefore, the incidents below impact more than just the planning region.

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

1989 - Periods of extreme cold and high winds combined with snow created a severe storm scenario. Stapleton Airport was closed and a 46-car pileup occurred on Interstate 25. More details on this storm are captured in Section 4.2.13.

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

December 16-18, 2006 - Extreme wind chills impacted the entire Front Range and plains regions. Lows in the Denver area were reported at -9°F. A homeless man found in his car, with a body temperature of only 85°F at the time, died a few hours later.

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

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

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

According to the National Weather Service Forecast Office for Denver/Boulder, there have been 82 streaks with temperatures of 90 degrees or greater since 1895, which accounts for more than

150 days of extremely hot temperatures in the metro area.[23] In addition, as of August 2008, the area documented 68 days with temperatures above 100°F and 29 days with temperatures below -20°F between February 2008 and 1872.[24]

Probability of Future Occurrences

Temperature extremes occur on a regular basis, with an average of 33 days a year exceeding 90°F and more than 150 where temperatures dip below freezing (32°F). Severe incidents or prolonged exposures to a temperature extreme are a higher threat to the community than isolated, seasonal occurrences. The information used in calculating the probability of future occurrences is drawn from the 2008 State Hazard Mitigation Plan and combines extreme heat and extreme cold incidents together. The data begins in 1934 but only extends through 2000. This data does not include incidents of severe winter storms or droughts which could include extreme temperature deviations. Therefore, this rating may actually be a low percentage of occurrences.

There have been 20 incidents in Jefferson County since 1934, or a span of 66 years. (2000-1934 = 66 years) The methodology for calculating the probability of future occurrences is described in Section 4.2.1. This formula evaluates that the probability of a severe temperature extreme occurring in any given year is 30%. This corresponds to a probability of future occurrences rating of **likely**.

Magnitude and Severity

In order to calculate a magnitude and severity rating for comparison with other hazards, and to assist in assessing the overall impact of the hazard on the planning area, information from the event of record is used. In some cases, the event of record represents an anticipated worst-case scenario, and in others, it is a reflection of common occurrence. Since temperature extremes refer to both extreme heat and extreme cold, there is not a single event of record. The event of record for extreme heat in Jefferson County occurred in the summer of 2000. While specific property damages are not available, the event coincided with a severe drought period, which caused extensive damages to crops and personal property, impacted overall water supplies, and caused economic damages due to both conditions. The event of record for extended periods of severe cold in Jefferson County occurred during December 18-24 in 1998. Damages caused by ruptured water pipes were considered extensive in both the private and public sectors. Power outages increased damages to property and impacted human lives. Hospitals documented a small surge in casualties either directly or indirectly attributed to the cold, and at least 15 injuries were reported. 5 deaths were attributed to the cold weather as well, with three of them due directly to exposure. Nationwide, extreme temperatures remain the leading cause of weather-related deaths.

[23] National Weather Service Weather Forecast Office for Denver/Boulder CO: http://www.crh.noaa.gov/bou/?n=consec90
[24] National Weather Service Weather Forecast Office for Denver/Boulder CO: http://www.crh.noaa.gov/bou/?n=tempxtrm

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

A search of the Colorado Health Information Dataset further confirms these findings. The data is limited, as it only tracks hospitalizations due to extreme cold, and therefore does not represent extreme heat or non-hospitalized injuries. In addition, the data only ranges from 1995 to 2006 and it tracks patients, not number of extreme temperature events. Still, according to the dataset, 68 individuals were hospitalized over an 11-year period, which averages to 6 hospitalizations a year. Of those 68 cases, 3 resulted in death and 8 in traumatic brain injuries and Jefferson County is not considered to have an anomalous number of reported incidents. This indicates that the impact of temperature extremes on exposed populations is critical.

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

Overall Hazard Significance

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

The impacts of extreme temperatures on a population are still undergoing analysis within the scientific community. In past risk assessments, the hazards have often been classified under the associated disaster conditions that they are often present during, such as blizzards and droughts. In doing so, the overall significance of these hazards may still be underestimated. In the examination of the few documented impacts of the hazards on the County indicates that they are, indeed, stand alone hazards that require attention and mitigation, where possible.

4.2.9 Flood

Description

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

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

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

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

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

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

Riverine or Overbank Flooding

Riverine or overbank flooding is defined as *a watercourse that exceeds its "bank-full" capacity* and is usually the most common type of flood event. Riverine flooding generally occurs as a result of prolonged rainfall, or rainfall that occurs when soils are already saturated or drainage

systems overloaded from previous rain events. The duration of riverine floods may vary from a few hours to several days and may exhibit a seasonal pattern over a course of years.

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

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

The most serious overbank flooding occurs during flash floods. They result from intense rainstorms, or following a dam or levee failure. The term "flash flood" describes localized flooding as an incident of *sizable peak flow and magnitude, in conjunction with quick onset and short duration*. Flash floods usually results from a heavy rainfall on a relatively small drainage areas can occur very quickly with little or no warning; locally, these are known as "cloudburst" storms. In contrast, frontal-type rainstorms or snowmelt runoff are more regional in nature, result from moderate rainfall or snowmelt over large areas. Though rain-on-snow flooding can occur, it is fairly infrequent in the Colorado Front Range (and Colorado in general), and does not produce maximum flooding. Figure 4.13 and Figure 4.14 show how quickly and with what magnitude a flash flood can strike. These pictures are not of property inside Jefferson County, but in a similar area in Colorado. These pictures are from a flash flood in Cherry Creek at Castlewood Canyon State Park in neighboring Douglas County.

Figure 4.13. Park Foot Bridge at 7:55 pm on July 2, 2006

Source: USGS

Figure 4.14. Same Foot Bridge at 8:12 pm on July 2, 2006

Source: USGS

In contrast to riverine flooding, this type of flood usually results from a heavy rainfall on a relatively small drainage area occurring very quickly with little or no warning. With residential and businesses development along these small drainages combined with the quickness of an overbank-type flash flooding, evacuation can be difficult. Early warning systems that include automated detection of heavy rainfall and stream level changes are imperative for the public's safety in these types of developed drainage-ways.

Gulches/Irrigation Ditch/Canal Flooding

Jefferson County has numerous valleys, gulches and creeks, canyons and draws, irrigation ditches, and canals used to convey water collected in the mountain reservoirs to downstream users. Ditches convey irrigation water along hillsides, following contours and, as a result, cut across the natural drainage pattern of stormwater runoff flowing down hillsides. Although efforts

are made to separate stormwater runoff and irrigation water, excessive runoff can flow into an irrigation ditch causing overbank flooding or a collapse of the ditch itself. Similar to flash floods, there is often little warning for these types of events.[25]

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.

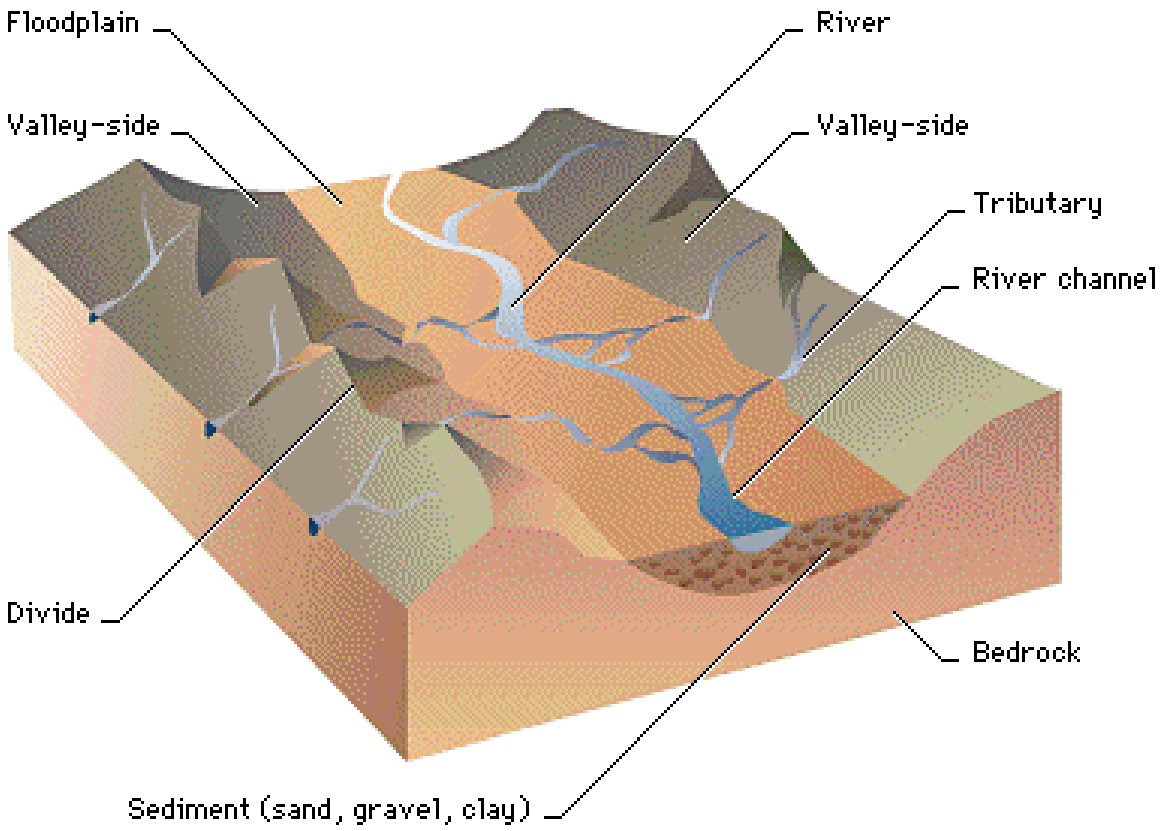
Floodplain

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

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

[25]Topographic Map Valley Features in Jefferson County, Colorado. http://www.topozone.com/states/Colorado.asp?county=Jefferson&feature=Valley

Figure 4.15. Floodplain Topography



Regulated floodplains are illustrated on inundation maps called Flood Insurance Rate Maps (FIRM). FIRM maps are currently being replaced with Digital Flood Insurance Rate Maps (DFRIM) as part of FEMA's map modernization project. A DFIRM will soon replace the FIRM in Jefferson County. It is the official map of a community on which the Federal Emergency Management Agency (FEMA) has delineated both the special flood hazard areas and the risk premium zones applicable to the community. Private citizens and insurance agents use FIRM's to determine whether or not specific properties are located within flood hazard areas. Community officials use FIRM's to administer floodplain management regulations and to mitigate flood damage. Lending institutions and federal agencies use FIRM's to locate properties and buildings in relation to mapped flood hazards, and to determine whether flood insurance is required when making loans or providing grants following a disaster for the purchase or construction of a building.

The floodplain most often refers to that area that is inundated by the *100-year flood*. The term "100-year flood" is misleading. It is not the flood that will occur once every 100 years. Rather, it is the flood elevation (or depth) that has a 1- percent chance of being equaled or exceeded each year. Thus, the 100-year flood could occur more than once in a relatively short period of time.

The 100-year flood, which is the minimum standard used by most Federal and state agencies, is used by the National Flood Insurance Program (NFIP) as the standard for floodplain management and to determine the need for flood insurance. Over a 30-year period (the term of a typical home mortgage), a structure located within a special flood hazard area has a one-in-four chance of experiencing the flood depicted on the NFIP map. The chance is even more likely that a damaging flood of lesser magnitude will occur, while the possibility of a much larger flood is also quite real. Extreme events have been measured at many locations that exceed the magnitude of the 100-year flood by three times or more. Figure 4.16 illustrates a 100-year floodplain. Figure 4.17 shows the 100-year floodplains in Jefferson County. Only major streams are highlighted; however, flooding can occur in any channel or drainage in the County.

Figure 4.16. 100-year Floodplain

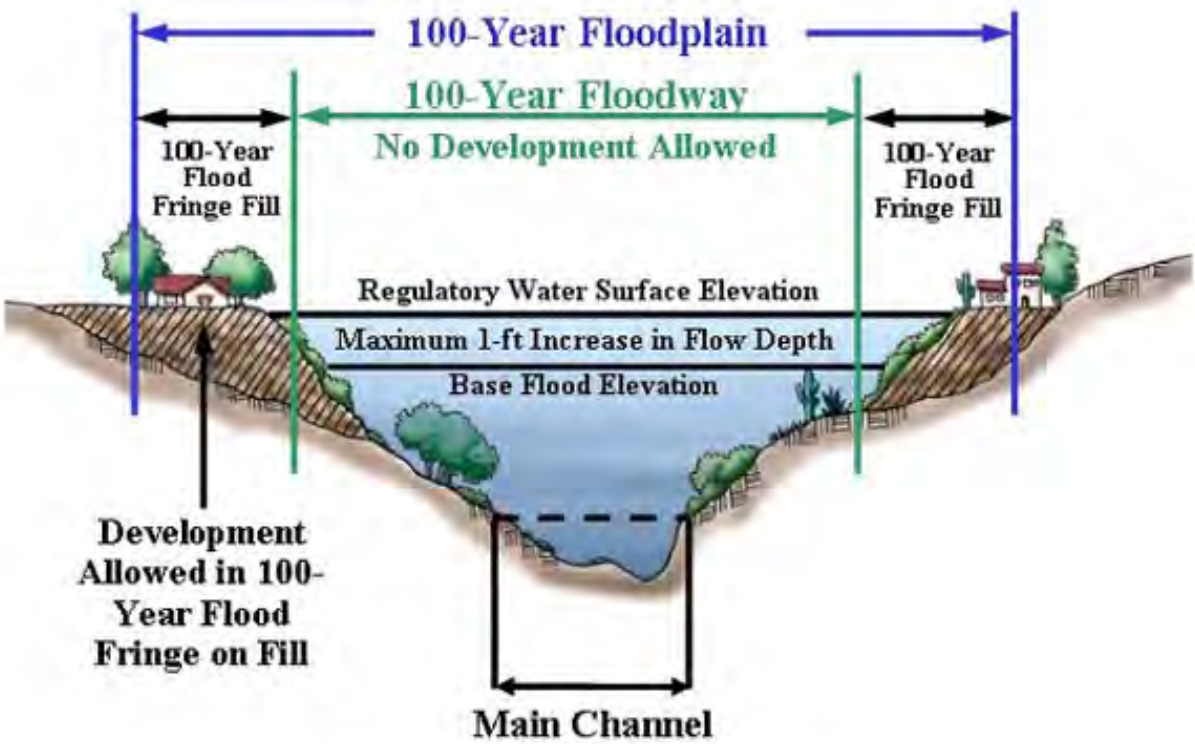
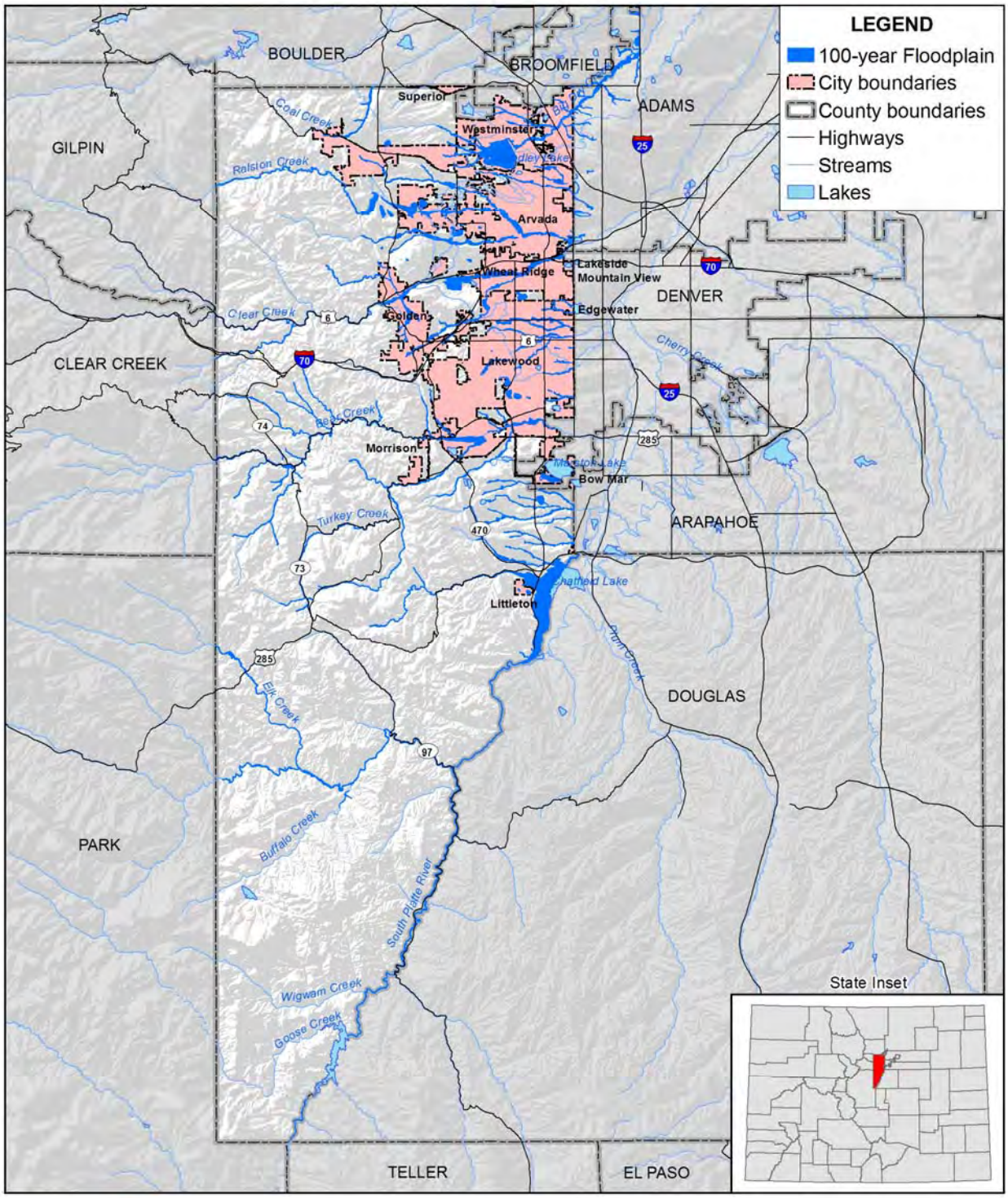


Figure 4.17. Jefferson County Flood Hazard Map



Map compiled 10/2009; intended for planning purposes only.
Data Source: Jefferson County, DFIRM, Urban Drainage and Flood Control District

Geographic Extent

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

The geographic extent rating for flooding is **limited** or between 10% to 25% of the County's area. The following section details the extent and history of flood hazards by the major watersheds in the County including Bear Creek, Clear Creek, South Platte River, Turkey Creek, and Ralston Creek.

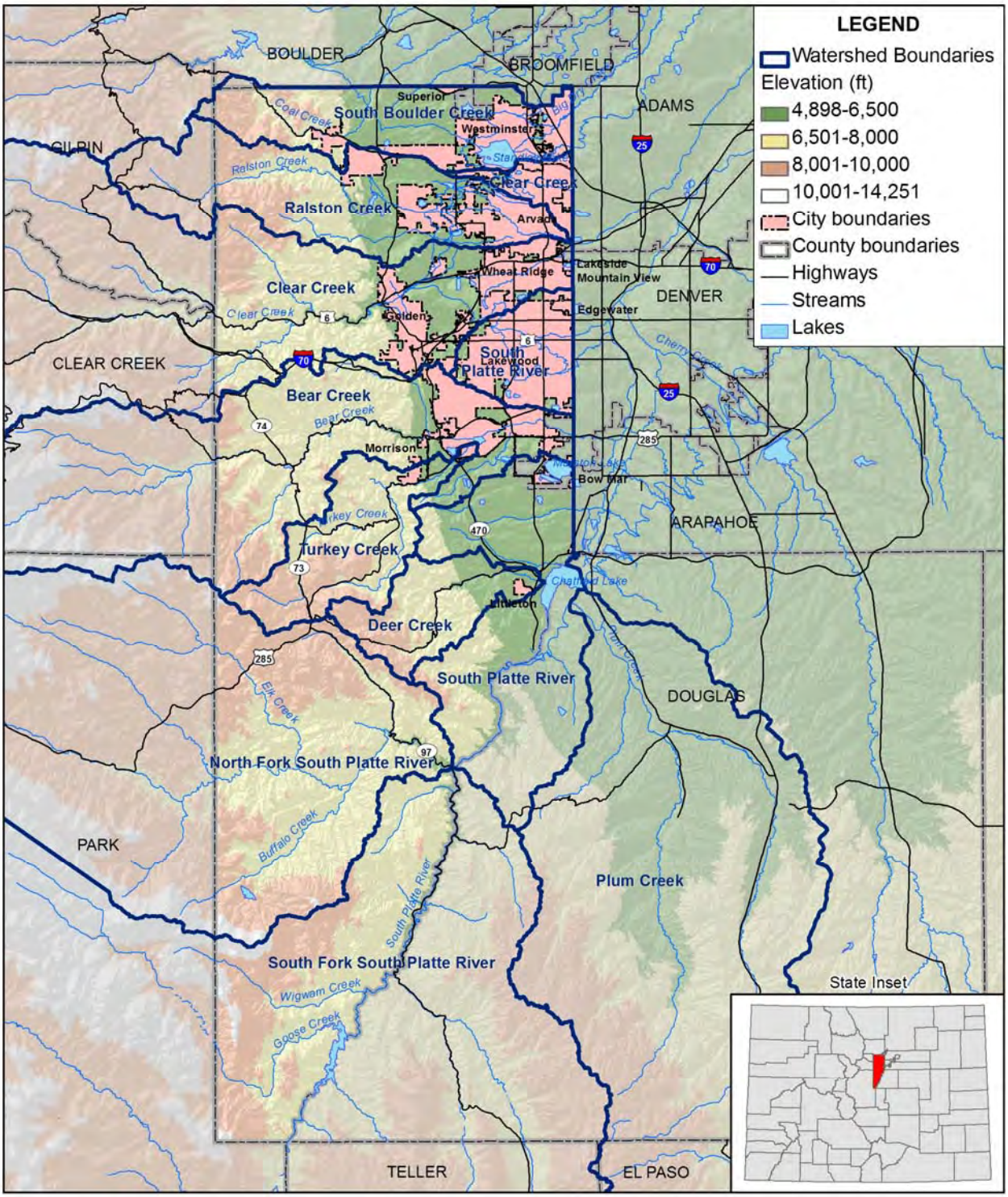
Watershed Drainage Systems

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

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

Figure 4.18 illustrates the watersheds in Jefferson County.

Figure 4.18. Watershed Map



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Map compiled 11/2009; intended for planning purposes only.
Data Source: Jefferson County

South Platte River Watershed

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

The Denver region covers about 535 square miles, all of which are in the South Platte River Watershed. The South Platte River is the main artery of the watershed, and is fed by the many creeks, lakes and minor tributaries that come down from the mountains and hills that surround Denver. Some of these tributaries include South Fork, Middle Fork, North Fork, Clear Creek, Bear Creek, Cherry Creek, and Sand Creek. Clear Creek and Bear Creek run through Jefferson County as they descend from the mountains to the plains. The water that fills Denver's lakes also eventually makes its way into the streams. In addition, drainage ditches, intermittent streams and, most critically, storm sewers, empty into the watershed. Figure 4.19 illustrates the South Platte River Basin Watershed.

Figure 4.19. South Platte River Basin Watersheds

South Platte River

Description

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

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

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

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

In an urban area where millions of people live and work, the cumulative actions of a watershed's residents can have a powerful impact on the health of the watershed. On the other hand, in sparsely populated areas of wildland urban interface, careless human-caused wildfires can

devastate a watershed leaving it vulnerable to the ravaging affects of post-wildfire flooding. The following flood history is a more recent schedule of events that have occurred post Buffalo Creek, Hi Meadow, and Hayman wildfire burns.

South Platte Watershed Flood History

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

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

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

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

August 4, 1999 - Flooding and flash flooding problems developed over portions of the Urban Corridor as slow moving thunderstorms dumped anywhere from 2 to 3.5 inches of rainfall in approximately 3 hours. Numerous outages were reported with widespread blackouts in Thornton

and Littleton. Along Massey Draw in Jefferson County, near Carr Street and Chatfield Reservoir, four homes were flood damaged and portions of their backyards washed out.

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

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

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

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

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

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

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

Bear Creek Drainage Basin

Bear Creek, which rises in the mountains southwest of Denver, is a left bank tributary of the South Platte River. The total drainage area at the mouth is 261 square miles of which 164 square miles are upstream of Morrison. The basin, shown in Figure 4.18 includes parts of Jefferson,

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

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

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

Turkey Creek Watershed Study

The USGS Mountain Ground Water Resources Study (MGWRS) on the Turkey Creek Watershed was conducted in 1999-2000. The purpose of the study was to better understand water resources, including surface and ground water quantity and quality, in the 47 square mile Turkey Creek Watershed. This study was considered a first step in developing scientifically sound management strategies and for the development of methods to assess ground water availability within different hydrologic settings, evapotranspiration (a term used to describe the sum of evaporation and plant transpiration from the land surface to the atmosphere) and ground water vulnerability to various land uses. Today there is an aggressive Turkey Creek Watershed monitoring program in force. The Precipitation Runoff Modeling System (PMRS) is used to evaluate the amount of precipitation received that is potentially available for ground water storage. The three most important components of runoff are surface runoff, sub-surface flow, and ground water flow. The PMRS results include the percent of precipitation that is returned to the atmosphere by evapotranspiration, the percent that leaves the watershed through surface runoff and subsurface flow, or becomes part of the long-term ground water storage system.

Bear Creek Drainage Basin Flood History

From 1866 to 1973 there have been 24 known floods in the Bear Creek basin; and from 1974 to 2007 there have been 23, which will be discussed later. Most of the floods from 1866 to 1973 were caused by runoff from intense rainstorms during the summer months. However, early season floods were caused from rainfall runoff in conjunction with snowmelt flows. The UDFCD monitors rainfall and streamflow from the Bear Creek basin as part of their early flood warning program, which runs from mid-April through mid-September. The peak discharge measurement

at the stream gage on Bear Creek at Morrison in 1896 was 8,600 cfs and the peak discharge on Bear Creek downstream of the gage below the confluence of Mount Vernon Creek during the 1938 flood was estimated to be considerably more than 10,000 cfs. The peak flow rate for Mount Vernon Creek alone was estimated at 9,230 cfs, which is more than twice the magnitude of the 100-year flood.

Mount Vernon Creek enters Bear Creek downstream of the Morrison Stream gage and has a drainage area of only 9.4 square miles. The headwaters of Mount Vernon Creek are at Genesee where I-70 begins its climb into the mountains along Mount Vernon Canyon. The south side of Lookout Mountain also drains into Mount Vernon Creek. At the Dakota Hogback the creek turns south, passing through Red Rocks Park and continuing to its mouth at Morrison, where a very narrow, confined stream channel exists.

A stream gage located east of Bear Creek Lake at Lowell Blvd. in Sheridan has continuously measured Bear Creek flows since 1927. The Morrison gage has partial records dating back to 1888 and continuous records since 1922. When comparing the gage records it can reveal variances in peak discharges for each flood event. This indicates the majority of flood drainage came from two different locations. For example, in the 1933, 1934 and 1938 floods, the storms were concentrated in the foothills and mountains of Bear Creek, and the resulting flood peaks attenuated between Morrison and Sheridan. For the 1957, 1965, 1969, and 1973 floods, the majority of runoff occurred from watershed areas downstream of Morrison or from Turkey Creek.

Bear Creek floods are characterized as rapid concentrations of runoff, sharp peak discharges, and rapid flood recession. Peaking time for floods on Bear Creek at Morrison is about 3 to 5 hours after the causing rainfall, while floods on Mount Vernon Creek peak between 1 and 3 hours.

Turkey Creek was the known principle contributor for the 1957, 1965, 1969 and 1973 flood events.

May 21-23, 1876 - Reported by the Denver Tribune on June 5 of that year; "... informs us that one resident had never seen such destruction in the region… He spent some days in the valleys of Soda and Bear Creeks and their tributaries and found new gullies worn to the depth of 20 feet in the action of the raging torrents."

May 29-June 1, 1894 - In the vicinity of Morrison, a flood that caused the loss of bridges, railroad tracks, houses, and destroyed the highway in the canyon.

July 24, 1896 - Intense rainfall centered on Cub Creek, a tributary of Bear Creek near Evergreen. "Without a moment's warning the largest flood that ever came down Bear Creek struck Morrison about 8 o'clock tonight (July 24), sweeping everything in its path ... although the water came down through the town nearly 3 feet deep in the main street, the buildings in the business section all withstood it."" Twenty-seven lives were lost in the flood (available records do not indicate where the deaths occurred) and severe damages were reported from Evergreen to the mouth of

Bear Creek. No rainfall records of this flood are available. The peak flow on Bear Creek at the Morrison gauging station was estimated at 8,600 cfs, which is the flood of record for the gage. The most recent hydrologic studies indicate that this flood would have a one in 40 chance of occurring in any year. It is not known to what extent Mount Vernon Creek contributed to the Morrison flooding. The Flood of 1896 was the most catastrophic flash flood to hit Bear Creek Canyon. Farms along Cub Creek were obliterated. “The water descended about Evergreen like a huge, moving wall carrying houses, sheds, barns and livestock with it”, according to the news. It was determined after the news account that 29 lives were actually lost.

July 7-8, 1933 - "Five persons known dead ... property damage of un-estimated degree and nearly all the highways between Mt. Morrison and Idledale ruined, is the toll up to date of one of the most devastating floods last Friday afternoon (July 7) ever to visit the Bear Creek Watershed. A cloudburst at about 1 o'clock in the neighborhood of Idledale sent a wall of water down Saw Mill Gulch leading to Bear Creek, and another raging torrent down Vernon Creek. ... The Vernon Creek waters reached a height of 15 feet ... in the narrow passage between the business houses. The highway up beautiful Bear Creek Canyon between Mt. Morrison and Idledale is practically ruined." The peak discharge at Morrison was 8,000 cfs on Bear Creek and estimated as 1,500 cfs on Mount Vernon Creek.

August 9, 1934 - The flood of August 9, 1934 in the Bear Creek basin was caused by cloudburst-type rainfall near Kittredge and at the head of Mount Vernon Creek. Six lives were lost and much property damage resulted. It was reported that Mount Vernon Creek ran higher than the previous year and much of the canyon roadway was destroyed. Damage to Morrison was reduced because the Bear Creek peak flow passed through the town before the Mount Vernon Creek high water arrived

September 2-3, 1938 - A widespread thunderstorm that began over the eastern slope of the Front Range on 30 August became most intense in the Morrison area on 2 September. An unofficial report stated that 7.9 inches fell just north of Morrison in six hours. The heaviest rainfall centered on the divide between Bear Creek and Mount Vernon Creek. The peak discharge on Bear Creek at Morrison above Mount Vernon Creek was 6,200 cfs. From post flood measurements the Mount Vernon Creek peak discharge was estimated at 9,230 cfs at a point 1/2 mile upstream from Morrison. From statements by local residents it appears that the peak discharge on Mount Vernon Creek reached Morrison at about 7 p.m., preceding that on Bear Creek by 1/2 hour. Six persons drowned when trapped in their automobile between Morrison and Kittredge. Damages in the basin were estimated at $450,000. If Morrison had not been warned, or if the flood had occurred late at night, the number of deaths would likely have been considerably higher.

August 24, 1946 - A heavy rain near Idledale caused Bear Creek to overflow. A Morrison woman was swept from her stranded car and drowned.

August 21, 1957 - Thunderstorms occurred over the Bear Creek basin with heavy rain and hail beginning about 1 p.m. east of Squaw Pass and northwest of Evergreen. At most locations the

rain stopped within an hour. The Mount Vernon Creek peak discharge at Morrison was estimated at 1,000 cfs at 2:30 p.m., and 1,640 cfs on Bear Creek at about 3 p.m. While most damages from Bear Creek occurred downstream of Morrison, which is a drainage from Turkey Creek. Mount Vernon Creek left debris on the grounds of six or seven residences in Morrison, flooded a garage and a used car lot, and broke a water main. State Highway 8 at Morrison was closed upon warning of the flood. Later, portions of the highway were flooded by both streams.

July 25, 1965 - On 23-24 July 1965, heavy rains over the headwaters of Bear Creek caused minor flooding throughout its length. Most damages occurred downstream of Morrison. A peak discharge of 1,030 cfs was measured for Bear Creek at Morrison on July 25, 1965.

May 7, 1969 - Heavy rains from May 4-8, 1969 resulted in flooding in the Bear Creek basin with most damages occurring downstream from Morrison. A weather station at Morrison reported a total storm rainfall of 11.27 inches, with a maximum daily amount of 5.77 inches. Unofficial rainfall amounts in the basin varied from 6.7 inches to 11.8 inches during the 5-day storm period. The peak flow for Bear Creek at Morrison was 2,340 cfs on May 7, 1969.

May 6, 1973 - The last significant flood to cause damages in the Bear Creek Basin. According to the National Weather Service, damages from the flood were estimated at around $120 million.[26] The following damage estimates were printed in the Denver Post on May 13, 1973. Damages estimates in Weld County, hardest hit by the flood, were $20 million. In Adams County, the estimate was $8 million. In Denver, the estimate had climbed to well over $6 million and in **Jefferson County, officials were reporting over $500,000 damage to roads, culverts, and other County property.** Two deaths were attributed to this event.

"The 1973 flood was the last big flood in Denver" (Brian Schat, Denver Public Works, personal communication 8/22/03). Rainfall was widespread along the Front Range with totals ranging from one to five inches. A sustained downpour dropped more than three inches in the Denver metropolitan area on Sunday, May 6. In the foothills, heavy snow fell.

Most of the damage was a result of river flooding. The South Platte was four feet above flood level at its crest when it measured 10.85 feet at the 19th Street Bridge early on the morning of May 7. The flood stage of the South Platte at W. Evans Ave. equaled that during the 1965 disaster. However, this flood was more of "a steady overflowing of water" as opposed to the "one surge" Denver experienced during the flood of 1965.

The South Platte flooding was compounded when normally dry gulches and tributaries from the mountains west of Denver became turbulent flows that emptied into the river. When Bear Creek reached southwest Denver, it had grown to be 150 yards wide in spots. Plum Creek and Indian Creek, other South Platte tributaries, also poured out of their banks, virtually isolating the town

[26] http://www.crh.noaa.gov/den/floods.html
http://libraryphoto.cr.usgs.gov/cgi-bin/search.cgi?free_form=hogback&search_mode=noPunct

of Louviers. In Englewood, the Highline Canal and the normally dry Little Dry Creek both overflowed.

Before evacuations were ordered in Denver, water began rising in Turkey, Bear, and Clear Creek Canyons because of the heavy snow runoff on May 5. By May 6, several Jefferson County roads in those areas had been washed out and residents had to be evacuated. In addition, several rockfalls and debris flows forced road closures.

Flooding in the Bear Creek watershed has killed 45 people and caused extensive property damage since the area was settled. It is idyllic for tourists and recreation seekers, unfortunately, under the right conditions Bear Creek Canyon and its tributaries can become death traps in a short amount of time. It doesn't take much rain to create a devastating flash flood. Retired Captain from the Jefferson County Sheriff's Office and historian, Dennis Potter, has documented 15 major floods that have taken place between 1864 and 1938. Of the 15, two occurred in May, one in June, eight in July, two in August, and two in September.

Clear Creek Watershed Drainage Basin

Located west of Denver, the Clear Creek Watershed spans 575-square miles from the 14,000-ft. mountain peaks along its southwestern edge on the basing and part of the Continental Divide, to the urbanized plains at its confluence to the South Platte River just north of Denver. The Clear Creek Watershed is the source of drinking water for more than 300,000 people. Clear Creek also provides water for irrigation, recreation and industry. 400 square miles of the watershed are located in the mountains west of Golden, and fully one-third of the Clear Creek Watershed lies within the Arapahoe & Roosevelt National Forests.

Clear Creek's headwaters begin in an area rimmed by four 14-ers (mountains that are 14,000 feet in elevation or higher) – Grays and Torreys Peaks, Mt. Evans, and Mt. Bierstadt. Major tributaries that feed into Clear Creek include the North, South and West Forks; Leavenworth, Lion, Trail, Chicago, Soda and Ralston Creeks; Fall River; Tucker Gulch; Kenneys Run; Lena Gulch; Little Dry Creek (confluence in Adams County); and Beaver Brook. The main-stem flows eastward along the Interstate 70 (I-70) corridor, through several communities, along approximately 12 miles of Highway 6 corridor through the Clear Creek Canyon and then back along the I-70 corridor through several Denver Front Range Communities.[27]

Clear Creek

Clear Creek is a tributary of the South Platte River, approximately 40 mi long, in north central Colorado in the United States. The creek drains a canyon, called Clear Creek Canyon in the Rocky Mountains directly west of Denver, descending through a long gorge to emerge on the

[27]For the complete Clear Creek Watershed 2007 report, *Exploring Watershed Sustainability* see http://www.clearcreekwater.org/pdfs/CCWF-2007-report-optimized.pdf

Colorado Eastern Plains where it joins the South Platte. The creek is famous as the location of the most intense early mining activity during the Colorado Gold Rush of 1859. The creek provided the route of the Colorado Central Railroad and later for the United States Highway 6 and Interstate 70 as they ascend to the Continental Divide west of Denver

The creek rises at the continental divide near Loveland Pass in the Front Range, northwest of Grays Peak in western Clear Creek County. It descends eastward through Clear Creek Canyon past the towns of Silver Plume, Georgetown, and Idaho Springs, all of which were founded as mining camps in the 1859 gold rush. Within the canyon it receives numerous smaller tributary creeks that descend from the rugged mountains on either side.

At the mouth of the canyon, in Jefferson County, the creek passes through the town of Golden, past the Coors brewery. East of the foothills, it flows through the northwest part of the Denver Metropolitan Area, passing through Wheat Ridge, southeastern Arvada, then roughly along the route of Interstate 76 (I-76). Along this section it is largely an undeveloped urban stream, with an undeveloped floodplain. Part of the creek path forms a wooded park with bicycle/foot path. It passes under Interstate 25 (I-25) between its junction with Interstate -70 (I-70) and U.S. Highway 36 (Hwy 36 - the Boulder-Denver Turnpike). It joins the South Platte from the west in southeast Thornton, near the junction of Interstate 76 (I-76) and State Highway 224 (Hwy 224).

Clear Creek Watershed Flood History

The Urban Drainage and Flood Control District (UDFCD), under joint sponsorship with the City and County of Denver, City of Wheat Ridge, City of Golden, Adams County, Jefferson County and ICON Engineering, Inc. conducted a study, *Planning and Flood Hazard Delineation Area for Clear Creek Drainageway,* which extends from Sheridan Boulevard at the downstream study limit to the City of Golden in Jefferson County, at the upstream study limit. The drainage area at the location of the Golden gage near the bluff line is approximately 400 square miles. From Golden, Clear Creek flows in a northeasterly direction, through the Denver Metropolitan Area to its confluence with the South Platte River, near Derby. At the Derby gage, located approximately 0.6 miles upstream from the mouth, Clear Creek has a drainage area of approximately 575 square miles. Elevations within the Clear Creek basin range from approximately 5,100 feet above mean sea level at the mouth to over 14,000 feet above mean sea level in the Rocky Mountains. For the full study including extensive mapping see footnote[28].

The intent of the report is to evaluate and document the existing floodplain along Clear Creek so that project stakeholders, and other users, can implement floodplain zoning ordinances, floodplain regulations, and other land-use controls, as needed, to reduce potential damages and adverse development in the floodplain. This report provides information on past flooding events and defines the nature and extent of probable future floods along an 11.6 mile reach of Clear

[28] http://www.udfcd.org/downloads/pdf/publications/fhad_new/Clear%20Creek%20FHAD%20Denver%20and%20Jeffco%202007.pdf

Creek, from Sheridan Boulevard to approximately 2,200 feet upstream of Highway 6 in the City of Golden. Discharge information along Clear Creek was originally computed by the U.S. Army Corps of Engineers (COE) and incorporated into previous Flood Hazard Area Delineation (FHAD) and Master Planning documents. Historically, flooding in the Clear Creek basin has been relatively infrequent. Since 1864, twelve floods have been reported on Clear Creek and its tributaries. The following descriptions include the floods of August 1888, July 1890, June 1956, and July 1965 (Gingery 1979).

Flood of August 1888 - This flood resulted from cloudbursts on the eastern slope of the Front Range of the Rocky Mountains. A discharge of 8,700 cubic feet per second (cfs) was reported at the mouth of Clear Creek canyon. This is the largest estimated peak discharge in the history of this gauging station, which is located 1.5 miles upstream from Golden.

July 19, 1890 - Severe rain storm begins after a long dry spell causing Clear Creek to flood. Flood waters reach Golden at 4:00 p.m. on the 20th. The deaths of two women and an 18-month-old baby were attributed to the flood.

July 26, 1923 – Cloudbursts in the foothills above Golden caused floods in all the gulches that enter Clear Creek from the north within 2 miles of Golden. At the mouth of Magpie Gulch the rainfall was moderate, but half a mile above it was a cloudburst. The rain began about 12:45 p.m. and the flood reached its crest by 1 p.m. and then fell so rapidly that by 1:40 p.m. the flow in the gulch was again normal. This flood deposited a gravel and boulder dam 10 feet high entirely across Clear Creek, a distance of about 70 feet. Some of the boulders moved by the flood weighed as much as 5 tons.

June 6, 1948 - there was a flash flood in Tucker Gulch, a left bank tributary to Clear Creek in Golden. The peak discharge in Golden was 11,600 cfs and there were substantial flood damages. This flood from the 11.2 mi^2 basin is nearly twice the largest flood in Clear Creek (~400 mi^2). This is one of the largest, if not the largest, flood for this size watershed in Colorado.

Flood of June 1956 - Unusually heavy snowmelt runoff resulted in the failure of the Georgetown Dam located about 1 mile downstream from Georgetown. The peak discharge passing the gage above Golden was 5,250 cfs. By the time the crest reached the gauging station near the mouth of Clear Creek, it was reduced to 2,880 cfs.

Flood of July 23-26, 1965 - On July 23 and 24, during severe storms over the headwaters of Clear Creek and Tucker Gulch, 4.5 inches of rain was reported to have fallen in Tucker Gulch in an hour, which caused flash flooding in Golden, however, flooding extended only a short distance downstream. In Golden, flood waters from Tucker Gulch spread over about 17 blocks and caused an estimated $112,000 damage to 69 residences, three commercial enterprises, three railroad bridges, four street bridges, and utility lines. At Georgetown, debris blocked the channel and diverted the waters down a street, thereby causing extensive washing of the surface and the flooding of several basements.

July 29, 2003 - Heavy rainfall caused flooding and flash flooding problems in north central Jefferson County. Officials were forced to briefly close State Highway 93, north of Golden, which was flooded by runoff and littered with debris. In Golden, flash floods left several backyards and basements full of standing water. At least one car was submerged in a garage. Radar estimated 1 to 1.5 inches of rain had fallen in the area in approximately 30 minutes.

June 8, 2004 - In Golden, heavy rains triggered a small debris flow on U.S. Highway 6, near the intersection of Colorado Highway 119. Automated gages in the area registered 2 to 3 inches of rain in one hour. Near the Colorado Mills Mall in the Lena Gulch drainage basin, numerous intersections were inundated from 1 to 3 feet of water and hail, stranding several vehicles, including a fire engine. Approximately 30 basements were flooded in Golden and Lakewood and many windows, to both cars and homes, were broken by large hail. June 8th was the first of five days in which flash flood warnings were issued for the UDFCD area. Seven other days warranted flash flood watches, making 2004 one of the most active flood seasons in the 26-year history of the District's flash flood prediction program. Fortunately, no lives were lost and the flooding that did occur was localized with total damages not reaching disaster proportions. An early morning cold front set the stage for 2004's first outbreak of flood producing storms. Around 8 p.m. storms began developing along the urban foothills of Jefferson County. Over the next two hours, Golden, Lakewood, Wheat Ridge, and nearby areas were pounded by heavy rain and hail. The Colorado Mills shopping mall was hit especially hard with over 3 inches of rain in 90 minutes. Homes were flooded and streets were closed in the vicinity of W. 32nd Ave. and I-70 where an unconfirmed precipitation measurement of 5" was reported. A Golden firefighter stated that flood fighting at the intersection of 20th Street and Washington was like working a swift water rescue. Hail depths up to 18 inches were reported in some areas and motorists in Lakewood were rescued from cars.

June 27, 2004 - A deluge of very heavy rain from nearly stationary thunderstorms caused flooding and flash flooding problems over parts of Jefferson County. In Jefferson County, an automated rain gauge north of Golden measure 3.6 inches of rain in one hour. Numerous homes were flooded in Golden, including one that was 146 years old. The home was listed as a complete loss. In addition, State Highway 93 had to be closed from the Pine Ridge subdivision (near 6th Ave and Hwy 93) to Golden Gate Canyon Road. At the height of the storm, about 4 feet of water covered Colorado 93 through Golden, forcing its temporary closure. Rockfall and debris flows were also reported in Golden Gate Canyon. Several intersections were also flooded and impassable. The worst flooding in Golden occurred along a small drainage known as Arapahoe Gulch, which runs along the west side of Washington Street. Affected residents there may have a similar predicament with regard to flood insurance since the hazard area associated with Arapahoe Gulch is not shown on the Flood Insurance Rate Map. The storm that caused this flooding produced between 3.5 and 4 inches of rain over the watershed. Based on surveyed high water marks and debris lines, peak flow rates in Arapahoe Gulch during the June 27 event were approximately 400 cfs. The peak flow estimate was nearly a 200-year event and greatly exceeded the capacity of the Arapahoe Gulch drainage system downstream of 2nd Street.

August 3, 2006 - Heavy rain caused flash flooding along Leyden Creek in unincorporated Jefferson County, northwest of Arvada. An automated rain gauge in upper Leyden Creek, 6 miles northwest of Arvada, measured 2.68 inches of rain in less than two hours. Two to three feet of water covered the roadway at 82nd and Quaker. Leyden Creek is a tributary to Ralston Creek

Ralston Creek Watershed

Ralston Creek is a tributary of Clear Creek, approximately 15 miles long. It drains a suburban and urban area of the northwestern Denver Metropolitan Area. It rises in the foothills in northeastern Gilpin County, in southern Golden Gate Canyon State Park. It descends through a valley eastward into Jefferson County following Drew Hill Road (County Road 57), emerging from the mountains approximately 3 miles north of Golden, where it is impounded to form Ralston Reservoir west of State Highway 93 and the Arvada/Blunn Reservoir on both sides downstream of State Highway 93. It flows eastward through Arvada and joins Clear Creek from the north in southeast Arvada, near the intersection of Sheridan Avenue and Interstate 76. The U.S. Army Corps of Engineers funded a flood and erosion control stream improvement project to the 100-year floodplain along Ralston Creek at the location of the Garrison Street Bridge in 2005.

Deer Creek Watershed

Deer Creek created Deer Creek Canyon. It is an important riparian corridor between the Hogback and Wetlands Conservation Areas. It is a rich butterfly habitat and a large portion of it is protected by the Deer Creek Canyon Park, which encompasses diverse, natural environments. Perhaps most striking is the scrub oak habitat, uncommon in Jefferson County. Although small in stature, the scrub oak provides important food and cover for wildlife including grouse, turkey, mule deer, elk, mountain lion, and black bear. Deer Creek discharges directly into Chatfield Reservoir.

Significant Jefferson County Gulches

As mentioned above there are over 90 gulches, canyons and draws in Jefferson County. Some gulches, where there is a high vulnerability to larger numbers of populations, are discussed in further detail below.

Lena Gulch

Lena Gulch is a tributary of Clear Creek with a confluence near 41st Avenue and Kipling Street. The total drainage area for the basin is 13.3 square miles. Lena Gulch is predominantly in the City of Wheat Ridge, but also through Golden, the Pleasant View area, Lakewood, Wheat Ridge and parts of unincorporated Jefferson County. The lower reach of Lena Gulch begins at Maple Grove Reservoir, which is a water storage reservoir operated by the Consolidated Mutual Water District Company. The drainage basin entering Maple Grove Reservoir is 10.5 square miles. Typically, low flows from the upper basin pass through the reservoir and are released downstream. The lower basin has a drainage area of 2.8 square miles. Lena Gulch is unusual for

a small foothills stream in that it has a constant base flow. This makes for an attractive stream setting with riparian zones and aquatic flora and fauna along the corridor. There are several areas of concern along Lena Gulch. Discussions for flood control projects are currently under way across several jurisdictions. Lena Gulch will be further discussed in the jurisdictional annex for the City of Wheat Ridge. A complete study of the Flood Hazard Area Delineation for Lena Gulch has been created.[29]

Lena Gulch Flood History

July 27, 1997 - Heavy rain caused Lena Gulch to surge 2 feet over its banks. The fire department had to rescue a man when his van stalled in the high water.

August 10, 1998 - Heavy rain caused flooding and flash flooding problems over southwest portions of Metropolitan Denver. An observer in Lakewood recorded 3.26 inches of rainfall in one hour. Several streets were flooded in central Lakewood. In addition, a trailer park along Lena Gulch in Wheat Ridge was evacuated due to the high waters.

June 8, 2004 - Heavy rain and large hail caused flooding and flash flooding across northeast Jefferson County. Automated gages in the area registered 2 to 3 inches of rain in one hour.

Lakewood Gulch

Lakewood Gulch is a well defined drainageway. It originates on the northwest slopes of Green Mountain in Lakewood, flows east through Sixth Avenue West Park, and continues east through Lakewood into Denver, where it joins the South Platte River southwest of the intersection of I-25 and Colfax Avenue. A small portion of the studied length of Lakewood Gulch is in unincorporated Jefferson County, while the predominant length lies in Lakewood. Lakewood Gulch will be further discussed in the jurisdiction annex for the City of Lakewood. A complete study of the Flood Hazard Area Delineation for Lakewood Gulch has been created.[30]

Lakewood Gulch Flood History

August 21, 1998 - While no flash flood warning was issued for the August 10th storm, extensive urban flooding did occur in Lakewood and Denver. Between 4:45 and 5:45 P.M., 3.26 inches of rain was measured in Lakewood near the intersection West 1st Ave. and Balsam Street. Rush-hour traffic was at a crawl while many homes had their basements flooded. Vehicles were floating in the Wal-Mart parking lot where the floodwater was 3 to 4 feet deep. This parking lot is located in the floodplain of South Lakewood Gulch near West 2nd Ave. and Wadsworth Blvd. East of Kipling Street, McIntyre Gulch was out of its banks at a number of locations. Lakewood Gulch in Denver overtopped Wolff Street by at least 3 feet. This event contributed directly to a Lakewood City County action exactly 2 weeks later endorsing a plan to form a stormwater utility

[29] http://www.udfcd.org/downloads/pdf/publications/fhad_new/Lena%20Gulch%20Lower%20FHAD%202007.pdf
[30] http://www.udfcd.org/downloads/pdf/publications/fhad_new/Lakewood%20Gulch%20FHAD%201979.pdf

and establish a fee of $0.88 a month for each 1,000 square feet of impervious surface area, costing the average homeowner $1.98 per month.

May 14, 2007 - a mother and her toddler got trapped in a flash flood on Lakewood Gulch in Denver. They were taking a walk along the gulch trail when it started to hail. They attempted to escape the hail from the storm by going further down into a small box culvert underneath Decatur Street adjoining the creek as it travels under Decatur Street in Denver. The mother lost the grip of her toddler's stroller and the child was swept downstream. He was found dead a few days later a few miles away on the banks of the South Platte River. After the incident, the bike path adjoining the creek was permanently closed.

Probability of Future Occurrences

There have been 41 floods in Jefferson County recorded since 1876; however, 31 of them (28 recorded by the NCDC, 3 recorded by NWS and a number of others by UDFCD) have occurred since 1950, or a span of 59 years (2008-1950 = 59 years). The methodology for calculating the probability of future occurrences using the number of incidents from 1950 is described in Section 4.2.1. This formula evaluates that the probability of a flood occurring in any given year is 52.5%. This corresponds to a probability of future occurrences rating of **likely.**

If the total number of flood incidents is used (41) over a period of 132 years, the probability of a flood occurring in any given year is 31.06%. This still corresponds to a probability of future occurrences rating of **likely.** A 100-year flood has an annual probability of 1%. A 500-year flood has a 0.2% chance of occurring in any given year.

Magnitude and Severity

Magnitude and severity can be described or evaluated in terms of a combination of the different levels of impact that a community sustains from a hazard event. Specific examples of negative impacts from flooding on Jefferson County span a comprehensive range and are summarized as follows:

- Floods cause damage to private property that often creates financial hardship for individuals and families;
- Floods cause damage to public infrastructure resulting in increased public expenditures and demand for tax dollars;
- Floods cause loss of personal income for agricultural producers that experience flood damages;
- Floods cause loss of income to businesses relying on recreational uses of County waterways;
- Floods cause emotional distress on individuals and families; and
- Floods can cause injury and death.

Jefferson County is uniquely located covering very populated urban areas as well as wildland urban interface foothills. Areas burned by wildfire tend to have a high runoff, resulting in flash

flooding in those areas. Hilly terrain, coupled with brief, heavy summer downpours can result in flash flooding in many areas in the County. Fast-moving water is extremely powerful. The result can be deadly to anyone in the water's path. The force of flash flood waters can be extremely dangerous to motorists who unwittingly or unknowingly drive over water-covered roads - only two feet of running water are needed to sweep away a car. Risks to life and property can be very high during periods of flash flooding.

The magnitude and severity of the flood hazard is usually determined by not only the extent of impact it has on the overall geographic area, but also by identifying the most catastrophic event in the previous flood history. Sometimes it is referred to as the "event of record." There are differences in how the various natural hazard events are recorded and therefore do not apply across the hazards equally. For this reason additional data was taken into consideration to define the term "flood of record." Normally a flood of record relates to official stream-flow information available from the USGS and other sources, which include the National Weather Service and Urban Drainage and Flood Control District. The "flood of record" is almost always correlated to a peak discharge at a gage, but that event may not have caused the worst historic flood impact in terms of property damage, deaths, etc.

The 1938 flood illustrates this point well. It was likely the most devastating flood that Morrison has ever experienced; however, the '38 flood was not the largest historic stream-flow measurement for the Bear Creek at Morrison gage. The 1896 Black Friday Flood peak discharge was 8,600 cfs versus 6,200 cfs for the 1938 flood. In 1933 the Bear Creek gage recorded a peak discharge of 8,110 cfs and deaths occurred, but the 1938 flood caused far more damage to the town.

With this said, it is important to evaluate all the variables when attempting to identify a "flood of record." The 1965 flood received much media attention along Plum Creek in Douglas County and along the South Platte River through Denver, but Jefferson County sustained its share of damages as well. When major floods happen, lesser impact areas from the same event are given less attention by the media. To get a handle on the flood year that caused the most damage, additional research was necessary. NFIP claims statistics for the past 30 years were considered, however, the two worst flood damage years predated the NFIP. Inflation adjustments were also calculated. The accumulated data pointed to the 1896 Black Friday Flood to be the "flood of record." There were 29 lives lost and devastation from Evergreen to the mouth of Bear Creek wiping out everything in its path. Farms were destroyed along with the livelihoods of most of those who lived in the area. The City of Golden was under siege by floodwaters coming in from two directions taking out all bridges and shutting down the electric plant. Miles of railroad tracks were twisted like pretzels up Clear Creek, and the town of Morrison was a mass of wreckage and ruin. Enormous amounts of debris were strewn from the mountains to the plains of Denver. It was considered an economic catastrophe of its time where reconstruction took years. A future event of this magnitude could have similar devastation to Morrison and Golden. Based on these factors, the magnitude severity ratings for flood are considered **critical**.

Overall Hazard Significance

Floods in Jefferson County can have a particular impact on the planning area. Widespread flooding is rare, but flash floods and flooding in small pockets of the County happens with regularity. The geographic extent of the hazard is considered **limited**. The probability of future occurrences is considered **likely** and the magnitude/severity for the event of record is **critical**. In addition, the HMPC considers the hazard to have a **high** overall impact rating on the County. This equates to an overall impact rating of **high**.

4.2.10 Hailstorm

Description

Hailstorms are any storm events where hailstones fall. Hailstones, often abbreviated to 'hail,' forms when updrafts carry raindrops into extremely cold areas of the atmosphere where the drops freeze into ice. Hail falls when it becomes heavy enough to overcome the strength of the updraft and is pulled by gravity towards the earth. The process of falling, thawing, moving up into the updraft and refreezing before failing again may repeat many times, increasing the size of the hailstone. Usually hailstones are less than 2" in diameter, but have been reported much larger and may fall at speeds of up to 120 mph. Hailstorms occur throughout the spring, summer, and fall in the region, but are more frequent in late spring and early summer. These events are often associated with thunderstorms that may also cause high winds and tornadoes. Hail causes nearly $1 billion in damage to crops and property each year in the United States. Hail is also one of the requirements which the National Weather Service uses to classify thunderstorms as 'severe.' If hail more than ¾ of an inch is produced in a thunderstorm, it qualifies as severe.

The National Weather Service classifies hail by diameter size, and corresponding everyday objects to help relay scope and severity to the population. The table below indicates the hailstone measurements utilized by the National Weather Service.

Table 4.8 Hailstone Measurements

Average Diameter	Corresponding Household Object
.25 inch	Pea
.5 inch	Marble/Mothball
.75 inch	Dime/Penny
.875 inch	Nickel
1.0 inch	Quarter
1.5 inch	Ping-pong ball
1.75 inch	Golf-Ball
2.0 inch	Hen Egg
2.5 inch	Tennis Ball
2.75 inch	Baseball

Average Diameter	Corresponding Household Object
3.00 inch	Teacup
4.00 inch	Grapefruit
4.5 inch	Softball

Source: National Weather Service

In Colorado, hail is one of the most damaging of natural hazards. In fact, the 1996 July hailstorm set a record for most damaging hailstorm on a national level. According to the 2008 State Hazard Mitigation Plan, the damaging hail season in Colorado ranges from mid-April to mid-August. Colorado's Front Range, including the entire planning area, is located in the heart of "Hail Alley," which receives the highest frequency of large hail in North America and most of the world. According to the Rocky Mountain Insurance Information Association (RMIIA), hail accounts for all ten of the most costly storms on record in terms of insured damage. Only two of those incidents also include damages from tornadoes.

Geographic Extent

Hailstorms occur during severe storms, which are regional in nature. However, just as the amount of precipitation in the form of snow or rain may vary significantly within a single storm, so may the amount, size, and duration of hail within a severe storm. This can have a wide range of impacts. In general, hail can fall anywhere in Colorado. The areas where hail is most frequently reported with damaging effects are in the eastern plains, where hail damages crops and livestock, and in the Denver metro area, where hailstorms damage buildings, cars and trees, and may cause driving conditions to deteriorate. The extent of impacts ranges from limited, where a single community within the planning area is affected, to significant, where more than 50% of the County was impacted. There are no known incidents where a single hailstorm impacted more than 75% of the County; however, so while hail is *possible* anywhere in the planning area, it is not likely to affect the entire area simultaneously.

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

Previous Occurrences

Since hailstorms are so prevalent in Colorado, the most useful previous occurrences to examine are those which caused a particularly high amount of damage or incurred some other unique cost or impact. The NCDC database records 269 hail events in the planning area between January 1, 1950 and March 31, 2009. 11 of those storms reported hailstones at least 2" in diameter. However, some of these storms reflect the different size hailstones for the same storm event, so the data is somewhat skewed. Several selected incidents, including some not captured in the NCDC database, are profiled below. These selections illustrate the severity of the hail hazard for the jurisdiction and are representative of the range and risk, but are not comprehensive.

July 20, 2009 - In an unusual overnight storm, rain, winds and golf-ball sized hail battered roofs, uprooted trees, damaged homes, and pounded vehicles in Wheat Ridge, Lakewood, Arvada and Englewood. Most of the damages in this storm are attributed to property losses, with 32,900 homeowner claims and 19,500 automobile claims filed as of July 27, 2009, which amounts to $350 million in insurance claims based on preliminary estimates. While the entire Denver metro area was impacted by the storm, the most significant damages were reported in Jefferson County. This storm is projected to be the second costliest natural disaster in Colorado, in terms of insured losses.

May 24, 2007 - Several fast moving storms dropped substantial amounts of hail in the foothills southwest of Denver. One hailstorm impacted U.S. Highway 285 near Aspen Park, where state patrol reported 2″ of pea-sized hail fell on the highway, causing it to become snow packed and slick. Four associated accidents were reported shortly thereafter, including three roll-overs in a 10 minute period of time. No injuries were reported and damages were estimated at $20,000 ($20,700 in 2009 dollars (most recent data available)).

June 8, 2004 - A series of hailstorms stretching along the Front Range from Colorado Springs to Larimer County and out to the eastern border of the state dropped hailstones ranging from dime to golf ball sized. The hail in Jefferson County fell mostly between 7:00 and 8:00 pm across Evergreen and Golden. The next afternoon, Morrison, Conifer, and Lakewood were all impacted by large hailstorms as well. Statewide, insurance damages were reported at $146.5 million ($166.4 million in 2009 dollars). This storm was classified as the eighth most costly hailstorm event in Colorado history as of July, 2009.

May 22, 1996 - A severe thunderstorm producing large hail ranging in size from 3/4 to 2 inches in diameter rumbled across the northwest and northern portions of the Denver metropolitan area. The thunderstorm apparently developed from an outflow boundary generated from the supercell thunderstorm that moved across extreme northeastern Colorado earlier in the evening. The storm developed near the foothills and moved east northeast across northern portions of the metro area. The hardest hit areas were cities of Arvada and Westminster, northwest of Denver. The insurance industry estimated $60 million in damage to homes and personal property and $62 million in damage to automobiles for a total of $122 million in insured losses ($166.8 million in 2009 dollars). This estimate also included the cities of Golden, Thornton, and Wheat Ridge.

October 1, 1994 - An afternoon hailstorm, lasting for nearly three hours as it crossed the Denver metro area, produced hail ranging from pea to golf ball sizes. Damages and incidents reported in the planning area include Arvada, Edgewater, and Wheat Ridge. Other impacted areas included Denver, Boulder, Last Chance, Bennett, Strasburg, Wiggins, Penrose, and the Buckley Air National Guard Base near Aurora. Overall insured estimates, sourced by RMIIA, totaled at $225 million ($326 million in 2009 dollars).

June 1, 1991. Intense thunderstorms formed in northern Jefferson County on June 1, 1991. These storms flooded streets and urban streams from Columbine County Club through

Lakewood into Golden with 0.75" to 1.5" diameter hail and 1.5"-3.5" rainfall in less than 1 hour. I didn't have information on the estimated damage for this event.

July 11, 1990 - A storm with hailstones of up to 2.75" in diameter incurred 13 injuries in the planning area. A companion entry for the same date indicated the hail size was 1.75" but that 47 injuries were reported, which were mostly documented in Elitch Gardens (then located in Denver County). The RMIIA placed the total insured hail damages for the affected area at $625 million ($1.03 billion in 2009 dollars). The storm impacted Adams, Arapahoe, Boulder, Denver, Elbert, Jefferson and Larimer counties, with the heaviest damages reported in Jefferson County. Additional accounts indicate that this was the costliest hailstorm in U.S. history, as hail ranged along the entire Front Range. Jefferson County also suffered severe damages to aircraft at the County Airport, power and utilizes were disrupted to thousands of residents, and storm drains clogged with hail flooded roads three to six feet deep in Arvada.

June 13, 1984 - A mega rain/hailstorm occurred on June 13, 1984. Severe thunderstorms crossed northern Jefferson County and western Adams County dropping 2-4" rain and 1"-3.5" diameter hail. There was serious flooding in Arvada, Westminster, Wheat Ridge and Lakewood. Damage was estimated at $350-$400 million ($723-$825 million in 2008 dollars) damage in Jefferson County

Probability of Future Occurrences

The planning area experiences an average of 2-3 days of significant hail per year. The record of previous occurrences, as discussed earlier, is incomplete as well, but provides a useful reference for hailstorms which produced significant size stones and/or caused damage. Calculating that Jefferson County expects 2 to 3 days of hail per year is less useful than determining how frequently the planning area may experience a severe event. According to RMIIA, there have been eight severe hailstorms which caused more than $100 million in damages that impacted Jefferson County in some way since 1990. The planning team identified an additional severe event in 1984. This data will be used to determine the probability of a severe hailstorm in Jefferson County.

There have been 9 severe incidents involving Jefferson County since 1990, or a span of 24 years. (2008-1984 = 24 years). The methodology for calculating the probability of future occurrences is described in Section 4.2.1. This formula evaluates that the probability of a severe hailstorm occurring in any given year is 37.5%. If the same methodology is applied to all hailstorms (including those that cause minimal damage), then there have been 269 events since 1950, for a span of 58 years (2008-1950=58 years). This indicates that Jefferson County can expect an average of 4.6 hailstorms a year.

This corresponds to a probability of future occurrences rating of **likely**.

Magnitude and Severity

In order to calculate a magnitude and severity rating for comparison with other hazards, and to assist in assessing the overall impact of the hazard on the planning area, information from the event of record is used. In some cases, the event of record represents an anticipated worst-case scenario, and in others, it is a reflection of common occurrence. The event of record for Jefferson County occurred on July 11, 1990 (pending the final results from the July 20, 2009 storm). The event damaged millions of dollars worth of property in the jurisdiction. The damages inflicted on critical facilities and services (critical infrastructure) resulted in a loss or disruption of serves for a minimal amount of time. Documented illnesses and injuries were considered critical, though the medical response of the jurisdiction was considered minimally impacted. The huge outliers of cost and injury rates push the overall rating up, as does the event's place as the costliest hailstorm in U.S. history.

Based on these factors, the magnitude severity rating for hailstorms is considered **critical**.

Overall Hazard Significance

Hailstorms in Jefferson County have a significant impact on the planning area. The costs of hailstorms are higher than any other natural disaster currently documented for the planning area. In addition, Jefferson County reports the highest number of hail-related injuries in the state at 60. The geographic extent of the hazard is considered **significant**. The probability of future occurrences is considered **likely** and the magnitude/severity for the event of record is **critical**. The HMPC considers the hazard to have an overall impact rating of low on the County. The data indicates, however, that an overall impact rating of **high** is most appropriate.

While hailstorms are not as high profile as other natural disasters such as tornadoes, blizzards, or floods, the amount of damage they inflict on the planning area is hugely significant. The hazard is frequent enough in occurrence to pose a significant financial risk to the planning area, and though mitigation measures are limited, the hazard deserves due consideration in the overall profile effort.

4.2.11 Landslides, Debris Flows, and Rockfalls

Description

Landslide

Landslides are a serious geologic hazard common to almost every state in the United States. It is estimated that nationally they cause up to $2 billion in damages and from 25 to 50 deaths annually. Some landslides move slowly and cause damage gradually, whereas others move so rapidly that they can destroy property and take lives suddenly and unexpectedly. Gravity is the force driving landslide movement. Factors that allow the force of gravity to overcome the resistance of earth material to landslide include: saturation by water, erosion or construction, alternate freezing or thawing, earthquake shaking, and volcanic eruptions.

Landslides are typically associated with periods of heavy rainfall or rapid snow melt and tend to worsen the effects of flooding that often accompanies these events. In areas burned by forest and brush fires, a lower threshold of precipitation may initiate landslides. Generally significant landsliding follows periods of above-average precipitation over an extended period, followed by several days of intense rainfall. It is on these days of intense rainfall that slides are most likely.

Areas that are generally prone to landslide hazards include existing old landslides; the bases of steep slopes; the bases of drainage channels; and developed hillsides where leach-field septic systems are used. The most vulnerable areas are the mountain corridors and the urbanized areas along the Rocky Mountain Front Range (Figure 11). Landslides are often a secondary hazard related to other natural disasters. Landslide triggering rainstorms often produce damaging floods. Earthquakes often induce landslides that can cause additional damage.

Slope failures typically damage or destroy portions of roads and railroads, sewer and water lines, homes and public buildings, and other utility lines. Even small-scale landslides are expensive due to clean up costs that may include debris clearance from streets, drains, streams and reservoirs; new or renewed support for road and rail embankments and slopes; minor vehicle and building damage; personal injury; and livestock, timber, crop and fencing losses and damaged utility systems.

The identification of areas susceptible to landslides is necessary to support grading, building, foundation design, housing density, and other land development regulations in reducing the risk of property damage and personal injury. Some work has been done to prevent development on top of or below slopes subject to sliding. More needs to be done to educate the public and to prevent development in vulnerable areas. Jefferson County has developed a dipping bedrock overlay zone that is designed to mitigate development in these areas that could be damaged by landslides (FEMA, Colorado Geological Survey).

Debris Flow

Debris flows, sometimes referred to as mudslides, mudflows, lahars, or debris avalanches, are common types of fast-moving landslides. They are a combination of fast moving water and a great volume of sediment and debris that surges down slope with tremendous force. These flows generally occur during periods of intense rainfall or rapid snowmelt and may occur with little onset warning, similar to a flash flood. They usually start on steep hillsides as shallow landslides that liquefy and accelerate to speeds that are typically about 10 miles per hour, but can exceed 35 miles per hour. The consistency of debris flow ranges from watery mud to thick, rocky mud that can carry large items such as boulders, trees, and cars. Debris flows from many different sources can combine in channels, and their destructive power may be greatly increased. When the flows reach flatter ground, the debris spreads over a broad area, sometimes accumulating in thick deposits that can wreak havoc in developed areas. Mudflows are covered under the National Flood Insurance Program; however, landslides are not. Figure 4.20 gives a description of debris flows, characteristics, and provides a picture of the leading edge of a debris flow.

Figure 4.20. Field Evidence of Debris Flow

Source: USGS publication "*Distinguishing between Debris Flows and Floods from Field Evidence in Small Watersheds*"

A drainage may have several debris flows a year, or none for several years or decades. They are common events in the steep terrain of Colorado and vary widely in size and destructiveness. Cloudbursts provide the usual source of water for a debris flow in Colorado.

Debris flows ruin substantial improvements with the force of the flow itself and the burying or erosion of them by mud and debris. The heavy mass pushes in walls, removes buildings from foundations, fills in basements and excavations and sweeps away cars, trucks heavy equipment and other substantial objects. Boulders and trees swept along by the muddy mass demolish buildings, and flatten fences and utility poles. In mountain areas, portions of valleys have been eroded to a depth of several feet by the flow process.

Removal of vegetation on steep slopes, dumping debris and fill in a mud flow path, and improper road building or earth moving can contribute to a debris flow. The failure of a dam, irrigation ditch or other water management structure can initiate debris flows if the escaping water can swiftly accumulate a large volume of soil materials. Similarly, a landslide that temporarily blocks a stream may cause or contribute to a debris flow.

Rockfall

Rockfalls are the fastest type of landslide and occur most frequently in mountains or other steep areas during early spring when there is abundant moisture and repeated freezing and thawing. The rocks may freefall or carom down in an erratic sequence of tumbling, rolling, and sliding. When a large number of rocks plummet downward at high velocity, it is called a rock avalanche.

Rockfall can be a continuous process over a considerable period of time or a single or series of single, intermittent events. Simultaneous activation of a large mass of rock can result in a rockfall avalanche or very rapid down slope and spreading movement of a large quantity of rock material.

Rockfalls are caused by the loss of support from underneath or detachment from a larger rock mass. Ice wedging, root growth, or ground shaking, as well as a loss of support through erosion or chemical weathering may start the fall.

Rockfalls can demolish structures and kill people. Rocks falling on highways may strike vehicles, block traffic, cause accidents, and sometimes damage the road. Minor but costly consequences are the work of clearing highways and borrow ditches in rockfall areas. Any structure in the path of a large rockfall is subject to damage or destruction.

Geographic Extent

This hazard is most prevalent in the foothills of western Jefferson County, particularly in the canyons that dissect the region, most of which have County roads or State highways running through them, and some residential development.

US Highway 6 in Clear Creek Canyon is prone to rockfall hazards. North and South Table Mountain in Golden can also produce rockfalls from the namesake basalt cliffs that formed them. The base of the foothills in Golden on the northwest side of the intersection of Highways 6 and 93 has also been prone to landslides. This landslide sits directly on top of the Golden Fault. Homes were developed just to the north of this landslide area shortly after the landslide was mitigated. The north side of Green Mountain in Lakewood has also had landslide problems.

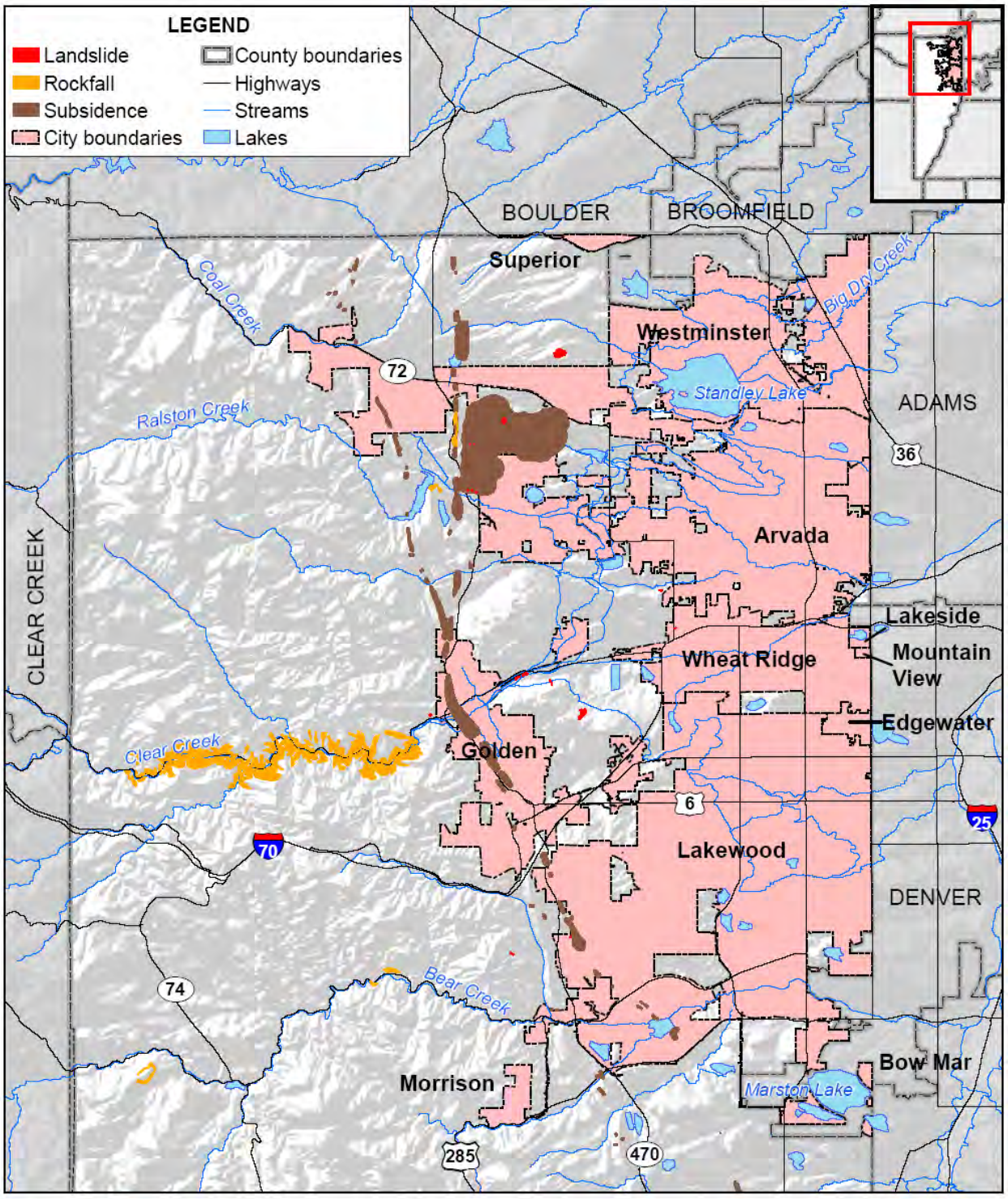
The Colorado Landslide Hazard Mitigation Plan, developed in 1988 and updated in 2002, identified 49 areas in Colorado where landslides could have the “most serious or immediate potential impact on communities, transportation corridors, lifelines, or the economy.” A Year 2002 Review and Priority List was done as part of an update of the 1988 Colorado Landslide Mitigation Plan. The update is a status report on 49 locations believed to pose the most serious landslide risk in Colorado that were identified in the 1988 plan. The hazard areas (landslide/rockfall or debris flow) are categorized into three tiers. Tier One listings are serious cases needing immediate or ongoing action or attention because of the severity of potential impacts. Tier Two listings are very significant but less severe; or where adequate information and/or some mitigation is in place, or where current development pressures are less extreme. Tier Three listings are similar to Tier Two but with less severe consequences or primarily local impact.

Rockfall areas along US HWY 6 in Clear Creek Canyon are considered Tier One rockfall areas. This area is considered a state priority due to the increased traffic and vulnerability of the traveling public to the gambling destinations of Blackhawk and Central City.

Two areas were identified as Tier One debris flow areas including the foothills of Jefferson County burned by the Hi Meadows wildfire in 2000 and the Schoonover wildfire in 2002. In addition, the burn area of the Hayman Fire must be considered a particularly vulnerable area. These wildfires leave the potential for debris flows, rockfalls, and extreme erosion in the area around the fire. Minor landslides will likely continue in susceptible areas as a result of post-fire conditions or when heavy precipitation occurs.

Two Tier Three landslide areas are identified: Golden to Boulder along CO Hwy 93 and the Morrison Town water plant. The report noted that impacts to Hwy 93 have lessened with roadway improvements and sound engineering practices. The Morrison Town water plant landslide has been mitigated but it is recommended that good drainage be maintained and that no construction or expansion of the facility be done without thorough geological evaluation and engineering design.

Figure 4.21. Landslide, Rockfall, and Subsidence Hazards in Jefferson County



amec

Map compiled 11/2009; intended for planning purposes only.
Data Source: Jefferson County

As demonstrated in Figure 4.21, a minimal portion of the planning area is prone to occurrences of landslide and rockfall hazards, and of that, only areas with development (such as highways, roads, and subdivisions) are particularly vulnerable to the direct impacts. It should be noted, however, that when this hazard causes road closures, the overall area affected indirectly can be much larger than the slide area itself, with impacts extending into multiple counties on both ends of the incident.

Based on this information, the geographic extent rating for landslide, debris flow, and rockfall is considered **limited.**

Previous Occurrences

Since landslides, debris flows, and rockfalls have a high level of prevalence in Colorado, and a moderate level of prevalence in Jefferson County, the most useful previous occurrences to examine are those which caused a particular high amount of damage or incurred some other cost or impact. Several selected incidents are profiled below. There is no public database or information clearinghouse for this particular hazard. Information regarding these incidents was sourced from multiple sources. This is not an exhaustive list, but it does illustrate the severity of impacts that landslides, debris flows, and rockfalls exert on Jefferson County.

March 1974 – a boulder the size of a small car hurtled down the steep west side of the hogbacks in Jefferson County. It bounced into a new subdivision and stopped after penetrating a wall in the back of an expensive home. No one was injured. Property damage was about $10,000, including the cost of measures to prevent similar incidents at that site in the immediate future. The incident could have been prevented easily in the subdivision development stage but it was not recognized.

1985 – A landslide directly upslope from the Morrison's water treatment plan became active in the spring of 1985. The problem was mitigated by removing most of the landslide-prone material, and has not had problems since (CO Landslide Mitigation Plan 2002 update).

1993-1994 – The Highway 93 Golden bypass at the base of the foothills in Golden on the northwest side of the intersection of Highways 6 and 93 was affected by a landslide shortly after its construction. CDOT spent $3 million in 1994 to mitigate the problem.[31]

August 31, 1997 – Rock and debris were deposited on the southbound lanes of Highway 285 at the base of the south and north flanks of the slide. Two cars on highway 285 were damaged due to the slide; one drove into rocks and debris on the highway and a second then ran into the first. North and south bound lanes of Highway 285, a major commuter route to and from Denver, were closed and traffic was diverted through Tiny Town along Turkey Creek Road. The southbound lane was closed for over one month. Movement was believed to have been triggered by the cumulative affect of above average rainfall in August.

[31] (GSA Field Guide 1 Colorado and Adjacent Areas, 1999).

1998 – Renewed movement of an older landslide deposit on the north side of Green Mountain resulted in three homes being damaged beyond repair and two other homes severely damaged. Earth anchors and drainage improvements have been installed to mitigate future movement.[32]

2000 – On U.S. 6 in Clear Creek Canyon, a vehicle crashed into a 2-ton rock on the highway. There were no serious injuries reported. In a separate incident, a motorist was injured when a basketball sized rock crashed through the windshield and hit him in leg.

2003 – Heavy rains in June of 2003 resulted in flash floods that moved substantial amounts of sediments, causing road obstructions, flooding, and extreme siltation of the South Platte River near Deckers, Colorado. This was a result of the burned out area caused by the Schoonover fire in 2002.

2005 – On U.S. 6 in Clear Creek Canyon 1,400 tons of rock fell during a rockfall. Two truck drivers and a motorist escaped injury. One boulder was measured to be the size of a minivan.

2006 – On U.S. 6 in Clear Creek Canyon, a car (unoccupied at the time) was flattened under a slab of rock.

2006 – In West Creek and Deckers, there were boulders and debris flows during rainstorms over areas previously affected by a wildfire burn.

2007 – On U.S. 6, a rock crashed through roof of SUV. The driver of the SUV sustained minor injuries. The rock was measured and reported to be the size of a beach ball.

July 21, 2009 – Highway 126 north of Deckers near Cheesman Reservoir was washed out due to a severe rainstorm, placing trees and debris on the road. Jefferson County closed the highway down to Deckers. No one was killed or injured. The road was severely undercut and washed away in several places. Jefferson County Road and Bridge performed maintenance on the area periodically for two to three weeks to repair the damage done to the roadway.

Probability of Future Occurrences

There have been 8 landslides, 8 debris flow incidents, and 5 rockfalls in Jefferson County (20 events) since 1983, or a span of 25 years. (2008-1983 = 25 years). Since the hazards are profiled together due to common onset and impacts, the probability of future occurrence is established collectively. The methodology for calculating the probability of future occurrences is described in Section 4.2.1. This formula evaluates that the probability of a landslide-type event occurring in any given year is 84%. This corresponds to a probability of future occurrences rating of **likely**.

[32] (GSA Field Guide 1 Colorado and Adjacent Areas, 1999).

Magnitude and Severity

The overall magnitude and severity rating is a reflection of the common occurrence of this hazard. Property damages from these hazards has been in the millions of dollars, but generally limited in extent and periodic, typically during wet cycles. The damages inflicted on critical facilities and services (critical infrastructure) are primarily highways in the planning region. This has resulted in a loss or disruption of services periodically in the Clear Creek Canyon HWY 6 corridor. By a combination of mitigation efforts and luck there has not been documented deaths from rockfall in Clear Creek Canyon, but the potential remains. Based on these factors, the magnitude severity ratings for landslide, debris flow, and rockfall are considered **limited**.

Overall Hazard Significance

Landslides, debris flow, and rockfall in Jefferson County periodically impact on the planning area. The geographic extent of the hazard is considered **limited**. The probability of future occurrences is considered **likely** and the magnitude/severity for the event of record is **limited**. This equates to an overall impact rating of **medium**. While landslides, debris flow, and rockfall do occur with some regularity in Jefferson County, the direct effect on the populace is low, but the potential for severe injury or death remains from rockfall. Singular individuals or small groups may be affected by the direct effects of landslides, debris flow, and rockfall. The secondary effect of closed roads is a greater threat to the larger populace, especially if the closed roads cut off emergency personnel from those who need assistance.

4.2.12 Lightning

Description

Lightning is an electrical discharge between positive and negative regions of a thunderstorm. A lightning flash is composed of a series of strokes with an average of about four. The length and duration of each lightning stroke vary, but typically average about 30 microseconds. Typically, thunderstorms include rain, hail, or other forms of precipitation. However, it is possible for a thunderstorm to produce lightning with no delivery of precipitation. These events are called ‘dry thunderstorms.’

Intra-cloud lightning is the most common type of discharge. This occurs between oppositely charged centers within the same cloud. Usually it takes place inside the cloud and looks from the outside of the cloud like a diffuse brightening that flickers. However, the flash may exit the boundary of the cloud, and a bright channel, similar to a cloud-to-ground flash, can be visible for many miles.

Cloud-to-ground lightning is the most damaging and dangerous form of lightning, though it is less common than intra-cloud occurrences. Most flashes originate near the lower-negative charge center and deliver negative charge to earth. However, some flashes carry positive charge to earth. These positive flashes often occur during the dissipating stage of a thunderstorm’s life.

Positive flashes are also more common as a percentage of total ground strikes during the winter months. This type of lightning is particularly dangerous for several reasons. It frequently strikes away from the rain core, either ahead or behind the thunderstorm, and can strike as far as 5 or 10 miles from the storm, and occur in areas where common observers may not recognize the danger. Positive lightning also has a longer duration, so fires are more easily ignited. Positive lightning strikes usually carry a high peak electrical current, which may potentially result in greater damage.

The ratio of cloud-to-ground and intra-cloud lightning varies significantly between storms. Depending upon cloud height above ground and changes in electric field strength between cloud and earth, the discharge either stays within the cloud or makes direct contact with the earth. If the field strength is highest in the lower regions of the cloud, a downward flash may occur from cloud to earth. Using a network of lightning detection systems, the United States monitors an average of 22 million strokes of lightning from the cloud-to-ground every year.

According to the Colorado Division of Emergency Management, lightning is the number one life threatening weather hazard. Each year, lightning is responsible for deaths, injuries, and millions of dollars in property damage, including damage to buildings, communications systems, power lines, and electrical systems. Lightning also causes forest and brush fires and deaths and injuries to livestock and other animals. According to the National Lightning Safety Institute, lightning causes more than 26,000 fires in the United States each year. The institute estimates property damage, increased operating costs, production delays, and lost revenue from lightning and secondary effects to be in excess of $6 billion per year. Lightning is so significant in Colorado that the Governor declares an annual Lightning and Wildfire Awareness Week each summer. As of 2003, the National Lightning Safety Institute ranks Colorado as third in number of deaths caused by lightning nationwide, though between 1996 and 2005 Colorado ranked 31st overall for flashes per year and flashes per square mile.

Previous Occurrences

Lightning occurs thousands of times a year. The selections below demonstrate some events which caused notable injury, death, or property damage, and those events which triggered wildfires. These records, drawn from the NCDC database, illustrate the wide variety of impacts that lightning poses to the planning area.

August 4, 2008 – Lightning sparked a grassfire that consumed 300 acres on the northern edge of Green Mountain. Gusty winds and very dry conditions allowed the fire to spread quickly and threaten several homes. Only minor damage was reported, caused by smoke and melted siding. Damages were estimated at $100,000.

July 27, 2007 – A man was struck and killed by lightning while jogging at Matthews Winters Park in Morrison. The thunderstorm produced numerous lightning strikes and caused a power outage at Red Rocks Amphitheatre, which forced the cancellation of a concert later in the evening. Damages were reported at $5,000.

July 23, 2004 – Lightning caused a power outage in Arvada, leaving approximately 9,800 customers without power for 90 minutes.

May 29, 2004 – A father and son practicing on the driving range at the Meadows Golf Club were struck by lightning. The father was killed and the teenage boy was seriously injured. Three other people standing nearby only received minor injuries.

June 19, 2002 – Lightning damaged the Evergreen Fire Protection District (EFPD) repeater. One microwave transmitter, the main fire channel transmitter and two solar panel controllers were ruined. Damage costs were estimated at $5,000.

May 27, 2002 – Lightning sparked a wildfire near Deckers. Extremely dry conditions and very strong winds the following day allowed the fire to consume 3,860 acres before it could be contained. Thirteen structures were destroyed, including 4 homes. This incident is discussed further in the wildfire hazard profile.

August 1, 2001 – Lightning coupled with strong thunderstorm winds knocked out power to approximately 10,000 Xcel Energy customers in Golden**.**

August 13, 2000 – Lightning sparked three separate grassfires near Golden. The fires were quickly contained, however.

July 29, 1997 – A woman received minor injuries when lightning struck her when it passed through the office window. She suffered temporary blindness for approximately 15 minutes.

September 2, 1996 – Lightning sparked a brush fire in the south buffer zone of the Rocky Flats Environmental Test Facility. No structures were damaged but the fire burned approximately 100 acres of grassland before it was contained.

July 3 - 5, 1996 – Lightning from a fast moving thunderstorm blasted a large hole in the side of a house in Lakewood, southwest of Denver. Lightning sparked a small fire near Buffalo Creek. Only one acre was burned before the fire was contained.

September 4, 1995 – Two people were injured when lightning struck their home. The lightning entered in the attic where it sparked a small fire. It then travelled through the walls exploding a mirror that sprayed glass on the residents. Damages were estimated at $4,500.

May 29, 1995 – Lightning struck a soccer goal post and injured six adults viewing a soccer game. Although no one received a direct hit, one woman was hospitalized.

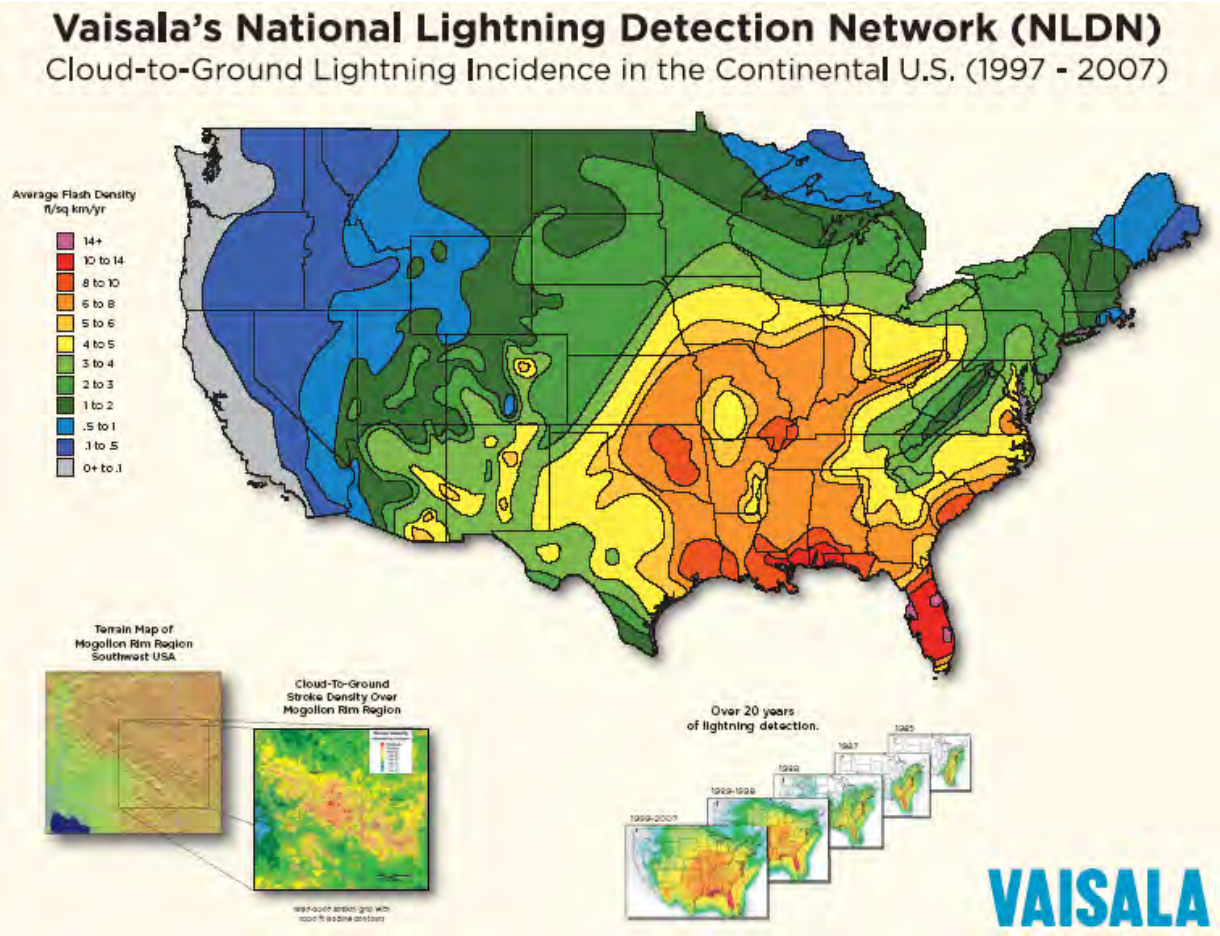
Geographic Extent

The geographic extent for lightning may be examined in two ways. In one regard, 'lightning' is a regional hazard measured by the possible places of occurrence. In the other, 'lighting incidents' refer to single-point occurrences and are measured according to density.

Acknowledging that lightning may occur anywhere in Colorado or in Jefferson County is important, but does not provide particularly insightful information. Examining the density of the lightning flashes may yield more useful information, particularly when the impacts of the hazard are examined. According to the NOAA, Jefferson County averages 7,000 lightning strikes per year. This results in approximately 8.9 lightning strikes per square mile per year (7000/785 mi^2). Figure 4.22 indicates that, for the most part, Colorado experiences an average density rating. Therefore, while 100% of the planning area is vulnerable to lightning strikes, the density of these single-point occurrences is fairly limited.

Based on this information, the geographic extent rating for lightning is **limited**.

Figure 4.22. Cloud-to-Ground Lightning Density



Source: http://www.lightningsafety.noaa.gov/more.htm

Probability of Future Occurrences

As identified earlier, lightning occurs thousands of times a year in Colorado alone. The average density for lightning strikes in Colorado is 5 per square mile. Assuming all other factors equal, that means the planning area, which is 785 square miles in size, experiences an average of 3,925

cloud-to-ground strikes of lightning a year. Knowing that the probability of any lightning event occurring in the future is highly likely helps underscore the importance of increased public education about the hazard. In order to fairly compare the lightning hazard to other hazards in the planning area, the probability of future occurrences for a lightning event that causes damage should also be computed.

The NCDC database is the only available dataset for county-specific lightning incidents that includes property and fire damages. Although this dataset is probably incomplete, it will be used as the source for the probability of occurrence calculation below. If additional lightning data becomes available for Jefferson County, then this section may need to be revisited. However, as all other data sets available reflect information that is consistent with the NCDC effort, the information calculated below is expected to remain fairly consistent with the application of a more comprehensive dataset. There have been 37 reported lightning strikes which impacted people or property in Jefferson County since 1993.

There have been 37 reported damaging incidents in Jefferson County since 1993, or a span of 15 years (2008-1993=15 years). The methodology for calculating the probability of future occurrences is described in Section 4.2.1. This formula evaluates that the probability of a damaging lighting strike occurring in any given year is 100%. This corresponds to a probability of future occurrences rating of **highly likely**.

Magnitude and Severity

Impacts for lightning are both direct and indirect. People or objects are directly impacted when struck, or indirectly damaged when the current of the bolt passes through or near the person or object. Other indirect impacts include the ignition of wildfires. The Colorado Division of Emergency Management estimates that more than half of all forest fires in Colorado are ignited by lightning, in addition to the rangeland and wheat-field fires that lightning causes. Lightning is most likely to cause wildfires during dry conditions or during dry thunderstorms. Records of previous incidents in the NCDC database indicates that most events damage only personal property incidents and do not significantly impact the availability of critical services or infrastructure, corresponding to negligible severity ratings in both categories. Isolated cases, usually those which trigger large wildfires, have a more significant impact on property damages, but the ratings are still classified as limited.

The National Weather Service Pueblo Lightning Page indicates that between 1980 and 2008, 8 people have been killed and 36 people have been injured by lightning strikes in Jefferson County. This equates to 9% of all killed and 9.2% of all injured reports for the state. The majority of lightning strikes with casualties for Colorado occurred between the hours of noon and 5:00 pm, peaking between 2:00 and 4:00 pm. This correlates to the times when the population are most exposed, as well: during the temperate summer months, on days where people are most likely to be outside, during peak times of day where outdoor activities are expected to occur. The injury and fatality rates associated with lightning are the greatest

indicators of magnitude and severity. It is particularly telling when the flash density of the State is considered. As discussed in the geographic extent section, Colorado experiences an average number of cloud-to-ground strikes when compared to the nation. However, Colorado's injury an fatality ratings are consistently in the top five, or top three when adjusted for population. Therefore, the magnitude and severity of lighting on the population is critical.

In order to calculate a magnitude and severity rating for comparison with other hazards, and to assist in assessing the overall impact of the hazard on the planning area, information from the event of record is used. In some cases, the event of record represents an anticipated worst-case scenario, and in others, it is a reflection of common occurrence. For lightning, there is no outstanding event of record, so the overall magnitude and severity rating for the County is determined based on the comprehensive discussion of severity contained above. Lightning events typically damage less than 10% of the property in the County. The damages inflicted on critical facilities and services (critical infrastructure) typically result in a loss or disruption of serves for less than 24 hours. Documented illnesses and injuries were considered critical, with a catastrophic fatality rating.

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

Overall Hazard Significance

Lightning strikes in Jefferson County have a particular impact on the planning area. The most serious impacts are the high numbers of injuries and deaths, with the most serious indirect impact associated with wildfire caused by lightning. The geographic extent of the hazard is considered **limited**. The probability of future occurrences is considered **highly likely** and the magnitude/severity for the event of record is **critical**. The HMPC considers the hazard to have a **low** overall impact on the County. Together, this equates to an overall impact rating of **medium**. This rating recognizes that other hazards may be a higher priority for the County or may possess more actionable mitigation solutions, while still addressing the significant threat that lightning poses to personal life safety for the jurisdiction's citizens. This is also consistent with the efforts of the Colorado Division of Emergency Management to increase lightning safety and awareness.

4.2.13 Severe Winter Storms

Description

The National Weather Service defines a storm as "any disturbed state of the atmosphere, especially affecting the Earth's surface, and strongly implying destructive and otherwise unpleasant weather." Winter storms, then, are storms that occur during the winter months and produce snow, ice, freezing rain, sleet, etc. Winter storms are a yearly occurrence in climates where precipitation may freeze and are not always considered a disaster or hazard. **For the**

purposes of this planning element, severe winter storms are those which produce heavy snow, significant ice accumulation, or prolonged blizzard conditions.[33] Disasters occur when the severe storms impact the operations of the affected community by damaging property, stalling the delivery of critical services, or causing injuries or deaths among the population.

Winter storm watches and warnings may be helpful for determining the difference between a seasonal winter storm and a severe winter storm. Warnings are issued if the storm is producing or suspected of producing heavy snow or significant ice accumulations. Watches are usually issued 24 to 36 hours in advance for storms capable of producing those conditions, though criteria may vary between locations. Winter Weather Advisories are issued when a low pressure system produces a combination of winter weather that presents a hazard but does not meet warning criteria.[34]

Heavy snow can immobilize a region, stranding commuters, stopping the flow of supplies, and disrupting emergency and medical services. Accumulations of snow can collapse roofs and knock down trees and power lines. In rural areas, homes and farms may be isolated for days, and unprotected livestock may be lost. The cost of snow removal, damage repair, and business losses can have a tremendous impact on cities and towns. Heavy accumulations of ice can bring down trees, electrical wires, telephone poles and lines, and communication towers. Communications and power can be disrupted for days until damages are repaired. Even small accumulations of ice may cause extreme hazards to motorists and pedestrians.

Some winter storms are accompanied by strong winds, creating blizzard conditions with blinding wind-driven snow, severe drifting, and dangerous wind chills. Strong winds with these intense storms and cold fronts can knock down trees, utility poles, and power lines. Blowing snow can reduce visibilities to only a few feet in areas where there are no trees or buildings. Serious vehicle accidents can result with injuries and deaths.

Winter storms in Jefferson County, including strong winds and blizzard conditions, may cause localized power and phone outages, closures of streets, highways, schools, businesses, and non-essential government operations, and increase the likelihood of winter-weather related injury or death. People may be stranded in vehicles or other locations not suited to sheltering operations or isolated from essential services. A winter storm can escalate, creating life threatening situations when emergency response is limited by severe winter conditions. Other issues associated with severe winter storms include the threat of physical overexertion that may lead to heart attacks or strokes. Snow removal costs can pose significant budget impacts, as can repairing the associated damages caused by downed power lines, trees, structural damages, etc.

[33] The National Weather Association (NWA) Online Glossary does not define a 'severe winter storm.' However, it does define a Severe Local Storm as "A convective storm that usually covers a relatively small geographic area, or moves in a narrow path, and is sufficiently intense to threaten life and/or property." Therefore, while the term 'severe winter storm' is not an official term from the NWA, it is drawn from other official definitions and is intended to reflect these standards as much as possible while still addressing the specific needs of this plan.

[34] This information is drawn from the National Weather Association Online Glossary, which may be accessed at http://www.weather.gov/glossary/

Heavy snowfall during winter can also lead to flooding or landslides during the spring if the area snowpack melts too quickly.

Geographic Extent

Winter storms are a yearly feature of the Colorado climate and may occur anywhere in the state. Generally, severe winter storm events are considered regional, which implies the storms impact multiple counties simultaneously, often for extended time periods. It is possible for the geographic extent of the hazard to vary significantly within a single county- a regional storm may directly impact only a small portion of the planning area while still extending over a large portion of the surrounding area. However, even in these instances, the impacts and affects of a regional hazard are still felt within the planning area. Therefore, while the percent of the planning area directly affected ranges from less than 10% to 100% depending on the specific circumstances, if any portion of the planning area is impacted by the storm, then the entire planning area suffers indirect impacts.

Based on this information, the geographic extent rating for severe winter storms is **extensive**.

Previous Occurrences

The National Climate Data Center database reflects a data-gap in reporting for the planning area, as the available records are minimal and incomplete. Acknowledging that severe winter storms are often regional in nature, it is reasonable to assume that the majority of Jefferson County experienced approximately 77 events since 1993, with the mountainous regions in the south and along the western edge of the County experiencing a higher number of seasonal storms.[35] The Colorado Division of Emergency Management and the Jefferson County Office of Emergency Management provided the following previous occurrences on a regional level, which only cover events in the last 20 years. Information specific to the planning area is noted where possible, though some events remain regional in focus.

March 26, 2009 – At Denver International Airport, hundreds of flights were canceled. In addition, schools throughout the region were shut down and many roads closed due to multiple accidents. Dozens of vehicles slid off Interstate 25 and an accident between Fort Collins and Cheyenne, Wyoming involved up to 75 vehicles. Portions of U.S. Highway 36, between Denver and Boulder, were also closed during the day. The Red Cross opened up six shelters for stranded motorists. Snow totals in and near Jefferson County averaged 11.5″.

January 12, 2009 – A fast moving storm system brought heavy snow to the foothills of Boulder and Jefferson Counties as well as the western and southern suburbs of the metropolitan Denver. The storm resulted in multiple accidents along the Urban Corridor. In the foothills storm totals

[35] This estimate was derived by taking the average number of reported storms documented on the NCDC website for Jefferson County's neighbors. When compiling the selected events of past significance, state-wide records were surveyed to assure inclusion of the most relevant materials.

ranged from 6 to 8″. In the suburbs, Lakewood reported 8″, with variances across the area ranging from 4.5 to 11″.

April 16, 2008 – Storm totals ranged from 9″ to 13″. A storm system brought heavy snow to parts of the North-Central Mountains, Front Range Foothills and Palmer Divide. The heaviest snow fell mainly south of the Interstate 70 corridor. Storm totals in the mountains and foothills ranged from 8″ to nearly 15″.

December 2006 – Back-to-back major storms occurred the third and fourth weeks of the month of December across the Front Range and Eastern Colorado. Heavy snow accumulated over three feet deep in some areas. Strong wind drifted the snow into 12′ to 20′ drifts and thousands of animals in the eastern plain were stranded from shelter and food by the snow. Travel was hampered for days in the hardest hit areas, including the Denver International Airport. Combined, these events qualified for a Presidential Emergency Declaration to assist communities with costs in the aftermath. Jefferson County was designated for public assistance after the first storm.

March 17 - 20, 2003 – A major snowstorm dumped more than 2′ of snow in the Rocky Mountain Region, which closed highways in Colorado and wide sections of Wyoming. Wind gusts of 30 mph reduced visibility across Denver, including the main boulevard leading to Denver International Airport, stranding travelers at the airport and along the roadways. Avalanche warnings were issued for Colorado mountainous areas where up to 29″ of snow fell. Upwards of 8′ of snow were reported in the Evergreen and Conifer areas of Jefferson County by members of the HMPC. This late season snowstorm stranded hundreds of people and resulted in a Presidential Emergency Declaration to help ease the burden of clean-up costs, which amounted to more than $8 million. The insurance industry estimates this blizzard to be the most costly winter storm in Colorado history, reporting at least $93.3 million ($109 million in 2009 dollars) in claims. Jefferson County was designated for emergency public assistance from this event. Figure 4.25 shows the distribution and snow totals in inches for the storm for the County and surrounding areas.

October 24-25, 1997 – One of the worst blizzards of the 1990s dumped 14 to 31 inches of snow across the Metro Denver Area. The heaviest snow occurred in the foothills west and southwest of Denver, including in Jefferson County, where 2′ to 4′ of snow were measured. Sustained winds of 40 mph with gusts as high as 60 mph reduced visibilities to zero and produced extremely cold wind chill temperatures of -25°F to -40°F. The strong winds also piled snow into drifts ranging from 4′ to 10′ deep. Several major roads and highways were closed as travel became impossible and Red Cross shelters were set up for hundreds of stranded travelers forced to abandon their vehicles. Two people were severely injured and five people were killed as a direct result of the event. At Denver International Airport, 4,000 travelers were stranded when the airport was forced to close and air carriers estimated losses at $20 million ($26.7 million 2009 dollars). Snowfall totaled 21.9″, setting a new 24-hour snowfall record of 19.1″ for the month.

March 8 - 9, 1992 – A springtime blizzard struck the Metro Denver Area with snowfall amounts of up to a foot and a half blown in on north winds at speeds of 30 to 40 mph with gusts as high as 52mph. Many roads were closed including Interstate 70 east of Denver and Interstate 25 north and south of Denver. Many homes and businesses lost power.

March 6, 1990 – Winds gusting up to 58 mph and heavy snow whipped into drifts 3 to 4 feet deep pummeled the Metro Denver Area. Streets and highways became impassable as many stores and schools closed. Police and National Guard rescued hundreds of stranded motorists, including the Governor who was stranded on Highway 36. An airliner with 82 passengers aboard skidded off a runway at Stapleton International Airport. Snowfall totaled 18 to 50″ in the foothills and between 9 to 24″ west of Interstate 25, including most of urbanized Jefferson County.

Often, snow totals is one of the major considerations in tallying a 'severe' winter storm. The top ten snowfall storms for the Denver Metro region since 1946, according to the National Weather Association, are listed below. It is helpful to remember that the official reckoning for snowfall in Denver is at the airport (Stapleton Airport until February 1995 and currently at Denver International Airport) and that snowfall totals may actually be higher for Jefferson County, particularly in the western communities.

Table 4.9 Top Ten Snowfall Storms in the Denver Metro Area since 1946

Date	Snowfall in Inches
March 18, 2003	31.8
November 3, 1946	30.4
December 24, 1982	23.8
October 25, 1997	21.9
November 27, 1983	21.5
November 19, 1991	21.2
December 20, 2006	20.7
March 5, 1983	18.7
November 19, 1979	17.7

Source: National Weather Service Weather Forecast Office: Denver/Boulder area

Probability of Future Occurrences

Winter storms are a yearly feature in Colorado, often occurring multiple times each winter, and thus are considered a seasonal feature. In that regard, these hazards are considered a highly likely occurrence. When an event is seasonal and an anticipated element in a given climate, it is also important to also examine the probability of future *severe* occurrences of the hazard.

There have been at least 8 incidents of severe winter storms that directly impacted Jefferson County since 1990, or a span of 19 years. (2008-1990 = 19 years). The methodology for calculating the probability of future occurrences is described in Section 4.2.1. This formula

evaluates that the probability of a severe winter storm occurring in any given year is 42.2%. This corresponds to a probability of future occurrences rating of **likely**.

Magnitude and Severity

The damages caused by severe winter storms and blizzards vary and are dependent on several factors: the duration of the storm; the geographic extent; the time of year; meteorological factors such as wind, moisture content of the snow, ground and air temperatures; and the advance warning of the storm. Impacts from the storm dictate the magnitude of the event, emphasizing that how much snow may not always directly correlate to how bad the storm is. Damaged power lines and dangerous or impassable roadways may forestall the delivery of critical services such as medical and emergency assistance, the delivery of food supplies and medications, or even the provision of basic utilities such as heat and running water. When events happen with a long warning time, it is possible to pre-mitigate the effects of insufficient supply levels or to pre-test emergency generators, which may prevent some of the previously described impacts from occurring. Unanticipated storms increase the number of people stranded, both in cars and at public locations, which may increase the number of injuries and deaths attributed to the event (often caused by exposure) and place uneven and unanticipated strains on public sheltering capacities. The weight of the snow, driven by the water content of the fall, increases the potential for damages caused to structures and trees. Lighter snow caused by extreme cold increases the damages caused to livestock, agriculture and landscaping due to freezing conditions. Winter storms which go through periods of thaw and freeze prolong dangerous icy conditions, increasing the likelihood of frozen and damaged water pipes, impassable or dangerous roadways, damaged communication lines, or more extensive damages to infrastructure and structures caused by seeping water freezing under roofs, porches, patios, inside sidings, or causing damage to vehicles.

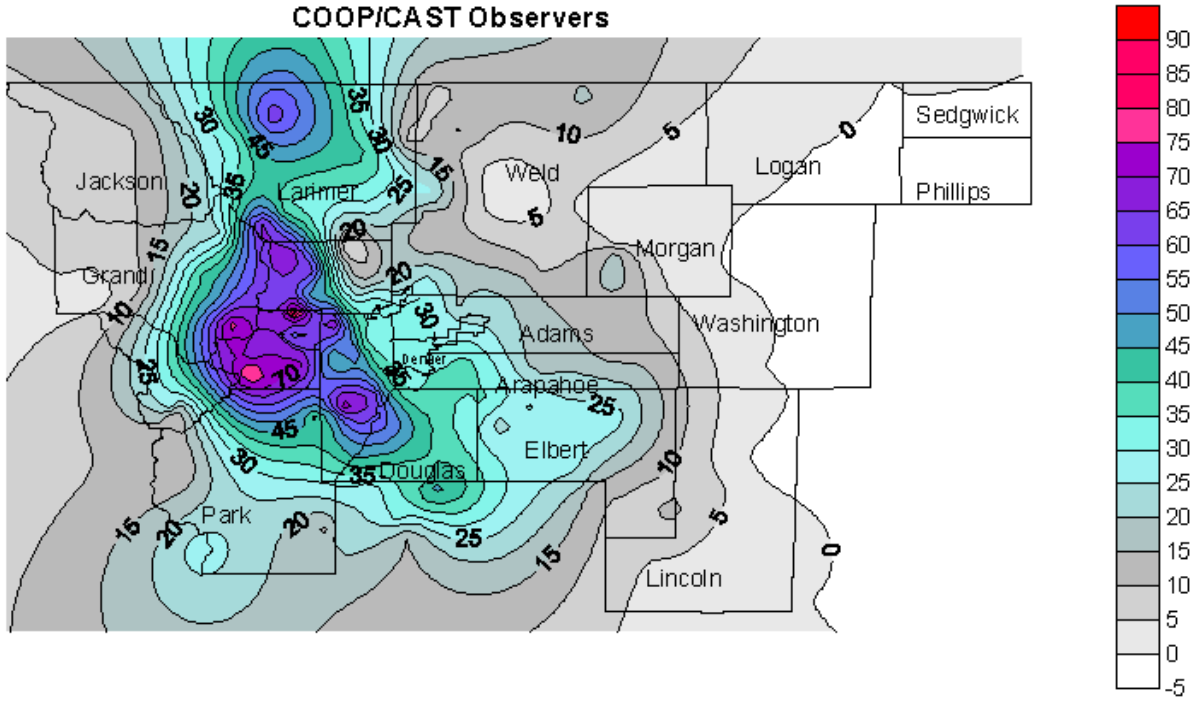
In order to calculate a magnitude and severity rating for comparison with other hazards, and to assist in assessing the overall impact of the hazard on the planning area, information from the event of record is used. In some cases, the event of record represents an anticipated worst-case scenario, and in others, it is a reflection of common occurrence. The most damaging event of record for Jefferson County occurred between March 17 and March 20, 2003. This is distinct from the snowstorm with the greatest amount of snowfall, which occurred from December 1-6, 1913, and officially documented 45.7 inches of snow. In order to reflect the significance of each, both events are considered in developing the severity and magnitude ratings.

As noted, the December 1913 storm snow totals in the metro area were officially recorded at 45.7 inches. Snow totals were even deeper in the mountains, where Georgetown reported 86 inches total. The high winds caused significant drifting which completely blocked all transportation as well. The Rocky Mountain News reported that one rescue party and eight miners were lost in the storm and thousands more moved into hotels for shelter. The city opened the auditorium and other public buildings to shelter the homeless during the event. Of interesting note, the snow removal costs were considered an economic advantage, citing that over 780 men

found employment and at least $700 ($15,169 in 2009) was spent in snow removal costs. The paper also reported that "(m)illions of dollars [in] additional wealth to Colorado were brought yesterday by the snowfall…it rang up the curtain on the 1914 crop outlook, revealing visions of unprecedented prosperity to every line of industry and bountiful harvest to the farmers."[36]

The March 17-20, 2003 snowfall in the metro area was officially tabulated at 31.8 inches, though up to eight feet of snow was reported in the Evergreen and Conifer areas. The event damaged huge amounts of infrastructure and property, with insurance losses alone estimated at more than $93.3 million ($109 million in 2009 dollars). Insurance losses note that more than 90% of those damages were based on homeowner's insurance claims, and that of the auto insurance claims, most were a result of the vehicle being crushed by the weight of the snow rather than weather-related accidents.[37] The event also resulted in a Presidential Emergency Declaration. The damages inflicted on critical facilities and services (critical infrastructure) resulted in a loss or disruption of services for several days, including power, telephone, and in some cases, heat. Emergency response personnel were hindered from response due to impassible roadways. Documented illnesses and injuries were considered critical, with two serious reported injuries and five directly attributed deaths. The medical response of the region was considered impaired to a limited extent.

Figure 4.23. March 17-20, 2003 Snowfall Totals



Source: National Weather Service Forecast Office: Denver/Boulder CO

[36] Reprinted online from the December 5, 1913 issue of the Rocky Mountain News. Available at http://www.rockymountainnews.com/news/2008/dec/21/the-rocky-150-years-blizzard-of-snow-news/ last accessed October 8, 2009.
[37] http://www.rmiia.org/News_room/catastrophe%20news/2003_04_07_blizzard.htm#

Based on these factors, the magnitude severity potential for severe winter storms which may impact Jefferson County are considered **critical**.

Overall Hazard Significance

Severe winter storms in Jefferson County have a significant impact on and presence in the planning area. Damages from winter storms are the second highest cause of insurance-related costs and claims for the County. The planning area is subjected to damaged trees and structures, icy and dangerous roadways, and the large costs associated with snow removal and cleanup after severe events. In addition, the hazard is regional in nature, indicating that if the planning area is impacted, it is likely that the planning area's immediate neighbors will also be impacted, reducing the available resources and aid capacities for response and recovery from the event.

The geographic extent of the hazard is considered **extensive**. The probability of future occurrences is considered **likely** and the magnitude/severity for the event of record is **critical**. In addition, the HMPC considers the hazard to have **high** impact on the County. This equates to an overall impact rating of **high**.

4.2.14 Subsidence

Description

The Colorado Geological Survey defines land subsidence as the sinking of the land over manmade or natural underground voids. Subsidence occurs naturally and also through man-driven or technologically exacerbated circumstances. Natural causes of subsidence occur when water in the ground dissolves minerals and other materials in the earth, creating pockets or voids. When the void can no longer support the weight of the earth above it, it collapses, causing a sinkhole depression in the landscape. Often, natural subsidence is associated with limestone erosion, but may also occur with other water-soluble minerals. Man-driven or technology-exacerbated subsidence conditions are associated with the lowering of water tables, extraction of natural gas, or subsurface mining activities. As the underground voids caused by these activities settle or collapse, subsidence occurs on the surface. In Jefferson County, past coal and clay mining activities have created surface subsidence in some areas and created the potential for subsidence in other areas. Any area where past sub-surface mining was documented has some risk of subsidence; however, tracking these areas is difficult. In some cases, coal was "poached" or more coal was removed from an area than would be noted on the mine map. Also, many mines were incorrectly located relative to surface features due to surveying errors. As such, maps of past mine workings and extents may be incorrect, but rough estimates are available.

Extraction of coal and clay from mines in Jefferson County varied based on the location of the material beds and the available technology.[38] Prior to World War II, nearly all mines in the

[38] Taken from Coal and Clay Mine Hazard Study and Estimated Unmined Coal Resources, Jefferson County, Colorado by Amuedo and Ivey, 1978, and reproduced online at http://inside.mines.edu/fs_home/tboyd/Coal/activity.html

County were worked using the room and pillar mining pattern. In the room and pillar technique, an opening (adit) was followed by a shaft that was driven or dug to the layer of coal or clay. Passageways were excavated in the material seam and rooms (stopes) were created when the materials were dug out along the original tunnel. The materials were then worked in the direction that correlated to the bed. Between the rooms, pillars of the material were left in place to support the roof of the mine, although sometimes the pillars were replaced with timbers. Subsidence occurs when the stopes collapse, either due to overhead pressure or when the support structures collapse. Other subsidence incidents may occur over air shafts and man shafts. This subsidence forms pits, which may range in diameters of 5′ to 20′ and range in depth from a few feet to 20′, depending on the amount of in-filling which has occurred since the mine was abandoned. Because subsidence incidents are often incomplete, an event may occur multiple times over the same area, increasing the risk and danger of this particular type of subsidence.

Troughs, or long lengths of subsidence, tend to occur over tunnels and slope entries and may range in length from 10′ to 80′ and in depth from 5′ to 15′ or more. Once they collapse, they present a reduced additional risk, as the subsidence is generally complete along the entire length of the tunnel. Another common form on subsidence in Jefferson County occurs when pits and trenches open over stopes that were extended to, or very close to, the surface during the mining process. These features are particularly evident along the east side of the Dakota hogback from I-70 north to Coal Creek Canyon and range in length from 10′ to 100′ and in widths of 5′ to 40′. This form of subsidence forms a minimal risk in the planning area, as it occurs in areas where development is highly regulated, but additional risks from these features are documented below. Subsidence over reclaimed land occurs when open pit mines are cosmetically back-filled, but the fill is not as compacted as the enclosing bedrock. When construction on the fill material occurs, the weight causes the fill material to compress more than the bedrock, creating a stress or bending movement in the structure, which can result in significant damage to the structures.[39]

Subsidence may result in serious structural damage to buildings, roads, irrigation ditches, underground utilities, and pipelines. It can disrupt and alter the flow of surface or underground water. Weight, including surface developments such as roads, reservoirs, and buildings and manmade vibrations from such activities as blasting or heavy truck or train traffic can accelerate natural processes of subsidence, or incur subsidence over manmade voids. Fluctuations in the level of underground water caused by pumping or by injecting fluids into the earth can initiate sinking to fill the empty space previously occupied by water or soluble minerals. The consequences of improper use of land subject to ground subsidence can be excessive economic losses, including the high costs of repair and maintenance for buildings, irrigation works, highways, utilities, and other structures. This results in direct economic losses to citizens as well as indirect economic losses through increased taxes and decreased property values.

[39] Taken from Coal and Clay Mine Hazard Study and Estimated Unmined Coal Resources, Jefferson County, Colorado by Amuedo and Ivey, 1978, and reproduced online at http://inside.mines.edu/fs_home/tboyd/Coal/activity.html

Geographic Extent

Coal deposits in Jefferson County were located mostly along the northeastern borders shared with Boulder, Adams, Denver and Arapahoe counties. Known coal mines in the County were confined along a narrow strip of land along Highway 93 from Arvada to approximately the junction with C-470, and then along the 470 corridor, without known extent into the northeastern portion of the coal field. As such, the location of inactive coal mines in the County is fairly limited compared to other counties.

Previous Occurrences

Most known areas of potential subsidence in the planning area occur in rural, undeveloped areas and, therefore, have caused no damage. However, there are few records on subsidence. In addition, the planning area exercises specific planning and zoning regulations to minimize the structures permitted on vulnerable lands, as demonstrated in Table 4.9. Areas of Jefferson County at risk for subsidence are shown in Figure 4.21 on the map of landslides and rockfall areas. While actual events of subsidence are visible throughout the County, extensive research on the hazard produced only one reportable incident. A family housing section built on the Colorado School of Mines campus, located in Golden, suffered damage when subsidence occurred over a reclaimed open-pit clay mine. Though the structures were built with mitigation techniques, differential compaction still occurred. Streets and sidewalks suffered damage, as did the structural integrity of several buildings. This report is contained in a County profile issued in 1978 and additional confirmation of the event, along the fate of the structures and associated damage estimates, are not currently available.

Figure 4.24. Locations of Inactive Coal Mines, State of Colorado

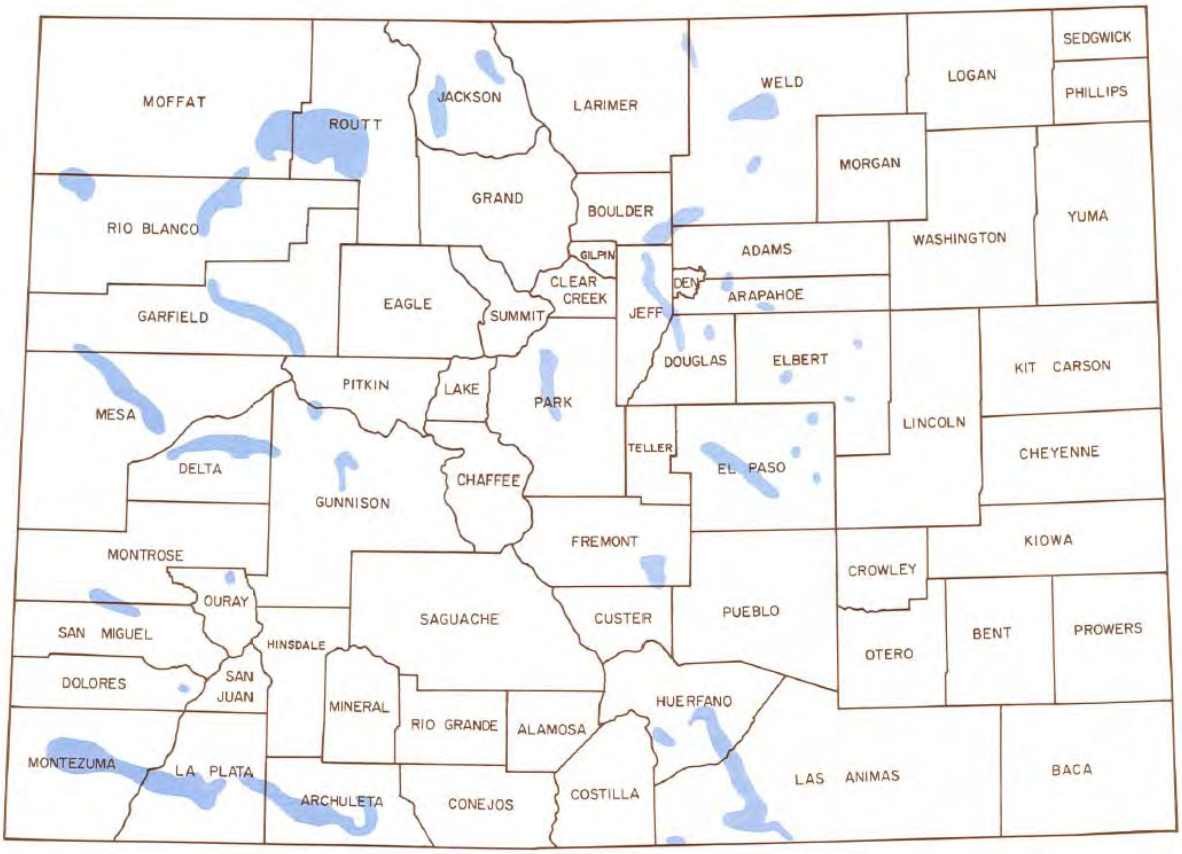


Figure 5. General locations of Inactive Coal Mines in Colorado.

Source: Subsidence above Inactive Coal Mines

According to the 2008 State Hazard Mitigation Plan, Jefferson County hosts 48 abandoned coal mines and 100 other types of abandoned mines. According to the Colorado Division of Minerals and Geology, as of September 2009 there are 104 mine permits in the County and 24 of those permits are active. The majorities of the mines permitted, whether active or not, are for clay, followed by sand and gravel, stone, granite and shale. There are no permitted or active coal mines in the County as of the completion of this plan.

Figure 4.21 illustrates the areas of suspected or known subsidence for Jefferson County, as determined by the County Geological Hazards data layer. The area, marked brown, only minimally corresponds to the areas of inactive coal mines in the County, and accounts for some subsidence vulnerabilities due to clay mining. Of particular note is the large area of vulnerability in unincorporated Jefferson County and portions of the City of Arvada, which is located south of Rocky Flats Lake and north of Arvada Reservoir, which extends east from Highway 93. While currently only minimally developed along the very edges of the suspected area, future development in the area would be vulnerable to subsidence issues. In Golden, developments along Highway 93 are exposed to the risk as well from the northern edge of the city down until

just north of the junction of Highway 93 and Highway 6. In the areas east and north of C-470, subsidence issues run along several developments along Kipling in Lakewood and the unincorporated County. This amounts to only a small portion of the total developed landmass in the County- somewhere between 10% and 25%.

Based on this information, the geographic extent rating for subsidence is **limited**.

Probability of Future Occurrences

This assessment was conducted to maintain consistency with other hazards profiled in this planning effort, but represents some significant problems. As the data of previous occurrence is skewed, the accuracy of future probability predictions is heavily impeded. In addition, the existing mitigation efforts in the planning area heavily restrict development in subsidence-prone areas, which reduces the number of occurrences that cause damages, and therefore, reduces the number of occurrences that are reported.

There has only been 1 reported incident in Jefferson County that caused property damage since 1978, or a span of 30 years. (2008-1978 = 30 years). The methodology for calculating the probability of future occurrences is described in Section 4.2.1. This formula evaluates that the probability of subsidence occurring in any given year is 3.3%. This corresponds to a probability of future occurrences rating of **occasional**.

Magnitude and Severity

The greatest dangers associated with subsidence are related to property damages incurred by the hazard. There are minimal risks to injury and death from unexpected subsidence or accidental exposure to it, but the risk is possible. No injuries or deaths related to subsidence have been reported in the planning area, but the 2008 State Hazard Mitigation plan documents two injuries related to subsidence in the state.

In order to calculate a magnitude and severity rating for comparison with other hazards, and to assist in assessing the overall impact of the hazard on the planning area, information from the event of record is used. In some cases, the event of record represents an anticipated worst-case scenario, and in others, it is a reflection of common occurrence. In this case, there is no event of record for the County related to subsidence. Instead, estimates based on predicted areas of vulnerability are used to complete the assessment for comparison purposes to other hazards profiled in this plan. The developed areas with the greatest vulnerability to known subsidence areas is in the neighborhoods just north and just south of the C-470 corridor on the western border of the urbanized planning area in Lakewood. Widespread subsidence in the area could damage houses, retail facilities, roads, sidewalks, utilities infrastructure, and critical infrastructure facilities located in the area. Such an event would not be expected to impact overall delivery of essential services and functions to the planning area, though the affected community may be affected for weeks as water, gas, power lines, roads, and houses are repaired.

If events are severe enough, structures may be deemed unsafe for continued occupancy, forcing residents to relocated. Injuries or deaths are possible, but not expected, in such an event.

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

Overall Hazard Significance

Subsidence events in Jefferson County have had minimal impacts on the planning area, due in large part to careful land use planning. The geographic extent of the hazard is considered **limited**. The probability of future occurrences is considered **occasional** and the magnitude/severity for the event of record is **limited**. In addition, the HMPC considers the hazard to have a **low** overall impact on the jurisdiction. This equates to an overall impact rating of **medium**.

This rating is based on the current development policies in place in the County, which limit construction in vulnerable areas. If previously unknown areas of subsidence are discovered, particularly in already-developed areas, this assessment may change. In addition, as development continues out and below the areas of mines worked in steep-slope conditions, those properties may experience a higher vulnerability to landslides caused by subsidence in those areas. This information is also addressed in the landslides profile, and can be avoided with continued good mitigation practices.

4.2.15 Tornado

Description

Tornadoes are rotating columns of air marked by a funnel-shaped downward extension of a cumulonimbus cloud whirling at destructive speeds of up to 300 mph, usually accompanying a thunderstorm. Tornadoes are the most powerful storms that exist. They can have the same pressure differential that fuels 300 mile wide hurricanes across a path less than 300 yards wide. Closely associated with tornadoes are funnel clouds, which are rotating columns of air and condensed water droplets that unlike tornadoes, do not make contact with the ground.

Prior to February 1, 2007, tornado intensity was measured by the Fujita (F) scale. This scale was revised and is now the Enhanced Fujita scale. Both scales are sets of wind estimates (not measurements) based on damage. The new scale provides more damage indicators (28) and associated degrees of damage, allowing for more detailed analysis, better correlation between damage and wind speed. It is also more precise because it takes into account the materials affected and the construction of structures damaged by a tornado. Table 4.10 shows the wind speeds associated with the original Fujita scale ratings and the damage that could result at various levels of intensity. Table 4.11 shows the wind speeds associated with the Enhanced Fujita Scale ratings. The Enhanced Fujita Scale's damage indicators and degrees of damage can be found online at www.spc.noaa.gov/efscale/ef-scale.html.

Table 4.10 Original Fujita Scale

Fujita (F) Scale	Fujita Scale Wind Estimate (mph)	Typical Damages
F0	< 73	Light damage. Some damage to chimneys; branches broken off trees; shallow-rooted trees pushed over; sign boards damaged.
F1	73-112	Moderate damage. Peels surface off roofs; mobile homes pushed off foundations or overturned; moving autos blown off roads.
F2	113-157	Considerable damage. Roofs torn off frame houses; mobile homes demolished; boxcars overturned; large trees snapped or uprooted; light-object missiles generated; cars lifted off ground.
F3	158-206	Severe damage. Roofs and some walls torn off well-constructed houses; trains overturned; most trees in forest uprooted; heavy cars lifted off the ground and thrown.
F4	207-260	Devastating damage. Well-constructed houses leveled; structures with weak foundations blown away some distance; cars thrown and large missiles generated.
F5	261-318	Incredible damage. Strong frame houses leveled off foundations and swept away; automobile-sized missiles fly through the air in excess of 100 meters (109 yards); trees debarked; incredible phenomena will occur.

Source: National Oceanic and Atmospheric Administration Storm Prediction Center, www.spc.noaa.gov/faq/tornado/f-scale.html

Table 4.11 Enhanced Fujita Scale

Enhanced Fujita (EF) Scale	Enhanced Fujita Scale Wind Estimate (mph)
EF-0	65-85
EF-1	86-110
EF-2	111-135
EF-3	136-165
EF4	166-200
EF-5	Over 200

Source: National Oceanic and Atmospheric Administration Storm Prediction Center, www.spc.noaa.gov/faq/tornado/ef-scale.html

Tornadoes form when cool, dry air sits on top of warm, moist air. In Colorado, this most often happens in the spring and early summer (i.e., May, June, and July) when cool, dry mountain air rolls east over the warm, moist air of the plains during the late afternoon and early evening hours. However, tornadoes are possible anywhere in the state, at any time of year and at any point during the day.

Tornadoes can cause damage to property and loss of life. While most tornado damage is caused by violent winds, most injuries and deaths result from flying debris. Property damage can include damage to buildings, fallen trees and power lines, broken gas lines, broken sewer and water mains, and the outbreak of fires. Agricultural crops and industries may also be damaged or destroyed. Access roads and streets may be blocked by debris, delaying necessary emergency response. Tornadoes which affect the developed portions of Jefferson County are more likely to

cause high dollar damage amounts, even if they are comparatively smaller, than tornadoes which strike in more rural parts of the County.

Geographic Extent

Tornadoes are possible anywhere in Colorado, even in mountainous terrain. In 2007, a tornado damaged thousands of trees outside of Woodland Park in Pike National Forest in Teller County. Teller County intersects the southeastern-most corner of Jefferson County. The severe weather conditions that spawn tornadoes are regional events which may impact any extent of the County at a given time, and in this regard, the possible geographic extent for tornadoes is **extensive**. However, tornadoes as a stand-alone event are single-point (or limited point) occurrences similar to lightning. While knowing that the entire planning area is vulnerable to a tornado, the realistic assessment of tornado occurrences indicates that these single point events occur in a **negligible** density. An average of the two extremes may yield the most likely extent rating.

Based on this information, the geographic extent rating for tornadoes is **limited**.

Previous Occurrences

According to the NCDC database, 13 documented tornadoes have occurred in Jefferson County since 1965. The majority of the events were F0 and F1 tornadoes with unknown durations and damages. All of the tornadoes have occurred in June and July, with no reported injuries or deaths.

June 3, 1981 – An F2 tornado impacted Jefferson County and caused $2.5 million in damages. Duration and length of the tornado were not recorded and specifics regarding the damages were unavailable, but no deaths or injuries were reported.

Since this is the only documented event in the County, two events affecting a similarly urbanized portion of nearby counties are also profiled, to provide context and possibility of scope.

June 15, 1988 – An F3 tornado touched down in Denver County. The event was reported at 200 yards wide and traveled for 3 miles, causing $25 million in damages. While no one was killed, seven people were injured during the storm.

May 22, 2008 – An F3 tornado estimated at a mile wide at times, traveled for 39 miles across Weld County and into Larimer County, beginning just west of Greeley and extending over the community of Windsor before ending just east of Severence. One man was killed and more than 75 injuries were reported. With damages estimated at more than $147 million, the storm is one of the most costly disasters in Colorado history. Of special note, the Jefferson County provided assistance to the affected communities.

Probability of Future Occurrences

There have been 13 documented incidents in Jefferson County since 1965, or a span of 43 years. (2008-1965 = 43 years). The methodology for calculating the probability of future occurrences is described in Section 4.2.1. This formula evaluates that the probability of a tornado occurring in any given year is 30.2%. This corresponds to a probability of future occurrences rating of **likely**.

Magnitude and Severity

In order to calculate a magnitude and severity rating for comparison with other hazards, and to assist in assessing the overall impact of the hazard on the planning area, information from the event of record is used. In some cases, the event of record represents an anticipated worst-case scenario, and in others, it is a reflection of common occurrence. The event of record for Jefferson County occurred on June 3, 1981. The event damaged an unknown percent of the property in the jurisdiction. The damages inflicted on critical facilities and services (critical infrastructure) resulted in no loss or disruption of services. Documented illnesses and injuries were considered minimal (as none were reported) and the medical response of the County was considered non-impacted. However, $2.5 million dollars of damage ($5.9 million in 2009 dollars) was reported.

Based on these factors, the magnitude severity ratings for tornadoes are considered **limited**.

Overall Hazard Significance

Tornadoes in Jefferson County do not have a particularly large or frequent impact on the planning area. The geographic extent of the hazard is considered **limited**. The probability of future occurrences is considered **likely** and the magnitude/severity for the event of record is **limited**. In addition, the HMPC considers the hazard to have a **medium** overall impact rating on the County. This equates to an overall impact rating of **medium**.

The low record of occurrence in the County, combined with minimal records indicating levels of damages caused by tornadoes, makes it difficult to establish a magnitude and severity rating for the event that yields a comparable rating to the known potential severities of tornadoes. Statewide, tornadoes have killed four people and injured nearly 175 since 1950. Damages caused by tornadoes in counties with similar population densities and development trends are significant- Denver County accounts for $32.575 million and Adams County accounts for $26.761 million. Tornadoes are depicted in the media as terrifying, devastatingly damaging storms and it is reasonable to assume that, despite the data, the County population considers tornado events a significant threat. This is reflected in the HMPC ranking, as well. Therefore, the psychological impacts of the hazard's potential merit an overall rating of medium for planning purposes, rather than a lower rating.

4.2.16 Wildfire

Description

Wildfires are an ongoing concern for Jefferson County and the state of Colorado. Wildfires are most likely during the fire season, which extends from mid-spring to late fall, and is most prominent during the driest summer months of July and August. However, the fire season's duration is impacted by local fire conditions. Fire conditions are impacted by hot weather, vegetation growth, and low moisture content in air and fuel. These conditions, especially when combined with high winds and years of drought, increase the potential for wildfire to occur. The wildfire risk is predominantly associated with the wildland-urban interface (WUI). The WUI is made of up of areas where development is interspersed or adjacent to landscapes that support wildland fire. While traditionally associated with forested mountain areas, WUI areas are also present in grasslands, prairies, valleys, or in any area where a sustained wildfire may occur and impact developed areas. Fires in the WUI may result in major losses of property and structures, threaten greater numbers of human lives, and incur larger financial costs. In addition, WUI fires may be more dangerous than wildfires that do not threaten developed areas, as firefighters may continue to work on more dangerous conditions in order to protect structures such as businesses and homes. As the development of WUI areas increases, the likelihood of a severe wildfire also increases.

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 and leaves, twigs, and branches to dead standing trees, live trees, brush, and cured grasses. Manmade structures, such as homes and associated combustibles, are also potential fuel sources. The type of prevalent fuel directly influences the behavior of wildfire. Light fuels such as grasses burn quickly and serve as a catalyst for fire spread. "Ladder fuels" are fuels low to the ground that can spread a surface fire upward through brush and into tree tops. These fires, known as crown fires, burn in the upper canopy of forests and are nearly impossible to control. The volume of available fuel is described in terms of fuel loading. Many areas in and surrounding Jefferson County are extremely vulnerable to wildfires as a result of dense vegetation combined with urban interface living.

Another important aspect to know about fuels is the condition of the types of fuels and how that will further fuel or diminish the fire behavior.

Energy Release Component (ERC) is a National Fire Danger Rating System (NFDRS) index related to how hot a fire could burn. It is related to the 24-hour potential worst case total energy (BTUs) released per unit area (square foot) within the flaming front at the head of a fire. Since wind and slope do not enter into the ERC calculation, the daily variations in ERC will be relatively small. Daily variations are due to changes in moisture content of the various fuels

present, both live and dead. The ERC is a cumulative or "build-up" type of index. As live fuels cure and dead fuels dry, the ERC values get higher thus providing a good reflection of drought conditions.

1000-Hour Fuel Moisture (1000-hr FM) represents the modeled moisture content in dead fuels in the 3 to 8 inch diameter class and the layer of the forest floor about four inches below the surface. The 1000-hr FM value is based on a running 7-day computed average using length of day, daily temperature, relative humidity extremes (maximum and minimum values), and the 24-hour precipitation duration values.

100-Hour Fuel Moisture (100-hr FM) represents the modeled moisture content of dead fuels in the 1 to 3 inch diameter class. It can also be used as a very rough estimate of the average moisture content of the forest floor from three-fourths inch to four inches below the surface. The 100-hr FM value is computed using length of day, maximum and minimum temperature, relative humidity, and precipitation duration in the previous 24 hours

Fuel Model G is used for dense conifer stands where there is a heavy accumulation of litter and downed woody material. Such stands are typically over-mature and may also be suffering insect, disease, wind, or ice damage -- natural events that create a very heavy buildup of dead material on the forest floor. The duff and litter are deep and much of the woody material is more than 3 inches in diameter. The undergrowth is variable, but shrubs are usually restricted to openings.

The presence of fine fuels and needle cast combined with the cumulative effects of previous drought years, vegetation mortality, tree mortality, and forest blowdowns (which are unexplained windfalls that blow down or break numerous trees in an area) are some examples of fuels in Jefferson County. Fuel is the easiest factor for human-driven mitigation of wildfires.

Topography - An area's terrain and land slopes affect its susceptibility to wildfire spread. Both the fire intensity and the rate of spread increase as slope increases due to the tendency of heat from a fire to rise via convection. The arrangement and types of vegetation throughout a hillside can also contribute to increased fire activity on slopes. In addition, topography impacts the ability of firefighters to combat the blaze by hampering access for equipment, supplies, materials and personnel.

Weather – Weather components such as temperature, relative humidity, wind, and lightning also affect the potential for wildfires. High temperatures and low relative humidity dry out the fuels that feed the wildfire, increasing the odds that fuel will more readily ignite and burn more intensely. Wind is the most treacherous weather factor. The greater the wind, the faster a fire will spread, and the more intense it will be. In addition to wind speed, wind shifts can occur suddenly due to temperature changes or the interaction of wind with topographical features such as slopes or steep hillsides. Lightning also ignites wildfires, which are often in terrain that is difficult for firefighters to reach. Drought conditions contribute to concerns about wildfire vulnerability. During periods of drought, the threat of wildfire increases. There are no known effective measures for human mitigation of weather conditions. Careful monitoring of weather

conditions that drive the activation and enforcement of fire-safety measures and programs, such as bans on open fires, are ongoing weather-related mitigation activities.

Mountain Pine Beetle Infestation

A related threat to forest health with wildfire hazard implications is the Mountain Pine Beetle. According to the Northern Front Range Mountain Pine Beetle Working Group, Mountain Pine Beetles (MPBs or *Dendroctonus ponderosae*) are a native insect to Colorado. The species normally resides at endemic levels in temperate pine forests across western North America, primarily in the Rocky Mountain region. The past decade has brought severe drought to many parts of the state accompanied by relatively warm temperatures in both summer and winter. These climatic conditions probably are the major reason why insect outbreaks have started in many different regions of the state. Once the outbreaks began, the beetles found an abundant food supply (trees) in most of Colorado's forests. Many stands are densely stocked with trees because they have not been disturbed for a very long time by fire, insects, or harvest. All of these factors have combined to create a "perfect storm" of bark beetle outbreaks across much of Colorado. As a result, the impact of the beetle epidemic is greater than ever seen before. The resulting weak (stressed) trees and warm temperatures are perfect habitat for beetles, causing their populations to explode.

MPBs, the size of a grain of rice, bore into trees, lay eggs, and introduce spores of blue stain fungi that germinate and grow in the tissues of the tree. Additionally, beetle larvae feed on the phloem of the tree, which weakens the tree. These activities interrupt the flow of water, decrease sap flow, and ultimately kill the trees. Figure 4.25 shows the life cycle of the MPB.

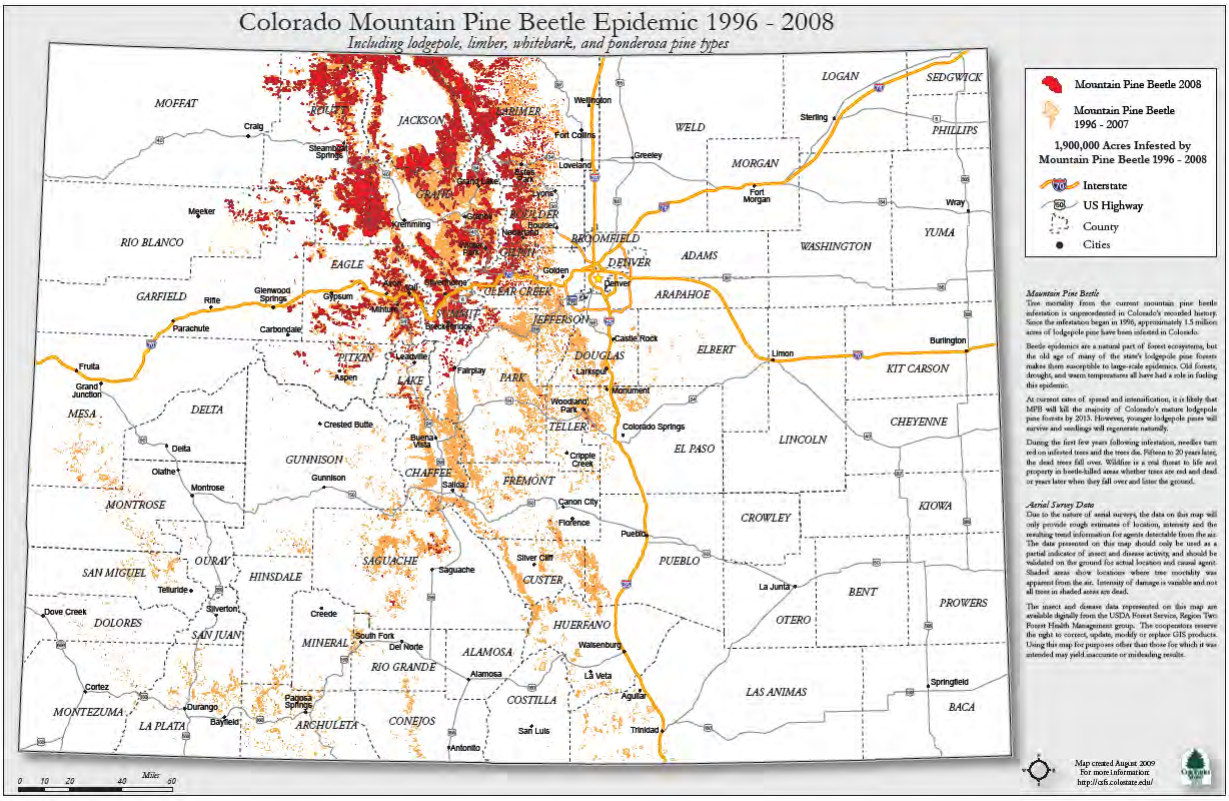
Figure 4.25. Mountain Pine Beetle Life Cycle

Source: Colorado State Forest Service

As shown above in Figure 4.25, once a tree is attacked in the summer/early fall, it will die the following spring or summer. During the spring/summer after infestation, the needles turn red (lodgepole pine trees) or light brown (ponderosa pine trees). The needles will fall off the tree two to three years later, and in many cases, trees start falling to the ground after five to seven

years. Since the current epidemic began in the 1990s, nearly 1.5 million acres of Colorado's lodgepole pine have been infested. Figure 4.26 shows the range of the recent MPB outbreak.

Figure 4.26. Colorado Mountain Pine Beetle Epidemic 1996-2008



Source: Colorado State Fire Service

MPB is a significant cause of fuel buildup in lodgepole pine forests and can result in intense fires. About 3-4 years after an outbreak, the majority of affected trees will be in the "red and dead" stage. At this time fire hazard increases because the red needles are very flammable. Fires burning in red-needled trees can burn more intensely than in live trees. One example is the June 2006 Y Fire in Grand County. Firefighters attribute the unusual intensity of the fire, given the moderate weather and early time of year for that elevation, to beetle-infested trees. Additionally, firefighters have noted the extreme volatility of beetle-killed trees versus live trees when conducting prescribed fires. However, fire hazard decreases substantially once these needles fall off of the trees and leave dead standing trees or "snags." After 15-20 years, when the majority of trees fall down, creating a jackstraw effect in the forest, the amount of surface or ground fuels increases fire hazard. In general, as trees start falling, the surface fuels contribute more heat to a stand of trees; therefore it is easier to create crown fire conditions as well as a more intense fire.

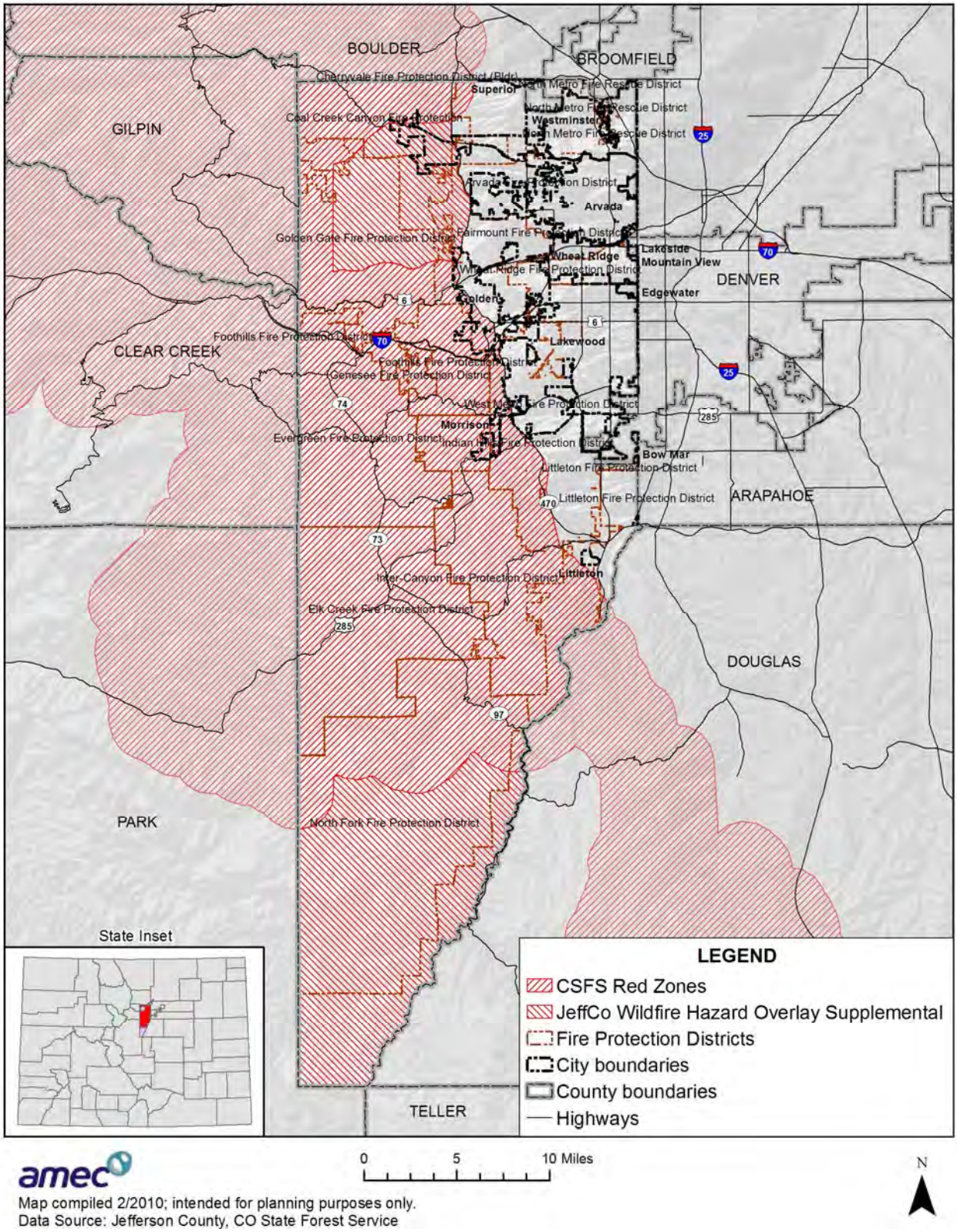
There is debate in the forest health/fire communities of what the effect will be on ponderosa pine along the Front Range of Colorado (including Jefferson County). Traditionally, as MPB epidemics erupt, the beetle might tend to favor the host species of origin (i.e. if the epidemic is rooted in ponderosa pines, the transition is limited); however, all epidemics are not equal. For a variety of factors each epidemic has its own characteristics.[40] The current epidemic has shown evidence of transitioning into neighboring ecotones including ponderosa pines along the Northern Front Range (Clear Creek, Boulder, Larimer counties). There are still questions about stand characteristics in lodgepole and ponderosa pine. It unclear as to whether or not the MPB population will spread once it enters areas like Jefferson County, with primarily ponderosa pine, and compounded in areas with Douglas-fir forest types.

Geographic Extent

Much of the County is susceptible to wildland fires, with highest risk areas located in the Front Range foothills in western and southern Jefferson County. Figure 4.27 portrays areas of Jefferson County susceptible to wildfire hazards. The HMPC determined that the best representation of the wildfire hazard area in Jefferson County is a combination of the Colorado State Forest Service Interface Areas of High Wildfire Risk in Colorado (Red Zone Data) and the Jefferson County Wildfire Hazard Overlay District Zone. These areas represent potential for forest fires. Areas susceptible to grass fires not represented in this map include North and South Table Mountain, Green Mountain, and portions of western Arvada.

[40] Witcosky, J.J. 2009. *Will the Mountain Pine Beetle Epidemic Spread from Lodgepole Pine into Ponderosa Pine along the Northern Front Range Counties of Colorado?*, Final Report to Joint Ecology Working Group, Front Range Fuels Roundtable and the Colorado Bark Beetle Cooperative. 36p.

Figure 4.27. Jefferson County Wildfire Hazard Area



Based on this assessment the geographic extent is classified as **significant**.

Previous Occurrences

The National Climactic Data Center (NCDC) only lists two wildfire events for the County: the Pine (Hi Meadows) fire (2000) and the Deckers (Schoonover) fire (2002). However, the Office of Emergency Management provided documentation for 25 significant wildfire events since 1978. Several particularly severe or significant events are profiled below.

September 21-24, 1978 – The Murphy Gulch fire burned approximately 3,300 acres. The first Emergency Fire Fund fire in the Front Range, several structures were lost to the blaze and many subdivisions were evacuated. Interagency resources were ordered to supplement local fire departments. The Federal Type 2 Team took over and managed the closeout. The agencies involved were the Inter-Canyon Fire Protection District (FPD) and Bancroft FPD. The fire burned along the foothills west of the Ken-Caryl Ranch subdivision.

September 7-9, 1988 – The North Table Mountain Fire burned between 1,300 and 2,000 acres. The human caused fire started off CO 93 and crossed the mountain, which threatened subdivisions on east side of mountain. Over 250 firefighters from 20 fire departments, the National Guard, and local law enforcement officers responded, in addition to a helicopter. In many areas, the focus was on structure protection and evacuation. The fire involved the Fairmount FPD as well as a helicopter. The area included the top, west, and east sides of North Table Mountain.

April 23-24, 1989 – The Mt. Falcon fire burned approximately 125 acres. The fire burned in open space properties, which lead to the voluntary fire reimbursement program by the County open space agencies to local fire departments to support the initial attack of the burn.

March 24-25, 1991 – The O'Fallon fire burned approximately 52 acres. Though small in comparison to other fires in this record, the fire occurred in the Denver Mountain Parks' open space areas, which lead to 100 firefighters from 5 different departments responding. Dry winter conditions, gusty winds, and limited access slowed the control efforts, underscoring the role of weather and terrain in fire response.

May 14-15, 1991 – The Elk Creek fire in the Golden Gate FPD burned 102 acres. The steep terrain with limited access lead to the use of hand crews formed from 80+ firefighters from 15 departments and ranging across multiple counties. The fire was managed jointly by the FPDs and the Jefferson County Sheriff's Office's newly formed Incident Management Group (IMG).

July 9-11, 1994 – The Carpenter Peak/Chatfield fires each burned small amounts. The fires were caused by dry lightning, as part of a larger fire bust that sparked across the entire Front Range. These particular fires resulted in evacuations from Roxborough Park, and involved 300 firefighters, 40 engines, and National Guard helicopters.

May 18-25, 1996 – The Buffalo Creek fire burned approximately 10,400 acres. High winds caused extreme fire behavior, leading to a 10 mile run in only six hours. 10 homes or other outbuildings were lost. This fire marked the first large WUI fire in the Front Range. Costs for the fire were estimated at $3,835,000.[41]

June 27 – July 5, 1998 – The Beartracks fire burned 500 acres. Heavy fuel loading in roadless area and human caused fire leads to heavy initial attack and extended attack by local fire agencies along with air resources. The fire posed a threat to the Upper Bear Creek drainage area and numerous homes. The Federal Type 2 Incident Management Team (IMT) relieved the IMG on day 3 and managed to closeout.

June 12-25, 2000 – The Hi Meadow fire, caused by humans, fell under initial attack by the local FPD and burned approximately 10,800 acres. The fire 'blew up' on the same day as the 10,000 acre Bobcat fire in Larimer County, causing a Front Range-wide stress on resources.[42] 52 homes were lost along with other miscellaneous structures. This fire was considered the "benchmark" WUI fire for Colorado until the Hayman fire in 2002. The fire burned from Burland Ranchettes on the west to Colorado Highway 126 on the east, and south to the Buffalo Creek Fire burn area and the town of Pine.

The Bobcat Fire also lasted several days and was started by a campfire, though the area had a long history of fire, included several caused by lightning. The control costs were estimated at $3.5 million ($4.3 in 2008) with no private losses, but the fire heavily impacted the watershed and water quality in the surrounding communities.[43] The concurrence of the two fires is significant due to the strains caused on the regional resources and mutual aid capabilities.

2002 Fire Season

The 2002 fire season is the most severe fire season on record in the state of Colorado and in particular for Jefferson County and the Front Range communities. 2002 was one of the most severe droughts on record in Colorado. During 2002, total suppression costs for the fires exceeded $152 million.[44] 3,409 fires were documented during the year for a cumulative total of 244,252 burned acres. This is the highest number of fires in any year in Colorado since 1990 and accounted for more than three times as many burned acres as the next-largest recorded damages for one season.[45] More than 16,500 firefighters responded to the events. Nine firefighters were killed during the year, and one air tanker and one helicopter were lost, killing three additional people. 384 homes were lost statewide, with an additional 624 structures lost.

[41] 2008 State Hazard Mitigation Plan. Hazards, page 38. In 2008 dollars, these losses equate to $5.2 million.
[42] According to the 2008 State Hazard Mitigation Plan, the Bobcat fire burned 10.600 acres and destroyed 18 structures.
[43] Information drawn from the 2003 Northern Colorado Regional Hazards Mitigation Plan, page 54.
[44] 2008 State Hazard Mitigation Plan, Hazards page 40. In 2008 dollars, the suppression costs equate to more than $180 million.
[45] Ibid., page 37.

Four of the fires that Jefferson County suffered during this year resulted in Fire Management Assistance Declarations: the Schoonover, Black Mountain, Snaking and Hayman fires. The first three fires burned from the end of April through the end of May, collectively, and the Hayman fire burned for more than a month. These fires are further profiled below, using information provided by the Jefferson County Office of Emergency Management and the 2008 State Hazard Mitigation Plan.

April 22 – May 2, 2002 – The Snaking Fire burned approximately 3,000 acres. Caused by humans outside of the 'normal' fire season, the event was exacerbated by high winds. The initial and extended attacks were coordinated mostly through Jefferson and Park Counties, with assistance from air resources. The fire threatened numerous homes and burned north of U.S. Highway 285 from Platte Canyon High School to Crow Hill, with 2 lost structures. The NRCS Emergency Watershed Protection Program authorized $72,883 in response and recovery funds.[46]

May 5-11, 2002 – The Black Mountain fire burned approximately 300 acres. While smaller than the other fires meriting emergency assistance in the County, the heavy fuel loading and steep terrain of the fire led to many difficulties in the suppression efforts. Local agencies from Jefferson and Park Counties responded along with air resources; with additional assistance from Clear Creek County, the United States Fire Service, Elk Creek FPD and the Evergreen FPD. The fire posed major threats to multiple subdivisions in Conifer and Evergreen and burned north of Conifer Mountain and south of Brook Forest. One injury was reported.

May 21-31, 2002 – The Schoonover fire was caused by lightning and burned approximately 3,000 acres. Initially under attack by USFS and local FPDs, the fire 'blew up' on the second day to make a 3,000 acre (four mile) run in steep terrain. The fire threatened homes, camps, businesses, watersheds, regional power lines, and other structures. 12 structures and 1 bridge were lost and 2 injuries were reported. The burn area included the area immediately south across the South Platte River from Jefferson County and burned from west of Deckers to near Moonridge. The NRCS Emergency Watershed Protection Program authorized $74,951 in response and recovery funds.

June 8 – mid-July, 2002 – The Hayman Fire burned more than 138,000 acres. The human caused fire expanded on the second day for a historic 19-mile run and 70,000 acres. Multiple evacuations over a two-week period were required as the fire made additional 'runs' in multiple counties. Over 150 homes and structures were lost, and large areas of damage were caused to Cheeseman Reservoir and South Platte Watershed areas. The fire is considered a nationally significant WUI fire for Colorado and the Rocky Mountain region. The fire is the event of record for the planning area. Insured losses were documented at $38.7 million and more than

[46] The purpose of the Emergency Watershed Protection (EWP) program is to undertake emergency measures, including the purchase of flood plain easements, for runoff retardation and soil erosion prevention to safeguard lives and property from floods, drought, and the products of erosion on any watershed whenever fire, flood or any other natural occurrence is causing or has caused a sudden impairment of the watershed. NRCS Website: http://www.nrcs.usda.gov/programs/ewp/

$5.6 million in recovery and response funds from the NRCS Emergency Watershed Protection Program. The Forest Service spent $38 million in suppression costs and projections for rehabilitation were estimated at $74 million.[47]

July 22-24, 2005 – The North Table Mountain fire of 2005 burned significantly less land than the previous event in 1988, but threatened multiple subdivisions on all sides. The steep terrain allowed the fire to escape the initial attack. Heavy use of air resources facilitated the transition between the initial attacks to structure protection response on the first day. The fire burned the top, east, north, and west sides of Table Mountain outside of Golden and was started by kids playing with fireworks.

April 2, 2006 – Rocky Flats fire burned 1,200 acres. The fire was started by humans and exacerbated by high winds to cause an outside of 'normal fire season' event. The fire moved through the open space areas of Rocky Flats NWR and the adjacent lands. The rate of spread, flame lengths, and limited access contributed to the fire threatening to cross several roads and endangered multiple subdivisions, businesses, and Rocky Mountain Airport. A multi-county approach, including Jefferson, Boulder, Gilpin, and Adams was requested. Wind conditions prevented the use of air resources. Difficulties with communications and fire management across multiple jurisdictions were documented.

July 21-23, 2006 – The Centennial Cone fire burned in the no-man's land adjacent to the Golden Gate FPD. The fire, which burned 22 acres, remained entirely contained within the open space park. However, the significant fire activity in steep terrain with no road access during the height of the 2006 national fire season limited the initial attack. The fire threatened U.S. Highway 6 in Clear Creek Canyon and those subdivisions. Limited air resources helped slow the spread of the fire, and an interagency "hotshot" hand crew supplemented local fire resources on the second day for a direct attack. Summer monsoons helped reduce fire danger on day three as the fire was controlled.

Probability of Future Occurrences

There have been 25 incidents in Jefferson County since 1978, for a span of 30 years. (2008-1978 = 30 years). The methodology for calculating the probability of future occurrences is described in Section 4.2.1. This formula evaluates that the probability of a severe wildfire occurring in any given year is 83.3%. This corresponds to a probability of future occurrences rating of **likely**.

Magnitude and Severity

Wildfire is a significant natural hazard in Jefferson County. The wildland-urban interface is especially at risk as decades of fire suppression have resulted in large concentrations of downed timber and fuels. This problem is exacerbated by the significant amount of residential

[47] The costs of the Hayman Fire were drawn from the "Hayman Fire Impacts" handout produced by the Wildland Fire Lessons Learned Center. The handout is available online at http://www.wildfirelessons.net/documents/Hayman_Fire_Impacts_FMT_Vol65_1.pdf

development in the semi-urban and rural portions of the region. Potential losses from wildfire include human life; structures and other improvements; natural and cultural resources; quality and quantity of the water supply; assets such as timber, range and crop land, and recreational opportunities; and economic losses. Smoke and air pollution from wildfires can be a severe health hazard. In addition, catastrophic wildfire can lead to secondary impacts or losses, such as future flooding and landslides during heavy rains.

In order to calculate a magnitude and severity rating for comparison with other hazards, and to assist in assessing the overall impact of the hazard on the planning area, information from the event of record is used. In some cases, the event of record represents an anticipated worst-case scenario, and in others, it is a reflection of common occurrence. The event of record for Jefferson County is the Hayman fire, which occurred in June and July of 2002. The event damaged 41,408 acres in the County, or about one fifth of the total acres burned. 600 buildings were destroyed, 5 wildland firefighters were killed (this was an indirect result of the wildfire, as the firefighters were from Oregon and were killed in a car accident near Grand Junction) and numerous people were evacuated or displaced due to the fire. The Hayman fire is the most expensive fire in Colorado history and took more than three weeks to contain and is considered a nationally-significant WUI fire. Based on these factors, the magnitude severity rating for wildfire is considered **critical.**

Overall Hazard Significance

Wildfires in Jefferson County are a significant concern. The geographic extent of the hazard is considered **significant.** The probability of future occurrences is considered **likely** and the magnitude/severity for the event of record is **critical.** In addition, the HMPC considers the hazard to have a **high** impact on the County. This equates to an overall impact rating of **high**.

4.2.17 Windstorm

Description

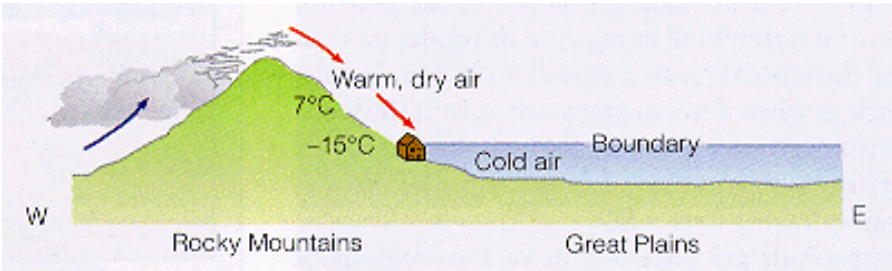
Wind is the flow of air or other gases that compose an atmosphere and consists of air molecules in motion. The differences in density between two air masses actually lead to wind. Winds are commonly classified by their spatial scale, their speed, the types of forces that cause them, the geographic regions in which they occur, and their effect. While wind is often a standalone weather phenomenon, it can also occur as part of a storm system, most notably in a cyclone. Winds are plotted indicating the direction the wind is blowing *from* as well as its strength. Shorter duration winds, such as wind gusts, can cause substantial damage to power lines. Winds with an intermediate duration, which sharply increase and last for a minute, are called squalls. Long-duration wind speeds have various names associated with their average strength, such as breeze, gale, storm, hurricane, and typhoon.

Wind occurs on a range of scales, from local breezes generated by heating of land surfaces and lasting tens of minutes, to global winds resulting from the difference in absorption of solar

energy between the climate zones. The two major driving factors of large scale atmospheric circulation are: 1) the differential heating between the equator and the poles, which causes the jet stream and the associated climatological mid-latitude westerlies, polar easterlies, and the trade winds; and 2) the rotation of the planet called the Coriolis Effect. The Coriolis Effect is what causes the circular motion of air around areas of high and low pressure in areas that have variable terrain where mountain and valley breezes dominate the wind pattern.

Downslope winds in Colorado are referred to as Chinook winds, after the Native American tribe of the Pacific Northwest. These downslope winds can occur with violent intensity in areas where mountains stand in the path of strong air currents. These warm and dry winds occur when the winds from the west blow across the Continental Divide and descend from the foothills and out onto the plains.

Figure 4.28. Chinook Wind Pattern



Source: University of Colorado at Boulder ATOC Weather Lab

Windfalls can be small scale or large scale forest blowdowns that literally force the trees down or to breakage by the means of wind. The health of the forest can determine which trees or how many are affected during a windfall incident. Windfalls can help spread wildfires. Windfalls can increase fuels for wildfire or can cause loss of animal habitat, erosion and soil depletion due to topsoil being ripped out of the ground by fallen trees. Conversely, they can create large patches of sunlight, which is good for the ground cover and increases seedling diversity in the ecosystem.

Wind can be very dangerous. Areas of wind shear, caused by various weather phenomena, can make treacherous situations for airplanes and other flying aircraft. When winds become too strong on the ground, boats can capsize, trees can be stripped of their branches or uprooted, and man-made structures become vulnerable to damaged or destruction. Wind speed, direction, and dryness are major factors in the spreading of wildfires. Using wind weather forecasting and modeling during a wildfire can be a useful tool to help firefighters with their fire suppression strategy.

Jefferson County wind patterns range from light and breezy to severe gale force winds. There is usually some level of a constant breeze due to Jefferson County's mountainous, Front Range, and plains topography. Other associated hazards of wind and wind damage include arcing power

lines, debris blocking streets and storm water drainage systems, dust storms, and occasional structure fires. Figure 4.29 demonstrates how destructive wind can be.

Figure 4.29. July 20, 2009 Damage in Wheat Ridge

Source: Fox News Online Photo Gallery

Table 4.12 shows The Beaufort Wind Scale. The replication of the scale only reflects land-based effects.

Table 4.12 The 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.
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, http://www.spc.noaa.gov/faq/tornado/beaufort.html

Geographic Extent

The entire planning area is susceptible to wind, windstorms, and wind associated with other storm systems that can have negative impacts on a community. Depending on the origination of the atmospheric system, its direction of travel, and its duration, a part of the planning area can be affected or the entire County. Typically, however, the hazard is predicted to affect between 50% and 75% of the planning area. Based on this information, the geographic extent rating for windstorms is **significant**.

Previous Occurrences

High winds associated with other severe weather and stand-alone windstorms are common occurrences in Jefferson County. The mountainous terrain and foothills topography lends itself to regular conflicts between systems of high and low pressure. Most of Colorado's most costly storms are hail-related and occurred in the Denver-metro area. Hail is usually accompanied by high winds; however the damages are not broken out to distinguish hail from wind damage.

The National Climactic Data Center recorded 22 windstorm occurrences recorded between June of 1960 and August of 2008 with wind speeds over 50 knots (approximately 57 mph). The most significant of those events are recorded below.

June 14, 1976 – 78 mph winds recorded at the Jefferson County Airport near Broomfield, 66 mph at Littleton.[48]

June 6, 1983 – Report of a thunderstorm with associated winds measured at 61 knots (70 mph).

August 15. 1982 – Report of a thunderstorm with associated winds measured at 61 knots (70 mph).

August 13, 1983 – Report of a thunderstorm with associated winds measured at 84 knots (97 mph).

June 9, 1987 – Report of a thunderstorm with associated winds measured at 63 knots (73 mph). One death reported

April 19, 1989 – Report of a thunderstorm with associated winds measured at 68 knots (78mph).

May 16, 1990 – Report of a thunderstorm with associated winds measured at 60 knots (69 mph).

May 26, 1993 – Report of a thunderstorm with associated winds measured at 70 knots (81mph).

October 26, 1995 – Report of a thunderstorm associated winds measured at 61 knots in Coal Creek Canyon (70 mph).

[48] Weather History www.examiner.com)

June 22, 1997 – Report of a dry microburst which produced 69 mph winds at the Jefferson County Airport.

June 10. 2000 – Report of a dry microburst which produced 67 mph winds at the Jefferson County Airport.

July 30, 2004 – Report of a thunderstorm associated winds measured at 62 knots (71 mph) in Evergreen.

July 20, 2009 – Golf ball-sized hail and strong winds battered roofs, uprooted trees and pounded vehicles in Wheat Ridge, Lakewood, and Arvada, and portions of neighboring Arapahoe County. The insured losses are totaled at more than $511 million in damage for Colorado's 2009 severe weather season as of August 2009.

The Rocky Mountain Insurance Information Association (RMIIA) tracks significant or catastrophic storms that impact the Front Range. This information, recorded in Table 4.13, records cumulative insured losses for the storm events. However, the information is not tracked by region or by hazard type, so the information presented below should be considered higher than actual costs inflicted on the planning area included in this document. In addition, information is not adjusted for inflation, so comparison between storms may vary by methodology.

Table 4.13 Top 10 Costliest Storms in Colorado

Rank	Cost of Insured Damage (in millions)	Associated Hazards	Date
1	$625	Hail	July 11, 1990
2*	$350	Hail and Wind	July 20, 2009
3	$276.7	Hail	June 13-14, 1984
4	$225	Hail	October 1, 1994
5	$193.5	Tornado and Hail (in Windsor)	May 22, 2008
6	$161.1	Hail	June 6-15, 2009
7	$146.5	Tornado and Hail	June 8-9, 2004
8	$128	Hail	August 11, 1997
9	$122	Hail	May 22, 1996
10	$100	Hail	May 30 - June 2, 1991

Source: Rocky Mountain Insurance Information Association
*Data from this storm is still being compiled as of submission of this plan.

Probability of Future Occurrences

There have been 22 incidents in Jefferson County from June 1960 to August 2008, or a span of 48 years (2008-1960 = 48). The methodology for calculating the probability of future occurrences is described in Section 4.2.1. This formula evaluates that the probability of a Windstorm occurring in any given year is 45.83%.

This corresponds to a probability of future occurrences rating of **likely**.

Magnitude and Severity

Windstorm severity is difficult to quantify. Wind, by itself, has not historically caused high insured dollar losses. For the insurance industry to track a weather event, it must be a large enough storm that insurance companies may declare it a "catastrophe,"[49] and then damage estimates for auto and homeowner claims are collected and published. This generally equates to damages in excess of $25 million; though significant events impacting small communities are also tracked occasionally. The following statistics from the Insurance Service Office, Inc. (ISO) include wind with hail and flood: from 1988-2007, hurricanes and tropical storms accounted for 45.6% of insured catastrophic losses, tornadoes 26.5%, for winter storms 7.9%, for terrorism 7.4%, for earthquakes 6.3%, for wind, hail and flood 3.2%, for fire 2.6%, for civil disorders 0.4%, and for water damage 0.1%.[50] Of important note, this does not include damages covered by the National Flood Insurance Program.

In order to calculate a magnitude and severity rating for comparison with other hazards, and to assist in assessing the overall impact of the hazard on the planning area, information from the event of record is used. In some cases, the event of record represents an anticipated worst-case scenario, and in others, it is a reflection of common occurrence. The significant wind and windstorm events of record for Jefferson County are identified in the Previous Occurences section of the windstorm hazard profile. Wind damage is usually identified by the number of insurance claims made as a result of a severe weather event. Wind is not broken out from a hailstorm, rainstorm, or a tornado. The damages inflicted on critical facilities and services (critical infrastructure) for Jefferson County are not specific to windstorm activity alone.

Based on these factors, the magnitude severity ratings for windstorm in Jefferson County would be **negligible;** however if the windstorm is considered a component of the larger weather system its magnitude and severity rating would be upgraded to **limited.**

Overall Hazard Significance

Windstorm in Jefferson County can have a particular impact on the planning area. Alone they can rip roofs from houses, collapse fences, tear off siding, project flying debris through windows, and uproot large trees. When accompanying other severe weather, like hail, damages are compounded. The geographic extent of the hazard is considered **significant**. The probability of future occurrences is considered **likely** and the magnitude/severity for the event of record is **limited**. The HMPC considers the hazard to have an overall impact rating of **medium** on Jefferson County. Overall, the data indicates that the overall hazard significance rating is **medium**.

[49] Note that this definition of 'catastrophe' is not congruent with the definition used in the emergency management field.
[50] Insurance Service Office, Inc. http://www.iso.com/

4.3 Vulnerability Assessment

Requirement §201.6(c)(2)(ii): [The risk assessment shall include 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.

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

Requirement §201.6(c)(2)(ii)(B): [The plan should describe vulnerability in terms of an] estimate of the potential dollar losses to vulnerable structures identified in paragraph (c)(2)(i)(A) of this section and a description of the methodology used to prepare the estimate.

Requirement §201.6(c)(2)(ii)(C): [The plan should describe vulnerability in terms of] 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.

With Jefferson County's hazards identified and profiled, the HMPC conducted a vulnerability assessment to describe the impact that the significant hazards would have on the County. The vulnerability assessment quantifies, to the extent feasible, assets at risk to natural hazards and estimates potential losses.

This vulnerability assessment followed the methodology described in the FEMA publication *Understanding Your Risks—Identifying Hazards and Estimating Losses*. The vulnerability assessment first describes the total vulnerability and values at risk and then discusses vulnerability by hazard.

4.3.1 Methodology

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

Data to support the vulnerability assessment was collected and compiled from the following sources:

- County and municipal GIS data (hazards, base layers, critical facilities and assessor's data);
- FEMA's HAZUS-MH MR 4 GIS-based inventory data (August 2009)

- Written descriptions of inventory and risks provided by participating jurisdictions;
- Existing plans and studies; and
- Personal interviews with planning team members, hazard experts, and County and municipal staff.

The scope of the vulnerability assessment is to describe the risks to the County as a whole. The vulnerability assessment first describes the assets in Jefferson County, including the total exposure of people and property; critical facilities and infrastructure; natural, historic, and cultural resources; and economic assets. Development trends, including population growth and land status, are analyzed in relation to hazard-prone areas. Next, where data was available, hazards are evaluated in more detail and potential losses are estimated. Data from each jurisdiction was also evaluated and is integrated here but specific variations of risk are noted in the appropriate annex.

The methods to assess vulnerability presented here include a more refined analysis than was previously performed for the County, Arvada, Lakewood and Wheat Ridge in the 2003 DRCOG plan. This includes a more detailed risk assessment for all hazards based on advanced methods and updated hazard and inventory data. Thus this 2010 plan should be considered the baseline for measuring changes in vulnerability during future updates, recognizing that vulnerability information should become more refined as data sources and methodologies improve over time. Examples of refinements and changes made in this plan include:

- Updated population and building inventory information;
- A more comprehensive inventory of critical facilities;
- An inventory of natural, historic, and cultural resources;
- More refined flood loss estimation by jurisdiction with the use of a level II HAZUS-MH MR4 analysis incorporating parcel level information and Digital Flood Insurance Rate Maps;
- Modeling of earthquake loss potential with HAZUS-MH MR4, including a 2,500 year probabilistic scenario and a hypothetical M 6.5 event on the Golden Fault;
- More detailed inventory by jurisdiction of potential structures and critical facilities at risk to geologic hazards including landslide and rockfall areas and areas of subsidence and heaving bedrock;
- More detailed inventory by jurisdiction of potential structures and critical facilities at risk to wildfire hazards

Another significant change for the jurisdictions that participated in the 2003 DRCOG plan is the inclusion of a capability assessment. Similar to the HMPC's effort to describe hazards, risks, and vulnerabilities of Jefferson County, this mitigation capability assessment describes the County's existing capabilities, programs, and policies currently in use to reduce hazard impacts or that could be used to implement hazard mitigation activities. This is described in Section 4.4 and in each jurisdictional annex.

4.3.2 Assets at Risk

Total Exposure of Population and Structures

Table 4.14 shows the estimated total population and number of housing units for each jurisdiction in 2008. Jurisdictions that straddle County boundaries are listed as MCP (Multi-County Place). The numbers listed for these jurisdictions only represent the Jefferson County portion. Table 4.15 shows the high risk population exposures for the County by jurisdiction. In this case, the data is drawn from the 2006-2008 American Community Survey 3-Year Estimates (where possible) and reflects the entire geographic area of the jurisdiction.

Table 4.14 Population and Housing Unit Exposure by Jurisdiction, 2008

Jurisdiction	2008 Population Estimate	2008 Housing Units Estimate
Arvada	104,818	43,166
Bow Mar	235	98
Edgewater	5,273	2,474
Golden	17,804	7,801
Lakeside	20	9
Lakewood	144,382	66,233
Littleton	1,556	766
Morrison	420	140
Mountain View	532	287
Superior	0	0
Westminster	46,382	18,287
Wheat Ridge	31,650	15,130
Unincorporated	189,981	76,505
Total County	**543,053**	**230,896**

Source: Colorado Department of Local Affairs Demography Section, www.dola.colorado.gov/dlg/demog/

Table 4.15 High Risk Population Exposure by Jurisdiction, 2008 (in %)

Jurisdiction	Age <5	Age 65<	Age 5< Reporting Some Disability*	Do Not Speak English at Home	Families Below Poverty Line	Individuals Below Poverty Line
Arvada (MCP)	6.1	12.3	15.0	8.9	5.3	7.1
Bow Mar (MCP)*	6.5	16.8	11.0	5.9	2.4	3.4
Edgewater*	8.3	10.0	23.4	22.9	8.1	10.2
Golden*	5.7	8.0	12.4	10.5	3.5	11.3
Lakeside*	5.0	20.0	0	12.5	66.7	44.4
Lakewood	6.0	14.0	16.7	16.0	9.7	11.8
Littleton (MCP)	4.9	16.5	15.3	12.2	7.2	11.8
Morrison*	1.6	43.7	11.2	3.1	4.9	5.5
Mountain View*	6.0	14.1	21.7	14.3	12.2	13.0

Superior (MCP)*	9.3	1.5	3.7	14.7	2.5	3.8
Westminster (MCP)	7.2	8.0	19.3	15.3	6.6	9.1
Wheat Ridge	5.2	17.9	21.6	-	8.8	10.0
Total County	5.9	11.4	14.1	11.1	5.7	7.9

Source: National Census Bureau 2006—2008 Estimates.
* indicates 2000 Census Data only is available.

Building value assessments in this plan are based on data from the Jefferson County's Assessor's Office.[51] Figure 4.17 shows the total property inventory from the Assessor's Office (June 2009) by the structure types commonly used to aggregate and analyze information in HAZUS-MH, FEMA's loss estimation software. Table 4.16 and Table 4.17 summarize the property inventory for the County and each participating jurisdiction, including jurisdictions which may not be participating in the plan, and the unincorporated area of the County.

Table 4.16 Jefferson County's Building Inventory and Value by Jurisdiction

	Structure Type	Structure Count	Building Value*	Contents Value**	Total Value
Countywide	Commercial	7,700	$11,671,377,312	$11,671,377,312	$23,342,754,624
	Government	21	$1,960,377	$1,960,377	$3,920,754
	Religious	12	$6,698,270	$6,698,270	$13,396,540
	Residential	171,527	$33,464,684,597	$16,732,342,299	$50,197,026,896
Total		**179,260**	**$45,144,720,556**	**$28,412,378,258**	**$73,557,098,814**

Source: Jefferson County Assessor June 2009
*The Assessor's Office values buildings for the specific purpose of valuation for ad valorem tax purposes and values represented do not reflect actual building replacement values.
**The Assessor does not have data about the contents of structures and the contents values shown in the table are not derived from Assessor data but are estimates based upon the structure value using FEMA recommended values (typically 50% for residential structures and 100% for commercial/industrial)

Table 4.17 Jefferson County's Building Inventory and Value by Jurisdiction

Jurisdiction	Occupancy	Structure Count	Building Value*	Contents Value**	Total Value
Arvada	Commercial	1,207	$1,526,517,849	$1,526,517,849	$3,053,035,698
	Government	8	$1,327,357	$1,327,357	$2,654,714
	Residential	33,342	$5,567,075,252	$2,783,537,626	$8,350,612,878
Bow Mar	Residential	95	$42,556,400	$21,278,200	$63,834,600
Edgewater	Commercial	106	$108,817,331	$108,817,331	$217,634,662
	Residential	1,344	$159,016,939	$79,508,470	$238,525,409
Golden	Commercial	595	$1,305,376,284	$1,305,376,284	$2,610,752,568
	Government	1	$59,340	$59,340	$118,680
	Residential	4,348	$1,093,124,400	$546,562,200	$1,639,686,600

[51] The Assessor does not have data about the contents of structures and the contents values shown in the table are not derived from Assessor data but are estimates based upon the structure value using FEMA recommended values (typically 50% for residential structures and 100% for commercial/industrial)

Jurisdiction	Occupancy	Structure Count	Building Value*	Contents Value**	Total Value
Lakeside	Commercial	8	$12,448,200	$12,448,200	$24,896,400
Lakewood	Commercial	2,384	$3,637,318,159	$3,637,318,159	$7,274,636,318
	Government	2	$158,590	$158,590	$317,180
	Religious	1	$950,500	$950,500	$1,901,000
	Residential	40,675	$6,787,794,945	$3,393,897,473	$10,181,692,418
Littleton	Commercial	2	$1,334,400	$1,334,400	$2,668,800
	Residential	737	$235,522,500	$117,761,250	$353,283,750
Morrison	Commercial	40	$12,993,700	$12,993,700	$25,987,400
	Residential	108	$21,529,500	$10,764,750	$32,294,250
Mountain View	Commercial	26	$6,907,600	$6,907,600	$13,815,200
	Residential	218	$23,431,200	$11,715,600	$35,146,800
Westminster	Commercial	316	$1,086,036,330	$1,086,036,330	$2,172,072,660
	Residential	13,283	$1,898,772,620	$949,386,310	$2,848,158,930
Wheat Ridge	Commercial	1,126	$911,487,213	$911,487,213	$1,822,974,426
	Residential	8,949	$1,343,182,187	$671,591,094	$2,014,773,281
Unincorporated	Commercial	1,890	$3,062,140,246	$3,062,140,246	$6,124,280,492
	Government	10	$415,090	$415,090	$830,180
	Religious	11	$5,747,770	$5,747,770	$11,495,540
	Residential	68,428	$16,292,678,654	$8,146,339,327	$24,439,017,981
Total		**179,260**	**$45,144,720,556**	**$28,412,378,259**	**$73,557,098,815**

Source: Jefferson County Assessor June 2009

*The Assessor's Office values buildings for the specific purpose of valuation for ad valorem tax purposes and values represented do not reflect actual building replacement values.

**The Assessor does not have data about the contents of structures and the contents values shown in the table are not derived from Assessor data but are estimates based upon the structure value using FEMA recommended values (typically 50% for residential structures and 100% for commercial/industrial)

Critical Facilities, Infrastructure, and Other Important Community Assets

A critical facility is defined for the purposes of this plan as one that is essential in providing utility or direction either during the response to an emergency or during the recovery operation. FEMA's HAZUS-MH loss estimation software uses the following three categories of critical assets. Essential facilities are those that if damaged would have devastating impacts on disaster response and/or recovery. High potential loss facilities are those that would have a high loss or impact on the community. Transportation and lifeline facilities are a third category of critical assets. Examples of each are provided below.

Essential Facilities

- Hospitals and other medical facilities
- Police stations
- Fire stations
- Emergency Operations Centers

High Potential Loss Facilities

- Power plants
- Dams and levees
- Military installations
- Hazardous material sites
- Schools
- Shelters
- Day care centers
- Nursing homes
- Main government buildings

Transportation and Lifelines

- Highways, bridges, and tunnels
- Railroads and facilities
- Airports
- Water treatment facilities
- Natural gas and oil facilities and pipelines
- Communications facilities

Jefferson County and certain municipalities have GIS databases of critical facilities and infrastructure. The data layer themes are noted in Table 4.18 below. The best available data was used, but some limitations include lack of complete or comprehensive data and values such as replacement costs. These databases were used in vulnerability assessments for hazards such as wildfire and flood, and are represented in maps and tables in the vulnerability by hazard section that follows. Figure 4.30 and Figure 4.31 illustrate the location of critical facilities in Jefferson County.

Table 4.18 Summary of Critical Facilities in GIS

Critical Facilities	Facility Count	Value
Airport	1	
Bridges	366	
Dams	73	
Emergency Operation Center	2	
Fire Stations	67	
Government Buildings	1	
Hazmat Facilities	11	
Health Facilities	10	
Oil & Gas Facilities	6	
Police Facilities	20	
Schools	169	

Critical Facilities	Facility Count	Value
Wastewater Facilities	13	
Total	**739**	

Source: Jefferson County Data Collection Guide

Figure 4.30. Jefferson County Critical Facilities

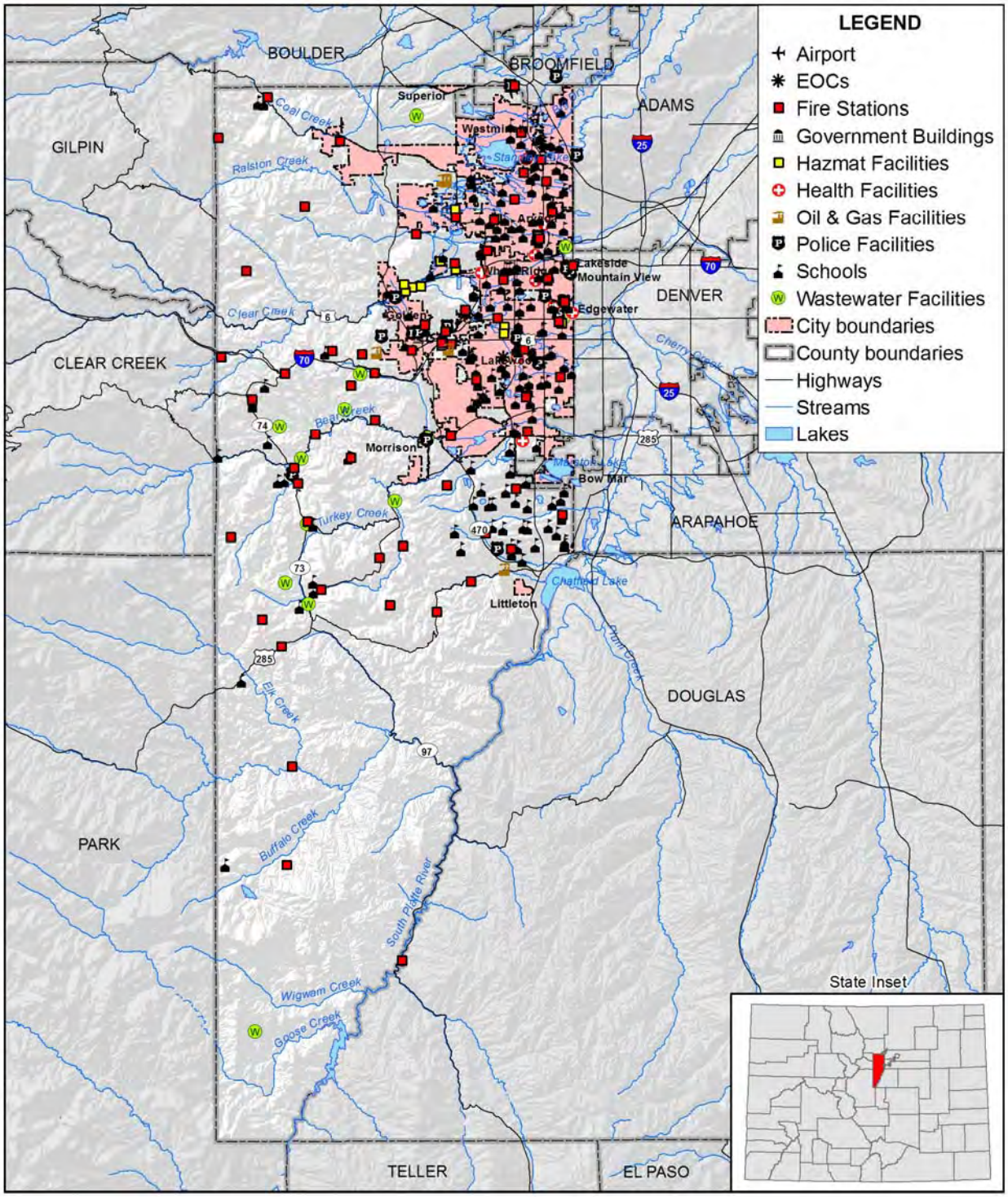
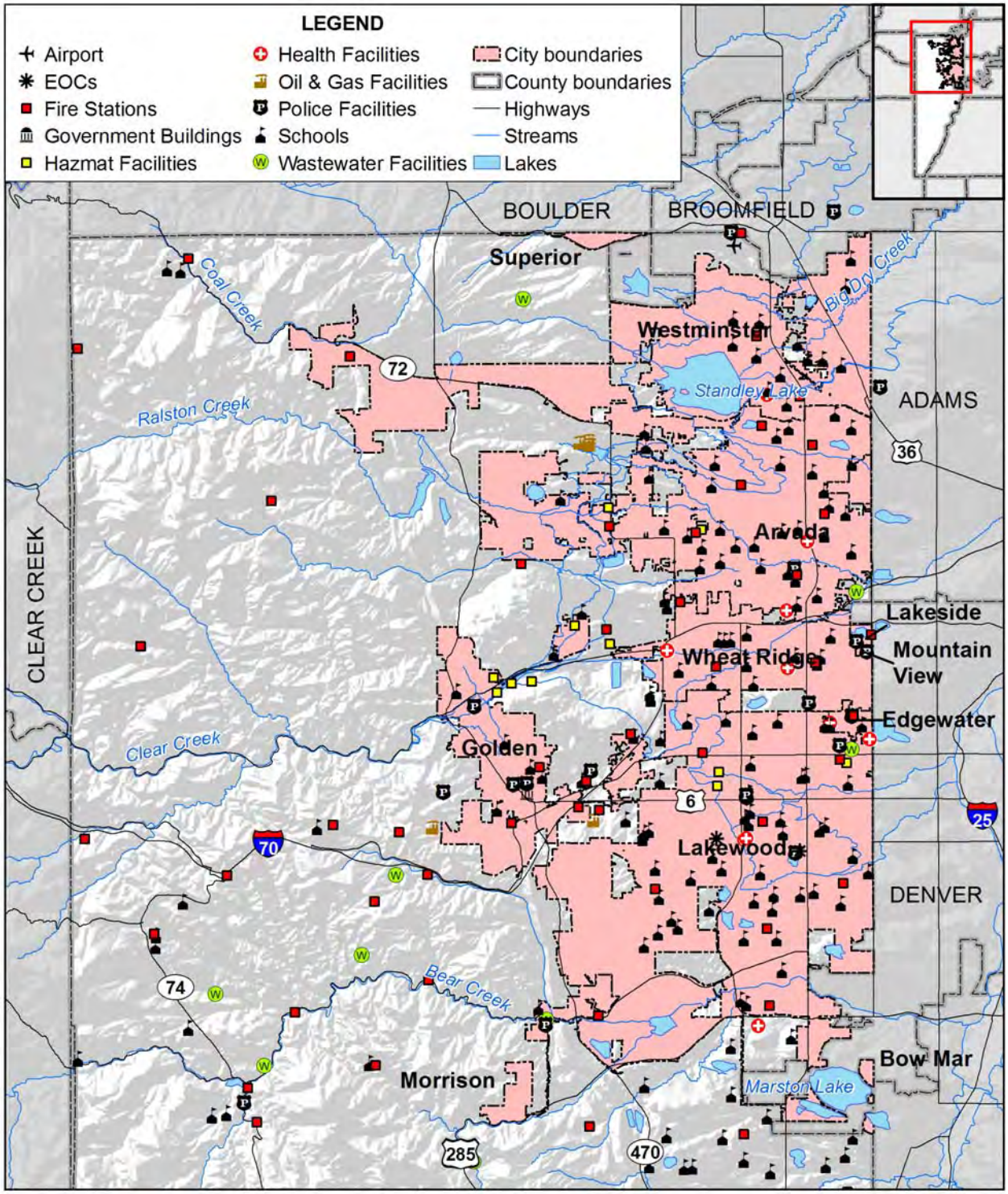


Figure 4.31. Jefferson County Critical Facilities (North Half)



amec

Map compiled 10/2009; intended for planning purposes only.
Data Source: Jefferson County, CDPH, CDOLA, HAZUS

Natural, Historic, and Cultural Resources

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

- The community may decide that these types of resources warrant a greater degree of protection due to their unique and irreplaceable nature and contribution to the overall economy.
- If these resources are impacted by a disaster, knowing so ahead of time allows for more prudent care in the immediate aftermath, when the potential for additional impacts are higher.
- The rules for reconstruction, restoration, rehabilitation, and/or replacement are often different for these types of designated resources.
- Natural resources can have beneficial functions that reduce the impacts of natural hazards, such as wetlands and riparian habitat, which help absorb and attenuate floodwaters.

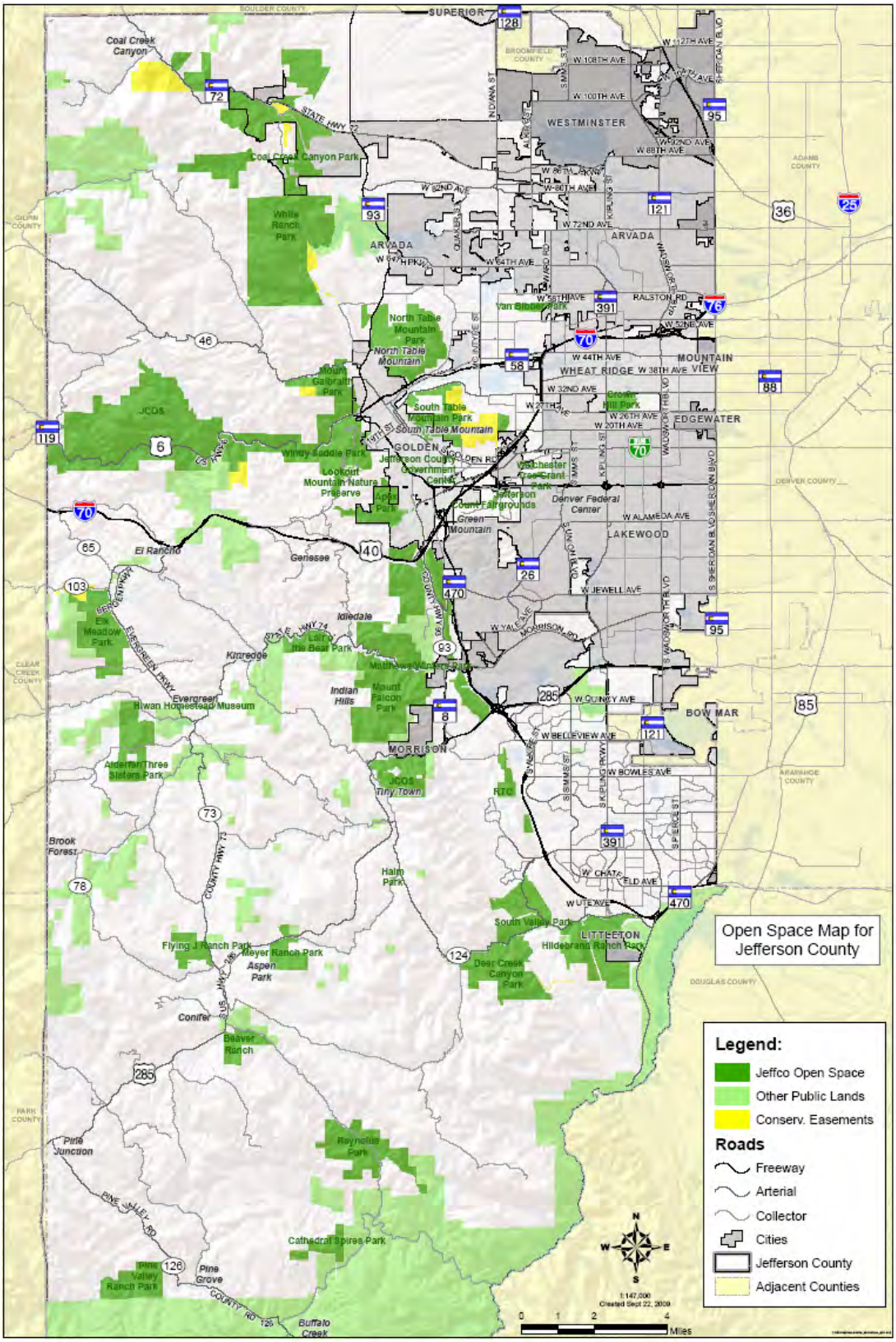
Natural Resources

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

Jefferson County contains a unique combination of prairie, forest, and tundra environments. The County recognizes three types of valuable natural resources worthy of protection: environmental conservation areas, natural landmarks, and natural areas. These areas are described below and mapped in Figure 4.32.

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

Figure 4.32. Jefferson County Conservation Areas, Open Space, and Public Lands



Wetlands

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

Endangered Species and Imperiled Natural Plant Communities

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

According to the U.S. Fish and Wildlife Service, as of February 2008, there were 10 federal endangered, threatened, or candidate species in Jefferson County. These species are listed in Table 4.19 along with state listed species (excluding those identified in the County as extirpated or casual/accidental). State special concern is not a statutory category, but suggests a species may be in danger.

Table 4.19 Select List of Important Species Found in Jefferson County

Common Name	Scientific Name	Type of Species	Status
Canada Lynx	*Lynx canadensis*	Mammal	T
Colorado butterfly plant	*Gaura neomexicana ssp. Coloradensis*	Plant	T
Gunnison's prairie dog	*Cynomys gunnisoni*	Mammal	C
Least tern (interior population)▲	*Sternula antillarum*	Bird	E
Mexican spotted owl	*Strix occidentalis lucida*	Bird	T
Pallid sturgeon▲	*Scaphirhynchus albus*	Fish	E
Pawnee montane skipper	*Hesperia leonardus montane*	Insect	T
Piping plover▲	*Charadrius melodus*	Bird	T
Preble's meadow jumping mouse©	*Zapus hudsonius preblei*	Mammal	T
Ute ladies'-tresses orchid	*Spiranthes diluvialis*	Plant	T
Whooping Crane▲	*Grus americana*	Bird	E

Common Name	Scientific Name	Type of Species	Status

Symbols:
▲ Water depletions in the South Platte River may affect the species and/or critical habitat in downstream reaches in other states.
T Threatened
E Endangered
P Proposed
X Experimental
C Candidate

Source: Endangered, Threatened, Proposed, and Candidate Species Colorado Counties (June 2009), U.S. Fish and Wildlife Service Mountain-Prairie Region, http://www.fws.gov/mountain-prairie/co.html
Note: State status information is from the NDIS, which does not track county occurrence of fish or insects at this time.

Historic and Cultural Resources

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

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

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

Table 4.20 lists the properties and districts in Jefferson County that are on the National Register of Historic Places and/or the Colorado State Register of Historic Properties.

Table 4.20 Jefferson County Historic Properties in National & State Registers

Property	Jurisdiction	Address	Date Listed
Arvada Downtown	Arvada	5580-5773 Wadsworth Blvd., 7207-7612 Grandview Ave., 755 Grant Pl., 5690 Yukon St., and 7314-7510 W. 57th Ave.	7/15/1998
Arvada Flour Mill	Arvada	5580 Wadsworth Blvd.	4/24/1975
Churches Ranch	Arvada	17999 W. 60th Ave	7/23/1998
Enterprise Grange No. 15	Arvada	7203 Simms St.	8/11/1999

Property	Jurisdiction	Address	Date Listed
Ralston Gold Discovery Site (Gold Strike Park)	Arvada	56th Ave. & Fenton St.	12/13/1995
Reno Park Addition	Arvada	7799-7899 W. 57th Ave., 7801-7906 Grandview Ave., 7800 & 7884 Ralston Rd., 5603-5720 Yarrow St., 5701-5723 Yukon St., & 5604-5723 Zephyr St.	9/29/1999
Russell-Graves House	Arvada	5605 Yukon St	5/9/1983
Stocke / Walter Addition	Arvada	6701-7014 Grandview Ave., 5708-7006 Ralston Rd., 5712-5724 Reed St. & 5705-5726 Saulsbury St.	9/24/1999
Silver Spruce Ranch	Bailey	20973 Wellington Rd.	6/12/1996
Blue Jay Inn	Buffalo Creek	Colo. Hwy. 126	10/1/1974
Green Mercantile Store	Buffalo Creek	Northwest of Buffalo Creek	10/1/1974
Green Mountain Ranch	Buffalo Creek	Colo. Hwy. 126, south of Buffalo Creek	10/1/1974
La Hacienda/John L. Jerome Summer Estate	Buffalo Creek	On State Rd., off US Hwy. 285	7/20/1973
Midway House/Meyer Ranch	Conifer	9345 US Hwy. 285, Conifer vicinity	9/18/1990
Pleasant Park School	Conifer	22551 Pleasant Park Rd.	6/12/1996
Bergen Park	Evergreen	Colo. Hwy. 74, Evergreen vicinity	11/15/1990
Corwina–Pence–O'fallon Parks	Evergreen	Southeast of junction of Kittredge and Myers Gulch Rd.	12/28/1990
Dedisse Park	Evergreen	29614 Upper Bear Creek Rd	11/15/1990
Evergreen Conference District	Evergreen	Bear Creek & Colo. Hwy. 74	5/1/1979
Everhardt Ranch / Herzman Ranch	Evergreen	Lone Peak Dr. & N. Mountain Park Rd.	5/7/1980
Fillius Park	Evergreen	Colo. Hwy. 74, Evergreen vicinity	2/24/1995
Hiwan Homestead	Evergreen	Meadow Dr.	4/9/1974
Humphrey House / Kinnikinnik Ranch	Evergreen	620 S. Soda Creek Rd	12/31/1974
Medlen School	Evergreen	South Turkey Creek Rd., Evergreen vicinity	3/8/1995
Ammunition Igloo	Golden	15001 Denver W. Pkwy., Camp George West	5/20/1993
Astor House Hotel / Lake House/Castle Rock House	Golden	822 12th St.	3/1/1973
Oscar Barber House	Golden	714 Cheyenne St.	7/13/1994
Barnes-Peery Residence	Golden	622 Water St.	10/12/2001
Calvary Episcopal Church	Golden	1300 Arapahoe St.	3/3/1995
Camp George West Historic District	Golden	15000 S. Golden Rd., Camp George West	2/11/1993
Colorado Amphitheater	Golden	15001 Denver W. Pkwy., Camp George West	5/20/1993
Colorado Midland Railway Observation Car No. 111	Golden	17155 W. 44th Ave., Colorado Railroad Museum	12/11/1996
Colorado National Guard Armory	Golden	1301 Arapahoe St.	12/18/1978

Property	Jurisdiction	Address	Date Listed
Colorow Point Park	Golden	900 Colorow Rd., Lookout Mountain	11/15/1990
Charles Deaton Sculptured House	Golden	24501 Ski Hill Drive, Golden vicinity	2/24/2004
Herman Coors House	Golden	1817 Arapahoe St.	10/17/1997
Denver & Rio Grande Railroad Business Car No. B-8	Golden	17155 W. 44th Ave., Colorado Railroad Museum	12/11/1996
Denver & Rio Grande Railroad Coach No. 60	Golden	17155 W. 44th Ave., Colorado Railroad Museum	6/12/1996
Denver & Rio Grande Railroad Coach No. 307	Golden	17155 W. 44th Ave., Colorado Railroad Museum	3/12/1997
Denver & Rio Grande Railway Caboose No. 49	Golden	17155 W. 44th Ave., Colorado Railroad Museum	9/11/1996
Denver & Rio Grande Western Railroad Caboose No. 0578	Golden	17155 W. 44th Ave., Colorado Railroad Museum	5/16/2001
Denver & Rio Grande Western Railroad Locomotive No. 50	Golden	17155 W. 44th Ave., Colorado Railroad Museum	12/11/1996
Denver & Rio Grande Western Railroad Locomotive No. 346	Golden	17155 W. 44th Ave., Colorado Railroad Museum	9/11/1996
Denver & Rio Grande Western Railroad Locomotive No. 683	Golden	17155 W. 44th Ave., Colorado Railroad Museum	9/11/1996
Denver & Salt Lake Railway Caboose No. 10060	Golden	17155 W. 44th Ave., Colorado Railroad Museum	6/10/1998
Denver South Park & Pacific Railroad Locomotive No. 191	Golden	17155 W. 44th Ave., Colorado Railroad Museum	12/11/1996
First Presbyterian Church Of Golden (Foothills Art Center)	Golden	809 15th St	3/14/1991
Genesee Park	Golden	26771 Genesee Ln.	11/15/1990
Golden High School	Golden	710 10th St.	3/14/1997
Golden Welcome Arch	Golden	1100 block of Washington Ave.	6/14/2000
Great Western Railway Combine No. 100	Golden	17155 W. 44th Ave., Colorado Railroad Museum	9/11/1996
Lariat Trail Scenic Mountain Drive	Golden	Lookout Mountain Rd.	11/15/1990
Lookout Mountain Park	Golden	987½ Lookout Mountain Rd.	11/15/1990
Lorraine Lodge / Charles Boettcher Summer Home	Golden	900 Colorow Rd., Lookout Mountain	1/18/1984
Loveland Building And Coors Building	Golden	1120-1122 Washington	5/16/1996
Magic Mountain Site	Golden	Heritage Square	8/21/1980
Mt. Vernon House / Robert W. Steele House	Golden	At I-70, Colo. 26 & Mt. Vernon Canyon Rd., 1 mile south of Golden	11/20/1970
Quaintance Block	Golden	805 13th St	3/25/1994
Queen Of Heaven Orphanage Summer Camp	Golden	20189 Cabrini Blvd., Golden vicinity	1/14/2000
Rio Grande Southern Railroad Engine No. 20	Golden	17155 W. 44th Ave., Colorado Railroad Museum	12/14/2000

Property	Jurisdiction	Address	Date Listed
Rio Grande Southern Railroad Motor No. 2 / Galloping Goose No. 2	Golden	17155 W. 44th Ave., Colorado Railroad Museum	2/14/1997
Rio Grande Southern Railroad Motor No. 6 / Galloping Goose No. 6	Golden	17155 W. 44th Ave., Colorado Railroad Museum	2/19/1997
Rio Grande Southern Railroad Motor No. 7 / Galloping Goose No. 7	Golden	17155 W. 44th Ave., Colorado Railroad Museum	3/12/1997
Rocky Flats Plant	Golden	Colo. Hwy. 93, north of Golden	5/19/1997
Rooney Ranch	Golden	Intersection of Rooney Rd. & Alameda Pkwy.	2/13/1975
Tallman Ranch	Golden	Golden Gate Canyon State Park, west of Golden	6/14/1995
Thiede Ranch	Golden	Approximately 6 miles west of Golden	1/11/1996
Twelfth St. Historic Residential District	Golden	11th, 13th, Elm, & Arapahoe Sts.	9/22/1983
Little Park	Idledale	Colo. Hwy. 74, vicinity of Idledale	2/24/1995
Starbuck Park	Idledale	Colo. Hwy. 74, vicinity of Idledale	6/30/1995
Indian Hills Community Hall And Firehouse	Indian Hills	5381 Parmalee Gulch Rd.	5/14/1997
Ken-Caryl South Valley Archaeological District	Indian Hills	Indian Hills vicinity	4/18/2003
Building 710, Defense Civil Preparedness Agency Region 6 Operations Center	Lakewood	Denver Federal Center, W. Alameda Ave. and S. Kipling St.	3/2/2000
Davies' Chuck Wagon Diner	Lakewood	9495 W. Colfax Ave.	7/2/1997
Denver & Intermountain Interurban No. 25	Lakewood	Denver Federal Center, W. Alameda Ave. and S. Kipling St.	12/10/1997
Hill Section, Golden Hill Cemetery	Lakewood	12000 W. Colfax Ave.	7/31/1995
Howell House	Lakewood	1575 Kipling St.	9/11/1996
JEWISH CONSUMPTIVE RELIEF SOCIETY HISTORIC DISTRICT (Rocky Mountain College Of Art And Design)	Lakewood	1600 Pierce St.	6/26/1980
Office Of Civil Defense Emergency Operations Center	Lakewood	Denver Federal Center, W. Alameda Ave. and S. Kipling St.	12/16/1999
Peterson House / Ticen Or Tyson House	Lakewood	Historic Belmar Village, Lakewood	9/10/1981
Schnell Farm	Lakewood	3113 S. Wadsworth Blvd.	2/14/1997
Stone House	Lakewood	Off S. Wadsworth, south of Lakewood	5/1/1975
Washington Heights School	Lakewood	6375 W. First Ave.	7/13/1994
Bradford House Ii	Littleton	Littleton vicinity	2/2/2001
Bradford-Perley House	Littleton	Kildeer Ln., North Ranch at Ken-Caryl	3/12/1997
Hildebrand Ranch	Littleton	Off Deer Creek Canyon Rd., 7 miles southwest of Littleton	3/13/1975

Property	Jurisdiction	Address	Date Listed
Bear Creek Canyon Scenic Mountain Drive	Morrison	Colo. Hwy. 74	11/15/1990
Bradford House III	Morrison	4 miles south of Morrison	4/8/1980
Craig, Katherine, Park	Morrison	US Hwy. 40/I-70, northwest of Morrison	6/30/1995
Dinosaur Ridge	Morrison	West of Morrison	3/10/1993
The Fort	Morrison	19192 State Highway 8, Morrison vicinity	7/14/2006
Lodaiska Site	Morrison	Morrison vicinity	9/25/2003
Morrison Historic District	Morrison	Colo. Hwy. 8	9/28/1976
Morrison School House	Morrison	226 Spring St.	9/4/1974
Red Rocks Park / Mt. Morrison Civilian Conservation Corps Camp	Morrison	16351 County Rd. 93	5/18/1990
Baehr Lodge / Baehr Den Of The Rockies (Pine Valley Lodge)	Pine	16405 Colo. Hwy. 126	6/10/1998
North Fork Historic District	Pine & South Platte	Pike National Forest	10/9/1974
Crown Hill Burial Park (Crown Hill Cemetery)	Wheat Ridge	7777 W. 29th Ave., Wheat Ridge vicinity	7/24/2008
Pioneer Sod House	Wheat Ridge	4610 Robb St.	3/14/1973
Richards Mansion / Hart Estate	Wheat Ridge	5349 W. 27th Ave.	9/15/1977
Tower Of Memories	Wheat Ridge	8500 W. 29th Ave., Crown Hill Cemetery	9/25/1987
Wheat Ridge Post Office	Wheat Ridge	4610 Robb Street	8/12/1992

Sources: Directory of Colorado State Register Properties, www.coloradohistory-oahp.org/programareas/register/1503/; National Register Information System, www.nr.nps.gov/
*Only on the Colorado State Register of Historic Properties

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

Economic Assets

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

4.3.3 Growth and Development Trends

Table 4.21 illustrates how Jefferson County has grown in terms of population and number of housing units between 2000 and 2007.

Table 4.21 Jefferson County's Change in Population and Housing Units, 2000-2007

Jurisdiction	2000 Population	2007 Population Estimate	Estimated Percent Change (%) 2000-2007	2000 # of Housing Units	2007 Estimated # of Housing Units	Estimated Percent Change (%) 2000-2007
Arvada (part)	99,306	103,514	4%	38,652	42,731	10.6%
Bow Mar (part)	240	234	-3%	95	98	3.1%
Edgewater	5,445	5,260	-3%	2,424	2,474	2.1%
Golden	17,159	17,701	3%	7,146	7,759	8.6%
Lakeside	20	20	0%	9	9	0%
Lakewood	144,126	143,109	-1%	62,422	65,797	5.4%
Morrison	430	418	-3%	136	139	2.2%
Mountain View	569	531	-7%	287	287	0%
Unincorporated Area	181,666	188,326	4%	69,460	76,019	9.4%
Wheat Ridge	32,913	31,557	-4%	14,931	15,120	1.3%
Total County	**527,056**	**538,323**	**2%**	**195,562**	**210,433**	**8.3%**

Source: Colorado Division of Local Government State Demography Office, www.dola.colorado.gov/dlg/demog/

As indicated above, Jefferson County has grown in recent years. Growth is projected to continue through 2035, though the growth levels are lower than those anticipated statewide. Table 4.22 shows the population forecasts for the County as a whole and for the State through 2035 in 5 year increments.

Table 4.22 Population Forecast for Jefferson County, 2010-2035

	2010	2015	2020	2025	2030	2035
County Population	551,617	572,770	603,182	637,274	664,586	684,166
Percent Change (%)	0.7%	0.8%	1.0%	1.1%	0.8%	0.6%
State Population	5,218,144	5,737,305	6,287,021	6,823,546	7,331,876	7,819,775
Percent Change (%)	2.0%	1.9%	1.8%	1.7%	1.4%	1.3%

Sources: Colorado Department of Local Affairs Demography Section, www.dola.colorado.gov/dlg/demog/

Concerns about hazards and future development are addressed by hazard in the following section.

4.3.4 Estimating Potential Losses

Dam Failure - High Hazard Significance

Existing Development

The impacts of a dam failure to existing development in Jefferson County could be catastrophic. Specific inundation maps and risk information are included in the dam-specific emergency action plans housed the Jefferson County Office of Emergency Management. Due to the sensitive nature of this information, it is not included in this plan. The estimated impacts to the County and its municipalities from a dam failure are similar in some cases to those associated with flood events (see the flood hazard vulnerability analysis and discussion). However, dam failures would potentially result in a much greater loss of life and more extensive destruction to property and infrastructure due to: the potential speed of onset; greater depth, extent, and velocity of flooding; and the wider damage areas caused by the ability of dam failures to flood areas outside of mapped floodplains.

The portions of the planning area exposed to significant impacts by a dam failure are numerous. As mentioned in the hazard profile section there are 22 high hazard, 18 significant hazard, and 52 low hazard dams in the County. In general, communities located below a dam and along a waterway are likely to be exposed to the impacts of a dam failure. The reservoirs located in the foothills and Rocky Mountains have the greatest potential impacts and include both those located in the planning area and those located outside and upstream of the planning area. The dams within the planning area include the large reservoirs of Arvada, Ralston, and Standley Lake. Bear Creek Dam is primarily a flood control dam. Antero, Chatfield, Cheesman, Eleven Mile, Strontia Springs, Marston Lake, and Spinney Lake are mostly outside of the planning area on the South Platte River. The South Platte River is also the southeast border of Jefferson County. Impacts in the South Platter River Canyon could be severe if any of these dams failed, but fortunately most of this area is sparsely developed. The impacts of any of these dam failures would be great in the Denver Metropolitan Area, but this would mostly be outside of Jefferson County. Jefferson County's first responders would likely be heavily involved in mutual aid assistance should an event occur. Table 4.23 lists the jurisdictions within the County and the number of high and significant hazard dams that threaten each respective jurisdiction, as in indicator of relative vulnerability. This table only lists dams that threaten municipal areas. High hazard dams threaten lives and property, significant hazard dams threaten property only. In the absence of digital dam failure inundation maps this table was prepared based on a visual inspection of GIS layers including dams, terrain, streams and floodplains. Dams may be located in or outside of the municipal boundaries. Many of the dams threaten unincorporated areas as well.

Table 4.23 Summary of Jurisdictions at Risk to Dam Failure

Jurisdiction Name	# of High Hazard Dams	# of Significant Hazard Dams
Arvada	4	5
BowMar	0	1
Golden	1	0
Lakewood	4	5
Littleton	0	3
Morrison	1	0
Westminster	1	1
Wheat Ridge	1	0

Source: National Dam Inventory, provided by Jefferson County Office of Emergency Management

Inundation maps that identify anticipated flooded areas (which may not coincide with known floodplains) are produced for all high hazard dams and are contained in the Emergency Action Plan (EAP) required for each dam. However, the information contained in those plans is considered sensitive and is not widely distributed. More information regarding the specific vulnerable buildings, populations, and infrastructure related to a dam failure can be referenced in EAPs on file with the Jefferson County Office of Emergency Management.

Losses from a dam failure vary based on the dam, cause of failure, warning time for impacted communities, and time of day. Potential property loss estimates are in the billions, along with multiple anticipated deaths and injuries. Impacts to critical facilities would be similar to those identified in the flood vulnerability analysis.

Future Development

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

There are currently 52 low hazard dams in the County. These could become significant or high hazard dams if development occurs below or downstream from them.

Drought – Medium Hazard Significance

Existing Development

Based on Jefferson County's recent multi-year droughts and Colorado's drought history, it is evident that all of Jefferson County is vulnerable to drought. However, the impacts of future droughts will vary by region. The agricultural industry of the County, though limited, could experience hardships, including agricultural losses, and livestock feeding expenses and deaths.

The County will see an increase in dry fuels, beetle kill, and associated wildfires and some loss of tourism/recreation revenue. Examples of potential impacts to recreation include low water flows in the Golden Whitewater park, fire bans and closures of campgrounds in the Pike National Forest, and water restrictions on golf courses. Water supply issues for municipal, industrial, and domestic needs will be a concern for the entire County during droughts. Water restrictions could lead to lawn and tree impacts in suburban areas. Most of Jefferson County's water comes from snow melt runoff in the high country of the western County that is captured in reservoir storage. Vulnerability increases with consecutive winters of below-average snow pack.

While widespread, the losses associated with drought are often the most difficult to track or quantify. While FEMA requires the potential losses to structures to be analyzed, drought does not normally have a structural impact. Drought can indirectly lead to property losses as a result of it contributing to extreme wildfire conditions (see discussion on wildfire vulnerability). This, combined with the potential for significant impacts to water intensive activities such as agriculture, wildfire suppression, municipal usage, commerce, tourism/recreation, and wildlife preservation, can lead to widespread economic ramifications.

Future Development

Drought vulnerability will increase with future development as there will be increased demands for limited water resources. Future growth in the unincorporated areas will mean more wells and more demands on groundwater and surface water resources. Increased development also lends itself to the increased potential for impervious surface development, which reduces the amount of water absorbed into the ground from precipitation.

Earthquake - Medium Hazard Significance

Existing Development

Traditionally, earthquakes have not been considered a very likely hazard for Front Range communities and, as such, it is unlikely that many structures are built to be earthquake-resistant. All structures in the planning area are potentially exposed to damage from an event, with older or historic structures more at risk. Damage potential will vary by the size, extent, and severity of the earthquake and the location of the event's epicenter. The entire population of the planning area may also be considered at risk, and likely unprepared for earthquakes. The population at risk will vary based on the timing of a large earthquake. HAZUS-MH modeling in Table 4.25 indicates most fatalities would occur during a mid-day earthquake when people are exposed to non-structural damage in office and industrial buildings.

Table 4.24 illustrates the potential earthquake losses in Jefferson County as compiled by the Colorado Geological Survey (CGS) Earthquake Report, issued in 2007 and utilized in the 2008 State Hazard Mitigation Plan.

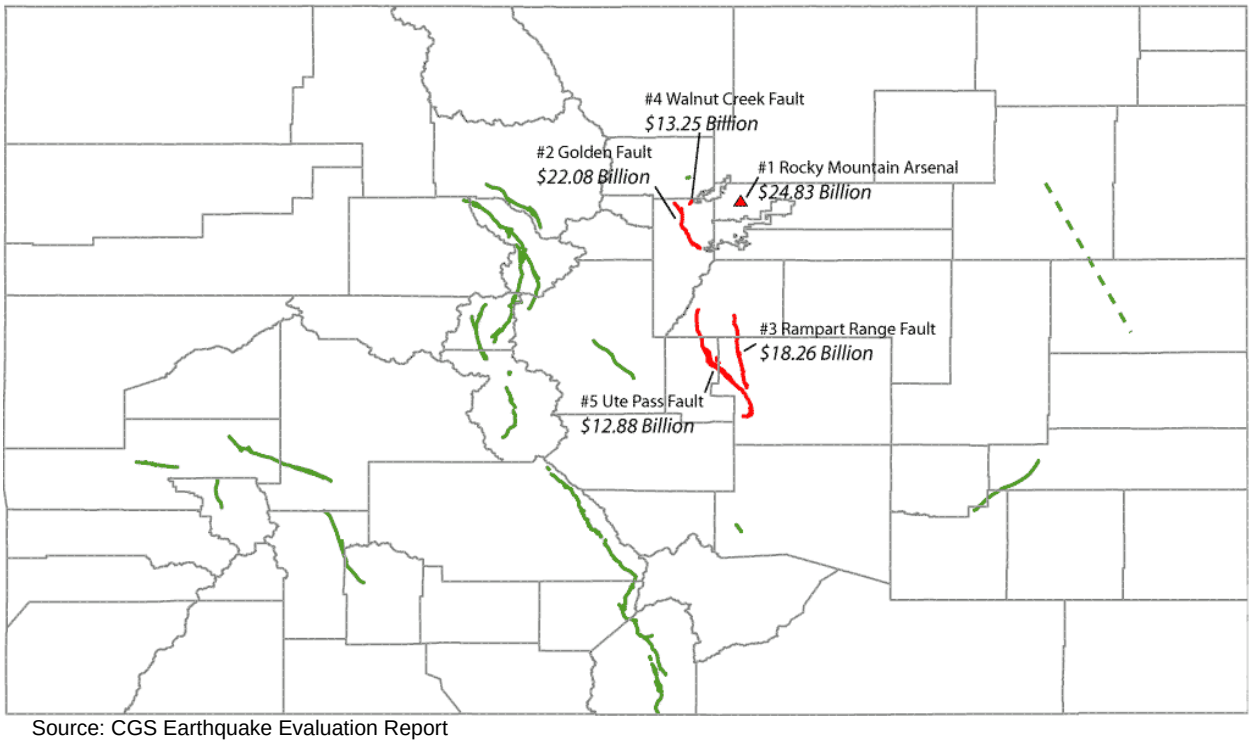
Table 4.24 Potential Earthquake Losses in Jefferson County by Fault

Fault/Magnitude	Fatalities	Total Economic Loss ($)*	Loss Ratio (%)**
Chase Gulch M6.75	0	$59.8 million	-0.16
Frontal M7.0	0	$57.4 million	-0.15
Golden M6.5 CEUS	322	$8.14 billion	-21.7
Golden M6.5 Reverse	328	$6.81 billion	-18.2
Golden M6.5 Normal	290	$5.97 billion	-15.9
Golden M6.0 Reverse	91	$3.20 billion	-8.5
Golden M5.5 CEUS	11	$2.06 billion	-5.5
Golden M5.0 Reverse	2	$385 million	-1.0
Mosquito M7.0	0	$53.7 million	-0.14
Rampart M7.0	3	$400.3 million	-1.1
Rampart M6.0	0	$23.3 million	-0.06
N. Sangre de Cristo M7.5	0	$30.5 million	-0.08
N Sawatch M7.0	0	$18.2 million	-0.05
Ute Pass M7.0	2	$246 million	-0.7
Valmont M5.0	0	$23.9 million	-0.06
Walnut Creek M6.0 CEUS	108	$4.71 billion	-12.6
Williams Fork M6.75	0	$36.4 million	-0.09
Williams Fork M5.5	0	$0.06 million	-0.00

Source: Earthquake Evaluation Report, www.dola.colorado.gov/dem/mitigation/earthquakerpt.pdf
*Direct and indirect losses
**Percentage of the total building stock value damaged; the higher this ratio, the more difficult it is to restore a community to viability (loss ratios 10 percent or greater are considered by FEMA to be critical)

According to the CGS report, the Rocky Mountain Arsenal, Golden, Rampart Range, Ute Pass, and Walnut Creek faults are considered the top five potentially most damaging faults in the state (which includes damage to other counties in the Denver Metropolitan Area). In Jefferson County, the top five most potentially damaging faults are Golden, Walnut Creek, Rampart Range, Ute Pass, and Chase Gulch. These faults are listed illustrated in Figure 4.33.

Figure 4.33. Total Direct Economic Loss from Top 5 Most Damaging Faults



Source: CGS Earthquake Evaluation Report

During the development of this plan in 2009, a HAZUS-MH probabilistic earthquake scenario was run with the latest version of HAZUS-MH (MR4, released August 2009). The methodology includes probabilistic seismic hazard contour maps developed by the USGS for the 2002 update of the National Seismic Hazard Maps that are included with HAZUS-MH. The USGS maps provide estimates of potential ground acceleration and spectral acceleration at periods of 0.3 second and 1.0 second, respectively. The 2,500-year return period analyzes ground shaking estimates with a 2 percent probability of being exceeded in 50 years, from the various seismic sources in the area. The International Building Code uses this level of ground shaking for building design in seismic areas. The CGS believes that the USGS probabilistic shaking maps likely underestimate the hazard, as there are limited studies of the earthquake hazard in the state to base the shaking maps on. Table 4.25 summarizes the results of the 2,500-year HAZUS-MH scenario. A 100-year return period scenario was also analyzed. This scenario did not produce any damage.

Another HAZUS-MH scenario was run to estimate the impacts from a large hypothetical earthquake on the Golden Fault. The Golden Fault is suspected to be capable of producing a M 6.5 earthquake. This fault was chosen due to its proximity to the City of Golden and the Jefferson County government offices, including the emergency operations center. The epicenter, or point on the ground surface where the earthquake originates, was chosen at an aribitray location on the fault near the intersection of Highways 93 and 6. The model used fault rupture parameters suggested by the CGS (depth: 10km, rupture length: 18km, orientation 157 degrees,

and a dip of 90 degrees), a soils layer provided by the CGS imported into HAZUS, and the western U.S. attenuation function. Table 4.26 summarizes the results of the earthquake loss scenario. Should this unlikely scenario occur the results would be extremely damaging, with over $3.5 billion in economic losses and the potential for multiple casualties.

Table 4.25 HAZUS-MH Earthquake Loss Estimation 2,500-Year Scenario Results

Type of Impact	Impacts to County
Total Buildings Damaged	Slight: 30,548 Moderate: 13,917 Extensive: 3,137 Complete: 183
Building and Income Related Losses	$1.28 Billion 61% of damage related to residential structures 23% of loss due to business interruption
Total Economic Losses (includes building, income and lifeline losses)	$1.36 Billion
Casualties (based on 2 a.m. time of occurrence)	Without requiring hospitalization: 237 Requiring hospitalization: 31 Life threatening: 2 Fatalities: 6
Casualties (based on 2 p.m. time of occurrence)	Without requiring hospitalization: 288 Requiring hospitalization: 46 Life threatening: 5 Fatalities: 9
Casualties (based on 5 p.m. time of occurrence)	Without requiring hospitalization: 260 Requiring hospitalization: 40 Life threatening: 5 Fatalities: 7
Damage to Transportation and Utility Systems and essential facilities	No transportation or pipeline damage, No damage shown to essential facilities
Displaced Households	828
Shelter Requirements	452

Source: HAZUS-MH MR4

Table 4.26 HAZUS-MH Earthquake Loss Estimation Golden Fault M 6.5 Scenario Results

Type of Impact	Impacts to County
Total Buildings Damaged	Slight: 42,703 Moderate: 26,591 Extensive: 9,079 Complete: 1,702
Building and Income Related Losses	$3.36 Billion 61% of damage related to residential structures 22% of loss due to business interruption
Total Economic Losses (includes building, income and lifeline losses)	$3.50 Billion
Casualties (based on 2 a.m. time of occurrence)	Without requiring hospitalization: 830 Requiring hospitalization: 171 Life threatening: 22 Fatalities: 43

Type of Impact	Impacts to County
Casualties (based on 2 p.m. time of occurrence)	Without requiring hospitalization: 1,132 Requiring hospitalization: 281 Life threatening: 43 Fatalities: 82
Casualties (based on 5 p.m. time of occurrence)	Without requiring hospitalization: 984 Requiring hospitalization: 243 Life threatening: 54 Fatalities: 68
Damage to Transportation and Utility Systems and essential facilities	No transportation or pipeline damage, No damage shown to essential facilities
Displaced Households	3,592
Shelter Requirements	1,953

Source: HAZUS-MH MR4

Future Development

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

Erosion and Deposition – Medium Hazard Significance

Existing Development

Two different areas of existing development are vulnerable to erosion. Erosion of soils due to slope grade, soil content and cover, and exposure to weather conditions is fairly limited and generally falls within underdeveloped areas. This is also due to the concurrence of erosion potential with other geologic hazard areas, such as dipping bedrock or subsidence regions, which are regulated for development by the County. Areas susceptible to wildfire-driven erosion, which often result in debris flow (see below) or the erosion and deposition of soil into watersheds, also does not usually directly impact developed areas. There are some areas of variance, particularly in the wildland-urban interface, where debris flows may impact housing and commercial districts. The larger concern centers on the pollution of the watersheds by soils, which impacts wildlife balances and degrades water quality for downstream habitats. Continued erosion and movement of soils in wildfire areas usually degrade watershed quality and thus exert a larger or disproportionate impact on the larger planning area. In addition, recovery for the washed out areas may be prolonged or difficult, as demonstrated in the burn areas of the Hayman fire, due to the loss of nutrient-rich soil. In this sense, ‘existing development’ may refer to any area vulnerable to wildfire, which covers an extensive portion of the planning area.

In addition to the general areas of existing vulnerability, scour critical bridges are also vulnerable to the effects of erosion and deposition. These bridges are depicted graphically in Figure 4.35 and in Table 4.34, both of which are in the flooding vulnerability section that follows. Erosion around bridges may compromise the construction of the structure, making them unsafe.

Deposition may also press up against the structures, causing structural strain or sweeping out the structure by debris. In this instance, the vulnerability overlaps those identified in the debris flow section that follows.

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.

Future Development

Future development on steep slopes is not likely, and the areas at the base of the hogbacks are regulated by the County, therefore future development exposed to slope-driven erosion is unlikely. Future developments subjected to erosion and deposition as a result of wildfire are vulnerable to the same extent as discussed in the landslide, debris flow, and rockslide hazard.

Expansive Soils – Medium Hazard Significance

Existing Development

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

Methodology

GIS was used to create a risk assessment for geological hazards in Jefferson County. Dipping bedrock (i.e. heaving bedrock) hazard data was overlaid on Jefferson County parcel and assessor's data.[52] For the purposes of the analysis, if the hazard zone intersects an improved

[52] Assessor parcel data is developed and used for ad valorem tax assessment only. The Assessor's parcel maps are not accurate representations of the actual physical location of the parcels for any other purpose. The location of improvements on the parcels are not described in any way in the Assessor parcel data.

parcel, its improved value is included and parcel is counted in Table 4.27. Results are sorted by occupancy type and by jurisdiction to demonstrate how the hazard's risk varies across the planning area.

Table 4.27 outlines the potential exposure of improvements built on dipping bedrock for existing development in the planning area. This represents only a tiny portion of the swelling-soil related building exposure, as a swelling soils GIS layer was not available. However, the exposure to the dipping bedrock alone identifies that there could be significant potential for damage from this hazard. The table indicates that Golden, Lakewood, and the unincorporated areas east of the foothills have the greatest exposure to this hazard. It is difficult to futher quantify the estimate of potential loss, but assuming that 1% of this inventory is damaged, an estimated $54 million in damages would occur. This analysis does not take into account site-specific mitigation measures that may be in place.

Table 4.27 Exposure of Buildings to Dipping Bedrock in Jefferson County

City	Occupancy Type	Count of Improved Parcels	Improvement Value*
Arvada	Commercial	3	$4,066,000
	Residential	1	$87,500
Golden	Commercial	181	$535,915,260
	Residential	1,348	$346,081,100
Lakewood	Commercial	18	$2,772,118
	Residential	485	$170,375,400
Littleton	Commercial	1	$863,600
	Residential	737	$ 235,522,500
Morrison	Commercial	3	$1,754,000
Unincorporated	Commercial	324	$797,276,010
	Residential	17,732	$3,318,036,402
Total		**20,833**	**$5,412,749,890**

Source: Jefferson County GIS and Assessor's Data

*The Assessor does not have data about the contents of structures and the contents values shown in the table are not derived from Assessor data but are estimates based upon the structure value using FEMA recommended values (typically 50% for residential structures and 100% for commercial/industrial)

Existing critical facilities impacted by dipping bedrock and other swelling soil hazards are of particular concern, as the damages caused to these structures may impact the ability of the planning area to provide critical services to the population. Schools built on the area may pose a danger to occupants if the buildings are severely damaged in an event. If building integrity is compromised, it may also reduce the sheltering capacity or public health distribution capacity of the County, as schools are often used for these functions. Table 4.28 includes the results of a GIS overlay of critical facilities on the dipping bedrock areas. A number of schools and fire stations in the planning area are potentially at risk. This analysis does not take into account site-specific mitigation measures that may be in place.

The most effective mitigation actions for expansive soil are complete avoidance or non-conflicting use, or correct engineering design (which includes foundation design, adequate drainage, landscaping, and appropriate interior finishing.) While some areas are devoted to non-conflicting use permits, in particular the areas which are included in the dipping bedrock zones, so much of the Colorado basin is covered in swelling soils that complete avoidance is not possible.[53]

Table 4.28 Critical Facilities in Dipping Bedrock Zones in Jefferson County

City	Facility Type	Name
Golden	Police Facilities	Dispatch, Emergency Management, Coroner
	Schools	Mitchell Elementary
Morrison	Fire Stations	West Metro Fire Station 9
Unincorporated	Fire Stations	West Metro Fire Station 13
	Fire Stations	West Metro Fire Station 14
	Oil & Gas Facilities	Public Service, Deer Creek Station
	Police Facilities	Jefferson County Sheriff South Precinct
	Schools	Chatfield Senior
	Schools	Collegiate Academy Of Colorado (K-12)
	Schools	Dakota Ridge Senior
	Schools	Deer Creek Middle School
	Schools	Falcon Bluffs Middle School
	Schools	Kendallvue Preschool & Elementary
	Schools	Mortensen Preschool & Elementary
	Schools	Mount Carbon Elementary
	Schools	Powderhorn Elementary
	Schools	Shaffer Elementary
	Schools	Summit Ridge Middle School
	Schools	Ute Meadows Elementary
	Schools	Westridge Preschool & Elementary

Source: AMEC analysis of data provided by Jefferson County GIS

Future Development

Land use planning regulations should temper the risk of swelling soil impacts on future development. Continued efforts to regulate building in areas of high or moderate swelling potential increase the number of structures and infrastructure built with swelling-adaptive methods, which in turn reduces the amount of damage incurred each year on the property. Continued education on the hazard, particularly in regards to landscaping and maintenance

[53] W.P. Rogers, L.R. Ladwig, A.L. Hornbaker, S.D. Schwochow, S.S. Hart, D.C. Shelton, D.L. Scroggs, and J.M. Soule, *Guidelines and Criteria for Identificaiton and Land-Use Controls of Geologic Hazard and Mineral Resource Areas* (Special Publication 6, Colorado Geological Survey, 1974. Reprinted in 1979.) pp 71-72.

concerns, will be needed to reduce the impacts of the hazard on development. As existing development deteriorates and requires either renovation or reconstruction, mitigation methods should be implemented to bring the developments up to contemporary mitigation standards.

Extreme Temperatures – Medium Hazard Significance

Existing Development

Recent research indicates that the impact of extreme temperatures, particularly on populations, has been historically under-represented. The risks of extreme temperatures are often profiled as part of larger hazards, such as severe winter storms or drought. However, as temperature variances may occur outside of larger hazards or outside of the expected seasons but still incur large costs, it is important to examine them as stand-alone hazards. Extreme heat may overload demands for electricity to run air conditioners in homes and businesses during prolonged periods of exposure and presents health concerns to individuals outside in the temperatures. Extreme heat may also be a secondary affect of droughts, or may cause drought-like conditions in a temporary setting. For example, several weeks of extreme heat increases evapotranspiration and reduces moisture content in vegetation, leading to higher wildfire vulnerability for that time period even if the rest of the season is relatively moist. Extreme cold impacts structures when pipes or water mains freeze and burst, causing damage. Cold can also, in the most extreme of circumstances, make materials more fragile and breakable, although the Front Range rarely gets this cold. Extreme cold may also lead to higher electricity and natural gas demands to maintain appropriate indoor heating levels combined with damages caused to the delivery infrastructure such as frozen lines and pipes. Cold may impact transportation as well. Exposed populations may be at risk while waiting for public transportation, particularly when combined with wind-chill, and some vehicles may not start which impacts the commute of the workforce and, in worst case scenarios, the movement of emergency services personnel.

The impacts of cold on health are also a consideration. Traditionally, the very young and very old are considered at higher risk to the affects of extreme cold, but any populations outdoors in the weather are exposed, including otherwise young and healthy adults. Arguably, the young-and-otherwise-healthy demographic may be more exposed and experience a higher vulnerability because of the increased likelihood that they will be out in the extreme temperature deviation, whether due to commuting for work or school, conducting property maintenance such as snow removal or lawn care, or for recreational reasons. On average, 6 individuals in the planning area will be hospitalized for severe cold related injuries each year and an average of 4% of all hospitalizations will result in death.

The impact of severe temperature deviation on power delivery is a significant factor when assessing current development exposure. Xcel Energy provided data for the number customers who experienced impacted power supply caused by temperature extremes between 2006 and August 2009. Xcel also estimates that outages cost approximately $50,000 per 20,000 people affected for repair and replacement costs, repair equipment usage, and crew overtimes. This cost is not directly tracked by Xcel, but is formulated based on estimates provided from the Xcel

engineering team. FEMA Standard Values for Loss of Service for Utilities, located in Appendix C of the FEMA BCA Reference Guide, were used to estimate the costs incurred on the individuals. This cost is calculated by applying a standard average rate ($126) per person, per day of service outage. This information is located in Table 4.29.

Table 4.29 Customers Experiencing Power Supply Delays due to Extreme Temperatures

Year	# of Days	# of Customers Affected	Approximate Cost to Xcel to Repair Outage	Cost of Complete Loss of Service to Population
2006	5	13,207	$33,018	$8,320,410

Source: Xcel Energy, August 2009

Future Development

Since structures are not usually directly impacted by severe temperature fluctuations, continued development is less impacted by this hazard than others in the plan. However, pre-emptive cautions such as construction of green buildings that require less energy to heat and cool, use of good insulation on pipes and electric wirings, and smart construction of walkways, parking structures, and pedestrian zones that minimize exposures to severe temperatures may help increase the overall durability of the buildings and the community to the variations. Continued development also implies continued population growth, which raises the number of individuals potentially exposed to variations. Public education efforts should continue to help the population understand the risks and vulnerabilities of outdoor activities, property maintenance, and regular exposures during periods of extreme heat and cold.

Flood – High Hazard Significance

Existing Development

Floods pose a significant risk to existing development in the planning area. In addition to the enormous economic loss potential associated with flood hazards, floods have historically been a source of significant loss of life in the planning area.

Methodology

A significant effort to quantify the flood risk in Jefferson County was undertaken during the development of this plan using HAZUS-MH MR4, FEMA's software program for estimating potential losses from disasters. The level II HAZUS analysis incorporated Jefferson County parcel data, DFIRM floodplain data, and HAZUS- generated floodplain depth information. A HAZUS-MH Jefferson County 100-year floodplain was generated using HAZUS-MH MR4. The 100-year floodplain was generated for major rivers and creeks in the County (those with a 2 square mile minimum drainage area). A USGS 30-meter resolution digital elevation model (DEM) was used as the terrain base in the model. HAZUS-MH produces a flood polygon and flood-depth grid that represents the base, or 100-year, flood.

Jefferson County's preliminary digital flood insurance rate map (DFIRM) was obtained from the Urban Drainage and Flood Control District and its 100-year flood hazard data was merged with the HAZUS-MH floodplain. The HAZUS-MH floodplain was generally not as extensive as the DFIRM floodplain. The addition of the DFIRM data served to more accurately reflect the extent of the flood hazard and fill in those areas of shallow flooding (generally in 'flatter' terrain) that the HAZUS-MH model did not cover.

Jefferson County's parcel and associated assessor's data[54] were used as the basis for the structure inventory values. Parcels and their attributes, including building and contents value, occupancy type (i.e. residential, commercial, industrial), year of building construction, number of floors in structure, and exterior building type were compiled and aggregated to the census block level. Potential losses to the County were modeled within HAZUS-MH, based on the aforementioned inventory and the 100-year flood hazard data. Building damage is estimated by census block based on the average depth of flooding within a given census block. Flood damage is directly related to the depth of flooding. HAZUS-MH uses depth-damage functions to model the losses. For example, a two-foot flood generally results in about 20 percent damage to the structure (which translates to 20 percent of the structure's replacement value). This analysis does not account for mitigation practices, such as elevated structures in the floodplain, that may be present.

HAZUS-MH provides reports on the number of buildings impacted, estimates of the building repair costs, and the associated loss of building contents and business inventory. Building damage can cause additional losses to a community as a whole by restricting the building's ability to function properly. Income loss data accounts for business interruption and rental income losses as well as the resources associated with damage repair and job and housing losses. These losses are calculated by HAZUS-MH using a methodology based on the building damage estimates. To estimate the potential dollar loss for each city, the flooded census blocks were extracted, and the damage costs were totaled using GIS and database methods. This was done for each city and the unincorporated area to illustrate how the risk varies across the planning area.

The following tables present the results of the loss estimation in detail. As shown in the tables below, the estimated damages for flooding exceed $700 million. HAZUS-MH also models displaced populations and shelter needs. According the analysis more than 19,000 potentially impacted individuals could be displaced, and more than 12,000 needing shelter. According to HAZUS there is approximately 1,592 structures in the floodplain. HAZUS estimated building counts often under-estimate the actual count of structures in the floodplain. Arvada, Golden, Lakewood, and the unincorporated County have the highest potential for economic losses from

[54] Assessor parcel data is developed and used for ad valorem tax assessment only. The Assessor's parcel maps are not accurate representations of the actual physical location of the parcels for any other purpose. The location of improvements on the parcels are not described in any way in the Assessor parcel data.

flooding. Though Morrison's economic impacts are lower, the loss ratio (ratio of damage versus entire building inventory) would be much higher. In addition, there is a greater potential for loss of life as indicated in Morrison's flood history. Also, it is unlikely that a flood would impact all of the flood prone areas in the County at the same time. Table 4.32 details the risk by jurisdiction, property type, and percent damage. Figure 4.34 gives a closer view of the floodplains in the more populated areas of the County. More detailed flood hazard maps can be referenced in the jurisdictional annexes.

Table 4.30 Jefferson County Property Values 100-Year Flood Zones

City	Cost Building Damage ($)*	Cost Contents Damage ($)**	Inventory Loss ($)	Relocation Loss ($)	Capital Related Loss ($)	Wages Loss ($)	Rental Income Loss ($)	Total Loss ($)
Arvada	46,001,000	49,344,000	1,338,000	137,000	12,000	559,000	32,000	98,107,000
Bow Mar	4,000	3,000	0	0	0	0	0	7,000
Edgewater	1,634,000	2,661,000	16,000	9,000	9,000	48,000	1,000	4,493,000
Golden	34,645,000	61,948,000	692,000	52,000	139,000	418,000	31,000	98,507,000
Lakeside	162,000	486,000	18,000	0	2,000	3,000	0	681,000
Lakewood	50,933,000	72,158,000	1,745,000	136,000	325,000	1,885,000	61,000	128,737,000
Littleton	938,000	530,000	1,000	0	0	0	0	1,470,000
Morrison	1,904,000	2,077,000	40,000	2,000	12,000	26,000	3,000	4,124,000
Westminster	17,271,000	30,244,000	544,000	46,000	84,000	102,000	20,000	48,577,000
Wheat Ridge	22,937,000	33,839,000	989,000	68,000	104,000	278,000	21,000	59,081,000
Unincorporated	122,275,000	152,970,000	1,899,000	167,000	220,000	574,000	42,000	279,432,000
Total	**298,704,000**	**406,260,000**	**7,282,000**	**617,000**	**907,000**	**3,893,000**	**211,000**	**723,216,000**

Source: HAZUS and Jefferson County Assessor's Data

*The Assessor's Office values buildings for the specific purpose of valuation for ad valorem tax purposes and values represented do not reflect actual building replacement values.

**The Assessor does not have data about the contents of structures and the contents values shown in the table are not derived from Assessor data but are estimates based upon the structure value using FEMA recommended values (typically 50% for residential structures and 100% for commercial/industrial)

Table 4.31 Jefferson County Population Affected by Flood

Location	Displaced Population	Short Term Shelter Needs
Arvada	5,016	3,579
Bow Mar	0	0
Edgewater	384	222
Golden	837	504
Lakeside	2	0
Lakewood	4,503	2,976
Littleton	3	0
Morrison	66	27
Westminster	1,107	872
Wheat Ridge	2,152	1,749
Unincorporated	5,553	2,740

Total	**19,623**	**12,669**

Source: HAZUS and 2000 US Census Population Data

Table 4.32 Jefferson County Residential & Commercial Building Counts by Damage Percentage

	1-10%		11-20%		21-30%		31-40%		41-50%		Substantial		
CITY	**RES**	**COMM**	**RES**	**COMM**	**RES**	**COMM**	**RES**	**COMM**	**RES**	**COMM**	**RES**	**COMM**	**TOTAL**
Arvada	0	14	55	0	292	0	17	0	55	0	5	0	**438**
Bow Mar	0	0	0	0	0	0	0	0	0	0	0	0	**0**
Edgewater	0	2	1	0	13	0	0	0	0	0	0	0	**16**
Golden	0	25	3	0	30	0	1	0	7	0	3	0	**69**
Lakeside	0	0	0	0	0	0	0	0	0	0	0	0	**0**
Lakewood	1	66	32	0	152	0	9	0	50	0	12	2	**324**
Littleton	0	0	3	0	9	0	0	0	0	0	0	0	**12**
Morrison	0	12	0	0	0	0	0	0	0	0	0	0	**12**
Westminster	0	0	9	0	59	0	2	0	8	0	2	0	**80**
Wheat Ridge	0	29	25	2	120	0	6	0	20	0	6	0	**208**
Unincorporated	1	25	47	0	286	0	17	0	45	0	12	0	**433**
Total	**2**	**173**	**175**	**2**	**961**	**0**	**52**	**0**	**185**	**0**	**40**	**2**	**1,592**

Source: HAZUS and Jefferson County Assessor's Data

Figure 4.34. Jefferson County Flood Hazard (North)

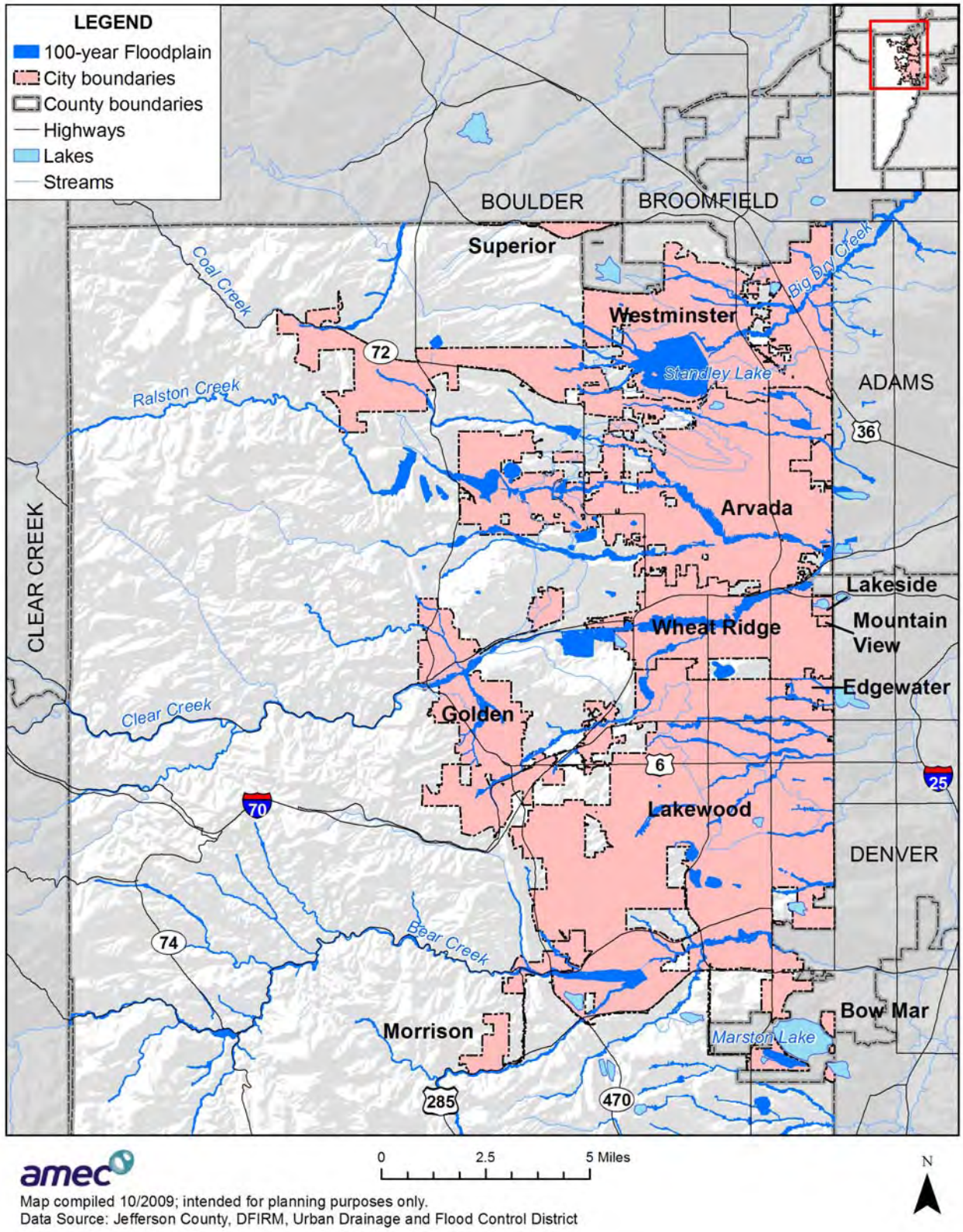
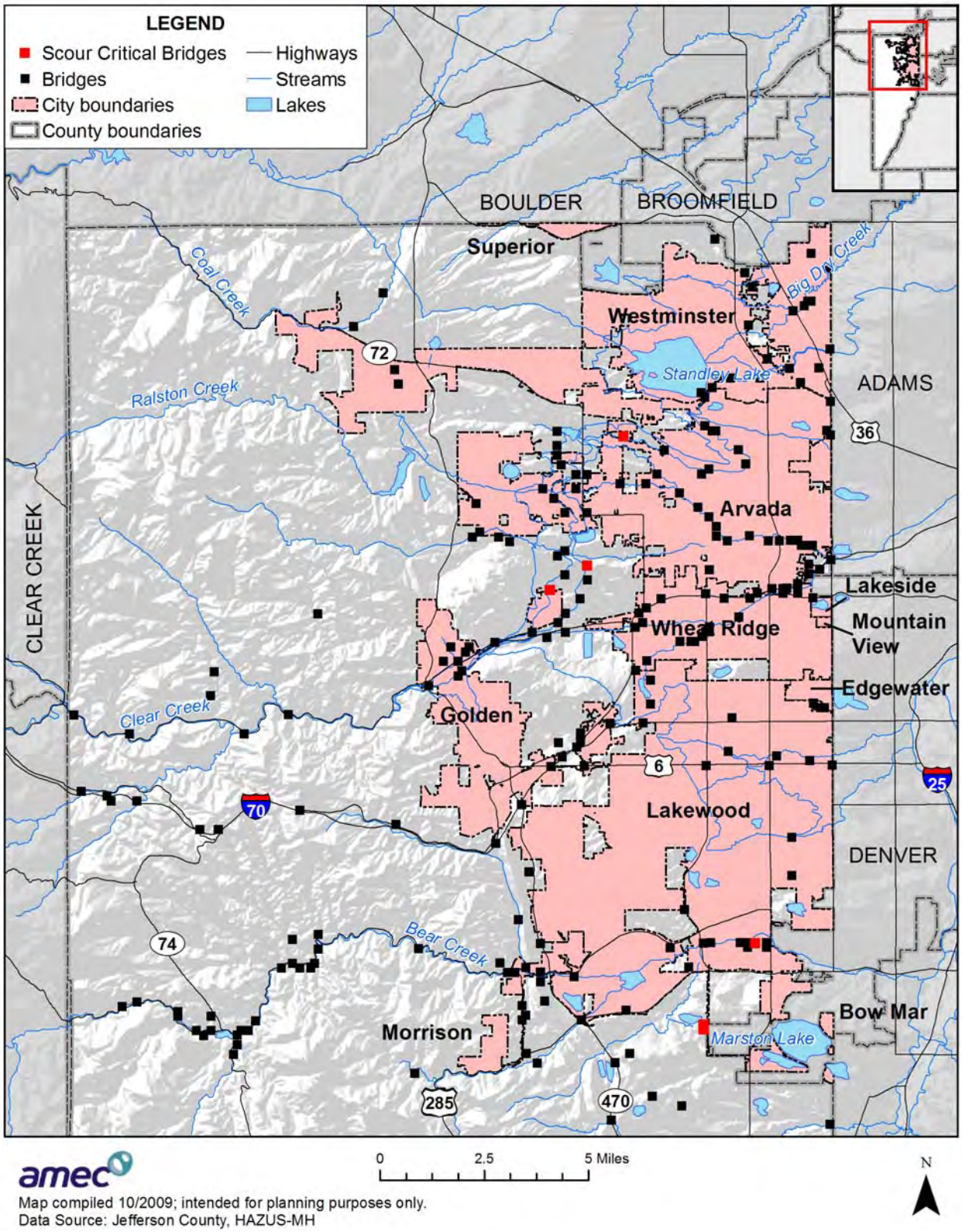


Figure 4.35. Jefferson County Bridges (Northern Section of the County)



Critical Facilities

To estimate the potential impact of floods on critical facilities a GIS overlay was performed of the flood hazard layer on existing critical facilities point locations. The results are shown in Table 4.33. Depth of flooding is estimated based on HAZUS flood modeling. Fortunately there are not many critical facilities within the 100-year floodplain, but according to this analysis there are some schools, fire and police stations potentially at risk.

Table 4.33 Critical Facilities in Flood Hazard Areas

Location	Facility Type	Facility Name	Depth
100-Year Floodplain			
Arvada	School	Excel Academy (K-8)	1.00
Golden	Hazmat Facilities	Trigen-Nations Energy Co. L.L.L.P.	1.00
	School	Golden Senior	1.00
	Police Facilities	Golden PD/Fire Department	10.50
Lakeside	Fire Stations	Lakeside Fire Station 1	1.89
Lakewood	Fire Stations	West Metro Fire Station 1 Repair Shop	1.00
Unincorporated	Wastewater Facilities	Evergreen Metropolitan Dist	1.00
	Wastewater Facilities	W. Jefferson County Metro Dist	20.75
	Hazmat Facilities	Coors Brewing Co.	19.65
	Fire Stations	Evergreen Fire Station 6	1.92
	Fire Stations	Foothills Fire Grapevine	8.85
500-Year Floodplain			
Arvada	Hazmat Facilities	Honeywell Inc. Golden Ops.	-
	Schools	Foster Preschool & Elementary	-
Golden	Police Facilities	Golden PD/Golden Fire Department	-
Wheat Ridge	Fire Stations	Wheat Ridge Fire Station 2	-
Unincorporated	Wastewater Facilities	Clear Creek Valley Water And Sanitation	-

Source: Based on data from Jefferson County
Note: There are not flood depths for the facilities in the 500-year flood, as we do not run a 500-year event with HAZUS (which would produce a depth grid). Instead, the DFIRM 500-year floodplain boundaries are evaluated to locate facilities.

Replacement values were not available with the data, thus an estimate of potential loss could not be performed. Impacts to any of these facilities could have wide ranging ramifications, in addition to property damage.

Bridges on the previous maps are from the National Bridge Inventory database that comes with HAZUS-MH. One of the database items includes a “scour index” that is used to quantify the vulnerability of bridges to scour during a flood. Bridges with a scour index between 1 and 3 are considered “scour critical,” or a bridge with a foundation element determined to be unstable for the observed or evaluated scour condition. These bridges are listed in Table 4.34 and shown in Figure 4.35.

Table 4.34 Scour Critical Bridges

Name	Scour Index	Owner	Jurisdiction
SH 121 ML	3	State	Lakewood
Alkire St.	3	County	Unincorporated
S. Lakehurst Way	3	County	Unincorporated
McIntyre St.	3	County	Unincorporated
Surrey Dr.	3	County	Unincorporated
W. 50th Ave.	3	County	Unincorporated

Source: National Bridge Inventory, HAZUS MH-MR4

National Flood Insurance Program/Community Rating System

The National Flood Insurance Program (NFIP) is a federal program enabling property owners in participating communities to purchase insurance as a protection against flood losses. A jurisdiction's eligibility to participate is premised on their adoption and enforcement of state and community floodplain management regulations intended to prevent unsafe development in the floodplain, thereby reducing future flood damages. Thus, participation in the NFIP is based on an agreement between communities and the federal government. If a community adopts and enforces a floodplain management ordinance to reduce future flood risk to new construction in floodplains, the federal government will make flood insurance available within the community as a financial protection against flood losses.

The Community Rating System (CRS) was created in 1990 to recognize communities whose floodplain management activities go above and beyond the NFIP's minimum requirements. Under the CRS, if a community implements certain program activities, such as public information, mapping, regulatory, loss reduction, and/or flood preparedness activities, then its residents can qualify for a flood insurance premium rate reduction.

Table 4.35 provides detailed information on NFIP participation in NFIP participating communities in Jefferson County and also provides the number of flood insurance claims. According to the data the unincorporated areas, Lakewood, Arvada, and Wheat Ridge have the highest number of flood insurance claims. These areas also have the highest number of policies in force.

Table 4.35 Community Participation in the NFIP and Community Rating System

Jurisdiction	Date Joined	Effective FIRM Date	Policies in Force	Insurance in Force ($)	Number of Claims	Claims Totals ($)	CRS Rating
Arvada, City of	10/1/1991	05/1/2006	521	106,760,600	50	38,289	6
Edgewater, City of	n/a	06/17/2003	35	7,722,100	23	51,637	n/a
Golden, City of	10/1/1996	10/1/1996	87	23,436,300	13	5,694	9
Lakewood, City of	10/1/1991	10/1/2005	428	96,384,300	117	382,030	6
Morrison, Town of	10/1/1996	10/1/1996	11	2,511,600	2	1,232	9
Westminster, City of	10/1/1991	05/1/2006	95	24,590,600	31	253,793	6
Wheat Ridge, City of	10/1/1991	10/1/1996	190	39,192,100	38	90,141	7
Unincorporated	10/1/2005	10/1/2005	435	104,965,200	77	269,234	9

Source: National Flood Insurance Program, November 2009; Community Rating System, October 2009

A "repetitive loss" property is one that has received two or more flood insurance claim payments for at least $1,000 each in any 10-year period since 1978. According to NFIP data provided by the Colorado Water Conservation Board and data provided by the City of Lakewood, there were 27 repetitive loss claims in Jefferson County at the time of this plan's development. 22 claims were associated with 8 properties in the City of Lakewood (6 of which are single family residential and 2 of which are non-residential) and 5 claims were associated with 2 properties in unincorporated areas of the County. One of those properties is single family residential and the other one is non-residential.

Future Development

Jefferson County's continued population, housing, and employment growth creates pressure for land use change and the supporting infrastructure improvements. Floodplain management practices implemented through local floodplain management ordinances should mitigate the flood risk to new development in floodplains. Urbanization and increasing impervious surface areas tend to increase both the rate and the volume of stormwater runoff. Thus, the largest issue with future development trends is urbanization and stormwater drainage issues that add to the peak discharge and volume of floodwaters in floodplains.

Hail – High Hazard Significance

Existing Development

Research into the damages inflicted by this hazard indicates the hazard has a high impact on the entire planning area, and perhaps the greatest economic impacts. Hail impacts anything exposed to the event, including structures, infrastructure, landscaping, personal property and vehicles, people, agriculture, and livestock. Jefferson County has the highest number of reported injuries due to hail in the state. Hail is also the most expensive insured-losses natural disaster to impact the state of Colorado, with nine separate incidents falling within the 'top ten disasters' list for the state. Existing development remains exposed to hail with minimal mitigation opportunities. Individuals can mitigate exposure by remaining indoors and away from windows during

hailstorm events. Vehicles can be parked under shelters to help minimize damage costs incurred in that arena. However, in many cases it is impossible to move existing development away from the impact areas. For example, hail heavily impacts the economic contributors who house merchandize outdoors, such as car retailers, home improvement stores and gardening stores. Damage to landscape and agriculture is also almost impossible to prevent, as the plants cannot be transported indoors for the storm.

Methodology

Past damages were analyzed to estimate the potential for future hailstorm losses. Nine of the ten costliest disasters in Colorado history are attributed to hail. The ten costliest hailstorms in Colorado total $3.25 billion dollars in damages (2009 estimates) over the last 25 years. If these were evenly distributed over the time period, that equates to $129 million dollars per year in damages to Colorado in insured losses alone. The Rocky Mountain Insurance Information Association (RMIIA) provided extensive insurance-based damages and losses for hailstorms in Colorado, which were helpful in establishing the severity of losses. However, storm damages are not typically tracked by specific area (example: Jefferson County or the Southwest Metro Area) or by variations or by damage type (hail damage separated from wind damage separated from lightning damages) unless the damage type is explicitly unique and quantifiable in a large dollar amount. As such, the plan relies on documentation about a given event to further interpret the RMIIA data for planning area-specific information. Thus it is difficult to calculate an average annual loss for Jefferson County alone.

The affect of wind, combined with lightning, rain and hail, on power delivery is a significant factor when assessing current development exposure. Xcel Energy provided data for the number customers within their service areawho experienced impacted power supply caused by these hazards between 2006 and August 2009. Xcel also estimates that outages cost approximately $50,000 per 20,000 people affected for repair and replacement costs, repair equipment usage, and crew overtimes. This cost is not directly tracked by Xcel, but is formulated based on estimates provided from the Xcel engineering team. FEMA Standard Values for Loss of Service for Utilities, located in Appendix C of the FEMA BCA Reference Guide, were used to estimate the costs incurred on the individuals. This cost is calculated by applying a standard average rate ($126) per person, per day of service outage. This information is located in Table 4.36. Based on 12 days of outages within 4 years this equates to an average of 3 days per year that power outages occur from these hazards. The average number of customers affected is 5,748. This equates to an average annual loss of $2,172,744 based on power outages alone (3 x 5,748 x $125). Unfortunately we cannot refine this number to solely reflect hail.

Table 4.36 Cost of Power Supply Delays due to Lightning, Wind, Rain & Hail

Year	# of Days	# of Customers Affected	Approximate Cost to Xcel to Repair Outage	Cost of Complete Loss of Service to Population
2009	1	7,399	$18,498	$932,274
	1	3,938	$9,845	$496,188
2008	2	15,063	$37,658	$3,795,876
	1	5,209	$13,023	$656,334
	1	646	$1,615	$81,396
2007	1	13,257	$33,143	$1,670,382
	1	5,309	$13,273	$668,934
	1	2,972	$7,430	$374,472
	1	7,924	$19,810	$998,424
2006	1	4,200	$10,500	$529,200
	1	3,059	$7,648	$385,434

Source: Xcel Energy, August 2009

Future Development

Consideration for future development may include the use of resilient landscaping, construction of covered parking, or semi-sheltered structures to minimize these extensive losses. The availability of shelters in the many open spaces of Jefferson County may afford some protection to recreation populations. In some cases, the costs of future mitigation efforts, even in new future development, may outweigh the potential insurance losses.

Landslides, Debris Flows, Rockfall - Medium Hazard Significance

Existing Development

Research in the hazard profile for landslide, debris flow, and rockfall events revealed sporadic impacts, particularly in the canyons that dissect the region, most of which have County roads or State highways running through them, and repetitive debris flow issues in areas that have had recent wildfire burns. Future property losses to existing developments would likely be minor, based on patterns of previous events, and impact mostly infrastructure. Rockfall impacts on Jefferson County foothill highways and County roads have the potential to cause significant indirect economic loss, in addition to the potential for serious injury or death. The most significant road that could be impacted by rockfall and related road closures is Highway 6 in Jefferson County in Clear Creek Canyon. Economic losses from this road closure and resulting detours could be estimated with traffic counts and detour mileage.

Methodology

GIS was used to create a risk assessment for geological hazards in Jefferson County. Landslide, rockfall, and slope failure hazard data was overlaid on Jefferson County parcel and assessors data.[55] For the purposes of the analysis, if the hazard zone intersects an improved parcel, its improvement value is included and parcel is counted in Table 4.37. This table shows the value of developed parcels exposed to the hazard. Results are sorted by occupancy type and by jurisdiction to demonstrate how the hazard's risk varies across the planning area. Maps that display the parcels affected by these hazards can be referenced in the applicable jurisdictional annexes.

Currently, there is only one critical facility exposed to these hazards in the planning area. The Valley Metal Container in Golden is listed as a hazardous materials facility and is shown by GIS data to fall in a slope failure-vulnerable area. Table 4.37 outlines the potential losses for other existing development in the planning area.

Table 4.37 Building Exposure to Landslides, Rockfall and Slope Failure in Jefferson County

Hazard Type	City	Occupancy Type	Improved Parcel Count	Improvement Value*	Contents Value**
Landslide	Unincorporated	Commercial	5	$165,367,385	$ 165,367,385
Landslide Total		**(Combined)**	**5**	**$165,367,385**	**$ 165,367,385**
Rockfall	Unincorporated	Commercial	1	$ 182,000	$ 182,000
	Unincorporated	Residential	2	$ 1,653,100	$ 826,550
Rockfall Total		**(Combined)**	**3**	**$ 1,835,100**	**$ 1,008,550**
Steep Slope Failure	Golden	Commercial	8	$ 36,094,700	$ 36,094,700
	Golden	Residential	341	$116,517,200	$ 58,258,600
	Lakewood	Commercial	3	$ 1,658,010	$ 1,658,010
	Lakewood	Residential	19	$ 4,935,300	$ 2,467,650
	Morrison	Commercial	8	$ 1,376,000	$ 1,376,000
	Morrison	Residential	7	$ 675,700	$ 337,850
	Unincorporated	Commercial	8	$166,296,185	$ 166,296,185
	Unincorporated	Residential	110	$ 48,158,100	$ 24,079,050
Steep Slope Failure Total		**(Combined)**	**504**	**$375,711,195**	**$ 290,568,045**

Source: Based on analysis of Jefferson County GIS and Assessor's Data
*The Assessor's Office values buildings for the specific purpose of valuation for ad valorem tax purposes and values represented do not reflect actual building replacement values.
**The Assessor does not have data about the contents of structures and the contents values shown in the table are not derived from Assessor data but are estimates based upon the structure value using FEMA recommended values (typically 50% for residential structures and 100% for commercial/industrial)

[55] Assessor parcel data is developed and used for ad valorem tax assessment only. The Assessor's parcel maps are not accurate representations of the actual physical location of the parcels for any other purpose. The location of improvements on the parcels are not described in any way in the Assessor parcel data.

Future Development

Steep slope regulations limit problems from these hazards for future development, thus the exposure of infrastructure to these hazards is not anticipated to grow. As expansion of the gambling communities grows in neaby Gilpin County, the amount of traffic along the Clear Creek Canyon HWY 6 corridor will increase, and thus the amount of people exposed to danger from rockfall hazards may increase. While mitigation projects are in place to reduce dangers to drivers from falling rock along this corridor, more may be necessary in the future.

Lightning – Medium Hazard Significance

Existing Development

It is difficult to quantify where specific losses will occur due to the random nature of this hazard. Given the lightning statistics for Colorado and Jefferson County, the County remains at risk and is vulnerable to the effects of lightning. Persons recreating or working outdoors during the months of April through September will be most at risk to lightning strikes. It is difficult to quantify future deaths and injuries due to lightning, other than to note that future occurrences are likely without increased public education.

Critical facilities and infrastructure will have the greatest consequences if damaged by a lightning strike. The greatest losses from lightning result from the secondary hazard of wildfire. The affect of wind, combined with lightning, rain and hail, on power delivery is a significant factor when assessing current development exposure. An analysis of this impact is described in the hail vulnerability section. Unfortunately we cannot refine the analysis to reflect potential economic losses from lightning triggered power outages alone.

Future Development

New critical facilities such as communications towers should be built with lightning protection measures. As the population continues to increase and the number of people exposed to the hazard increases, it is reasonable to assume that injuries and deaths will also increase proportionately. Construction of lightning shelters at outdoor venues and increased public awareness campaigns may help minimize increase effects of lightning on growing populations.

Severe Winter Storms – High Hazard Significance

Existing Development

All buildings in the planning area are exposed to winter storms at some level, as are all members of the population. The threat to public safety is typically the greatest concern when it comes to impacts of winter storms, but these storms also impact the local economy by disrupting transportation and commercial activities. Winter storms are occasionally severe enough to overwhelm snow removal efforts, transportation, livestock management, and business and commercial activities. Travelers on highways in Jefferson County, particularly along remote

stretches of road or on steeply graded passages can become stranded, requiring search and rescue assistance and shelter provisions. The County may experience high winds and drifting snow during winter storms that can occasionally isolate individuals and/or entire communities and lead to serious damage to property. Winter storms are also a direct contributor to extremely cold temperatures, which are profiled separately in this plan.

Research presented in Section 4.2.13 yielded significant impacts from this hazard in the past. Structural losses to buildings are possible and structural damage from winter storms in Colorado has resulted from severe snow loads on rooftops. Older buildings are more at risk, as are buildings with large flat rooftops; often found in public buildings, commercial structures, and schools. The commuting population, particularly those that commute to the Denver metropolitan area, is another demographic potentially at risk during winter storm events due to increased dangers in driving conditions and the potential for being stranded. Special needs populations such as long term care facilities, daycare centers, and hospitals may be more vulnerable to heavy snowfall that strands or isolates staff and residents, delays the delivery of critical supplies, or interrupts power and heat to the facilities. Mountain communities or individuals living the foothills of unincorporated Jefferson County may be isolated from services and emergency assistance for extended periods of time during and immediately after a severe winter storm event.

The affect of winter storms on power delivery is a significant factor when assessing current development exposure. Xcel Energy provided data for the number customers who experienced impacted power supply caused by snow and ice between 2006 and August 2009. Xcel also estimates that outages cost approximately $50,000 per 20,000 people affected for repair and replacement costs, repair equipment usage, and crew overtimes. This cost is not directly tracked by Xcel, but is formulated based on estimates provided from the Xcel engineering team. FEMA Standard Values for Loss of Service for Utilities, located in Appendix C of the FEMA BCA Reference Guide, were used to estimate the costs incurred on the individuals. This cost is calculated by applying a standard average rate ($126) per person, per day of service outage. This information is located in Table 4.38. Based on 8 days of outages within 4 years this equates to an average of 2 days per year that power outages occur from winter storms. The average number of customers affected is 24,404. This equates to an average annual loss of $6,011,000 based on power outages alone (2 x 24,404 x $125).

Table 4.38 Customers Experiencing Power Supply Interruptions due to Snow and Ice

Year	# of Days	# of Customers Affected	Approximate Cost to Xcel to Repair Outage	Cost of Complete Loss of Service to Population
2009	3	21,846	$ 54,615	$ 8,257,788
2008	1	4,404	$ 11,010	$ 554,904
	1	8,592	$ 21,480	$ 1,082,592
2007	1	7,817	$ 19,543	$ 984,942
2006	1	118,387	$ 295,968	$ 14,916,762
	1	34,188	$ 85,470	$ 4,307,688

Source: Xcel Energy, August 2009

Future Development

Future residential or commercial buildings built to code should be able to withstand snow loads from severe winter storms. Population and commercial growth in the County will increase the potential for complications with traffic and commerce interruptions associated winter storms, as well as increased exposed populations vulnerable to the impacts of a severe winter storm such as power outages or delays in vital services. Future power outages or delays in power delivery to future developments may be mitigated by construction considerations such as buried power lines. Future development will also require future considerations for snow removal capacity including equipment, personnel, and logistical support. Adequate planning will help establish the cost-effective balance.

Public education efforts may help minimize the risks to future populations by increasing knowledge of appropriate mitigation behaviors, clothing, sheltering capacities, and decision making regarding snow totals, icy roads, driving conditions, and outdoor activities (all of which are contributors to decreased public safety during severe winter storms.) New establishments or increased populations who are particularly vulnerable to severe winter storms (such as those with health concerns or those who live in communities that may be isolated for extended periods of time due to the hazard) should be encouraged to maintain at least a 72-hour self sufficiency as recommended by FEMA. Encouraging contingency planning for businesses may help alleviate future economic losses caused by such hazards while simultaneously limiting the population exposed to the hazards during commuting or commerce-driven activities.

Subsidence – Medium Hazard Significance

Existing Development

Existing development makes up almost all of the risk to subsidence in the planning area; the hazard rating for subsidence was elevated based on the existing development vulnerabilities and losses. The areas of subsidence vulnerability, as identified in Figure 4.21, make up a fairly limited area of the County and is largely undeveloped. However, there are areas of Golden, Arvada, Lakewood, and the unincorporated County that are already developed, which means there is exposure to the hazard. Once the land is developed, subsidence mitigation becomes extremely expensive. In addition, poor or inaccurate mapping of former mining efforts may lead to unknown areas of vulnerability which are only discovered after the land is developed, when pre-emptive techniques are unavailable. Vulnerable construction includes roads, homes, business, and landscaped recreational areas. Dangers include damage caused to structures or roads and the secondary impacts such as injuries to occupants or passers-by, the rapid development of deep holes under people or cars which results in injury, death and/or property damage, and the fiscal cost of the damages.

Methodology

GIS was used to create a risk assessment for geological hazards in Jefferson County. Subsidence hazard data was overlaid on Jefferson County parcel and assessor's data.[56] For the purposes of the analysis, if the hazard zone intersects an improved parcel, its improvement value is included and parcel is counted in Table 4.37. Results are sorted by occupancy type and by jurisdiction to demonstrate how the hazard's risk varies for commercial and residential properties across the planning area. According to this analysis over $375 million in structure value is potentially exposed to the hazard. It is difficult to estimate potential losses beyond this exposure analysis. The City of Golden has the greatest exposure to the hazard.

Table 4.39 Exposure of Improved Properties to Subsidence in Jefferson County

City	Occupancy Type	Count of Improved Parcels	Improvement Value*	Contents Value**
Arvada	Commercial	1	$ 1,373,000	$ 1,373,000
	Residential	3	$ 994,800	$ 497,400
Golden	Commercial	49	$119,443,100	$ 119,443,100
	Residential	364	$101,857,700	$ 50,928,850
Lakewood	Commercial	3	$ 114,110	$ 114,110
	Residential	1	$ 2,195,800	$ 1,097,900
Unincorporated	Commercial	18	$118,933,900	$ 118,933,900
	Residential	119	$ 30,677,094	$ 15,338,547
Total	**(combined)**	**562**	**$375,589,504**	**$ 307,726,807**

Source: Jefferson County GIS

*The Assessor's Office values buildings for the specific purpose of valuation for ad valorem tax purposes and values represented do not reflect actual building replacement values.

**The Assessor does not have data about the contents of structures and the contents values shown in the table are not derived from Assessor data but are estimates based upon the structure value using FEMA recommended values (typically 50% for residential structures and 100% for commercial/industrial)

Future Development

New development will largely fall outside of known subsidence-vulnerable areas due to building regulations adopted by the County. In addition, since areas of vulnerability are identified, new development can include subsidence-resistant construction and mitigation efforts during the initial construction phase. This is more cost effective than retroactive mitigation efforts and helps prevent damage from occurring. As such, vulnerability to this hazard is not anticipated to increase with new development, provided that land use planning and engineering practices are followed. Increased efforts to monitor mining operations, increased accuracy of mapping of former mining works, and emphasis on appropriate grading and ground compaction during

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development will help alleviate vulnerability for future development in unknown areas of risk. In many ways, the efforts of Jefferson County to pre-empt the subsidence hazard (along with the erosion and swelling soils hazards) is a best-practices example for successful mitigation efforts and projects.

Tornado – Medium Hazard Significance

Existing Development

The National Climatic Data Center's 2005 Annual Summaries indicates that based on national state-level tornado data from 1953 to 2005, Colorado ranks 8th for frequency and 35th for number of deaths. When the tornado frequency per 10,000 square miles is compared with other states, Colorado ranks 35th for frequency and ties for 35th with 16 other states that average 0 deaths per 10,000 square miles. During a 43-year period (1965-2008), 13 tornadoes occurred in Jefferson County, which equates to one tornado every 3.3 years, on average. Of these tornadoes, seven were magnitude F0, five were reported as magnitude F1, and one was an F2. Tornadoes are possible anywhere in the planning area. Generally, it is difficult to assign an area of the County at higher risk than others, as tornadoes have been reported in all topographic conditions represented in the planning area, even in the higher elevations. In addition, the random nature of tornadoes causes difficulty in quantifying losses further and hinders attempts to estimate impacts on critical facilities. In general, vulnerabilities to existing developments are determined by structure type. Therefore, critical infrastructures built from less-sturdy materials or without solid, attached foundations are more vulnerable to tornadoes. In addition, historic and cultural resources, due to age, construction, or location, may also be particularly vulnerable to the effects of a tornado.

The affect of tornadic winds on power delivery is a significant factor when assessing current development exposure. Xcel Energy provided data for the number customers who experienced impacted power supply caused by this hazard in 2009. Xcel also estimates that outages cost approximately $50,000 per 20,000 people affected for repair and replacement costs, repair equipment usage, and crew overtimes. This cost is not directly tracked by Xcel, but is formulated based on estimates provided from the Xcel engineering team. FEMA Standard Values for Loss of Service for Utilities, located in Appendix C of the FEMA BCA Reference Guide, were used to estimate the costs incurred on the individuals. This cost is calculated by applying a standard average rate ($126) per person, per day of service outage. This information is located in Table 4.40. The only data available was for the July 20, 2009 hail and windstorm. This event is still in dispute as to the official 'tornado' designation, so losses may be moved under the other 'windstorm' category at a later time. This does not include additional losses to structures such as trees that fell on private property including cars and houses, and blown out windows. From this data alone it is evident that a tornado affecting anywhere in the urbanized Jefferson County area would have losses amounting to at least several million dollars.

Table 4.40 Cost of Power Supply Delays due to Tornadic Winds

Year	# of Days	# of Customers Affected	Approximate Cost to Xcel to Repair Outage	Cost of Complete Loss of Service to Population
2009	2	67,128	$167,820	$16,916,256

Source: Xcel Energy, August 2009

Future Development

As the County continues to develop, the number of people and housing developments exposed to the hazard increases. Proper education on building techniques and the use of sturdy building materials, basements, attached foundations, and other structural techniques may minimize the property vulnerabilities. Public shelters at parks and open spaces may help reduce the impacts of tornadoes on the recreational populations exposed to storms.

Wildfire – High Hazard Significance

Existing Development

Wildfire has the potential to cause widespread damage and loss of life in Jefferson County. The significance of this hazard and the availability of digital hazard data in GIS drove the development of a detailed vulnerability assessment that is discussed in the following pages.

Methodology

The HMPC determined that the best representation of wildfire risk in Jefferson County is a combination of the Colorado State Forest Service Interface Areas of High Wildfire Risk in Colorado (Red Zone Data) and the Jefferson County Wildfire Hazard Overlay District Zone.

The Colorado State Forest Service Red Zone data identifies where hazards, risks, and structure values have increased likelihood of wildfire and risk to life and property. Factors considered in the model include slope, aspect, fuels, vegetation, and population/housing density. The original Red Zone analysis was completed for areas of the Front Range of Colorado in late 1996; a statewide analysis was then completed in 1999.

The Jefferson County Wildfire Hazard Overlay District Zone designates those areas that are considered to have high wildfire risk. A regulation, approved in 2002, states that building permits in this District Zone will be granted only if defensible space and access standard issues are addressed.

The HMPC determined that sections of the Red Zone was not completely inclusive of the Overlay District Zone, and in some areas extended into the urbanized areas of Golden, Wheat Ridge and Bow Mar. The Red Zone areas in the Cities of Golden, Wheat Ridge and Bow Mar have grass land-fuel types that are not consistent with the forested areas of the rest of the Wildfire Hazard Overlay District Zone. These sections of the Red Zone data were not included in the analysis. Additionally, the Wildfire Hazard Overlay District Zone was used to fill in gaps

in the Red Zone data in areas that were considered by the HMPC to be a high wildfire hazard zone. These areas included portions of northern Jefferson County generally west of Highways 93 and C470, as well as all of southern Jefferson County.

A map of the data used in this analysis is shown in Figure 4.27 in the wildfire hazard profile. More detailed maps are shown in the jurisdictional annexes.

The new GIS layer indicates the extensiveness of the wildfire hazard in the county. Jefferson County's parcel and associated assessor's data were used as the basis for the inventory of developed parcels.[57] Parcels and their attributes, including building and contents value and occupancy type (i.e. residential, commercial, industrial) were compiled and intersected with the wildfire data. GIS was used to create a centroid, or point, representing the center of each parcel polygon. These centroids were overlayed on the wildfire hazard data. For the purposes of this analysis, if a parcel's centroid intersected the wildfire hazard data, the entire parcel is considered to be in the high wildfire threat area.

Results were sorted by occupancy type, and then organized by jurisdiction and fire protection district. The following discussion, maps and tables present the results of the loss estimation in detail. The results of the analysis are shown in Table 4.41 broken out by jurisdiction and display the value of structures at risk and an estimated contents value (a percentage applied dependant on the structure's occupancy type). According to this analysis, 26,470 developed parcels are within the wildfire hazard zone, with a total value (structure plus estimated contents) of $13.6 billion. Based on observations in wildland-urban interface fires, structures and contents are often completely destroyed, thus the estimated total value also represents potential dollar losses. Land value can decline following a large wildfire. This reduction in property value results in lower property taxes collected, and can significantly impact the County's tax revenue. Finally, a wildfire is not likely to burn all the wildland-urban interface areas in Jefferson County at once, though it is possible. Table 4.42 provides the results of this analysis aggregated by fire protection district.

Table 4.43 captures the population at risk to wildfire by jurisdiction. Population was estimated by applying the 2005-2007 American Community Survey 3-Year Estimate average household size of 2.43 to the count of residential structures affected. Total population at risk within the Red Zone is 62,008. This represents 12% of the total County population.

This analysis provides a general overview of the amount of people and property exposed to the wildfire hazard in Jefferson County. It does not account for mitigation efforts that have been ongoing within the County to moderate the risk. More detail on specific vulnerabilities and fuels treatment priorities can be referenced in the local Community Wildfire Protection Plans.

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Table 4.41 Structures in Red Zones & Jefferson County Wildfire Hazard Overlay Zone by Jurisdiction

City	Occupancy	Structure Count	Structure Value	Contents Value
Arvada	commercial	1	$56,800	$56,800
	residential	8	$4,309,256	$2,154,628
Golden	commercial	93	$94,493,400	$94,493,400
	residential	1,401	$403,488,400	$201,744,200
Lakewood	commercial	6	$1,144,800	$1,144,800
Morrison	commercial	39	$12,182,600	$ 12,182,600
	residential	108	$21,529,500	$10,764,750
Unincorporated	commercial	795	$ 868,694,990	$868,694,990
	government	8	$334,670	$334,670
	religious	10	$5,661,770	$5,661,770
	residential	24,001	$7,353,705,297	$3,676,852,649
		26,470	**$8,765,601,483**	**$4,874,085,257**

Source: HAZUS and Jefferson County Assessor's Data

*The Assessor does not have data about the contents of structures and the contents values shown in the table are not derived from Assessor data but are estimates based upon the structure value using FEMA recommended values (typically 50% for residential structures and 100% for commercial/industrial)

Table 4.42 Structures in Red Zones & Jefferson County Wildfire Hazard Overlay Zone by Fire Protection District

Fire Protection	Occupancy	Structure Count	Structure Value	Contents Value
Coal Creek Canyon Fire Protection	commercial	29	$ 8,696,100	$ 8,696,100
	government	1	$ 79,480	$ 79,480
	religious	1	$ 10,880	$ 10,880
	residential	971	$196,383,218	$ 98,191,609
Elk Creek Fire Protection District	commercial	117	$124,470,700	$124,470,700
	government	3	$1,380	$1,380
	religious	1	$61,550	$ 61,550
	residential	5,158	$ 1,206,015,816	$ 603,007,908
Evergreen Fire Protection District	commercial	354	$ 255,146,770	$ 255,146,770
	government	1	$ 700	$700
	religious	6	$ 5,312,340	$5,312,340
	residential	8,409	$112,610,597,917	$1,305,298,959
Fairmount Fire Protection District	commercial	1	$180,600	$180,600
	residential	64	$41,810,287	$20,905,144
Foothills Fire Protection District	commercial	5	$ 109,572,200	$109,572,200
	residential	1,722	$604,366,434	$302,183,217
Genesee Fire Protection District	commercial	27	$36,477,900	$36,477,900

Fire Protection	Occupancy	Structure Count	Structure Value	Contents Value
	residential	1,141	$447,103,000	$223,551,500
Golden Fire	commercial	93	$94,493,400	$94,493,400
	residential	1,401	$403,488,400	$201,744,200
Golden Gate Fire Protection District	commercial	2	$147,900	$147,900
	residential	368	$122,652,124	$61,326,062
Indian Hills Fire Protection District	commercial	21	$ 6,064,800	$ 6,064,800
	religious	1	$177,000	$177,000
	residential	673	$166,267,250	$83,133,625
Inter-Canyon Fire Protection District	commercial	31	$7,673,960	$7,673,960
	residential	1,806	$538,604,014	$269,302,007
North Fork Fire Protection District	commercial	52	$33,320,360	$33,320,360
	government	1	$ 135,170	$135,170
	religious	1	$100,000	$100,000
	residential	483	$ 70,556,213	$35,278,107
West Metro Fire Protection District	commercial	102	$170,447,400	$170,447,400
	residential	3,199	$1,353,933,773	$676,966,887
Non-District	commercial	20	$129,880,500	$129,880,500
	government	2	$117,940	$ 117,940
	residential	123	$ 21,254,007	$10,627,004
		26,470	**$ 8,765,601,483**	**$ 4,874,085,257**

Source: HAZUS
*Population assumes average household size of 2.43 for the County, drawn from the 2005-2007 American Community Survey 3-Year Estimates.

Table 4.43 Population in Red Zone and Jefferson County Wildfire Overlay Zone by Jurisdiction

City	Residential Structure Count	At Risk Population
Arvada	8	19
Golden	1,401	3,404
Morrison	108	262
Unincorporated	24,001	58,322
Total	**25,518**	**62,007**

Source: HAZUS and Census Data
*Population assumes average household size of 2.43 for the County, drawn from the 2005-2007 American Community Survey 3-Year Estimates.

To estimate the potential impact of wildfires on critical facilities a GIS overlay was performed of the wildfire hazard layer on existing critical facilities point locations. The results are shown in Table 4.44.

Table 4.44 Critical Facilities Located in Red Zones & Jefferson County Wildfire Hazard Overlay Zone

City	Type	Name
Arvada	Fire Stations	Coal Creek Canyon Station 3
Golden	Fire Stations	Golden Fire Station 4
	Schools	Shelton Elementary
Morrison	Police Facilities	Morrison PD
	Wastewater Facilities	MORRISON TOWN OF
Unincorporated	Fire Stations	Coal Creek Canyon Station 1
	Fire Stations	Coal Creek Canyon Station 4
	Fire Stations	Elk Creek Fire Station 1
	Fire Stations	Elk Creek Fire Station 3
	Fire Stations	Elk Creek Fire Station 4
	Fire Stations	Elk Creek Fire Vehicle Maintenance Bld
	Fire Stations	Evergreen Fire Station 1
	Fire Stations	Evergreen Fire Station 2
	Fire Stations	Evergreen Fire Station 3
	Fire Stations	Evergreen Fire Station 4
	Fire Stations	Evergreen Fire Station 6
	Fire Stations	Evergreen Fir eStation 7
	Fire Stations	Evergreen Fire Station 8
	Fire Stations	Foothills Fire Grapevine
	Fire Stations	Foothills Fire Idledale
	Fire Stations	Foothills Fire Mt. Vernon
	Fire Stations	Foothills Fire Rainbow Hills
	Fire Stations	Foothills Fire Lookout Mountain
	Fire Stations	Genesee Fire One Station
	Fire Stations	Golden Gate Station1
	Fire Stations	Golden Gate Station 2
	Fire Stations	Indian Hills Fire One Station
	Fire Stations	Inter-Canyon Fire Station 1
	Fire Stations	Inter-Canyon Fire Station 2
	Fire Stations	Inter-Canyon Fire Station 3
	Fire Stations	Inter-Canyon Fire Station 4
	Fire Stations	Inter-Canyon Fire Station 5
	Fire Stations	North Fork Fire Station 1
	Fire Stations	North Fork Fire Station 2
	Fire Stations	North Fork Fire Station 3
	Fire Stations	West Metro Fire Station 11
	Oil & Gas Facilities	Rex Oil Co
	Police Facilities	Radio Tower

City	Type	Name
	Police Facilities	Jefferson County Sheriff Mountain Preci*
	Schools	Marshdale Elementary
	Schools	Bergen Meadow Preschool & Elementary
	Schools	Bradford Primary
	Schools	Dakota Ridge Senior
	Schools	Coal Creek Canyon (K-8)
	Schools	Parmalee Elementary
	Schools	Red Rocks Elementary
	Schools	Elk Creek Elementary
	Schools	Bradford Intermediate
	Schools	Outdoor Education Lab Mt Evans
	Schools	Conifer Senior
	Schools	Rocky Mountain Academy Evergreen K-8
	Schools	Outdoor Education Lab Windy Peak
	Schools	Bergen Valley Elementary (3-5)
	Schools	West Jefferson Preschool & Elementary
	Schools	Wilmot Preschool & Elementary
	Schools	Evergreen Middle School
	Schools	West Jefferson Middle School
	Schools	Evergreen Senior
	Schools	Mountain Phoenix Community
	Schools	Ralston Elementary
	Wastewater Facilities	Genesee Water & San District
	Wastewater Facilities	Forest Hills Metropolitan Dist
	Wastewater Facilities	Evergreen Metropolitan Dist
	Wastewater Facilities	Falcon/Westminster 2 Partnership
	Wastewater Facilities	Jefferson County Schl Dist R-1
	Wastewater Facilities	Kittredge Sanitation & Water District
	Wastewater Facilities	Tiny Town
	Wastewater Facilities	W. Jefferson County Metro Dist
	Wastewater Facilities	Jefferson Co. School Dist-R1

Source: Data provided by Jefferson County

Notes on Fire Protection District Analysis:

- There are 9 parcels in northwest Arvada that were attributed to the Coal Creek Canyon Fire Protection District.
- There are 6 parcels in Lakewood, outside of West Metro FPD (just south of I-70, just west of C-470) that were attributed to the West Metro FPD group.
- Parcels in Morrison were attributed to West Metro FPD.
- Parcels in Golden were attributed to Golden Fire.

Future Development

Growth in the wildland urban interface has been significant in the past twenty years in Jefferson County. While this growth has recently slowed, there still remains potential for development of primary and secondary residences in wildfire hazard areas in the unincorporated County. Wildfire risk to future development in these areas will be tempered by the County's land use regulations.

There are currently endemic populations of MPB in Jefferson County that are monitored annually by the Colorado State Forest Service through aerial survey techniques. These endemic levels are a fraction in comparison to the levels within the epidemic. It is something that will need to be monitored closely. Currently at least one community if Jefferson County has developed a MPB Action Plan (Genesee Foundation).

Windstorm – Medium Hazard Significance

Existing Development

Based on the hazard profile in Section 4.2, windstorms will continue to cause property damage annually in Jefferson County. Due to the random and widespread nature of the hazard it is difficult to estimate future losses and where they will occur. Communities in and along the base of the foothills are most susceptible to the hazard, but high winds can damage communities anywhere in the County. Highway 93 between Golden and Boulder is an area that is subject to severe cross winds that threatens motorists typically in the winter months. Periodic road closures help mitigate car and truck damage and injuries and deaths, but economic impacts and traffic jams resulting from detours remain.

Windstorms can cause injury and death in Jefferson County. The highest risk demographic is to first responders who are dealing with emergency situations resulting from the windstorm. Those working or recreating outdoors will be susceptible to injury from wind borne debris. Winds can also be hazardous to hikers in areas of beetle or fire killed trees, which occurred when a hiker was killed by a falling tree in Rocky Mountain National Park in 2007. Another wind-related death was reported in June 1987 on the NCDC database, though no further details were provided. Other injuries can occur to occupants of buildings if windows are blown in, or to people outside who are injured by flying debris. Wind can also blow cars across lanes or off of roadways. High profile vehicles have been tipped over, leading to transportation-related accidents.

Impacts to critical facilities are difficult to estimate, but buildings could be susceptible to roof and window damage, such as the losses experienced across Jefferson County in July of 2009, though those losses also included heavy hail damages.

The affect of wind, combined with lightning, rain and hail, on power delivery is a significant factor when assessing current development exposure. Xcel Energy provided data for the number customers who experienced impacted power supply caused by these hazards between 2006 and

August 2009. This information is located in Table 4.36. This equates to an average annual loss of $2,172,744 based on power outages alone (3 x 5,748 x $125). Unfortunately the data cannot be refined to reflect wind alone.

Future Development

Construction sites are particularly vulnerable to windstorms. Wind-borne construction materials can become hazards to life and property. New construction designed in accordance with the Jefferson County wind load map should be able to withstand or at least resist wind damage if properly constructed. Backup power systems in critical facilities could help mitigate impacts from power outages associated with windstorms.

4.4 Capabilities Assessment

Thus far, the planning process has identified the natural hazards posing a threat to Jefferson County and described, in general, the vulnerability of the County to these risks. The next step is to assess what loss prevention mechanisms are already in place. This part of the planning process is the mitigation capability assessment. Combining the risk assessment with the mitigation capability assessment results in the County's "net vulnerability" to disasters, and more accurately focuses the goals, objectives, and proposed actions of this plan.

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

This section presents Jefferson County's mitigation capabilities and discusses select state and federal mitigation capabilities that are applicable to Jefferson County. Information about capabilities specific to the other participating jurisdictions can be found in the annexes to this plan.

Similar to the HMPC's effort to describe hazards, risks, and vulnerabilities of Jefferson County, this mitigation capability assessment describes the County's existing capabilities, programs, and policies currently in use to reduce hazard impacts or that could be used to implement hazard mitigation activities. This assessment is divided into four sections: regulatory mitigation capabilities; administrative and technical mitigation capabilities; fiscal mitigation capabilities; and mitigation outreach and partnerships.

4.4.1 Jefferson County Regulatory Mitigation Capabilities

Table 4.45 lists planning and land management tools typically used by local jurisdictions to implement hazard mitigation activities and indicates those that are in place in Jefferson County. Excerpts from applicable policies, regulations, and plans and program descriptions follow to provide more detail on existing mitigation capabilities.

Table 4.45 Jefferson County Regulatory Mitigation Capabilities

Regulatory Tool (ordinances, codes, plans)	Yes/No	Comments
General or Comprehensive plan	Y	
Zoning resolution	Y	Wildfire
Land development regulation	Y	
Growth management ordinance	Y	
Floodplain overlay district	Y	

Regulatory Tool (ordinances, codes, plans)	Yes/No	Comments
Overlay district (stormwater, steep slope, wildfire)	Y	
Building code	Y	
Fire department ISO rating	Y	
Erosion or sediment control program	Y	
Storm water management program	Y	
Site plan review requirements	Y	
Capital improvements plan	Y	
Economic development plan	y	
Local emergency operations plan	Y	2007 EOP, County Fire Plan, Dams, Airport Plan, I-70 Evacuation Plan, 2008 Debris Plan, ADP
Other special plans		
Flood insurance study or other engineering study for streams	Y	
Elevation certificates (for floodplain development)	Y	
Other		

Source: Jefferson County

Jefferson County Comprehensive Land Use Plan

The Jefferson County Comprehensive Land Use Plan is currently under revision. Its approval date is set for December 9, 2009 once all comments are received and incorporated. Jefferson County has a proven history of developing proactive measures that incorporate mitigation strategies into its existing planning mechanisms. The Comprehensive Land Use Plan is a perfect example. Their vision acknowledges sustainable balance and use of residential, commercial, community, and recreational lands. This balance protects and maintains the quality of the mountain and plains environment, provides economic vitality for current and future generations, and maintains Jefferson County as a place of choice to live, work, and recreate. The plan identifies that location, availability and the convenience of goods and services is an important element in the quality of life, and that a balance of such key services as an educated workforce, schools, commercial services, and recreational and employment opportunities are vital. Well-planned retail and service levels provide a source of community identity. The roads, rivers, and trails that connect homes, offices, stores, schools, and parks are the conduits for social interaction that knit together a community. Ensuring that residential areas are balanced by commercial and service centers can contribute to an orderly pattern of development and sense of place.

The general land use management goal is to encourage diversity of residential, commercial, community, recreational, and open land uses. The plan identifies Urban and Non-Urban Interface development with an objective to accommodate higher intensity uses in areas with adequate infrastructure and minimal hazards, and provide decreasing land use intensity where constraints exist and as distance to services increases. There are policies that protect important

wildlife habitats and avoid development or mitigate impacts in severe wildfire areas, such as steep forested canyons and slopes greater than 30%. The plan includes provisions for infill and redevelopment, which supports adaptive reuse of historical and outdated buildings; and future growth, which complements the existing community character with efforts to accommodate anticipated growth in the Denver metro area over the next 30 years. The policy states that the County should incorporate land planning techniques that manage resources effectively.

Building Codes

The Jefferson County Building Department enforces building codes in Jefferson County. Listed below are the codes effective July 1, 2007.

International Residential Code

- 2006 International Residential Code
- 2008 National Electrical Code (effective 08/01/08)
- 2006 International Energy Conservation Code

International Building Code

- 2006 International Building Code
- 2008 National Electrical Code (effective 08/01/08)
- 2006 International Energy Conservation Code

International Fire Code

- 2009 ICC International Fire Code

In addition, the Jefferson County Board of County Commissioners adopted and promulgated deletions and additions to the 2006 International Residential Code and the 2006 International Building Code. This Code shall apply to the unincorporated area of Jefferson County. These plans can be accessed at http://www.co.jefferson.co.us/building/building_T45_R14.htm.

Local fire districts have individual authority to enforce fire code standards beyond the County's requirements.

Highlights of 2006 Residential and International Building Code Supplement include:

Wildfire

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

Restrictions in Wildfire Zone 1

Roof coverings: Roof coverings for new buildings or structures or additions thereto or roof coverings utilized for re-roofing shall be Class A in accordance with Section 1505.2. Re-roofing includes any repairs of more than 10% of the total roof covering during any three-year period. A repair of 10% or less of the total roof covering in any three-year period may utilize approved roofing materials comparable to the existing roofing materials.

Restrictions in Wildfire Zone 2

Roof coverings: Roof coverings for new buildings or structures or additions thereto or roof coverings utilized for re-roofing shall be Class A, Class B, Class C, or any other roof covering permitted by this Code.

New Fireplaces: Every new fireplace shall have permanently installed either approved gas logs or other approved gas or alcohol specific appliances; or an approved solid fuel appliance insert meeting the most stringent emission standards for wood stoves established under State statute and/or regulations promulgated by the State Air Quality Control Commission (AQCC) as of the time of installation of the fireplace.

Snow

The roof structure shall be designed for snow loads as determined by the Basic Snow Load Design Table 1608.1.1, except in no case shall the snow load be less than 30 pounds per square foot.

Wind

Basic wind speed: Basic wind speed for determining wind pressure shall be 100 miles per hour.

Foundations and Soils Investigation

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

Flood Loads

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

Floodplain Management

In accordance with the National Flood Insurance Act of 1968 and the Flood Disaster Protection Act of 1973, Jefferson County has applied and subsequently qualified for participation in the National Flood Insurance Program. Jefferson County joined the NFIP on August 5, 1986 and the Community Rating System (CRS) on October 1, 2005.

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

Stormwater Management

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

Jefferson County has created stormwater management regulations. These regulations together with all future amendments will be known as the "Jefferson County Storm Drainage Design and Technical Criteria" as referenced in the Jefferson County Land Development Regulation. The criteria apply to all lands within the unincorporated areas of the County, including all public lands. Policies and technical criteria not specifically addressed in these criteria will follow the provisions of the Urban Drainage and Flood Control District "Urban Storm Drainage Criteria Manual."

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

Wildfire Hazard Overlay District Zoning Resolution

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

No building permit may be issued for a new dwelling, the replacement of an existing dwelling, or for additional space of 400 square feet or more (cumulatively measured) from May 21, 2002, the date of this regulation's adoption, until written evidence has been submitted and approved by the

Zoning Administrator or his/her appointed designee stating that the following have been satisfied:

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

Grading, Erosion, and Sediment Control Regulation

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

- The existing and final contours shall be shown at 2-foot intervals for subdivisions within the plains area and contours at 5-foot intervals for subdivisions within the mountain areas including the method utilized to obtain all contour intervals. Contours shall be accurate to within 0.5 contour. Elevations shall be based on USGS sea level datum. The USGS quad maps shall not be accepted as evidence for topographic contours.
- Grading, erosion and sediment control plans shall be prepared in accordance with and in compliance with the standards in the Land Disturbance Section of the Zoning Resolution.
- Grading, erosion and sediment control plans must include the following:
  - Plans for all private and public streets/roads in accordance with the Roadway Design and Construction Manual and the Circulation Section.
  - Conceptual driveway plans if existing slopes exceed 30%.
  - Overlot grading plans for all non-residential, multi-family, manufactured home developments, and single family residential developments with lot sizes under ½ acre. Overlot grading plans are not required for single family residential lots over ½ acre in size if the developer is not proposing overlot grading, grading is not required and/or shown on the drainage plan, and the slopes in the buildable areas do not exceed 30%. Overlot grading plans must be consistent with the grading and basin boundaries shown on the drainage plan.
  - Plans for all drainage improvements including but not limited to detention/ water quality facilities, drainage channels, storm sewer, and outlet protection.
  - Grading, erosion and sediment control plans for each lot in residential developments with lot sizes under ½ acre shall be prepared in accordance with and in compliance with the Notice of Intent standards in the Land Disturbance Section of the Zoning Resolution.
- Approvals: The Planning and Zoning Division shall approve the plans prior to development approval. The Jefferson Conservation District shall approve the seed mix and mulching rates.

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

Geologic and Geotechnical Regulations

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

- Reasonably free from geologic hazards or adequately mitigated from geologic hazards.
- Free of adverse soil conditions, constructed away from adverse soil conditions, or constructed in areas where adverse soil conditions have been abated.

All areas which fall within the Dipping Bedrock Overlay District shall be subject to the restrictions in the Dipping Bedrock Overlay District of the Jefferson County Zoning Resolution.

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

or

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

Land Disturbance Regulation

The purpose of the Land Disturbance Section is to:

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

- Establish performance standards to:
  - Define grading, drainage, erosion and sediment control, and waste disposal requirements;
  - Ensure mitigation of adverse impacts; and (orig. 10-12-04)
  - Ensure the reclamation of disturbed land. (orig. 10-12-04)

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

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

Roadway Design and Construction Regulations

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

4.4.2 Jefferson Count Administrative/Technical Mitigation Capabilities

Table 4.46 identifies the County personnel responsible for activities related to mitigation and loss prevention in Jefferson County.

Table 4.46 Administrative and Technical Mitigation Capabilities

Personnel Resources	Yes/No	Department/Position	Comments
Planner/engineer with knowledge of land development/land management practices	Y		
Engineer/professional trained in construction practices related to buildings and/or infrastructure	Y		
Planner/engineer/scientist with an understanding of natural hazards	Y		
Personnel skilled in GIS	Y		
Full time building official	Y		
Floodplain manager	Y	Charles Barthel cbarthel@jeffco.us	
Emergency manager	Y	Tim McSherry jmcsherr@jeffco.us	

Personnel Resources	Yes/No	Department/Position	Comments
Grant writer	Y	Elizabeth Mundell Emundell@jeffco.us	
Other personnel	Y		
GIS Data Resources (Hazard areas, critical facilities, land use, building footprints, etc.)	Y	Callie Broome CBroome@jeffco.us	
Warning Systems/Services (Reverse 9-11,	Y	Jefferson County Dispatch	

Source: Jefferson County

4.4.3 Jefferson Count y Fiscal Mitigation Capabilities

Table 4.47 identifies financial tools or resources that the County could potentially use to help fund mitigation activities.

Table 4.47 Fiscal Mitigation Capabilities

Financial Resources	Accessible/Eligible to Use (Yes/No)	Comments
Community Development Block Grants	Y	
Capital improvements project funding	Y	
Authority to levy taxes for specific purposes	Y	
Fees for water, sewer, gas, or electric services	N	
Impact fees for new development	Y	
Incur debt through general obligation bonds	Y	
Incur debt through special tax bonds	Y	

Source: Jefferson County

4.4.4 Other Mitigation Efforts

In 2009 the Colorado State Legislature adopted Senate Bill 09-001, an act which amends Title 23, Article 31, Part 3, §1. This law requires Community Wildfire Protection Plans (CWPPs) for all unincorporated portions of a County where a fire hazard exists. According to the 2008 State Hazard Mitigation Plan, the communities of Elk Creek, Inter-Canyon FPD, Indian Hills FPD, West Metro FPD, Coal Creek FPD, Evergreen FPD, Foothills FPD, Fairmount FPD, Genesee FPD, Golden FD, Golden Gate FPD, and Lookout Mountain Water District have CWPPs.

Flood and Wildfire Task Force

The Flood and Fire Task Force is attended by various agencies interested in a proactive look at flooding or wildfire. The Task Force meets on a bi-weekly basis from April through September. The discussion revolves around weather, staffing levels for wildfire, resources available, and criteria for fire restrictions and fire bans. The Task Force acts in an advisory capacity to the Sherriff for fire restrictions and fire bans.

Agencies regularly represented on the Task Force are:

- Jefferson County Emergency Management
- Jefferson County Sherriff's Office
- Jefferson County Open Space
- Jefferson County Road and Bridge
- Jefferson County Public Information
- The National Weather Service
- UDFCD
- Colorado State Forest Service
- US Forest Service
- Elk Creek Fire Department
- Jefferson County Fire Council
- West Metro Fire Department

5 MITIGATION STRATEGY

Requirement §201.6(c)(3): [The plan shall include] a mitigation strategy that provides the jurisdiction's blueprint for reducing the potential losses identified in the risk assessment, based on existing authorities, policies, programs and resources, and its ability to expand on and improve these existing tools.

This section describes the mitigation strategy process and mitigation action plan for the Jefferson County Multi-Hazard Mitigation Plan. This section describes how the County accomplished Phase 3 of FEMA's 4-phase guidance - Develop the Mitigation Plan - and includes the following from the 10-step planning process:

- Planning Step 6: Set Goals
- Planning Step 7: Review Possible Activities
- Planning Step 8: Draft an Action Plan

5.1 Goals and Objectives

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

Up to this point in the planning process, the Hazard Mitigation Planning Committee (HMPC) has organized resources, assessed natural hazards and risks, and documented mitigation capabilities. A profile of the County's vulnerability to natural hazards resulted from this effort, which is documented in the preceding chapter. The resulting goals, objectives, and mitigation actions were developed based on this profile as well as a review of the 2003 Denver Regional Natural Hazard Mitigation Plan's actions, which were determined to be too general in nature to update. The HMPC developed the new mitigation strategy based on a series of meetings and worksheets designed to achieve a collaborative mitigation planning effort, as described further in this section.

Goals were defined for the purpose of this mitigation plan as broad-based public policy statements that:

- Represent basic desires of the community;
- Encompass all aspects of community, public and private;
- Are nonspecific, in that they refer to the quality (not the quantity) of the outcome;
- Are future-oriented, in that they are achievable in the future; and
- Are time-independent, in that they are not scheduled events.

Goals are stated without regard for implementation, that is, implementation cost, schedule, and means are not considered. Goals are defined before considering how to accomplish them so that the goals are not dependent on the means of achievement. Goal statements form the basis for objectives and actions that will be used as means to achieve the goals. Objectives define strategies to attain the goals and are more specific and measurable.

A separate meeting of the HMPC was held to develop goals for this plan. HMPC members were given a list of sample goals to consider, including the goals of the Colorado Hazard Mitigation Plan, the Denver Regional Council of Governments Natural Hazard Mitigation Plan, and the related goals and polices outlined in the Hazard section of the Jefferson County Comprehensive Land Use Plan (in draft form as part of a 2009 update). Other related plans suggested for reference included the Community Land Use Plans for specific areas of the unincorporated County, the Jefferson County Open Space Master Plan, Community Wildfire Protection Plans and the municipal Comprehensive Plans and Parks and Open Space Master Plans. It is also important to integrate this mitigation strategy with other existing goals to ensure consistency, efficiency, and effectiveness, which is also useful in identifying funding opportunities. The HMPC was instructed that they could use, combine, or revise the statements they were provided or develop new ones on their own, keeping the risk assessment in mind. Team members were provided sticky notepads and asked to write 2 or 3 proposed goals. These goal statements were collected by the consultant project manager and grouped into similar themes for further discussion. Some of the statements were determined to be better suited as objectives or actual mitigation projects, and were designated as such. The team came up with three draft goal statements and a number of supporting objectives. These were compiled into a document which was circulated via email and accepted with minor revisions and consensus of the HMPC at a followup mitigation planning meeting.

Based upon the risk assessment review and goal setting process, the HMPC developed the following goals and objectives. These goals and objectives provide the direction for reducing future hazard-related losses within Jefferson County. They are listed below, with their objectives.

Goal 1: Increase awareness about natural hazards

- Create a public outreach effort on the hazards identified in this plan.
- Provide timely notification and direction to the public of imminent and potential hazards.
- Provide notification for properties within hazard areas.
- Provide education on hazard resistant construction techniques.
- Engage constituency to take personal responsibility for their own exposure and mitigation.
- Increase public awareness of the need for funding for disaster mitigation & preparedness.

Goal 2: Reduce impacts of natural hazards on life, property, and the environment

- Continue to manage development and placement of structures in hazard-prone areas.
- Protect existing property to the extent possible.

- Utilize the risk assessment as the basis for jurisdictional response and evacuation plans.
- Protect critical facilities and infrastructure to minimize loss of critical services following a hazard event.
- Create incentives for the public to mitigate hazards on their own property.
- Strongly communicate wildfire mitigation with all land use proposals and existing land uses.
- Continue CWPP Efforts and Implementation, wildfire fuel breaks, wildfire safe zones and defensible space, fuels reduction and biomass use.
- Increase wildfire mitigation efforts.
- Reduce the economic impact to public and private entities from hazards.
- Enhance ability of businesses to mitigate and recover from disasters.
- Continue to reduce flood losses through compliance with National Flood Insurance Program requirements.
- Continue to participate with Community Rating System, where applicable (i.e., Jefferson County, Arvada, Golden, Wheat Ridge and Lakewood).

Goal 3: Strengthen and develop partnerships in regards to mitigating hazard impacts

- Promote planning efforts that foster cooperation and coordination among jurisdictions, agencies, and community aide organizations involved in hazard mitigation and response.
- Maximize the use of shared resources to leverage funding for hazard mitigation projects between all levels of government and the private sector.
- Develop links between emergency planning and land use planning.
- Strengthen community partnerships and confidence in the ability of local government to mitigate and respond to hazard events.

5.2 Identification and Analysis of Mitigation Actions

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

In order to identify and select mitigation measures to support the mitigation goals, each hazard identified in Section 4.1: Identifying Hazards was evaluated in regards to the various options for mitigation. Hazards that pose a significant threat to the community were considered the priority in the development of hazard specific mitigation measures.

The HMPC considered the four primary natural hazard mitigation strategies: Alter, Avert, Adapt, and Avoid. A comprehensive hazard mitigation plan considers the options as applicable under each mitigation strategy. A matrix was prepared to assist the planning team with the analysis of the alternatives by hazard, which is shown in Table 5.1 Primary Mitigation Strategies by Hazard.

The matrix indicates that the available options will typically vary by hazard, but the "Adapt" strategy can be applied to each hazard.

Table 5.1 Primary Mitigation Strategies by Hazard

Hazard	Primary Mitigation Strategies-the Four "A's"			
	Alter-Reduce frequency or intensity of hazard	**Avert**-Redirect hazard impacts away from vulnerable areas	**Adapt**-Reduce vulnerability to hazard	**Avoid**-Remove or do not put people and structures in risky areas
Avalanche	X	X	X	X
Dam Failure			X	X
Drought			X	
Earthquake			X	
Erosion and Deposition	X		X	X
Expansive Soils			X	X
Extreme Temperatures			X	
Flood	X	X	X	X
Hailstorm			X	
Landslide/Debris Flow/Rock Falls	X	X	X	X
Lightning			X	
Severe Winter Storms		X	X	
Subsidence			X	X
Tornadoes			X	
Wildfire	X	X	X	X
Windstorms			X	

In addition to the "four A's" each HMPC member was provided the following list of categories of mitigation measures, which originate from the National Flood Insurance Program's Community Rating System:

- Prevention
- Property Protection
- Structural Projects
- Natural Resource Protection
- Emergency Services
- Public Information

The HMPC members were also provided with several lists of alternative multi-hazard mitigation actions for each of the above categories. Another reference handout titled "Mitigation Ideas" developed by FEMA Region V was distributed to the HMPC. This handout lists the common alternatives for mitigation by hazard. A facilitated discussion then took place to examine and

analyze the alternatives. With an understanding of the alternatives, a brainstorming session was conducted to generate a list of preferred mitigation actions, beginning with discussion regarding the priority hazards. HMPC members wrote project ideas on large sticky notes. These were posted on flip charts labeled with the goals. The result was a number of project ideas with the intent of meeting the identified goals.

HMPC members considered actions that would mitigate impacts to both new and existing buildings and infrastructure. The HMPC noted that the Hazard section of the Jefferson County Comprehensive Land Use Plan and related Land Use Code is oriented towards reducing impacts to future development and will be used as the primary implementation mechanism for ongoing land use planning related to hazards. This plan works in tandem with the Land Use Plan and puts forth recommendations that will reduce losses to both new and existing infrastructure, but can be viewed as having a primary focus on reducing impacts to existing buildings, populations, and infrastructure.

5.3 Mitigation Action Plan

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

This section outlines the development of the final 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.

Existing and planned mitigation actions from the 2003 DRCOG Regional Mitigation Plan were reviewed for the County, Arvada, Lakewood and Wheat Ridge. The actions were very general categories of mitigation actions rather than specific actions. The DRCOG plan grouped the categories by the same list used by the NFIP Community Rating System noted previously in Section 5.2 (prevention, property protection, natural resources protection, emergency services, structural projects and public information, see Table 5.2). The majority of the action items identified for these jurisdictions were the continuation of ongoing capabilities, such as maintaining and updating building codes, floodplain regulations, stormwater management, erosion and sediment control, best management practices, etc. During the 2009-2010 development of this plan several of the existing actions related to ongoing capabilities for Jefferson County, Arvada, Lakewood, and Wheat Ridge were deleted from the mitigation action plan and captured in each respective capability assessment, which is also organized by CRS mitigation category. Thus the actions identified in Section 5.3 represent new actions or those actions further refined from the DRCOG plan. Examples of this include the DRCOG "Floodplain Development Regulations" action, which is now refined to include: "Continue to

Implement Sound Floodplain Management Practices through Participation in the National Flood Insurance Program (Lakewood), National Flood Insurance Program (NFIP) and Community Rating System (CRS) Participation (Jefferson County and Arvada), NFIP/CRS/CIP/Stormwater Utility (Wheat Ridge).

Table 5.2 DRCOG 2003 Mitigation Action Status Table – Jefferson County

Local Mitigation Measures/ Action Strategies	Status: Completed, Deleted, Deferred, Ongoing	Comments
Prevention:		
Adopt or Revise Building Code	Deleted	Ongoing; see capability assessment
Planning And Zoning: Land Development Regulations	Deleted	Ongoing; see capability assessment
Open Space Preservation	Deleted	Ongoing; see capability assessment
Floodplain Development Regulations	Deleted	See progress notes; replaced by NFIP compliance action in table 5.2
Storm Water Management	Deleted	Replaced by drainage- specific actions in table 5.2; capability assessment
Wildland Fuel Management	Ongoing	See notes on progress, CWPP action in table 5.2
Property Protection:	None identified	
Natural Resource Protection:		
Erosion and Sedimentation Control	Deleted	Addressed in development regulations
Best Management Practices	Deleted	Too generic. Ongoing with fire departments, part of development regulations, stormwater regulations.
Emergency Services:		
Flood Warning Systems	Completed	County participates in Urban Drainage and Flood Control District's system. See notes in progress
Flood Response	Completed	EOP updated. Removed to keep plan's focus on mitigation
Health and Safety Maintenance	Deleted	Ongoing; Removed to keep plan's focus on specific mitigation strategies.
Structural Projects:	None identified	
Public Information:		
Map Information	Ongoing	See GIS Layer updates action in table 5.2
Outreach Projects	Ongoing	See progress notes; actions related to Storm Ready and Bi-Lingual publications and dam safety in Table 5.2
Library/ Environmental Education	Ongoing	See progress notes; actions related to Bi-Lingual publications in Table 5.2

The County and its jurisdictions have made progress on actions and strengthening its mitigation capabilities towards reducing future losses. Examples of this include:

- Development of Community Wildfire Protection Plans for each Fire Protection District (all but one have been completed by mid 2010, see Section 4.4.4).
- Wildland fuels management projects by Jefferson County in cooperation with fire districts: In 2008 and 2009 hazardous fuels mitigation work was done on Elk Meadow, White Ranch and Mount Falcon Open Space areas, Conifer High School and the Yegge Road community. In 2008 over 310 acres were treated and in 2009 over 94 acres were treated either by cutting or grinding; approximately 90 acres were treated with prescribed fires, and 139 slash piles were burned by the Fuels Crew. These projects are done in partnership with the Colorado State Forest Service, the US Forest Service and Jefferson County Open Space, and were in accordance with the Community Wildfire Protection Plans. The County, in partnership with several of the local Fire Districts, hosts remote slash collection sites each summer. Since 2005, over 133,750 cubic yards of slash has been collected and removed from the Wildland Urban Interface of Jefferson County.
- Flood warning systems: In late 2009 Jefferson County Emergency Management purchased 300 NOAA Weather Radios with the assistance of a State Hazard Mitigation Program grant. These radios have been distributed to all public schools in the district as well as daycare centers and many nursing homes and assisted living centers in the county.
- Floodplain management: Since 2005 the county has worked hard to upgrade its Community Rating System class. In early 2010, Jefferson County received a class 6 rating which is one of the best ratings of any county in the state.
- Outreach projects: Jefferson County Emergency Management is constantly trying to raise the public's preparedness for any type of disaster. Since September 2005 over 30,000 Emergency Preparedness guidebooks have been distributed to the public by means of safety fairs, community meetings, and presentations to groups like Kiwanis's clubs and Boy Scouts of America. Since 2007, Emergency Management has worked with caregivers of those with special needs to create and exercise emergency plans. These trainings have been held for group homes, nursing homes, and assisted living facilities within the county.

5.3.1 Prioritization Process

Once the mitigation actions were identified, the HMPC members were provided with several sets of decision-making tools, including FEMA's recommended criteria, STAPLE/E (which considers social, technical, administrative, political, legal, economic, and environmental constraints and benefits).

- Social: Does the measure treat people fairly?
- Technical: Will it work? (Does it solve the problem? Is it feasible?)
- Administrative: Is there capacity to implement and manage the project?
- Political: Who are the stakeholders? Did they get to participate? Is there public support? Is political leadership willing to support the project?
- Legal: Does your organization have the authority to implement? Is it legal? Are there liability implications?

- Economic: Is it cost-beneficial? Is there funding? Does it contribute to the local economy or economic development? Does it reduce direct property losses or indirect economic losses?
- Environmental: Does it comply with environmental regulations or have adverse environmental impacts?

In accordance with the DMA requirements, an emphasis was placed on the importance of a benefit-cost analysis in determining project priority (the 'economic' factor of STAPLE/E). Other criteria used to recommend what actions might be more important, more effective, or more likely to be implemented than another included:

- Does 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)?

With these criteria in mind, team members were given a set of ten green sticky-dots. The team was asked to use the dots to prioritize projects with the above criteria in mind, essentially voting on the projects. The projects with the most dots became the higher priority projects. This process provided both consensus and priority for the recommendations. The results of the project identification and prioritization exercise are summarized below in Table 5.3. The actions are grouped by jurisdiction and priority. Appendix A contains more detail about the actions identified for Jefferson County, including a description of the activity, the entity responsible for implementation, any other alternatives considered, cost estimate, and a schedule for implementation. The jurisdictional annexes contain the detailed action item descriptions respective to each jurisdiction.

Follow-up meetings were held within each jurisdiction to finalize the actions that are part of this plan. Participating jurisdictions were given the leeway to prioritize the actions specific to them, using the previously mentioned criteria. This process was used during a meeting with Jefferson County department representatives on held November 16th 2009 to finalize the County-specific actions and their prioritization.

Table 5.3 Mitigation Action Plan Summary

Title	Jurisdiction	Priority*	Goals	Hazards
Create a Community Wildfire Protection Plan	Jefferson County	High	2	Wildfire
Fairmount Drainage Improvement Program.	Jefferson County	Medium	1	Flood
Drake Outfall	Jefferson County	Medium	2	Flood
Beer Sisters Reservoir Rehabilitation	Jefferson County	High	2	Dam Failure
North Branch of Coon Creek Culvert at Miller Street	Jefferson County	Medium	2	Flood
South Weir Gulch Rehabilitation	Jefferson County	Medium	2	Dam Failure

Title	Jurisdiction	Priority*	Goals	Hazards
National Flood Insurance Program (NFIP) and Community Rating System (CRS) Participation**	Jefferson County	Medium	1,2,3	Flood
Multi-Jurisdiction Storm Ready Program participation.	Jefferson County	Low	1,2,3	Dam Failure, Flood, Hailstorm, Lightning, Tornado, Windstorm, and Severe Winter Storm
Produce Bi-lingual publications for Jefferson County residents.	Jefferson County	Medium	1	Multi- hazard
Provide NOAA Radios to Facilities in Jefferson County.	Jefferson County	High	1,2	Multi- hazard
Public Awareness for those in Dam Inundation Areas.	Jefferson County	High	1, 2	Dam Failure
Fire Danger Operating Plan	Jefferson County	Medium	2	Wildfire
Geographic Information System Layer Updates	Jefferson County	Medium	2	Wildfire
Evaluate all power/backup power systems for police, fire (etc) and repeater tower sites.	Jefferson County	Medium	2	Dam Failure, Flood, Hailstorm, Lightning, Tornado, Windstorm, and Severe Winter Storm
Evaluate Possible Mountain Pine Beetle Infestation	Jefferson County	Medium	2	Wildfire
Environmental Damage Protection	City of Arvada	Medium	2	Erosion
Road Weather Information System (RWIS)	City of Arvada	High	2	Severe Winter Storm
Continue to Implement Sound Floodplain Management Practices through Participation in the National Flood Insurance Program.**	City of Arvada	Medium		Flood
Continue to Implement Sound Floodplain Management Practices through Participation in the National Flood Insurance Program	City of Edgewater	High	1,2	Flood
Coordinate Management with the Urban Drainage Flood Control District on the Storm Water Drainage Detention Basins	City of Edgewater	High	1,2	Flood
Continued Validation of Flood Response Protocol Identified in the NIMS Compliant Emergency Operations Plan of 2007 through Practical Training and Exercises Design.	City of Edgewater	High	1,2	Flood
Emergency Operations Plan Development	City of Golden	High		Multi-hazard
Continue to Implement Sound Floodplain Management Practices through Participation in the National Flood Insurance Program**	City of Golden	Medium		Flood
Winter Weather Citizen Shelter Facility Identification and Readiness	City of Golden	High	2	Severe Winter Weather
Kenney's Run Culvert Improvements	City of Golden	High	2	Flood
Burying Power Lines to Green Mountain Repeater Site	City of Lakewood	High	2	Lightning, Severe Winter Storm, Windstorm, Wildfire, Tornado

Title	Jurisdiction	Priority*	Goals	Hazards
Continue to Implement Sound Floodplain Management Practices through Participation in the National Flood Insurance Program.**	City of Lakewood	Medium		Flood
Lena Gulch Channelization	City of Wheat Ridge	High	2	Dam Failure, Flood
Emergency Warning System	City of Wheat Ridge	High	1,2	Dam Failure, Flood, Hailstorm, Lightning, Tornado, Windstorm, and Wildfire
Emergency Operations Plan	City of Wheat Ridge	High	2,3	Dam Failure, Earthquake, Flood, Hailstorm, Tornado, Wildfire, Windstorm, and Winter Weather
NFIP/CRS/CIP/Stormwater Utility**	City of Wheat Ridge	High	1,2,3	Dam Failure, Flood
City of Wheat Ridge Open Space Wildfire Management Plan	City of Wheat Ridge	High	2,3	Wildfire
Education and ordinances regarding the mitigation of trees as hazards	City of Wheat Ridge	High	1,2	Flood, Hailstorm, Lightning, Tornado, and Windstorm
Channel 8/Website Updates	City of Wheat Ridge	Medium	1	Multi-hazard
Stormwater Program and Maintenance Operations	City of Wheat Ridge	Medium	2	Flood, Erosion
No action identified in 2010 planning process	Town of Lakeside	-	-	-
Emergency warning system	Town of Morrison	High	1,2	Flood
Relocation of town shops	Town of Morrison	High	2	Flood
Continue to Implement Sound Floodplain Management Practices through Participation in the National Flood Insurance Program.**	Town of Morrison	Medium	1	Flood
Storm Water Drainage	Town of Mountain View	Low	2	Flood
Educate the Public on Wildfire Mitigation	Evergreen Fire Protection District	Medium/ High	1	Wildfire
Community Emergency Response Team (CERT) Training Program	Indian Hills Fire Protection District	Medium	2,3	Multi-Hazard Response
Recruit & Retain additional Volunteer Firefighters	North Fork Fire Protection District	High	2	Wildfire
Flood mitigation of Lena Gulch through Pleasant View Community Park at Camp George West located at 1220 Kilmer St.	Pleasant View Metropolitan District	Medium/ High	2	Flood
Flood mitigation of Lena Gulch through West Blade Park located at 16780 Mt Vernon Road.	Pleasant View Metropolitan District	Medium/ High	2	Flood
Replacement of the Aged Section of the Main Pipeline from Clear Creek County and Jefferson County Line East for Approximately ½ Mile.	Lookout Mountain Water District	High	2	Drought
Installation of Meters on Lateral Line Connections that Serve Various Communities	Lookout Mountain Water District	Medium	2	Drought

Title	Jurisdiction	Priority*	Goals	Hazards
Partial Renovation and Improvement to Sections of the Main Pipeline	Lookout Mountain Water District	Low/ Medium	2	Drought
Research Funding Opportunities with Neighboring Agencies to Reduce Flooding Potential on Beaver Brook	Lookout Mountain Water District	Low/ Medium	2, 3	Flood
Conduct a Leak Detection Survey	Lookout Mountain Water District	Low/ Medium	2	Drought

*Goal 1: Increase awareness about natural hazards; Goal 2: Reduce impacts of natural hazards on life, property, and the environment; Goal 3: Strengthen and develop partnerships in regards to mitigating hazard impacts

** Indicates protection of future buildings and infrastructure

6 PLAN ADOPTION

Requirement §201.6(c)(5): [The local hazard mitigation plan shall include] documentation that the plan has been formally approved by the governing body of the jurisdiction requesting approval of the plan (e.g., City Council, county commissioner, Tribal Council).

The purpose of formally adopting this plan is to secure buy-in from Jefferson County and 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 hazard mitigation plan by passing a resolution. A copy of the generic resolution and the executed copies are included in Appendix C Plan Adoption. This plan will be re-adopted every five years in concurrence with the required DMA local plan update requirements.

7 PLAN IMPLEMENTATION AND MAINTENANCE

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

Implementation and maintenance of the plan is critical to the overall success of hazard mitigation planning. This is Planning Step 10 of the 10-step planning process, and phase 4 of FEMA's 4 phase process. This chapter outlines how this plan will be implemented and updated.

7.1 Implementation

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 Appendix A Mitigation Actions and the actions detailed in the jurisdictional annexes) and through constant, pervasive, and energetic efforts to network and highlight the multi-objective, win-win benefits of each project to the Jefferson County community and its stakeholders. These efforts include the routine actions of monitoring agendas, attending meetings, and promoting a safe, sustainable community. The three main components of implementation are:

- IMPLEMENT the action plan recommendations of this plan;
- UTILIZE existing rules, regulations, policies and procedures already in existence; and
- COMMUNICATE the hazard information collected and analyzed through this planning process so that the community better understands what can happen where, and what they can do themselves to be better prepared. Also, publicize the "success stories" that are achieved through the HMPC's ongoing efforts.

Simultaneously to these efforts, the HMPC will constantly monitor funding opportunities that could be leveraged to implement some of the more costly actions. This will include creating and maintaining a bank of ideas on how to meet required local match or participation requirements. When funding does become available, the HMPC will be in a position to capitalize on the opportunity. Funding opportunities to be monitored include special pre- and post-disaster funds, special district budgeted funds, state and federal earmarked funds, and other grant programs, including those that can serve or support multi-objective applications.

7.1.1 Role of Hazard Mitigation Planning Committee in Implementation and Maintenance

With adoption of this plan, the Hazard Mitigation Planning Committee (HMPC) will be tasked with plan implementation and maintenance. The HMPC will be led by the Jefferson County Office of Emergency Management (OEM). The HMPC will act as an advisory body. Its primary duty is to see the plan successfully carried out and to report to the community governing boards and the public on the status of plan implementation and mitigation opportunities. The HMPC agrees 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 vigilant 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 Jefferson Board of County Commissioners; 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 County website and local newspapers.

7.2 Maintenance/Monitoring

Plan maintenance implies an ongoing effort to monitor and evaluate plan implementation and to update the plan as required or as progress, roadblocks, or changing circumstances are recognized.

7.2.1 Maintenance/Monitoring Schedule

In order to track progress and update the mitigation strategies identified in the action plan, the HMPC will revisit this plan annually or after a significant hazard event or disaster declaration. Jefferson OEM is responsible for initiating this review and convening members of the HMPC on a once yearly basis, or more frequently as needed. The annual review will be held in October of each year.

This plan will be updated, approved and adopted within a five-year cycle as per Requirement §201.6(c)(4)(i) of the Disaster Mitigation Act of 2000. With the initial approval of this plan occurring in mid-2010, the plan will need to be updated, re-approved by the Colorado Division

of Emergency Management (CDEM) and FEMA Region VIII, and re-adopted by all participating jurisdictions no later than June of 2015. The County will submit a Pre-Disaster Mitigation planning grant application to the Colorado Division of Emergency Management (CDEM)/FEMA for funds to assist with the update. This grant should be submitted in 2012, as there is a three year performance period to expend the funds, plus there is no guarantee that the grant will be awarded when initially submitted. This allows time to resubmit the grant in 2013 if needed.

7.2.2 Maintenance Evaluation Process

Updates to this plan will follow the latest FEMA and CDEM planning guidance. Evaluation of progress can be achieved by monitoring changes in vulnerabilities identified in the plan. Changes in vulnerability can be identified by noting:

- Decreased vulnerability as a result of implementing recommended actions:
- Increased vulnerability as a result of failed or ineffective mitigation actions: and/or
- Increased vulnerability as a result of new development (and/or annexation).

The HMPC will use the following process to evaluate progress and any changes in vulnerability as a result of plan implementation.

- A representative from the responsible entity identified in each mitigation measure will be responsible for tracking and reporting on an annual basis to the HMPC on project status and provide input on whether the project as implemented meets the defined objectives and is likely to be successful in reducing vulnerabilities.
- If the project does not meet identified objectives, the HMPC will determine what alternate projects may be implemented
- New projects identified will require an individual assigned to be responsible for defining the project scope, implementing the project, and monitoring success of the project.
- Projects that were not ranked high priority but were identified as potential mitigation strategies will be reviewed as well during the monitoring and update of this plan to determine feasibility of future implementation.
- Changes will be made to the plan to accommodate for projects that have failed or are not considered feasible after a review for their consistency with established criteria, the time frame, priorities, and/or funding resources.

Updates to this plan will:

- Consider changes in vulnerability due to project implementation;
- Document success stories where mitigation efforts have been completed or proven effective;
- Document areas where mitigation actions were not effective;
- Document any new hazards that may arise or were previously overlooked;
- Document hazard events and impacts that occurred within the five-year period;

- Incorporate new data or studies on hazards and risks;
- Incorporate new capabilities or changes in capabilities;
- Incorporate documentation of continued public involvement;
- Incorporate documentation to update the planning process that may include new or additional stakeholder involvement;
- Incorporate growth and development-related changes to building inventories;
- Incorporate new project recommendations or changes in project prioritization;
- Include a public involvement process to receive public comment on the updated plan prior to submitting the updated plan to CDEM/FEMA; and
- Include re-adoption by all participating entities following CDEM/FEMA approval.

7.2.3 Incorporation into Existing Planning Mechanisms

Another important implementation mechanism that is highly effective and low-cost is incorporation of the hazard mitigation plan recommendations and their underlying principles into other existing or new County and city plans and mechanisms. Mitigation is most successful when it is incorporated into the day-to-day functions and priorities of government and development. As stated in Section 7.1 of this plan, implementation through existing plans and/or programs is recommended, where possible. This point is re-emphasized here. The County and participating entities already have existing policies and programs to reduce losses to life and property from natural hazards. These are summarized in this plan's capability assessment. This plan builds upon the momentum developed through previous and related planning efforts and mitigation programs and recommends implementing projects, where possible, through these other program mechanisms. These existing mechanisms include:

- Jefferson County Comprehensive Land Use Plan
- Community and Land Use Plans including:
  - Conifer/285 Corridor Area Community Plan
  - Central Plains Community Plan
  - Central Mountains Community Plan
  - Clear Creek/I-76 Plans Evergreen Area Community Plan
  - Indian Hills Community Plan
  - South Jefferson County Community Plan
  - North Mountains Community Plan
  - The North Plains Community Plan
  - Jefferson County Telecommunications Land Use Plan
  - Northeast Comprehensive Development Plan
  - Mineral Extraction Policy Plan
  - Sanitary Landfill Plan Policy Summary

- Municipal Master Plans
- Arvada Flood Recovery Assistance Plan

- Jefferson County Open Space Master Plan and Municipal Park and Recreation Plans
- Community Wildfire Protection Plans
- Jefferson County Capital Improvement Plan – 2010-2013

HMPC members involved in the updates to these mechanisms will be responsible for integrating the findings and recommendations of this plan with these other plans, as appropriate. An example would be using the risk assessment information to update the hazard analysis in the County Emergency Operations Plan, and specifically linking duties of Emergency Support Function-14 (Long Term Recovery and Mitigation) with this plan.

The initial development of this plan was coordinated with an update occurring with Jefferson County Comprehensive Land Use Plan in 2009. Jefferson County Planning and Development staff participated and contributed to the development of this mitigation plan. Both planning processes were discussed at a public meeting in Conifer in November 2009. As mentioned in Chapter 5: Mitigation Strategy the Hazard section of the Jefferson County Comprehensive Land Use Plan and related Land Use Code is oriented toward reducing impacts to future development and will be used as the primary implementation mechanism for ongoing land use planning related to hazards. This plan works in tandem with the Land Use Plan and puts forth recommendations that will reduce losses to both new and existing infrastructure, but can be viewed as having a primary focus on reducing impacts to existing and future buildings, populations and infrastructure.

It was discussed at planning meetings that elements of this mitigation plan will be integrated into the updates of the Community and Land Use Plans of the unincorporated areas of the County. This could include building additional hazard and risk elements into these plans, further refining the hazard planning considerations at the community level in the unincorporated areas. Most of these plans already identify hazards in their communities which should be mitigated or eliminated prior to development. These plans also provide hazard polices and implementation recommendations.

7.2.4 Continued Public Involvement

Continued public involvement is also imperative to the overall success of the plan's implementation. The update process provides an opportunity to solicit participation from new and existing stakeholders and to publicize success stories from the plan implementation and seek additional public comment. In reconvening, the HMPC plans to identify a public outreach subcommittee, which will be responsible for coordinating the activities necessary to involve the greater public. The subcommittee will disseminate information through a variety of media channels and receive public comment on the plan revision draft. Jefferson County anticipates that the update process will begin in 2012 with the requests for PDM grant funding support, if necessary. In 2013, new data collection can begin for the revision and by early 2014 a public draft should be available for comment. The new draft will be distributed through a website or an interactive portal that allows for convenient comment interchange as well as offered through

designated committee meetings, press releases, libraries and local news media. Comments will then be addressed and incorporated as appropriate.